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SMITHSONIAN

MISCELLANEOUS COLLECTIONS

VOL. 66

"EVERY MAN IS A VALUABLE MEMBER OF SOCIETY WHO, BY HIS OBSERVATIONS, RESEARCHES, AND EXPERIMENTS, PROCURES KNOWLEDGE FOR MEN"—SMITHSON

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CHARLES D. WALCOTT,
Secretary of the Smithsonian Institution.

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SMITHSONIAN MISCELLANEOUS COLLECTIONS
VOLUME 66, NUMBER 1

DESCRIPTIONS OF A NEW GENUS AND EIGHT NEW SPECIES AND SUBSPECIES OF AFRICAN MAMMALS

BY
N. HOLLISTER

(Publication 2406)

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
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DESCRIPTIONS OF A NEW GENUS AND EIGHT NEW SPECIES AND SUBSPECIES OF AFRICAN MAMMALS

By N. HOLLISTER

The new East African mammals herewith described were collected by members of the Smithsonian African Expedition, 1909-1910, and of the Rainey African Expedition, 1911-1912.

SURDISOREX POLULUS, sp. nov.

Type from west side of Mount Kenia, British East Africa, at 10,700 feet altitude. United States National Museum No. 163992, skin and skull of adult male (teeth moderately worn). Collected September 30, 1909, by J. A. Loring. Orig. No. 7562.

Description.—Like *Surdisorex noræ* Thomas, but smaller, with smaller skull and teeth; hind foot larger. Color indistinguishable from that of *S. noræ.* Upper unicuspid teeth all smaller than in *S. noræ,* the first and third especially small and the first conspicuously narrow.

Measurements.—Type, compared with average measurements of seven adults of *S. noræ* from the Aberdare Range, the latter in parentheses: Head and body, 92 (100) mm.; tail vertebræ, 30 (33); hind foot, 17 (15.6). Skull: Condylobasal length, 24.5 (25.2); zygomatic breadth, 6.8 (7.3); breadth of braincase, 12.5 (13.4); mandible, 14.4 (14.6); upper tooth row, entire (alveoli), 10.6 (11.1); lower tooth row, entire (alveoli), 9.6 (10.1).

Specimens examined.—Thirty-five from Mount Kenia. These have been compared with a series of nine specimens of *Surdisorex noræ* from the Aberdare Range. There is in no case any doubt as to which form any specimen in this series belongs. The two lots are readily separated by the characters of the unicuspid teeth.

CERCOCTENUS, gen. nov.

(Macroscelidæ.)

Type species.—*Petrodromus sultan* Thomas.

Characters.—Like *Petrodromus* but tail thinly haired and with irregular rows of long, stiff, club-like bristles along under side; fingers longer. Skull without the large posterior palatine vacuities, which in *Petrodromus* extend from near the plane of the anterior border of pm^3, in palatine plate of maxillæ, to line of center of m^1 in the palatines. Teeth in general as in *Petrodromus*, but pm^1 apparently always a simple hooked cone, without small posterior spikelet as in *Petrodromus*; and pm^3 more complex, deeply grooved on outer side, and distinctly four-cusped.

The forms included in the genus are *Cercoctenus sultan* (Thomas), *Cercoctenus sultan sangi* (Heller), and *Cercoctenus schwanni* (Thomas and Wroughton).

RHINOLOPHUS KENIENSIS, sp. nov.

Type from west side of Mount Kenia, British East Africa, at 7,000 feet altitude. United States National Museum No. 166352, adult male in alcohol with skull removed. Collected August 27, 1909, by Edmund Heller. Orig. No. 1154.

Description.—A small member of the *Rhinolophus augur* group, differing from *R. a. zambesiensis* in the small size of the nose-leaf (greatest width of horse-shoe, 6.8; compared with 8.0-8.3 in *zambesiensis*), shorter forearm, and shorter tibia. Skull somewhat larger, with slightly more robust teeth, than in *zambesiensis.*

Measurements of type.—Forearm, 52 mm.; tibia, 21; greatest length of ear from anterior margin, 18.9; greatest width of ear, 12.2; third finger metacarpal, 34.8; first phalanx, 17.4; fourth metacarpal, 39.5; first phalanx, 11.3; fifth metacarpal, 40.3; first phalanx, 12.8. Skull: Greatest length, 22.8; condylobasal length, 20.4; zygomatic breadth, 12; postorbital constriction, 3; mastoid breadth, 10.7; mandible, 15. Teeth: Canine to m^3, 8.6; breadth across upper canines, 6.6; greatest breadth across upper last molars, 8.4; lower canine to m_3, 9.

Remarks.—This new bat is readily separable from all the other species of *Rhinolophus* known from British East Africa by the combination of narrow horse-shoe, hairless sella, and position of small upper premolar entirely without the tooth row. It is doubtless a northern representative of *R. augur,* and perhaps it intergrades directly into *R. a. zambesiensis.* Doctor Lönnberg and Mr. Oldfield Thomas have recorded *R. a. zambesiensis* from Kilimanjaro,[1] but I am not aware that a member of the group has up to now been noted in British East Africa.

Specimen examined.—One, the type.

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[1] Lönnberg, Wiss. Erg. Schwedischen Zool. Exp. Kilimandjaro, Mamm., pp. 8-10, 1908; Thomas, Ann. and Mag. Nat. Hist., ser. 8, Vol. 11, p. 315, March, 1913.

EPTESICUS UGANDÆ, sp. nov.

Type from Ledgus, Uganda. United States National Museum No. 166520, adult female in alcohol (skull removed). Collected February 15, 1910, by J. Alden Loring. Orig. No. 9022.

Description.—A small brown species related to *Eptesicus capensis somalicus* (Thomas), but with larger, flatter skull. Ears broad, somewhat evenly triangular, with rounded tip; when laid forward reaching to tip of muzzle. Tragus comparatively long, broadest at center, the tip bluntly rounded and not turned forward; inner side nearly straight for two-thirds its length; outer side evenly convex from tip to opposite anterior notch, where there is a small sharp lobe, beneath which is a sharply concave margin and a larger triangular basal lobe, immediately above the outer notch. Wing from base of toes; tail vertebræ entirely within the interfemoral membrane, but a small fleshy tip extending very slightly beyond; postcalcaneal lobe comparatively small, sharply emarginate anteriorly and evenly sloping posteriorly. Hair extending only slightly on to wings but thinly covering the interfemoral membrane to line of ankles and, along tail, to slightly beyond. Color (from alcoholic specimens) apparently much as in *somalicus* but somewhat darker throughout; wings dark grayish brown, faintly lined along posterior edges with buffy; interfemoral membrane slightly lighter than wings. Skull decidedly larger than in *somalicus* (as represented by specimens from the Northern Guaso Nyiro) with relatively and actually broader rostrum and braincase, and relatively much lower sinciput. Upper inner incisors broad and heavy, distinctly bifurcate at tip (except in a much worn specimen); outer upper incisors small, barely reaching beyond cingulum of inner incisors. Lower incisors all trifid, considerably crowded in the row. Cheek teeth essentially as in *somalicus* but slightly more robust.

Measurements.—Type: Forearm, 29.6 mm.; outer height ear, 12.3; greatest breadth ear, 8.1; tragus from outer notch, 5.4; third finger metacarpal, 26.8; first phalanx, 10.3; fourth finger metacarpal, 27.7; first phalanx, 9.2; fifth finger metacarpal, 28.1; first phalanx, 7.3; tibia and foot, including claws, 16. Skull: Greatest length, 12.8; condylobasal length, 11.8; breadth of braincase, 6.8; depth of braincase, 4.6; mastoid breadth, 7.3; postorbital constriction, 3.5; mandible, 8.8. Teeth: Upper maxillary row, 4.3; breadth across upper canines, 3.9; entire lower row, 5.8.

Remarks.—In addition to other characters, this species may readily be separated from the other small forms of *Eptesicus* known in East

Africa by its dark-colored wing membranes [distinguishing from *tenuipinnis, rendalli,* and *phasma*], short outer upper incisors [distinguishing from *grandidieri*], large, flattened skull, and distinctly bifurcate inner upper incisors [distinguishing from *somalicus*]. In addition to the type there are two topotypes and three other specimens from Gondokoro in the collection.

CHÆREPHON PUMILUS NAIVASHÆ, subsp. nov.

Type from Naivasha Station, British East Africa. United States National Museum No. 166658, male, in alcohol, with skull removed. Collected August 7, 1909, by J. Alden Loring. Orig. No. 6955.

Description.—Like *Chærephon pumilus pumilus* Cretzschmar, but larger, with longer forearm and larger skull; color averaging somewhat darker.

Measurements.—Type, compared with adult male of true *pumilus* from Saaita, Eritrea (number 143166), measurements of the latter in parentheses: Forearm, 42 (38) mm.; skull, condylobasal length, 16.0 (15.4); zygomatic breadth, 10.8 (10.4); interorbital constriction, 4.0 (3.6); mastoid breadth, 9.9 (9.2); mandible, 11.7 (11.8); maxillary tooth row, including canine, 6.3 (6.2); entire lower tooth row, 7.3 (7.0). Average of length of forearm in fifteen adults of *naivashæ,* 40.3; in eighteen adults of *pumilus* from Eritrea, Sudan, and Northern Uganda, 36.5.

GENETTA PUMILA, sp. nov.

Type from Mount Gargues (North Creek, at 6,000 feet), British East Africa. United States National Museum No. 182704, skin and skull of adult male (basal suture closed). Collected September 1, 1911, by Edmund Heller. Orig. No. 4193.

Description.—Like *Genetta stuhlmanni* Matschie, but much smaller, with smaller skull and teeth. Color as in the paler specimens of *stuhlmanni* which approach somewhat the characteristic coloration of *G. erlangeri* Matschie. Ground color of body buff or cream-buff with a grayish tinge; dorsal stripe blackish; large spots along dorsal stripe reddish brown; smaller spots on hips and flanks seal-brown or blackish; outer shoulder stripes, from crown to arms, sharply marked, the three inner stripes to withers much less distinct; crown reddish brown, a narrow stripe of same color extending to the duller brown of nose; sides of face sharply marked by buffy white patch between eye and lips; upper lips whitish; fore and hind feet buffy above, the hind feet dark brown below. Chin and throat grayish buff;

lower neck buffy, sparingly spotted with reddish brown; underparts of body yellowish buff, the middle area spotted with dark brown, the lower belly unspotted. Tail with nine dark bands of reddish brown, those of mid-tail almost chestnut, and eight light bands of buff hairs with darker, pale reddish brown tips. Tip of tail broadly dark blackish brown.

Measurements of type.—Head and body, 380 mm.; tail vertebræ, 355; hind foot, 76; ear, 38. Skull and teeth: Condylobasal length, 75; zygomatic breadth, 38; mastoid breadth, 24.6; interorbital breadth, 10; lachrymal foramen to alveolar point, 23.3; mandible, 51; upper tooth row, including canine, 29.5; upper carnassial, 7.0×4.3; lower tooth row, including canine, 32.6.

Remarks.—In a series of fifty specimens of genets of this group from British East Africa this specimen is remarkable for its very small size. Although the animal is an adult male, the skull is much smaller than skulls of considerably younger females of other species, and when compared with male skulls of *stuhlmanni* or *erlangeri* of equal age is actually diminutive. There is only a single specimen in the collection. A genet from the neighboring Mount Lololokwi is referred to *Genetta stuhlmanni*. It is somewhat younger than the type of *pumila* but has a much larger skull. There will be no difficulty in distinguishing, by size alone, either skins or skulls of this new form from other genets found in the same general region.

MUNGOS SANGUINEUS PARVIPES, subsp. nov.

Type from Kaimosi, British East Africa. United States National Museum No. 182739, skin and skull of adult male (basal and nasal sutures closed). Collected February 5, 1912, by Edmund Heller. Orig. No. 5601.

Description.—Smaller than *Mungos sanguineus ibeæ* Wroughton and *M. s. proteus* Thomas, with smaller hind foot and skull. Type, in blackish phase, darker, more blackish, than *proteus;* general color dull blackish, indistinctly marked with minute vermiculations of brownish, the sides of neck, sides of body, and middle of tail especially so marked; head, nape, center of back, hands and feet, and terminal third of tail almost pure dull blackish; underfur everywhere brownish black. A specimen in the grizzled phase is much like certain specimens of *M. s. ibeæ* in like coat, but is generally darker and richer colored, with more ochraceous than in any specimen of *ibeæ* in the National Museum collections; under side of tail especially brighter ochraceous, the median line scarcely vermiculated and the black terminal third sharply marked; hands and feet heavily grizzled. Skull like that of *M. s. ibeæ*, but decidedly smaller; teeth smaller.

Measurements of type.—Compared with adult male of same age (with basal and nasal sutures closed) of *Mungos sanguineus ibeæ* from Kitanga, British East Africa, measurements of the latter in parentheses: Head and body, 305 (350) mm.; tail vertebræ, 247 (325); hind foot, 54 (67); ear, 24 (—). Skull: Condylobasal length, 61.3 (65.1); zygomatic breadth, 30.9 (33.8); mastoid breadth, 23.2 (24.3); least postorbital constriction, 9.6 (10.9); breadth of rostrum over canine, 10.9 (11.9); length of mandible, 39.3 (42.2); maxillary tooth row, including canine, 21.7 (23.9); lower tooth row, including canine, 24.2 (26.5).

Remarks.—This form needs no special comparison with the Uganda forms described by Wroughton, *M. s. ugandæ* and *M. s. galbus*; both are larger races and both have the hind feet unicolored ochraceous. Two specimens of the new Kavirondo form are in the collection, the type and an adult male from Lukosa River. The small size of the hind foot and skull readily distinguish them from specimens of the neighboring forms. The adult male skull is about the size of the female skulls of *proteus* and considerably smaller than any female skull in a series of specimens of *ibeæ*. Matschie has recently named several "species" of mungooses of this group from various localities in East Africa,[1] but none of his descriptions agrees with the specimens on which this new variety is based.

MUNGOS ALBICAUDUS DIALEUCOS, subsp. nov.

Type from Mount Lololokwi, British East Africa. United States National Museum No. 184794, skin and skull of adult male (basal and nasal sutures closed; teeth much worn). Collected September 18, 1911, by Edmund Heller.

Description.—Like *Mungos albicaudus ibeanus* Thomas but lighter colored; more grayish buff and silvery, less brownish buff and blackish. Underfur and long hairs of sides of body especially paler, more silvery gray and very light buff; sides of neck, cheeks, and muzzle grayer. Skull and teeth as in *ibeanus*, the lower molars showing no reduction in size as in the northern form, *Mungos albicaudus leucurus*.

[1] Sitz-ber. Ges. Nat. Freunde Berlin, 1914, pp. 435-457. December.

Measurements of type.—Skull: Greatest length, 105 mm.; condylobasal length, 104; zygomatic breadth, 54; mastoid breadth, 37.1; postorbital constriction, 20.2; breadth of rostrum over canine, 20.3; length of mandible, 69.5. Teeth of type and of a younger adult male from the type locality in which the molars are less worn, measurements of the latter in parentheses: Upper row, including canine, 39.8 (40.8); lower row, including canine, 44.8 (45.8); last lower molar, 7.6×4.2 (7.7×4.5).

Remarks.—This new subspecies of *Mungos albicaudus* is based on three specimens from the type locality and an additional skin from Merelle Water, on the Marsabit Road. These four skins are all lighter colored than any skins of *ibeanus* in the collection, and when placed together the series as a whole is sharply differentiated from a suite of seventeen skins of *ibeanus* collected at points along the Uganda Railroad from Kavirondo to the coast.

HELOGALE UNDULATA AFFINIS, subsp. nov.

Type from summit of Mount Lololokwi, 6,000 feet, British East Africa. United States National Museum No. 182715, skin and skull of adult male (basal and nasal sutures closed). Collected September 2, 1911, by Edmund Heller. Orig. No. 4296.

Description.—Most like *Helogale undulata rufula* Thomas, but smaller, with smaller teeth, and darker and richer colored. Color of whole pelage more heavily suffused with hazel and russet, the feet especially darker (rich dark russet), the underfur everywhere darker, (dark cinnamon brown rather than ochraceous, or tawny brown) and the whole head and neck strongly washed with bright russet, much darker than in *rufula*. Underparts also considerably darker russet, almost "reddish"; a stripe of rich tawny russet along under side of tail to tip. Hands and feet speckled like limbs to near bases of toes; lower hands and toes clear rich dark russet.

Measurements of type.—Head and body, 220 mm.; tail vertebræ, 175; hind foot, 46; ear, 18. Skull: Condylobasal length, 49.7; zygomatic breadth, 29.6; mastoid breadth, 22.8; postorbital constriction, 9.2; breadth of rostrum over canine, 9.5; mandible, 33.8; maxillary tooth row, 16.5; upper carnassial, 3.9×4.0; lower molar-premolar row, 14.2.

Specimens examined.—Two from the summit of Mount Lololowki and four from Rumathe Water, Northern Guaso Nyiro, British East Africa.

Remarks.—This new form differs from H. *atkinsoni* in its rich russet colored face and muzzle, longer tail, larger hind foot, and presence of a conspicuous internal cusp on *pm* ³. From *H. macmillani* it is distinguished by longer tail and hind foot, the less finely speckled upperparts, the speckled upper half of the hand and foot, and the conspicuous russet stripe entire length of under side of tail. It needs no special comparison with *Helogale hirtula ahlselli* Lönnberg, which is found in the same general region.

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A List of the Birds Observed in Alaska and Northeastern Siberia During the Summer of 1914

BY
F. SEYMOUR HERSEY

(Publication 2408)

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A LIST OF THE BIRDS OBSERVED IN ALASKA AND NORTHEASTERN SIBERIA DURING THE SUMMER OF 1914

By F. SEYMOUR HERSEY

During the summer of 1914 the writer had the good fortune to make a rather extended trip along the Alaskan coast. Besides brief visits to one or two points in southern Alaska and the Aleutian Islands, stops of varying extent, but mostly of brief duration, were made at practically every village between the mouth of the Yukon River and Barrow, as well as several of the islands in Bering Sea and four points on the Siberian coast. The trip was made in the interest of Mr. A. C. Bent, to obtain data, and especially nesting photographs, for his work on the "Life Histories of North American Birds."

We left Seattle May 12 on the Revenue Cutter *Bear,* and for four days steamed slowly northward through the narrow and often tortuous channels of the "Inside Passage." The scenery was delightful. Mountains, clothed with the luxuriant evergreen growth so characteristic of the northwest coast, rose abruptly from the water's edge, with here and there a loftier peak, capped with snow, towering above its neighbors. Wooded islands were sighted and left behind, and once or twice we passed a small steamer. Finally we dropped anchor at Ketchikan on the afternoon of May 16.

This part of the country is heavily wooded with great evergreens. Beneath the trees the partly decayed trunks of fallen trees are numerous; these and the ground itself being covered with a heavy growth of green mosses, and everything dripping with moisture. Small birds did not appear to be plentiful, but our stay was too short to allow of any extended work. Northern Bald Eagles were common and we found one or two species here which were not seen at any other place.

We left Ketchikan that night and passed out through Dixon's Entrance, heading for Unalaska. Although the weather was fine, a heavy swell caused us to roll badly. Soon after leaving the land behind, I began to notice various members of the Tubinares. These became more abundant as we neared the "pass." Sooty Shearwaters were the most common, with Fork-tailed Petrels next. Leach's and Fisher's Petrels were often seen, and several Black-footed Albatrosses followed us until we neared land, when they disappeared.

As we approached Unimak Pass the number of birds increased to a point almost beyond belief. As far as the eye could see great masses of birds were bedded on the water. California (and perhaps Pallas's) Murres and Tufted Puffins were everywhere, with a smaller proportion of Horned Puffins. As we steamed through the pass, they swam or fluttered to one side barely clearing the sides of the vessel. Ahead of us great clouds of Sooty Shearwaters rose, and flying a short distance, again settled on the water. It was utterly impossible to form any definite estimate of the number of birds seen. "Hundreds of thousands" does not exaggerate their abundance. We were several hours in going through the pass and it was not until we reached Unalaska in the evening, that we saw the last of this vast number of birds.

We planned to spend two days at Unalaska but a bad storm kept us there a third. The time was profitably spent collecting the various species peculiar to this locality.

Our next stops were at St. George and St. Paul Islands, but we did not land. Crested, Paroquet, and Least Auklets, and Rodger's Fulmars, were about the ship during our brief stays here.

Nome was our next port, which we reached on June 1. I shall long remember the novelty of this day's experiences. Early in the morning we sighted ice and the day was spent laboriously forcing our way through it. We finally anchored to the ice a little way off shore about 10.30 p. m., and dog teams came out from the town and took off the mail. During the day we had been within sight of the steamer *Corwin*—formerly a revenue cutter, but now owned and operated by a Seattle steamship company—and just before midnight she steamed in and anchored near us. Her passengers were landed on the ice and transferred by dog team to the shore. The long Arctic day was drawing to a close, but there was still enough light to obtain photographs of this interesting scene.

After leaving Nome we were again delayed by ice, but reached St. Michael early in the morning of June 5. Here I left the ship, and arrangements being made with the owner of a small open power-boat to carry me and my outfit to the mouth of the Yukon River, we left St. Michael Monday morning, June 8. We went through the "canal" (so called), a tide channel which separates St. Michael Island from the mainland. When a distance of about 25 miles had been covered a storm arose which forced us to make camp, and I remained here until June 11. Although impatient of this delay, I found birds plentiful and the time was employed to good advantage. Eggs of the Pectoral Sandpiper and Long-billed Dowitcher, as well as several other species, were secured while here. At last we were able to resume our journey and left this point about seven o'clock at night and reached our destination at four o'clock the next morning.

Headquarters were established at the wireless station at the mouth of the river. There were no houses near; the village of Kotlik, eight miles away, being the nearest settlement. The people of this village, mostly natives, were at this time at their summer fishing camps, some distance away. Excepting the men at the station, I saw almost no one during my stay here.

The country is low tundra, very little above sea level, flat and monotonous. It is dotted with little sloughs and ponds, and intersected by numerous creeks. The drier parts are covered with a grayish moss and a little grass and low creeping vines, but about the creeks the grass is heavier and greener. Small clumps of dwarf willows and alders are found in places. Scattered along the shore of the river are low mud flats, sometimes quite extensive. They are covered by water at high tide and support a scant growth of stiff, coarse grass about 6 or 8 inches high. These flats make safe feeding grounds for Little Brown Cranes and geese, as it is impossible to approach them unobserved. So bare and level is the country that a photograph of the river, taken from the shore, shows the opposite bank as nothing but a straight black line, such as might be made across the print with a ruler and coarse stub pen.

The bulk of the breeding season was spent here, during which time many miles of tundra were tramped over, and with a boat I explored such of the flats in the river as I could reach. I found Pintails and several species of shore birds breeding abundantly. Gulls, Terns, and Jaegers were common, and among the willows and alders were Hoary and common Redpolls, and Alaska Yellow Wagtails. Willow Ptarmigan and Alaska Longspurs were common and widely distributed species in the region.

Several species found by Mr. Nelson at the time of his visit were not seen by me, or were present in very small numbers. As I was in the country a comparatively short time, I was not able to explore a large section, especially the great expanse of territory between the Yukon and Kuskoquim Rivers. Could I have done so it is possible that I would have found some of these species, although, personally, I believe that many of the geese and other water birds that Mr. Nelson found in such large numbers, now breed there very rarely or not at all.

Leaving the Yukon in July, I returned to Nome and rejoined the *Bear,* the remainder of the summer being spent in cruising along the coast. Stops were made at the following places on the dates indicated:

Golovin Bay, July 13 and 21.
St. Lawrence Island, July 24 and 25.
St. Lawrence Bay, Siberia, July 26.
Teller Reindeer Station, Alaska, July 28.
Cape Prince of Wales, July 29.
Deering, August 1.
Chamisso Island, Kotzebue Sound, August 1 to 3.
Cape Espenberg, August 5.
Point Hope, August 7.
Cape Dyer, August 7 (at 9 p. m.).
Cape Lisburne, August 8.
Wainwright Inlet, August 10 to 20.
Point Franklin, August 18 and 20.
Barrow, August 21.

Golovin Bay, a narrow inlet surrounded by low hills, was a particularly favorable spot for small land birds. Low willows were more in evidence here than at most places on the coast, and in them were found several species not noted elsewhere. St. Lawrence Island impressed me as a particularly promising locality and I would gladly have spent more time there. At two places on the north side of the island where landings were made, the land was high rolling tundra. At the northwestern part, a native village is located on a level gravel spit. Back of the village rise high cliffs in which Crested, Paroquet, and Least Auklets, Pallas's Murres, Pacific Kittiwakes, Glaucous Gulls, Horned Puffins, and perhaps Rodger's Fulmars, were breeding. The natives are superior to any I saw on the mainland. They are unusually clean, have substantially built houses and good boats. The excellent English spoken by many of them, and the evidence of their familiarity with the use of soap and water, reflect great credit on the government school and its teacher.

Near Deering, on the north coast of the Seward Peninsula, are several rocky cliffs where Pallas's Murres and Horned Puffins breed. Several Gyrfalcons were seen about these cliffs and probably bred here. Chamisso Island, and Puffin Island near by, contained the largest breeding colonies of Horned Puffins that I saw anywhere in Alaska. On Puffin Island they were crowded together on the rocks and cliffs, and for every bird thus seen there was (presumably) a mate hidden away among the rocks or in the nesting burrows. Those that could not find room on Puffin Island had settled on Chamisso. Here there were about three thousand pairs of birds, but it was impossible to even guess how many were on Puffin Island. Besides the Puffins were many Pallas's Murres and about four hundred Pacific Kittiwakes.

One of the most interesting localities north of Kotzebue Sound was Point Hope. Behind a long gravel spit was a large lagoon, bordered by an extent of level tundra. At the farther end of the spit was a native village with a smaller lagoon. Birds of many kinds were seen everywhere. In the large lagoon were Old-squaws and various ducks; on the end of the spit rested a large flock of gulls, while Pallas's Murres were flying by outside. In the village, Snow Buntings, (Ruddy?) Turnstones, Red-backed Sandpipers, and Alaska Longspurs were much in evidence, and in the small lagoon Northern Phalaropes and a small flock of Sabine's Gulls were swimming, while many small sandpipers waded about the shore.

About Cape Dyer and Cape Lisburne the shore is more or less rocky, but north of this latter point it again becomes level tundra but little higher than sea level. North of Point Franklin it rises gradually, although still level, and in places attains an elevation of probably 30 or 40 feet.

The first ice was encountered on this northern trip as we passed Icy Cape, and when Wainwright Inlet was reached we were forced to stop. Here 10 days were spent, sometimes going ahead a few miles as an apparent "lead" opened through the ice, only to be compelled to retreat later. At last, on August 20, a favorable wind allowed us to go forward with some prospect of successfully reaching our destination, and the following evening we made Barrow. With the ice conditions so bad, it was unsafe to stay here any longer than necessary, so having landed the mail, and taken aboard several men who had been caught by the ice the previous season and obliged to winter there, we turned south. Among the men who came aboard at Barrow was Mr. W. S. Brooks, a member of the *Polar Bear* party. Mr. Brooks had been collecting for the Museum of Comparative Zoology. He had reached Barrow but a few days previous to our arrival, having travelled from the eastward on a small gasoline schooner bringing his collections with him.

As soon as the ship was out of the ice the course was changed to west and an effort made to reach Wrangel Island, where the shipwrecked crew of the *Karluk* was known to have wintered. Fog, snow, and general bad weather prevented our reaching this point, and after 10 days cruising we returned to Nome for more coal. On the way stops were made at two points near Cape Serdze, and at East Cape, Siberia. Cape Serdze is a high rocky point. Each side of the cape are stretches of low rolling tundra with several lagoons. East Cape is marked by a rocky precipice rising abruptly from the sea to a height of several hundred feet. Large colonies of Pallas's Murres, Horned Puffins, and Pacific Kittiwakes were breeding on the cliffs. At both capes are small native villages. From Nome the writer took passage for Seattle on the steamship *Victoria*.

During the season careful notes were recorded of all birds seen or taken. A daily list was made in which were entered the species seen and their abundance, the actual numbers present being set down whenever possible. A field journal was also kept wherein were entered accounts of the localities visited, the character of the country, flowers or animals seen, and any other items of interest not properly belonging to the daily list. In addition to the above, extensive notes were made on the habits of the various species. In the list which follows I have omitted these latter notes, as this material will be used by Mr. Bent in his forthcoming work.

In conclusion I desire to express my thanks for courtesies received. Acknowledgments are due the Revenue Cutter Service for permission to accompany the *Bear*, and to Mr. H. J. Lee, U. S. Deputy Marshal at St. Michael, for assistance in securing transportation to the mouth of the Yukon River.

Especially do I appreciate the many kindnesses extended to me by Capt. C. S. Cochran and his officers while aboard the *Bear*. Everything possible was done to facilitate my work and to make the trip comfortable and pleasant. My thanks are also due Messrs. S. F. Rathbun and D. E. Brown for favors received while in Seattle.

Finally, I wish to express my indebtedness to Mr. A. C. Bent of Taunton, Massachusetts, through whose kindness and generosity I was enabled to make the journey here described.

LIST OF SPECIES

COLUMBUS AURITUS

Horned Grebe

Not common. The species was noted several times in the sloughs and creeks at the mouth of the Yukon. Near Deering three birds were seen together a short distance out from shore on August 1. They allowed us to row quite near to them when they dove and swam away. This was the farthest north that the species was seen. No specimens were taken.

GAVIA ADAMSI

Yellow-billed Loon

Although constantly on the watch for this species, I saw no indication of its presence until we reached Kivalina, a few miles south of Point Hope. Here a native brought out a skin from the head of a bird which he had shot the previous week. Upon being questioned he stated that this species was rarely seen there. I was told a few breed about Point Hope, but it was not until we reached Wainwright Inlet that I found them in any numbers. Between this place and Point Barrow a number were seen, in fact they were fairly common for a bird of this family. I was told a bird accompanied by a downy young had been shot at Wainwright shortly before I arrived.

GAVIA ARCTICA

Black-throated Loon

GAVIA PACIFICA

Pacific Loon

As no specimens were taken I am unable to determine the status of these two species in the territory. A few were seen about the Yukon and St. Michael, but were not tame enough to allow of approach to within gunshot distance. These were supposed to be the Black-throated Loon, as this is the species recorded by Nelson from this locality.

North of Bering Strait they were more abundant, the greatest number being seen between Wainwright Inlet and Point Barrow. Here the Pacific Loon only is supposed to occur. While trying to work our way slowly north, we surprised a bird, one day, in a little patch of open water of 4 or 5 yards in extent and entirely surrounded by ice cakes. The size of the patch of open water was not sufficient to allow him to take wing, and the surrounding ice kept him for a time, from escaping by diving. As we could not stop to pick him up, I did not shoot the bird, but watched him until the movement of the ice at last opened up a lane of open water allowing him to swim out.

GAVIA STELLATA

Red-throated Loon

The most common Loon in Alaska. The heads and necks of this species are used by the Eskimos for a variety of fancy articles. The skin is removed and made into tobacco pouches or split open and spread out flat and then trimmed into square or oblong-shaped pieces which are combined with similar pieces from the various Eiders and made into small mats. These are often very neatly and smoothly made and are quite pretty.

LUNDA CIRRHATA

Tufted Puffin

From the Aleutian Islands southward, this is the commonest Puffin. In Unimak Pass they are particularly abundant as already stated. North of this locality the Horned Puffin takes the place of the Tufted, although a limited number were noted in all the Horned Puffin colonies as far north as East Cape, Siberia, and Kotzebue Sound.

FRATERCULA CORNICULATA

Horned Puffin

As we steamed through Unimak Pass large numbers of this species were met with for the first time. Although the total number of individuals was large, it is probable that *corniculata* did not compose more than 10 per cent of the thousands of Puffins that abound in these waters. Throughout Bering Sea, wherever there are steep, rocky cliffs or suitable islands, colonies of these curious birds may be found breeding. These colonies range in size from 100 or so pairs, as at St. Michael, to the great hordes found at Chamisso Island, where it would be difficult, if not impossible, to estimate their numbers.

North of East Cape, Siberia, and Chamisso Island the species was not seen, but I did not visit the large colony of Pallas's Murres at Cape Lisburne where Nelson reports it as also breeding.

The breeding season in these large colonies is greatly prolonged. At the date of our visit to Chamisso Island (August 2) many birds still had eggs only slightly incubated, while a larger number were bringing food to their young. On July 16 I found that most of the eggs in the colony at St. Michael were hatched, and the young could be heard in the crevices among the rocks, although they were beyond reach. At the colony at East Cape the young were still in the nests as late as August 29. In fact, no young were seen either on the wing or in the water up to the time I left the region (September 12), and none of the adults showed any indications of moult either of bill or plumage.

PHALERIS PSITTACULA
Paroquet Auklet

ÆTHIA CRISTATELLA
Crested Auklet

ÆTHIA PUSILLA
Least Auklet

Myriads of these interesting little birds were met with about all the larger islands of Bering Sea, but as very little work was done on the islands, I did not visit their breeding places. On St. Lawrence Island the natives catch numbers of them in nets. At the time of my visit nearly every family had a dozen or more. I picked out a number of the best birds, thus securing a good series of Crested and Least, but only found one Paroquet. It may be that this latter species is less plentiful here.

I was told that these birds were used regularly for food and were considered very nice and that their skins were used for clothing. Eighty-five skins of the Crested Auklet were said be to used in making a "parka" and a larger number of the Least are needed.

Auklets were plentiful about East Cape and the Diomede Islands, but were not seen north of Bering Strait.

SYNTHLIBORAMPHUS ANTIQUUS
Ancient Murrelet

This species was met with only at Ketchikan where a specimen was secured. A number were seen.

CEPPHUS COLUMBA

Pigeon Guillemot

This species was not seen on the Alaskan coast north of the Aleutians, but a few were met with on the Siberian side. At East Cape I estimated there were about 150 birds flying with the circling clouds of Pallas's Murres and Horned Puffins.

URIA TROILE CALIFORNICA

California Murre

URIA LOMVIA ARRA

Pallas's Murre

All along the coast from the Shumagins to Barrow large numbers of Murres were observed. Both species occur in the Pribilof Islands, but north of that point Pallas's Murre is the most common. All the specimens taken (St. Lawrence Island and East Cape) were of this form. They nest abundantly wherever suitable rocky cliffs are found. The most northern breeding colony is at Cape Lisburne where natives brought out eggs nearly fresh on August 8. Most of the Murres at Chamisso Island had well-grown young on August 2, but a few were still sitting on their single eggs.

Note.—On August 10, while slowly forcing our way through the ice near Wainwright Inlet, we came upon a pair of small *Alcidæ*. They were swimming in a bit of open water and allowed us to pass them at a distance of not more than 50 feet. As we could not have picked them up I did not shoot either but observed them closely with a good glass for about a half hour. They were glossy black above, with white markings on the scapulars plainly visible, and throat and upper breast black. The small size and dark color of the bill were clearly noted. They were very much too small for Murres, with shorter bill, and certainly were not Auklets, as the *black* bill and *glossy blackness* of the plumage indicates. I am very sure they were Dovekies, but as neither was taken, and I can find no record for this part of the Arctic Ocean, I make but this mention of the species.

STERCORARIUS POMARINUS

Pomarine Jaeger

In Thayer and Bangs' "Notes on the Birds and Mammals of the Arctic Coast of East Siberia" it is stated that "the Pomarine Jaeger is much more common south of Bering Strait than northward." This is doubtless true of the Siberian coast, but on the Alaskan side I found them most numerous north of Kotzebue Sound. Nelson speaks of their abundance at the mouth of the Yukon during the spring migration, but I did not note their presence there during the breeding season. The other two species were common. From Cape Espenberg to Barrow they were met with rather frequently, although usually not more than one was seen at a time, and they were never as common as the Parasitic and Long-tailed.

STERCORARIUS PARASITICUS

Parasitic Jaeger

This is the most evenly distributed and probably the most abundant Jaeger in Alaska, although exceeded in numbers in one or two localities by the Long-tailed. They were found nearly everywhere that stops were made from the Yukon Delta to Barrow. Among the large number seen during the summer, only two were in the dark phase of plumage, one of which was secured.

The dusky patches on the sides of the breast, when viewed from a distance, give this bird the appearance of having a broad black band across the breast. This is an excellent field mark and readily distinguishes this species from the Long-tailed Jaeger when flying toward one or otherwise in a position where the tail feathers are hidden from sight.

STERCORARIUS LONGICAUDUS

Long-tailed Jaeger

This graceful bird was found commonly between Golovin Bay and the mouth of the Yukon River. About St. Michael it was very numerous. As we worked northward it was rarely seen, until near Point Barrow it again appeared in numbers.

This species showed less variations in plumage than the Parasitic. The specimens taken and the birds observed were quite uniform in color, although the length of the central tail feathers varied much in different birds.

RISSA TRIDACTYLA POLLICARIS

Pacific Kittiwake

Very common off shore throughout the region. They did not usually come very near the land except where breeding and they were not seen at the Yukon, where the water is very shallow for long distances off shore. An exception was noted at Nome where they were frequently seen flying about the beach.

They nest at East Cape, Puffin Island, and many other places. On August 2 most of the nests on Puffin Island held young birds about one-fourth the size of adults, but a few eggs were noted. The nests were inaccessible, but looking over the edge of the cliff from the top of the island I could see the contents of about 100 nests below me. At East Cape young were still in the nests on August 29, but young on the wing were also seen about this date.

LARUS HYPERBOREUS

Glaucous Gull

The dominant bird of Bering Sea. They were abundant everywhere north of the Seal Islands. They followed the ship as we cruised along the coast and bedded in the water all around us when we anchored.

Where so many were gathered together, great variations were noted in their plumages. Four very distinct types were represented. First, and perhaps most abundant, was a quite dark mottled bird with blackish primaries and a bill mostly dusky. These were birds of the previous year and were from 10 to 12 months old. The second stage was a much lighter, brownish or ecru-colored bird apparently barred rather than mottled, with light primaries, sometimes nearly white, and a dark bill. This form was more common in August and early September, at which time many birds intermediate between this and the first stage were noted. I believe this is the second winter plumage, the intermediate specimens seen being probably moulting birds. Earlier in the season (June and July) a comparatively small number similarly colored were seen, which may have been precocious individuals of about one year, or fully as likely backward birds of the second summer which still retained the plumage of the previous winter. Some birds in this plumage also had gray feathers in the back. The third and rarest was the white *hutchinsii* type. This phase was only seen in early summer and seldom were birds *pure* white. Usually they had a small amount of gray in the mantle. A bird of this kind was shot June 29. I doubt if this plumage is regularly assumed by any very large proportion of the species. I am inclined to think that it is produced by birds lacking in vitality or otherwise unable to take on the complete adult plumage at one moult. They may be birds that have started to acquire the adult plumage earlier than usual but lack the necessary pigment to produce it entire. I think it represents birds 22 to 24 months old in the second nuptial plumage, but normally the second nuptial plumage appears to be the light ecru-drab second stage plus a greater or less proportion of gray feathers in the mantle. The fourth type of plumage was the fully adult with white underparts, head and tail and light pearl gray mantle. The proportion of adults in the flocks about the ship was small as most of the old birds were attending to their domestic duties. I doubt if any number ever assume full adult plumage until the third winter or breed before they are three years old. The great amount of variation in the plumages of the immature birds seems to indicate this, the differences being too great to be merely individual variation in birds of the same age, that is, one year old or less, which would necessarily be the case if the birds become adult and breed when two years old.

It may be of interest to mention that, in company with Mr. D. E. Brown, I took a Glaucous Gull on Tacoma Bay, May 2. Dawson and Bowles, in the "Birds of Washington," mention the species only in the "hypothetical list."

LARUS GLAUCESCENS

Glaucous-winged Gull

A large number of these gulls followed us from Seattle to Ketchikan. Upon our arrival they were joined by others and were the most common species in southeastern Alaska. At Unalaska they were abundant and very tame, and throughout the southern part of Bering Sea were continually seen. None were observed north of St. Michael.

LARUS SCHISTISAGUS

Slaty-backed Gull

A small number were seen from the steamer on the homeward trip, when only a few hours out from Nome. They were easily identified among the Pacific Kittiwakes and Glaucous Gulls.

LARUS OCCIDENTALIS

Western Gull

LARUS ARGENTATUS

Herring Gull

Both these species were common about Seattle and quite a number of the latter followed us through the "inside passage" to Ketchikan. Among the Herring Gulls were about an equal number of Western Gulls quite conspicuous by their darker colored backs. These gradually left us, a few at a time, until by the time we anchored at Ketchikan there were not more than four remaining.

LARUS VEGÆ

Vega Gull

This species appears in small numbers off the coast of Nome during the early part of September. Among the white-winged Glaucous Gulls their presence is readily detected.

LARUS CALIFORNICUS

California Gull

LARUS DELAWARENSIS

Ring-billed Gull

Among the Herring and Western Gulls that followed the ship through the Inside Passage were several California Gulls. At Ketchikan they joined the large mixed flocks of gulls already there. These flocks were made up largely of Ring-bills and Glaucous-winged, but may have contained other California Gulls also. The range of the California Gull is not generally considered to include any part of Alaska, but I believe it regularly passes up and down the coast at least as far as this point. I collected one bird there and have seen at least one other skin taken in that locality.

The Ring-billed Gull is common at Ketchikan, but was not met with elsewhere.

LARUS BRACHYRHYNCHUS

Short-billed Gull

Very common about St. Michael and the Yukon Delta. Not found north of Norton Sound. On the homeward voyage the steamer stopped at St. Michael, September 9. At this date nearly all had left for the south, only one or two being seen.

XEMA SABINI

Sabine's Gull

This exquisite little gull is very plentiful at St. Michael and also quite common at the mouth of the Yukon. It appears to be unevenly distributed although generally numerous in any locality where it occurs at all. None were seen north of St. Michael until Point Hope was reached, where a small flock was seen and one specimen taken. They were next met with a few miles south of Point Barrow. Among a very large flock of Jaegers, Pacific Kittiwakes, and Arctic Terns were about 100 Sabine's Gulls. They were also seen at Cape Serdze, Siberia, where the first young birds were noted on August

28. July 14 a bird was seen with some white feathers in the dark hood (perhaps a bird in first nuptial plumage), but even as late as September 9 very few birds showed much sign of moult. I saw no missing flight feathers and very little white about the head. Several of the spring birds collected, but not over 25 per cent, had a faint tinge of pink on the underparts which was always lost before the specimen became wholly dry.

Birds in any plumage can be identified in life by the arrangement of the white feathers in the wing. When flying they appear to have a large wedge-shaped piece taken from the center of each wing.

STERNA PARADISÆA

Arctic Tern

A very common bird throughout the region.

STERNA ALEUTICA

Aleutian Tern

My first sight of this rare bird was on June 3, when in the ice a few miles off Cape Nome. Two terns were seen approaching and were watched through a good glass as they passed close to the ship. The light was favorable and the white forehead was plainly seen.

The next meeting with the species was on July 8. I had become temporarily separated from my baggage and the day had been spent in an effort to get it. Toward evening I borrowed a gun and a handful of shells loaded with number two shot—the smallest I could get— and started out for a short stroll. I was told of some Spectacled Eiders that had been seen a few days before by a native, so obtaining a boat I rowed out on the bay. I saw nothing of the Eiders and after rowing some distance I had about decided to return, for it was nearly nine o'clock and the sun was getting low, when I sighted a small island. Several terns were flying about so I landed to look for nests. As I did so I saw at once that they were not Arctic Terns. Two were shot and proved to be, as I expected, Aleutian Terns. As the large shot made bad work of their plumage I did not kill any more at this time. A hasty search showed no nests and I reluctantly left the island with the determination, however, to return as soon as possible.

This I did not do until July 17, on which date I secured 13 more birds. I went over the island very carefully but found no nests, although the birds were doubtless breeding somewhere near. The birds collected had evidently laid eggs at a fairly recent date. No young were seen on the wing and the total number of adults did not exceed (apparently) 100 birds.

The Aleutian Tern is easily distinguished from the Arctic Tern in life. It appears larger and much darker, in some lights nearly black. The white forehead is rarely visible unless the bird is flying low and the light is strong.

DIOMEDEA NIGRIPES

Black-footed Albatross

Common on the Pacific but not seen in Bering Sea. Among the birds that followed the ship were some probably younger birds in which the white about the base of the bill and upon the rump was much restricted, or occasionally seemed to be wholly absent. Also one or two were seen in which the white about the face was of larger extent than usual.

On the homeward voyage the species was more abundant than in the spring. Nine birds were counted at one time and it was not until within about 75 miles of Vancouver Island that the last one disappeared.

FULMARUS RODGERSI

Rodger's Fulmar

Often abundant in rough weather, especially about the Seal Islands, East Cape and other rocky cliffs in Bering Sea. A number were seen in the Arctic Ocean some hundred and fifty miles north of Cape Serdze, Siberia.

As we pitched about in the rough weather the Fulmars came close about the ship and often rested on the water like gulls. At such times, as we rode high over the oncoming waves, one could look down on the backs of a score or more of these birds calmly resting in the trough of the sea with huge masses of swirling gray water threatening to engulf them at every turn. In such positions I could note every detail of their plumage. Many had the gray of the mantle as extensive and unbroken as in *glupischa*.

PUFFINUS GRISEUS

Sooty Shearwater

PUFFINUS TENUIROSTRIS

Slender-billed Shearwater

I have already spoken of the thousands of Sooty Shearwaters in the North Pacific and about the Aleutian Islands. Among these a smaller bird was sometimes noted with a lighter colored throat, which I referred to the Slender-billed. I do not believe, however, that there is any character conspicuous enough to positively identify this species in life, and it is probable that both of the above species were equally abundant. They did not extend very far into Bering Sea and on my return in early September most of them had left, although two or three good sized flocks were still to be seen.

ÆSTRELATA FISHERI

Fisher's Petrel

One of the pleasures of the trip across the North Pacific was the repeated occurrence of this species. The first one was seen May 18, and during the next three days they were very common. May 22 we were near the Shumagin Islands and none were noted. On the return two were observed September 14 and again next day.

Among the large dark Shearwaters, and smaller but also darker Petrels, this species was easily distinguished. One bird came close up to the stern of the vessel where he was not more than 25 feet from me. He remained at this distance for about three minutes, which gave me a very satisfactory opportunity to examine him closely.

OCEANODROMA FURCATA

Fork-tailed Petrel

OCEANODROMA LEUCORHOA

Leach's Petrel

Both of these Petrels were very abundant in the North Pacific.

PHALACROCORAX PELAGICUS PELAGICUS

Pelagic Cormorant

This is the most common member of the family in the northern parts of Bering Sea and is the only one I positively identified. They were nesting at East Cape where a young bird, able to fly, was taken.

A Cormorant which I thought might be *robustus,* if that form is really distinct from *pelagicus,* was shot at Unalaska but fell into the sea a few feet from shore. Before I could get a boat the swiftly ebbing tide had carried it out of sight.

About St. Paul Island many Cormorants were flying about which may have been *urile,* but they kept at a distance and I failed to satisfactorily identify them.

ANAS PLATYRHYNCHOS

Mallard

A Mallard was flushed from her nest and eight eggs on June 19. They were not common.

NETTION CRECCA

European Teal

Lord William Percy shot one of these ducks at Unalaska.

NETTION CAROLINENSE

Green-winged Teal

A female was taken at St. Michael June 9.

DAFILA ACUTA

Pintail

This is the most abundant fresh water duck in Alaska. A number of nests were found about St. Michael and the Yukon. Not observed north of Cape Espenberg.

MARILA MARILA

Scaup Duck

Quite common at St. Michael and the Yukon Delta.

HARELDA HYEMALIS

Old-squaw

This species was common at many points along the coast. They are remarkably tame and I often watched birds from a distance of a very few feet. All were in the handsome breeding plumage, but fully one-half of the males had a trace of white still remaining on the crown, and some had quite a good sized patch of it. One curious specimen was largely marked with white on the entire head and neck. Downy young were taken at Cape Lisburne.

HISTRIONICUS HISTRIONICUS

Harlequin Duck

Quite common at Unalaska and two or three were noted to the east of St. Lawrence Island.

POLYSTICTA STELLERI

Steller's Eider

Never will I forget my first meeting with this handsome little Eider. As we neared Lutke Island, in St. Lawrence Bay, the sand was seen to be dotted with black and white birds which soon took wing. Part were Pacific Eiders which passed us and flew out to sea, but the Steller's remained and flew around the island in a great cloud. I had put little faith in the stories I had heard of whalers feeding their entire crews on these ducks, but I no longer doubt that it was often done. We shot a number and found them very palatable, being far superior to the other Eiders. The birds collected were all moulting into " eclipse " plumage and were very fat.

We found the species common during the summer from St. Lawrence Bay, St. Lawrence Island and Teller Reindeer Station northward on both sides of Bering Sea and along the Arctic coast to Point Barrow. I understand they also occur for some distance to the eastward of Point Barrow. At Point Hope I saw the remains of these birds about the dog kennels, although the dogs are usually fed on fish.

ARCTONETTA FISCHERI

Spectacled Eider

This Eider is irregularly distributed and nowhere does it appear to be common. The only locality where I personally saw the birds in life was in the vicinity of St. Michael, but they also occur in small numbers at St. Lawrence Island and on the Siberian coast at St. Lawrence Bay. The heads of this species are often combined with those of the Pacific Eider, by the natives, in various ornamental articles, and these, of course, also served to indicate the distribution of the species. They are apparently absent from the Seward Peninsula north of Norton Sound and I failed to find any signs of them about the mouth of the Yukon. A trader whom I met told me he had seen them between the Yukon and the Kuskoquim, but I had no opportunity to test the truth of his statement. It is probable that they occur there in small numbers as they did when Nelson visited the locality.

I did not observe them about Kotzebue Sound, and Kivalina was the first point north of the sound where I saw any indication of their presence. Here a native brought out a head and upon being questioned about the species he stated that they were not often seen or shot. At Point Hope I was told that they occurred rather frequently and a few bred. One had been shot the night before I arrived, but was cooked and eaten that morning. Between Point Hope and Point Barrow they occur in small numbers in suitable localities.

SOMATERIA V-NIGRA

Pacific Eider

The most generally distributed Eider in the region and very common everywhere along the coast. In the vicinity of Point Barrow they are, however, exceeded in numbers by the following species.

SOMATERIA SPECTABILIS

King Eider

From Cape Lisburne to Point Barrow this species occurs abundantly. While anchored off Wainwright Inlet, great flocks were constantly passing. As you looked northward over the great expanse of water thickly dotted with drift ice, the eye became conscious of a faint undulating grayish patch on the distant horizon, which appeared like heat waves rising from the glaring beach sand of more southern regions on a day in midsummer. As you watched, this indistinct mass gradually became clearer, until at last you were able to make out a vast flock of flying birds. Although the individual birds were flying swiftly, the flock as a whole seemed to move slowly and it was several seconds, often minutes, before they swept by, usually a quarter of a mile or more from the ship, but the roar of their wings plainly audible, and finally disappeared to the southwest. These flocks were mostly composed of King Eiders, and there were few times during the day when one or more of them were not in sight.

At Point Barrow "ice cellars" are dug below ground in which the temperature does not rise above freezing. While the Eiders are flying large numbers are shot and placed in these cold storage cellars for winter use, and I was told from 1,800 to 2,000 birds were on hand at the time I landed there. Most of those I examined, although originally in the best of plumage, were not then in condition to make into good specimens, but I secured one male in nearly full "eclipse" that had been very recently killed and was still unfrozen.

During the summer the King Eider occurs regularly as far south as St. Lawrence Island where they doubtless breed, but I did not find them about St. Michael or anywhere to the southward.

OIDEMIA AMERICANA

Scoter

OIDEMIA DEGLANDI

White-winged Scoter

OIDEMIA PERSPICILLATA

Surf Scoter

About St. Michael the American Scoter was noted several times and a few were also seen at the mouth of the Yukon where a female was taken. The White-winged Scoter was not seen north of Unalaska, where it was rather common. They were also plentiful at Ketchikan and probably occur all along the coast of southern Alaska. I saw very little of the Surf Scoter, although it was occasionally noted as far north as Kotzebue Sound.

ANSER ALBIFRONS GAMBELI

White-fronted Goose

At the mouth of the Yukon five downy young were collected together with the male parent on June 21. At Cape Serdze, Siberia, several flocks of White-fronted Geese were seen flying, but as none were taken I do not know whether they were the American form or *albifrons*. (No Snow Geese were seen anywhere during the trip.)

BRANTA CANADENSIS (Subsp?)

Once or twice flocks of 12 to 20 small geese were seen which belonged to this group, but as none were taken their subspecific identity was not established.

BRANTA NIGRICANS

Black Brant

On August 15, while standing on deck, a flock of 21 Black Brant flew over the ship at very close range. They were flying slowly and it would not have been difficult, had I had a gun at the time, to have dropped one or more of the birds on the deck. We were, at that time, anchored off Wainwright Inlet.

PHILACTE CANAGICA

Emperor Goose

I had confidently expected to find this species nesting plentifully about the mouth of the Yukon River, but was disappointed. Single birds were seen now and then, but the total number so observed would not aggregate a dozen individuals. No nests were found. The natives' habit of driving these birds into nets during the season when they have moulted their flight feathers, as described by Mr. Nelson (Rept. on Nat. Hist. Coll. made in Alaska, p. 91), probably accounts for their present scarcity in the locality.

I was repeatedly told that Emperor Geese occur in large numbers on the south side of St. Lawrence Island during the period when engaged in the post-nuptial moult, and I believe that the center of their abundance to-day is on this island.

[I was several times told of swans being heard or seen at the Yukon mouth, but I did not myself see the birds.]

GRUS CANADENSIS

Little Brown Crane

Cranes were seen rather frequently both at St. Michael and at the Yukon. At the latter place they fed on the broad mud flats that were exposed by the falling tide. As there was no concealment in such places they were safe from the approach of the hunter or collector, and I never was able to get nearer than a quarter of a mile without having them take wing.

PHALAROPUS FULICARIUS

Red Phalarope

This species appears to be a more northern bird than *lobatus*. I did not find it at St. Michael or southward during the nesting season, but north of the Seward Peninsula it occurs commonly. On the Siberian side it is abundant and apparently nests farther south than on the Alaskan shore.

A number of specimens collected at Cape Serdze on August 28 were all in winter plumage. Some were young birds, but only one, of several adults, had any chestnut feathers of the nuptial plumage remaining and these were scattered through the plumage of the breast and belly.

LOBIPES LOBATUS

Northern Phalarope

On the barren Arctic tundra, level and monotonous, this richly colored little bird finds a congenial summer home, where, lightly swimming about the edges of the many marshy pools, its dainty, graceful motions, and gentle notes add a touch of life and beauty to the otherwise dreary northern wastes.

About St. Michael and the Yukon Delta they were very common, and at both places eggs were found. I did not observe them north of Cape Lisburne—from this locality to Point Barrow the Red Phalarope being the only species met with. On August 7 I found a large flock at Point Hope. All were well advanced in the autumnal moult, only a few stray feathers of the nuptial plumage remaining.

GALLINAGO DELICATA

Wilson's Snipe

Not common. A few spend the summer at the Yukon Delta. On June 17, as I was tramping along the edge of a marshy spot, a small brown bird fluttered from four eggs in a slight depression and slipped away through the grass. I had but a glimpse of her as she disappeared, which resulted in my making a mental note of her as a probable Dowitcher. Without touching the eggs I withdrew, and again passing that way some hours later the bird was flushed under more favorable conditions and was seen to be a Wilson's Snipe. After photographing the nest I was chagrined to find that the eggs were on the point of hatching.

A few days later another bird was flushed from the border of a willow patch that from its actions had either a nest or young close by

MACRORHAMPHUS GRISEUS SCOLOPACEUS

Long-billed Dowitcher

While the Dowitcher is not common in the same sense that the Western Sandpiper is, an hour's walk in the vicinity of St. Michael or the Yukon Delta would hardly ever fail to disclose the presence of two or three pairs of the birds. Seldom do we find more than two birds together, but as a pair were found in almost every half mile or so travelled the total number of birds must be large.

Eggs were taken near St. Michael on June 9, at which time incubation was about one-half advanced, and downy young were collected June 20 at the mouth of the Yukon River.

ARQUATELLA MARITIMA COUESI

Aleutian Sandpiper

ARQUATELLA MARITIMA PTILOCNEMIS

Pribilof Sandpiper

About the middle of July a species of *Arquatella* appeared about St. Michael, frequenting the rocky shores about the bay. No specimens were secured, but I have no doubt that they were Aleutian Sandpipers.

About ten o'clock, on the night of July 24, we landed at a reindeer camp on the north side of St. Lawrence Island to secure a supply of fresh meat. The sun had set and the soft twilight, which takes the place of night during the short Arctic summer, was settling over the earth. As I strolled along the beach, gun in hand, the faint whistling of shore birds was heard. Surmounting a small ridge, I found a long irregular shaped lagoon with stony shore, from which again came the same call notes. As I made my way along the shore, stumbling now and then over some half-hidden rock, a small flock of birds would fly out over the water, circle, and return to the land. With the water of the lagoon as a background they were plainly visible, but upon alighting on the shore, were at once swallowed up in the deep gloom. If shot while flying they would have fallen into the water and have been lost, but by some half dozen shots into the darkness, in the direction in which they appeared to alight, I succeeded in obtaining four specimens. They proved to be Pribilof Sandpipers, the only ones met with during the trip.

PISOBIA MACULATA

Pectoral Sandpiper

This species was met with only at St. Michael and at the mouth of the Yukon, and at neither place did I find it common. Eggs were taken and specimens of the downy young.

PELIDNA ALPINA SAKHALINA

Red-backed Sandpiper

At no time during the breeding season was this species met with south of Bering Strait. A few were seen August 7 at Point Hope, and I was given two eggs that were taken there during June. They were very plentiful near Cape Lisburne and also on the Siberian coast.

EREUNETES PUSILLUS

Semipalmated Sandpiper

The only specimens of this bird that I saw were two shot on July 28, at Imaruk Basin.

EREUNETES MAURI

Western Sandpiper

With the possible exception of the Alaska Longspur this is the most abundant bird on the stretch of tundra that borders the Bering

Sea coast from Norton Sound to the Yukon mouth. Their great abundance, lack of fear and gentle manner combine to make them one of the most charming birds in all that bleak and inhospitable region. As one walks over the tundra the birds are found scattered about everywhere and they run on ahead, if disturbed, with a dainty gracefulness of carriage that is most pleasing.

At the army post at St. Michael I have seen them running about on the boardwalks, and especially do I remember one bird that came aboard ship during a heavy rain while we were well out of sight of land. He spent the afternoon running about the deck, wading in the little pools of water that settled near the scuppers and trying to probe the spaces between the deck planks.

Wherever found the species breeds and many nests were examined. A small series of eggs was collected and several downy young of various ages were obtained. Young just from the shell were noted as early as June 10.

LIMOSA LAPPONICA BAUERI

Pacific Godwit

As a person walks about over the tundra these birds are rather frequently seen. They are not exactly abundant, but are pretty evenly distributed and the total number of individuals must be large. They were most abundant at the mouth of the Yukon and none were seen north of Nome. A fair series was obtained including the young in down.

HETERACTITIS INCANUS

Wandering Tatler

Although constantly on the watch for the Wandering Tatler, the species was encountered but once. On May 18 a Tatler came aboard the *Bear* and for several minutes rested on the deck. We were at the time in the North Pacific, one day out from Dixon's Entrance.

NUMENIUS HUDSONICUS

Hudsonian Curlew

The day that the Wandering Tatler came aboard, two of these Curlews circled about the ship several times and apparently wished to alight and rest. They finally flew away to the westward. A few were noted at the Yukon mouth but were never plentiful.

The Bristle-thighed Curlew was not met with.

SQUATAROLA SQUATAROLA

Black-bellied Plover

Observed only at St. Michael and the Yukon and not common at either place. They doubtless breed there, but I did not find their nest.

CHARADRIUS DOMINICUS FULVUS

Pacific Golden Plover

A single bird taken at Point Hope on August 7 is referred to this form. No others were seen.

ARENARIA INTERPRES MORINELLA

Ruddy Turnstone

South from Norton Sound to the delta of the Yukon these birds were met with in small numbers. At the latter locality a specimen was obtained in natal down. Two adults, the only specimens secured, were submitted to Dr. Bishop for identification and proved to be of this form.

At Point Hope quite a number were found feeding about the native houses. Considerable care was required to shoot specimens without endangering the lives of the people. After much trouble I managed to shoot five or six of them, only to have some half-fed native dog appear at the sound of each shot and instantly swallow the birds before I could reach the spot and prevent the animal from doing so.

Had I secured any of these it is not improbable that they would have proved to be *interpres*.

ARENARIA MELANOCEPHALA

Black Turnstone

Noted both at St. Michael and the Yukon mouth. Only at one or two points where rocky beaches occur about St. Michael Bay were they at all numerous.

LAGOPUS LAGOPUS LAGOPUS

Willow Ptarmigan

Very common wherever stops were made until Cape Espenberg was reached. North of this point none were seen. Many nests were found and a series of photographs secured of incubating birds on their nests. The first broods of young were seen June 20, and July 2 some barely able to fly were found. During this time the males collected were in very ragged plumage with large patches of pin feathers about the neck and upper breast and much difficulty was experienced in making good skins. Up to September 8, when I sailed for Seattle, no birds were seen with white appearing in their plumage.

LAGOPUS RUPESTRIS RUPESTRIS

Rock Ptarmigan

First seen at Cape Lisburne where a specimen was taken. Early in September the natives about Nome occasionally brought a few Rock Ptarmigan into town, with larger bags of Willow, and offered them for sale. All those seen at this time showed considerable white among the feathers of the back and head.

LAGOPUS RUPESTRIS NELSONI

Nelson's Ptarmigan

Two specimens, both males, were secured at Unalaska.

ARCHIBUTEO LAGOPUS SANCTI-JOHANNIS

Rough-legged Hawk

At Unalaska a pair were found nesting on the face of a cliff. One of the parents was secured. It was a dark colored bird and does not appear to differ greatly from specimens from various parts of the United States.

HALIÆETUS LEUCOCEPHALUS ALASCANUS

Northern Bald Eagle

Eagles are abundant at Unalaska and even more so at Ketchikan. At the latter place ten were counted in sight at one time and about an hour later six were seen perched in one tree. They were exceedingly tame and allowed me to walk under them as they sat about in the tree tops.

FALCO RUSTICOLUS RUSTICOLUS

Gray Gyrfalcon

About Deering are several high cliffs and here were seen five Gyrfalcons. Two birds, an adult and young, sitting together on a rocky projection, were shot. The adult was secured, but the young bird remained on the ledge and was inaccessible.

I was told that these hawks were quite plentiful in late fall and early winter, and were known to the residents as Ptarmigan Hawks.

FALCO PEREGRINUS ANATUM

Duck Hawk

One or two were seen about the Aleutians (Dutch Harbor and Akutan Pass) on September 12, and a pair were shot at Chamisso Island, August 1. The Aleutian birds may have been *pealei,* but they did not appear to be different from the pair taken. They were probably migrants from some part of the mainland.

SCOTIAPTEX NEBULOSA (Subsp?)

June 24, while pushing my way through a willow thicket, a Great Gray Owl was flushed. The density of the thicket prevented the use of the gun. Two days later the same bird was again seen, this time on a little mound in a patch of very wet tundra. A mob of Redpolls, Longspurs and Arctic Terns were darting about his head and he soon took wing. As Mr. L. M. Turner took a specimen of *lapponica* in this locality (the mouth of the Yukon), there is a possibility of the bird seen by me being also this subspecies. When seen on June 26, the bird was watched for a few minutes through a glass, but nothing diagnostic was observed about its plumage.

[A day or two before leaving Nome a Hawk Owl was reported as having been seen back of the town.]

SELASPHORUS RUFUS

Rufous Hummingbird

A single male was taken at Ketchikan, May 16.

CORVUS CORAX PRINCIPALIS

Northern Raven

At Ketchikan and Unalaska these birds are very abundant and exceedingly tame. Still they were not easy birds to collect and I got but two or three. They seemed to be able, without apparent effort, to keep just beyond gun range and could carry off a surprising amount of shot.

North of the Aleutian Islands they are not common. Two or three were seen at Cape Serdze where they were very shy.

PINICOLA ENUCLEATOR (Subsp?)

While we were at Unalaska, May 24, I was told a small flock of "Robins" had been seen in the village. From the descriptions given they were apparently Pine Grosbeaks. The next day I had two of the birds pointed out to me and, as I had surmised, they were *Pinicola*. They were perched on the roof of one of the houses, where they remained but a few seconds before taking flight.

While at Golovin Bay, July 13, another bird was seen in a tangle of dwarf willows. After a half hour spent in fruitless attempts to get close to it, I finally shot it at long range. It fluttered into another thicket and was lost.

These birds may have been *alascensis* or *flammula* or perhaps both forms were represented.

LEUCOSTICTE GRISEONUCHA

Aleutian Rosy Finch

This beautiful finch was found to be common about the patches of snow on the mountain-tops at Unalaska, and Amaknak Islands. A number were taken.

ACANTHIS HORNEMANNI EXILIPES

Hoary Redpoll

This species was very abundant about St. Michael and the Yukon, greatly exceeding in numbers the common Redpoll. Several nests were found. Newly hatched young were noted as early as June 17, while perfectly fresh eggs were taken as late as June 19. None were met with north of Kotzebue Sound.

ACANTHIS LINARIA LINARIA

Redpoll

In nearly every flock of *exilipes* one or two birds of this species were seen. Their crimson breasts—much brighter than in any winter birds I have ever seen—distinguish them from the Hoary Redpoll at a long distance.

PLECTROPHENAX NIVALIS NIVALIS

Snow Bunting

On the Alaskan side this species was seen only at Point Hope and Point Franklin. At the former locality only two birds were observed, but at Point Franklin they were rather common. On the Siberian side they were more abundant and several were taken including the young.

In juvenal plumage they bear considerable resemblance in size and general color to a Junco. At this date, August 28, all the adults had about completed the post-nuptial moult.

PLECTROPHENAX NIVALIS TOWNSENDI
Pribilof Snow Bunting

At Unalaska several Snow Buntings were collected. All were in breeding plumage and were (presumably) breeding there at the time. Most of them are more or less intermediate between this form and *nivalis*.

It appears to me that the bill of *townsendi* is blacker than in the common Snow Bunting. I have seen specimens of *nivalis* from Labrador, in full nuptial plumage, which still retain a trace of yellowish at the base of the lower mandible, but all skins of *townsendi* that I have examined show the entire bill solid black.

CALCARIUS LAPPONICUS ALASCENSIS
Alaska Longspur

This hardy bit of Arctic bird life is one of the first species whose acquaintance one makes in northern Alaska. Wherever one goes dozens of them will be seen walking about over the tundra or standing on little raised mounds of moss or grassy tussocks. They are very attractive in their nuptial plumage and their song, usually given on the wing and frequently by three or four birds at the same time, is a joyous melody that wins them a place in the hearts of all who hear it. About St. Michael they are called larks or, occasionally, skylarks.

They breed early, as young just able to fly were seen June 21, and several broods were seen on the wing a few days later.

PASSERCULUS SANDWICHENSIS SANDWICHENSIS
Aleutian Savannah Sparrow

These birds were common at Ketchikan, May 16, where specimens were taken. During our brief stop at Unalaska they were also very abundant.

PASSERCULUS SANDWICHENSIS ALAUDINUS
Western Savannah Sparrow

Common at the Yukon and about St. Michael where it breeds.

ZONOTRICHIA LEUCOPHRYS GAMBELI
Gambel's Sparrow

A common bird about St. Michael where they are frequently heard singing from the roof of some building.

ZONOTRICHIA CORONATA

Golden-crowned Sparrow

In the clumps of willows and alders about Golovin Bay a single specimen of this sparrow was obtained on July 13.

SPIZELLA MONTICOLA OCHRACEA

Western Tree Sparrow

Wherever patches of willow bushes occur on the tundra or hillsides about St. Michael and the Yukon Delta the sweet notes of this species may be heard. They are rather shy and slip away through the shrubbery at the approach of a stranger, but if the observer sits quietly down and partially conceals himself, the singer will soon return to its perch on the topmost twig of a nearby bush and resume its simple song.

Where song birds are in the minority, and the air is filled with the harsh cries of gulls and terns, the quacking of ducks, and the weird call notes of loons, even the simplest of melodies is appreciated. While the vocal efforts of the Tree Sparrow probably would attract but scant notice in a locality frequented by more brilliant songsters, they would be sadly missed were the species to forsake its accustomed haunts in these cheerless regions.

MELOSPIZA MELODIA SANAKA

Aleutian Song Sparrow

This bird was seen at Unalaska but was not common. It was most often seen about the dock where it hopped about like a catbird or thrasher, which it strongly reminded me of. Its song was like our eastern bird, but in other respects it seemed to me to resemble it but little.

PASSERELLA ILIACA ILIACA

Fox Sparrow

The Fox Sparrow is rather common as far north as Golovin Bay. They are very shy when on their breeding grounds—much more so than during their migrations. At the mouth of the Yukon I have seen them, at times, come close up to the house and feed beneath our windows, but only when everyone was in the house. At such times the sound of a movement within doors or an attempt to watch the bird from the window always resulted in a hasty retreat to the nearest thicket.

HIRUNDO ERYTHROGASTRA

Barn Swallow

In the vicinity of St. Michael Barn Swallows are rather common, and were suitable nesting places more numerous I have little doubt they would increase. Several birds were building in an empty house near St. Michael while I was there, and a finished nest, without eggs, was found June 10. It was built in a deserted and more or less delapidated Eskimo sod house.

IRIDOPROCNE BICOLOR

Tree Swallow

Common about St. Michael. A pair built a nest and raised a brood in the space between the inner and outer walls of the wireless station at the Yukon Delta. A hole had been cut in the wall for the exhaust pipe of the engine and the nest was directly below this pipe. While the engine was running this pipe became very hot and at such times the nest must have been very uncomfortable.

WILSONIA PUSILLA PILEOLATA

Pileolated Warbler

A number of birds were seen and one secured at Golovin Bay, July 13.

MOTACILLA OCULARIS

Swinhoe's Wagtail

Although this bird has been considered merely a straggler to Alaska, there are reasons for believing that the species is slowly extending its range and becoming established on our coast. During the northern cruise a number of individuals were seen between Kotzebue Sound and Cape Lisburne.

At Chamisso Island, on August 1, a pair of birds were carrying food into a crevice in the rocks at an inaccessible point on the cliff. One or two were also seen at other points, and at Cape Lisburne I succeeded in shooting a bird which, unfortunately, fell on the farther side of a creek where it could not be found.

My failure to secure specimens was due to the excessively restless habits of the birds. When on the ground they were largely concealed by intervening clumps of moss and the general character of the tundra, while they were liable to take wing at a moment's notice and usually flew long distances. Their flight was so erratic that it was exceedingly difficult to shoot them on the wing and, as I repeatedly found from experience with the Yellow Wagtail, a small bird which fell on the tundra could scarcely ever be found, no matter how carefully the spot was marked.

On the Siberian side this species was not uncommon, both at St. Lawrence Bay and Cape Serdze.

BUDYTES FLAVUS ALASCENSIS

Alaska Yellow Wagtail

A common bird from the Yukon Delta to Nome and probably as far as Kotzebue Sound, although, except at Cape Espenberg, I did not meet with it north of Bering Strait. This was on account of my attention being given to other species and very little time spent in localities suitable to this bird.

A small series was obtained at the mouth of the Yukon, all being in adult nuptial plumage. No young were seen up to July 2, from which I infer that they nest later than most of the small land birds do in this region.

ANTHUS RUBESCENS

Pipit

Seen only at Unalaska where it was very common.

HYLOCICHLA ALICIÆ ALICIÆ

Gray-cheeked Thrush

About the mouth of the Yukon, in June, the song of this species may be heard from practically every extensive patch of dwarf willows and alders. If it were not for its song the Gray-cheeked Thrush would long remain undiscovered in these dense thickets, for they are among the shyest of birds. No amount of "squeaking" ever succeeded in bringing one of them into view, although from their calls I often knew that two or three birds were moving about within a dozen yards of me. Only by sitting motionless for a considerable period did I ever get a glimpse of them.

The swarms of mosquitos that infest these localities, at this season, render it difficult to sit motionless for more than a few minutes at a time, but the slightest movement of any kind is sufficient to send this shy thrush into the shelter of the heaviest part of the thicket, from which nothing could induce it to return.

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EXPLORATIONS AND FIELD-WORK OF THE SMITHSONIAN INSTITUTION IN 1915

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EXPLORATIONS AND FIELD-WORK OF THE SMITHSONIAN INSTITUTION IN 1915

The Smithsonian Institution every year initiates or cooperates with other institutions in numerous expeditions to various parts of the world in the interest of theoretical and practical science. Accounts of the principal expeditions engaged in during the year 1915 are presented herein chiefly in the words of the investigators themselves, while those of more than routine importance are signed with the names of the writers. The various lines of research include geology, zoology, botany, anthropology, physics, and astrophysics.

Of the several branches of the Institution, only the United States National Museum, the Bureau of American Ethnology, and the Astrophysical Observatory are mentioned in this account as having engaged in field-work. The National Museum has no specific funds for this purpose, but whenever possible embraces opportunities to take part in natural history investigations and to add to its collections and exhibition series. Researches in American ethnology consist largely of field-work among the Indian tribes, detailed accounts of which will be found in the annual reports of the Bureau. The Astrophysical Observatory undertakes expeditions here and abroad for the purpose of observations in connection with its regular work of studying the physical properties of the sun and their effects on the earth.

The results of these explorations and field-work have been to increase scientific knowledge and to yield valuable material for the collections and study series of the National Museum and the Bureau of American Ethnology. The Institution is forced every year to forego numerous opportunities to participate in other expeditions owing to its limited means.

GEOLOGICAL EXPLORATIONS IN THE ROCKY MOUNTAINS

In continuation of previous work in the Rocky Mountain region, Dr. Charles D. Walcott, Secretary of the Smithsonian Institution, was engaged in field investigation in the Yellowstone Park area, and from there north into the Belt Mountains east of Helena, Montana. The work in the Yellowstone Park was carried on with two objects in view:

First: To determine, if possible, the extent to which the lower forms of algæ and possibly bacteria contributed, through their activities, to the deposition from the geyser and hot-spring waters of the contained carbonate of lime and silica.

FIG. 1.—Riverside Geyser in eruption, Upper Geyser Basin. Water falls into Firehole River. Photograph by Mary Vaux Walcott.

Second: The securing for the National Museum, of a series of geyser and hot-spring deposits, also silicified wood from the petrified forests and certain types of volcanic rocks.

FIG. 2.—Camp in meadows near Apollinaris Spring, close to main road traversed by a thousand tourists daily. The bears made frequent visits, two grizzlies, two black, and one brown bear calling in an afternoon. Photograph by Walcott.

FIG. 3.—Lone Star Geyser in action. Siliceous matter in hot waters deposited to form very beautiful cone, standing on large mass of evenly bedded siliceous deposits. Photograph by Walcott.

During the investigations and collecting, numerous photographs, some of which are here reproduced, were taken by Dr. and Mrs. Walcott, of geysers and hot springs, and of deposits made from the waters through evaporation and organic agencies.

The collections were brought in to the various camps on pack

FIG. 4.—Nearer view of cone of Lone Star Geyser, showing outer appearance of deposit. Photograph by Walcott.

horses and buckboard, and subsequently packed for shipment at Fort Yellowstone and Yellowstone. Material assistance was afforded by the cooperation of the Acting Superintendent of the Park, Col. L. M. Brett, U. S. Army, and officers of the United States Engineer Corps who are in charge of the maintenance and development of the park roads and trails.

Upwards of five tons of specimens were collected and shipped to the National Museum. This collection permits of the preparation of a special Yellowstone Park exhibit of great beauty and interest.[1]

FIG. 5.—Liberty Cap at Mammoth Hot Springs. A dead geyser cone slowly being destroyed through action of rain, frost, and changing temperatures. Profile on right-hand face of cone suggests spirit of dead geyser. Photograph by Walcott.

[1] In his work through the Park, Dr. Walcott was assisted by Mrs. Walcott and Messrs. Sidney and Stuart Walcott, and Charles D. Flaherty.

Fig. 6.—White Dome Geyser, near Great Fountain, in eruption with hot waters cascading down its sides. This dome is in midst of broad plain, and owes its prominence to gradual deposit of siliceous matter largely by evaporation. Photograph by Walcott.

Fig. 7.—Ruins of Grotto Geyser, with two centers of eruption, Upper Geyser Basin. Photograph by Walcott.

FIG. 8.—Platform of thin-bedded sinter deposits beneath giant geyser cone, Grotto Geyser of Upper Geyser Basin. Photograph by Walcott.

FIG. 9.—Mouth of Great Fountain Geyser showing water at rest just before a great eruption, as seen in Fig. 10. Photograph by Walcott. Alternate wetting and drying of area about the geyser results in deposition of salica in beautiful forms all about its basin.

FIG. 10. Great Fountain Geyser in eruption with arrows of water shooting 150 feet above mouth shown in Fig. 9. Photograph by Walcott.

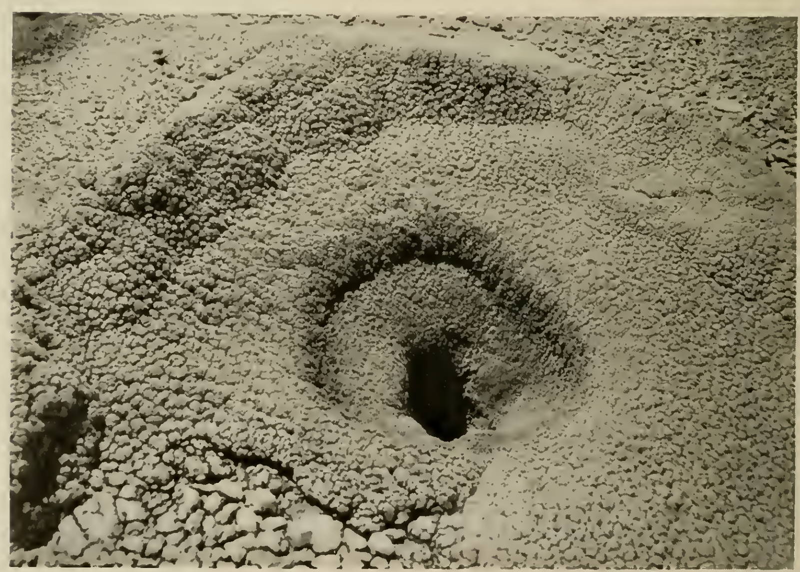


FIG. 11. Looking down into throat of small geyser near Firehole River in Upper Geyser Basin. A type of siliceous deposit relatively rare. Photograph by Walcott.

FIG. 12.—Small geyser and hot spring on bank of Firehole River, showing geyser and hot-spring deposit side by side. Small vents on side of spring erupt quite frequently. Photograph by Walcott.

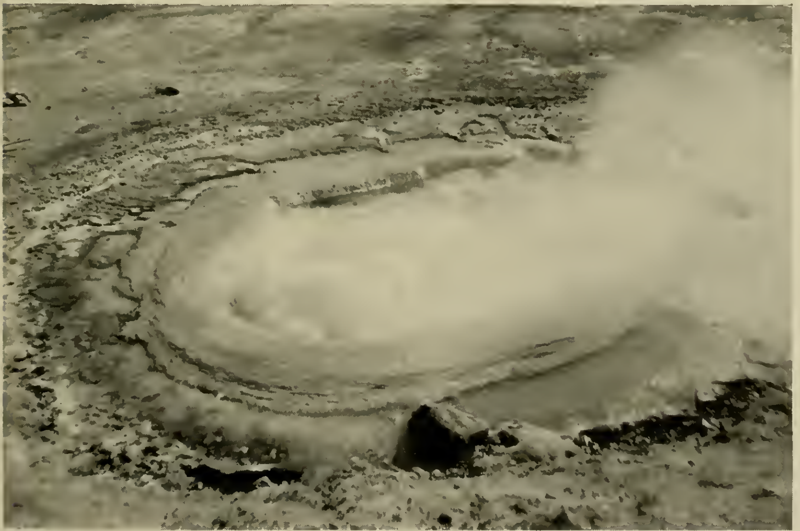


FIG. 13.—Sulphur Mountain Geyser boiling, prior to small eruption. Coloring in mouth and throat of geyser varies from rich cream above to deep red and buff below. Minor details of siliceous deposit about area flooded by hot siliceous water are most beautiful. Photograph by Walcott.

Fig. 14.—Panoramic view of Norris Geyser Basin, with several small geysers in eruption. Many fine specimens were secured for National Museum from this area. Photograph by Walcott.

FIG. 15.—Sidney and Stuart Walcott cutting out specimen near the Growler, Norris Geyser Basin. They were driven back many times before the hot rock was finally secured. Photograph by Walcott.

FIG. 16.—Algal growth in cool pond where there was no mineral matter in solution to be deposited. Photograph by Walcott.

It was found that algal growth was everywhere present when the temperature of the waters was from 70° to not much above 180° Fahrenheit, and that this growth had a marked effect upon the

FIG. 17.—Three of the Seven Sisters Hot Springs above Black Warrior Geyser, one mile northeast of Great Fountain Geyser. These springs, although very beautiful and each of a different color, are rarely visited by tourists, and the same is true of most of the Great Fountain group. Photograph by Walcott.

amount and character of both calcareous and siliceous deposits. Some of these are shown in the accompanying illustrations.

FIG. 18.—One of the Three Sisters Springs filled with boiling hot water, through which bubbles of steam are rising. Photograph by Walcott.

FIG. 19.—Great Sulfosel Hot Spring, about one mile northeast of Great Fountain Geyser, elevation 7,300 feet. The main opening of the spring has a temperature of 201.2° F. (93° to 94° C.). Water cools toward run-off in foreground, to 172.4° F. (78° C.). Siliceous deposits about this spring extend as cornices out over edges. Algal growth abundant in water at 134.6° F. (57° C.). Fine specimens were collected for National Museum. Photograph by Walcott.

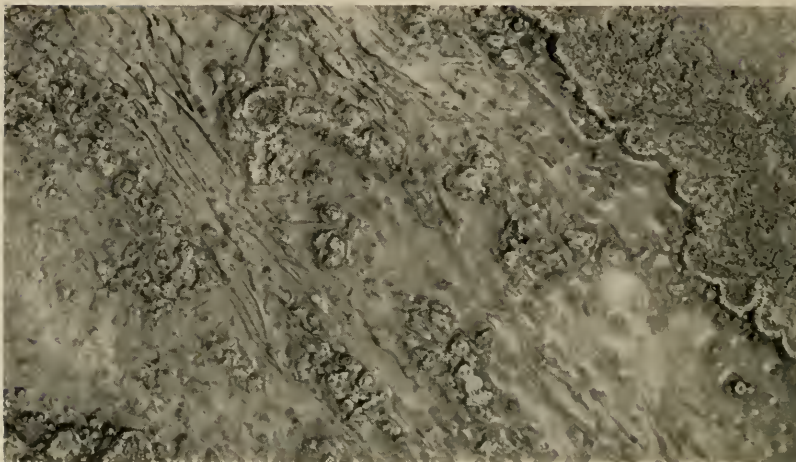


FIG. 20.—Illustration of algal growth in rapidly moving hot water in run-off from hot spring shown by Fig. 19. White siliceous deposit is made over and through algal growth, latter being gradually replaced and changed from soft gelatinous, spongy mass to hard siliceous permanent deposit. Photograph by Walcott.

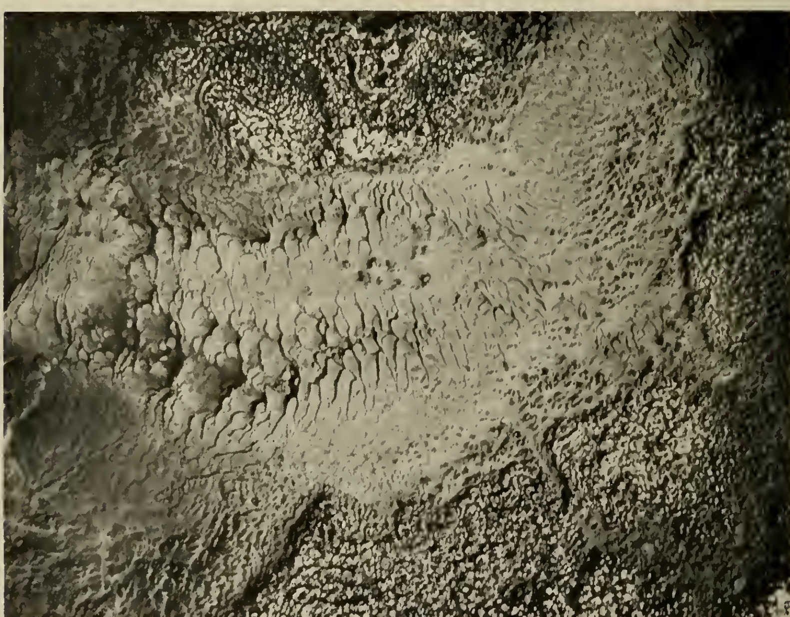


FIG. 21.—Cream-colored siliceous deposit in run-off from Artemisia Geyser, Upper Geyser Basin. Photograph taken looking down through the water. Photograph by Walcott.

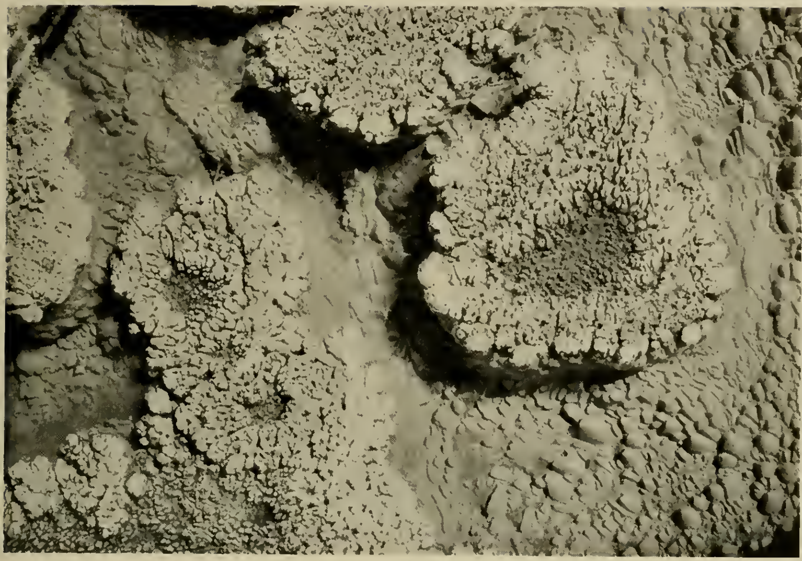


FIG. 22.—Beautiful light cream-colored siliceous deposit in run-off from Artemisia Geyser, about one-eighth natural size. Photographed looking down into the hot water. The pebbly looking bottom is from 6 to 8 inches beneath surface, and is formed by the deposit in very much the same manner as the ripple deposits in Fig. 21. Photograph by Walcott.

FIG. 23.—Yellowstone Canyon below Tower Falls Creek, showing two beautiful bands of columnar basalt interbedded in the early basic breccia formed of fragments of pyroxene-andesite, hornblende-andesite, and basalt associated with basic lava flow. Photograph by Walcott.

FIG. 24.—Beautiful "Tower Falls," short distance above canyon of Yellowstone River, in northeastern section of the Park. Photograph by Walcott.

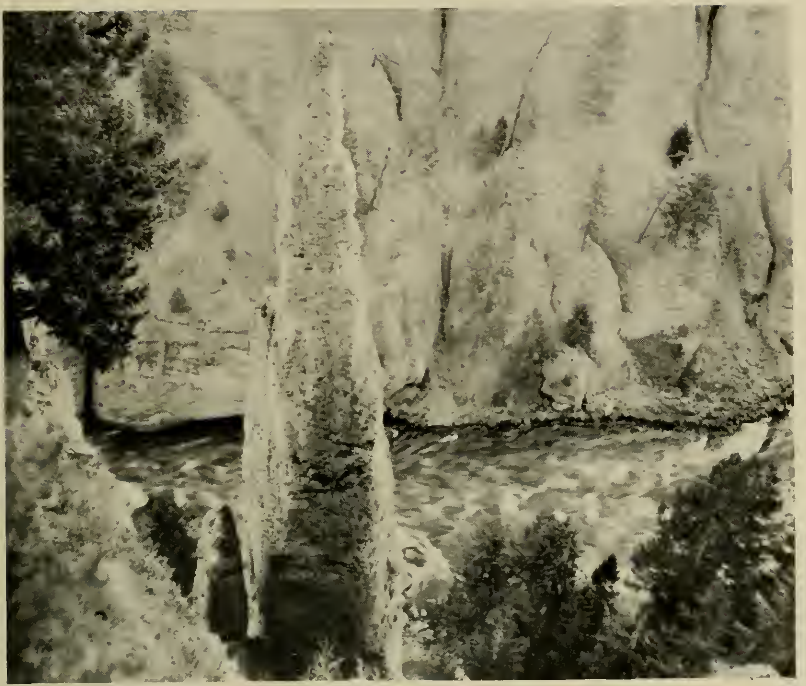


FIG. 25.—Great Needle in Yellowstone Canyon, a half mile below Tower Falls, shown by Fig. 24. Picture taken by hanging camera in limb of a tree about 300 feet above top of Needle. Needle probably 400 to 600 feet in height. Photograph by Walcott.

FIG. 26.—Obsidian Cliff, Norris Geyser Basin, showing columnar structure in obsidian and massive-bedded rhyolite above. This cliff is one of the interesting geological phenomena of the Park. Photograph by Walcott.

Fig. 27.—Boulder of volcanic breccia rolled down from the cliffs shown in Fig. 28. Fragments forming the breccia include pyroxene-andesite, hornblende-pyroxene-andesite, and basalt. Photograph by Walcott.

After completing the investigation of the geyser and hot-spring deposits, a trip was made to the Fossil Forest in the northeastern section of the Park, in the Lamar River Valley. Large collections were made of silicified wood and various minerals; one of the latter being a remarkable and beautiful form of calcite rosettes (figs. 29, 30, 31, 32).

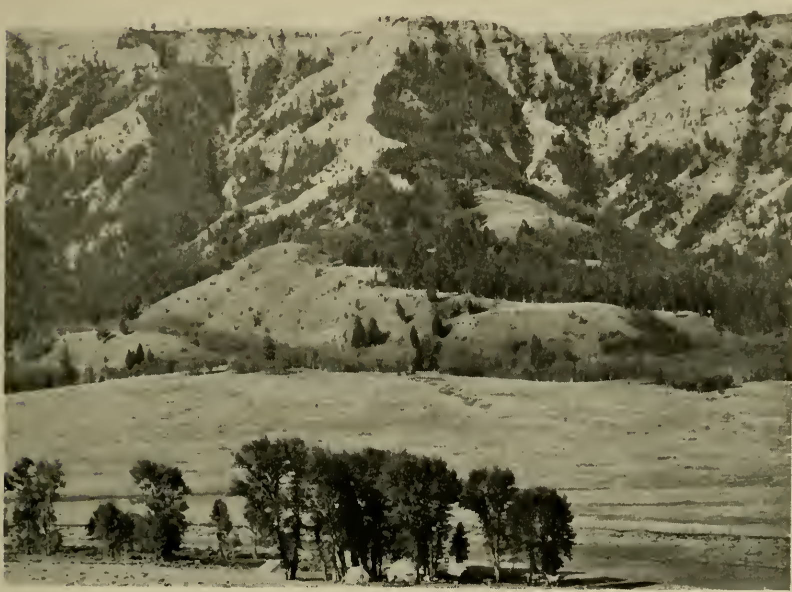


Fig. 28.—Looking across Lamar River from the north to fossil forest ridge 2,500 feet above the valley. Ridge formed of great thickness of volcanic breccia deposited in great layers at intervals sufficient to permit of growth of coniferous forests. Stumps of fossil trees were measured 9 feet in diameter, 6 feet above their roots. Seven successive forests that had been destroyed by volcanic deposits were seen in the cliffs shown in this view. Walcott camp in the foreground. Photograph by Walcott.

Dr. Wherry, assistant curator, division of mineralogy and petrology, U. S. National Museum, describes the calcite rosettes as follows:

The remarkable character of these specimens is illustrated by the photographs of four of them shown in figures 29, 30, 31, and 32. They consist of close groups of thick tabular rhombohedrons of calcite, the faces of which are deeply curved into saddle-shape forms, a structure frequently found in the mineral dolomite, but comparatively rare in calcite. That the latter mineral is represented, however, was proved by qualitative chemical tests, which showed only traces of magnesium, and by measurement of the index of refraction ω, which was found to be 1.660, essentially that of calcite.

Fig. 29.—A calcite rosette collected by Mrs. Walcott and B. Stuart Walcott high up on the cliffs shown in Fig. 28. Photograph by Mr. T. W. Smillie, U. S. National Museum.

The fundamental crystallographic form toward which all of the crystals tend is the negative rhombohedron, $01\bar{1}2$. One specimen, which is shown in figure 32, approaches this form quite definitely. The angle between two adjacent faces of this crystal close to their intersection, measured with the contact goniometer, is about 46°, while the theoretical angle is 45° 3′. No other faces have been noted on the specimens, although cleavage planes, beveling the edges of the surface form, are visible here and there. The faces of the negative rhombohedron are not smooth nor simple, but are built up of a series of innumerable smaller faces, belonging to individuals in approximate parallel position, though with enough divergence to cause the curvature of the faces; while at the thin edges of the crystals the individuals are still more distinctly

Fig. 30.—Calcite rosette showing somewhat different structure from that of Fig. 29. Dr. Edgar T. Wherry, of the United States National Museum, explains their origin as due to starting of crystallization at numerous closely crowded points, the crystals being perhaps at the start quite parallel, but as they grew crowding one another out of parallelism, although not enough to prevent approximately equal growth of every individual. He states that this type of crystallization of the mineral calcite is comparatively rare. Photograph by Mr. T. W. Smillie, U. S. National Museum.

separated, so that the effect is that of superposed layers of curved sheets, resembling the petals of the rose to such an extent that the first word to describe them which suggests itself is "rosette."

That this curvature is not merely a superficial phenomenon, due to the development of vicinal planes, as is often the case in curved crystal faces, is shown by the fact that the cleavage faces are also curved, their relative position with respect to the surface faces being always retained, no matter where they are developed. The composite character exhibited by the external faces is also shown by these cleavages, which proves that the curvature of the crystals is only apparent, and is not due to actual deformation by pressure. This is borne out by microscopic examination, for the cleavage flakes show between

FIG. 31.—Calcite rosette, varying in form from Figs. 29 and 30. Photograph by Mr. T. W. Smillie, U. S. National Museum.

crossed nicols quite uniform extinction, without a trace of the wavy darkening characteristic of crystals which have been distorted by pressure.

The origin of these specimens is to be explained, then, as due to the starting of crystallization at numerous closely crowded points, the crystals being perhaps at the start quite parallel, but as they grew crowding one another out of parallelism, although not enough to prevent approximately equal growth of every individual. The resulting groups form unusually fine display specimens, all the more interesting because of the comparative rarity of this type of crystallization in the mineral calcite.

FIG. 32.—Calcite rosette with fundamental crystal form preserved. Photograph by Mr. T. W. Smillie, U. S. National Museum.

FIG. 33.—Distant view of bison grazing on the gently sloping bottom of Lamar River Valley in northeastern section of Park; 220 bulls, cows, and calves were counted in this herd. Photograph by Walcott.

FIG. 34.—Nearer view of some of the bison shown in the distance in Fig. 33. Photograph by Walcott.

FIG. 35.—Kodak snapshot of two bison bulls and a cow in herd shown in Fig. 34. By remaining on horseback it is possible to get quite near to some of the animals. Photograph by Mary Vaux Walcott.

Fig. 36.—View near the mouth of Squaw Creek, West Gallatin River Canyon. The rocks in the immediate foreground on the right are of pre-Cambrian age, those in the cliffs at the base of Castle Mountain are of Cambrian age, the cliffs just below the summit of Devonian age, and those forming the castle on the summit, of Carboniferous age, the entire section embracing over 3,000 feet of bedded limestone. Photograph by Walcott.

Fig. 37.—Rural delivery station, Deep Creek Canyon, Belt Mountains, 16 miles east of Townsend, Montana, where we received a promptly delivered daily mail. Photograph by Walcott.

FIG. 38.—Wood road in one of upper canyon valleys of Belt Mountains. Forest Ranger Orrin C. Bradeen coming in from patrol. Photograph by Walcott.

FIG. 39.—Summits of the Big Belt Mountains, with Mount Baldy capped by September snow. In foreground wheat harvest on dry farming slopes. Photograph by Walcott.

The camp site in the Lamar Valley was one of unusual interest and beauty (fig. 28). The high hills to the south show the rock cliffs containing silicified wood, calcite rosettes, and beautiful specimens of chalcedony. A little way from the camp the party met with a large herd of bison grazing freely in the broad open valley, also herds of elk, bands of antelope, a few black bear, and an occasional wolf.

FIG. 40.—Wheat farms on slopes farther from mountains shown in Fig. 39, where there is a commingling of dry farming and irrigation. Richness of the soil is indicated by shocks of wheat.

On leaving the Park, after 675 miles of travel with the camp outfit, the party proceeded down the West Gallatin River Canyon, stopping to examine the section of Cambrian rocks at the mouth of Squaw Creek (fig. 36). The next permanent camp was made in Deep Creek Canyon, 17 miles east of Townsend, Montana, where the extensive pre-Cambrian sections of the Big Belt Mountains are beautifully shown. About two tons of pre-Cambrian specimens were collected in this vicinity, before the storms of late September closed the season's field-work.

THE INDIANA MASTODON

Each year the Museum receives reports of many finds of mastodon and mammoth remains, especially from different localities in those States bordering on the Great Lakes. These "finds," which come for the most part from swamp deposits of the Pleistocene, usually consist of a few isolated bones or teeth, but they give evidence of the great abundance of these larger creatures which roamed over this continent during the geological age just preceding the present. Compared, however, with the great number of remains found, complete skeletons are rare. This is due in large part to the fact that by far the greater number of the finds are made by men of no

FIG. 41.—Ditch where Indiana mastodon was found. The long iron rod was used in probing in the swamp for the remains. Photograph by Gidley.

experience in collecting and usually little or no knowledge of what they are finding. The National Museum is therefore fortunate in the recent acquisition of a fine, nearly complete adult male mastodon skeleton from a swamp deposit in northwestern Indiana.

This specimen was donated to the National Museum by Mr. W. D. Pattison of Winamac, Indiana, and Captain H. H. Pattison, U. S. Army, on whose farm, about 15 miles northwest of Winamac, it was found.

A part of the skull, four limb bones, a few ribs and vertebræ, were unearthed by a dredge crew while excavating a drainage canal on the Pattison farm in the spring of 1914 (see fig. 41). On learning of the discovery, Mr. Pattison took immediate steps to preserve these bones, but before he could prevent it a few of them were carried away as curiosities by people of the vicinity. These were, however, for the most part recovered. Mr. Pattison, recognizing the value for public exhibition of such a specimen if properly handled, and judging correctly that the greater part of the skeleton might be secured by an experienced collector, very generously packed and shipped the bones then in his possession to the National Museum, at the same time extending an invitation to the Smithsonian Institution to send an expedition to his farm to recover, if possible, the remaining parts of the skeleton. A small appropriation was set aside for this purpose, and the first expedition to the Pattison farm, under the direction of J. W. Gidley of the National Museum, was undertaken in June, 1915. This resulted in securing the lower jaws, most of the remaining vertebræ and ribs, parts of the pelvis, and a few more limb and foot bones. The undertaking was too extensive for the funds then available, and Mr. Gidley was obliged to return to Washington before the search was completed. Most of the bones secured on this trip were found in working over the material thrown out by the steam shovel on either side of the ditch at the time the dredging was done.

In October a second appropriation was made available, and Mr. Gidley again visited the locality of the find, this time completing the work which resulted in securing from the undisturbed deposit at the bottom of the ditch the last of the missing sections of the vertebral column, several more foot bones, and other important fragments.

At this time it was necessary to sink a coffer-dam across the ditch, which is about 20 feet wide, and at this place contains about six feet of water and mud before coming to a hard sand bottom. Mr. Gidley thus was enabled to study the formation and make an accurate estimate of the conditions of deposition of the skeleton.

On assembling in the laboratory the bones of this skeleton received from all sources, it has been found that, with comparatively little artificial restoration, a much more than usually fine and complete specimen of the American mastodon can be assembled. This is now being mounted and will soon be placed on exhibition as one of the striking features of the Fossil Vertebrate Hall.

PALEONTOLOGICAL AND STRATIGRAPHIC STUDIES IN THE PALEOZOIC ROCKS

Dr. E. O. Ulrich, associate in paleontology in the U. S. National Museum, was occupied for several months during the field season of 1915, under the auspices of the U. S. Geological Survey, in a study of the Lower Paleozoic deposits of the Mississippi Valley. He was engaged chiefly in seeking evidence respecting the boundary line between the Cambrian and Ozarkian systems. For this purpose many of the outcrops of these rocks were visited, but the most important evidence was found in the Upper Mississippi Valley and in Missouri where the Upper Cambrian rocks are particularly well displayed, and the succeeding deposits of the Ozarkian system are more commonly fossiliferous than elsewhere. The relative abundance of fossils in these areas permitted the actual boundary between the two systems to be accurately determined after considerable study. This boundary, when determined, was found to coincide with the uneven plane (see fig. 42) formed at the junction of the deposits

Fig. 42.—Contact between Cambrian (Jordan sandstone) and Ozarkian (Oneota dolomite) two miles south of Boscobel, Wisconsin. The undulating line of unconformity is distinctly visible. Photograph by Ulrich.

laid down by the retreating Cambrian sea and by those formed by the return of the waters in the succeeding Ozarkian time. During the progress of these stratigraphic studies numerous collections of fossils were secured for the Museum series, and incidentally the investigations resulted in the proper placement of many fossils whose stratigraphic position had hitherto been uncertain.

In the latter part of the season Dr. Ulrich worked out the field relations of some insufficiently located collections of Paleozoic fossils made in southwest Virginia at various times in the past. The most important result of these investigations is the proof that a large coral fauna, exceedingly like that which marks the horizon of the Onondaga limestone throughout the extent of this well known and widely distributed Middle Devonian formation, had already invaded the continental basins as far as southwest Virginia during the closing stages of the preceding Lower Devonian. This instance of recurring fossil faunas is regarded as one of the most important of the many similar instances that have been established through the field studies of Dr. Ulrich during the past 25 years. All have served in correcting erroneous correlations of formations that had arisen through the confusion of earlier or later appearances of faunas with the one recognized in the standardized sequence of stratigraphic units.

Mr. R. D. Mesler, under the supervision of Dr. Ulrich, spent the summer of 1915 in making collections of Ordovician and Silurian fossils from formations and localities in the Appalachian and Mississippi Valleys which had hitherto been little represented in the Museum collections. A large number of fossils resulted from his trip, particularly from the Middle Ordovician rocks of east Tennessee, which will form the basis of a future monograph on the paleontology of that region.

EXPLORATIONS IN SIBERIA

Through the liberality of a friend the Museum was enabled to send Mr. B. Alexander with the Koren Expedition to the Kolyma River region of northern Siberia. The expedition left Seattle, Washington, about June 1, 1914, and returned a year from the following September. The immediate purpose of the trip was to obtain remains of large extinct animals, particularly of the mammoth for which the region is noted. The results were not all that were hoped for, but a considerable quantity of material was obtained, though no complete skeleton.

The following report, with photographs taken by his party, was submitted by Mr. Alexander at the conclusion of his field-work:

In May, 1914, the Smithsonian Institution appointed me as a collector, with instructions "to obtain geological, mineralogical, and paleontological specimens" for the Institution, and particularly "to secure remains of the Siberian mammoth" in the Kolyma Valley, northeastern Siberia. For this purpose I was attached to a trading company which left Seattle in a small power schooner June 24, 1914, arriving at Nizhni Kolymsk on August 26.

Nizhni Kolymsk is the oldest and outermost permanent Russian settlement in the Yakutsk government, northeastern Siberia. The village now consists of about 26 inhabited log houses and one Russian orthodox church, and is located near the 69th degree of northern latitude, a short distance above the mouth of the Kolyma and just inside the Arctic tree limit.

The Kolyma is the most easterly of the great rivers of northern Siberia, and is here about three versts (two miles) [a verst is 0.621 mile] wide. It heads in the Stanovoi Mountains and approaches the Alaskan Yukon in length, drainage, and volume.

The town site is situated near the lower end of a narrow, low island surrounded by two arms of the Kolyma River and about 100 versts long. Near the upper end of this island the Omolon empties into the Kolyma from the right. Opposite Nizhni Kolymsk and but a few versts apart, the two Anyui rivers—Big and Little—flow into the Kolyma, likewise from the right.

These three rivers are the most important tributaries and head also in the Stanovoi Mountains. But while the mountain passes beyond the sources of the Kolyma and Omolon lead to tributaries of the Sea of Okhotsk, the headwaters of the two Anyui connect with those of the Anadyr.

Fig. 43.—Little Anyui River. First elevated silt bank, showing detail; going up-river, September, 1914.

As there remained only a few weeks of open weather before the beginning of winter, I concluded the nearest field for promising research would be the two Anyui rivers. Accordingly I started upon my first exploring trip on September 3 in the schooner's dory, accompanied by three members of the party who intended to do some hunting and photographing.

We entered the Little Anyui and explored this river for a distance of approximately 150 versts from the mouth upward. For about the first 100 versts the ascent was quite easy and made by rowing. After that tracking had to be resorted to almost exclusively, the current of the river increasing rapidly almost at once.

For the lower 100 versts the river flows—after the manner of many sub-Arctic rivers in Alaska and Canada—through a low tundra, covered with dense willow thickets and puny larches, the east forelopers of the great Siberian taiga that stretches from the Urals to the Pacific. The river course forms enormous bends swinging alternately from the right to the left. The current cuts away the unconsolidated alluvium of the outer bands (here generally from 10 to 20 feet high), depositing the material removed in the shape of extensive bars on the inner curves below.

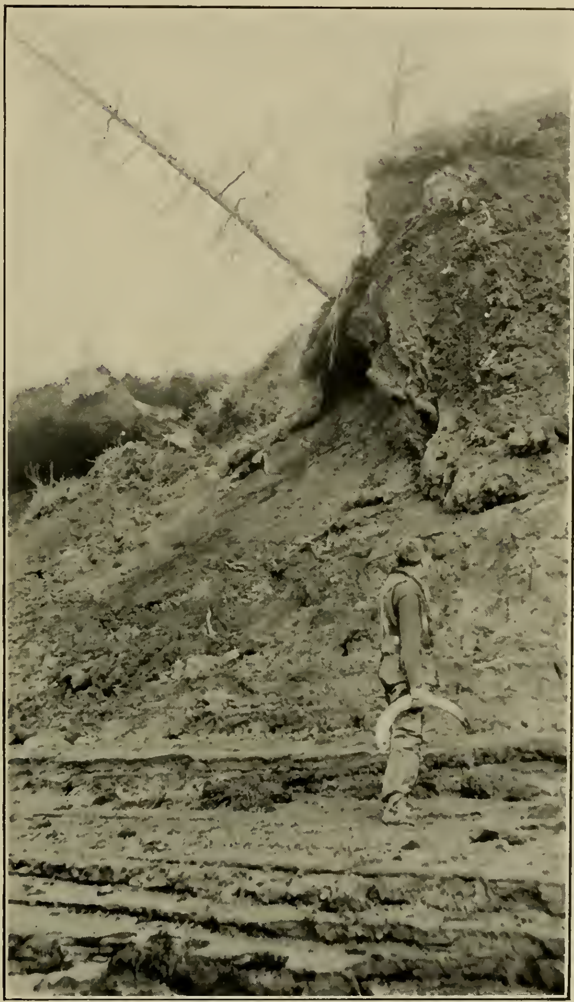


FIG. 44.—Little Anyui River. Third-elevated silt bank, showing detail near center. Up-river trip, September, 1914.

These bars are generally quite boggy on the water's edge and mostly covered with driftwood piles and a rich verdure of equisetum—now swiftly dying or already dead—upon which the numberless swarms of wild geese have been fattening that are now gathering together to return to the South.

The driftwood is composed not only of the larches of the lower river, but also frequently of birches and poplars that thrive along the upper river reaches.

Many decaying cabins, long since deserted, prove that at some former time a comparatively numerous population lived along the river banks.

On the steep higher banks, thawed by the sun and undermined by the current, frequently large outer slabs slide into the stream, carrying with them willows and larches that grew upon the meager upper crust. Under the remaining overhanging drapery of tenacious moss and lichen, thin, peaty layers alternating with clear ice and frozen silt may be observed.

Approximately 100 versts above the mouth of the Little Anyui the first elevated silt beds—so characteristic of the fossil deposits along the Yukon—were observed on the right bank reaching a height of about 100 feet and

FIG. 45.—Little Anyui River. Third elevated silt bank, looking up-stream from lower end. Up-river trip, September, 1914.

extending for three versts along the whole outside curve of the river. During the next 50 versts five more similar silt ridges came into view along the outside bends of the river front.

The second one was on the left bank, about 80 feet high and fronting the river for about 100 yards.

The third elevated silt bank was once more on the right bank of the river, from 100 to 150 feet high and occupying, as did the first, the whole length of the outer river bend, this time about four versts long.

The fourth and fifth ridges (both on the right river bank) were only about each 300 yards long and reached a height of approximately 80 feet.

The sixth (and last) ridge observed was on the left bank of the Little Anyui River, extended for about 300 yards and reached a height of approximately 80 feet.

The fifth and sixth high silt banks, separated from the main branch of the river by shallow sloughs, exhibited no recent slides, were largely overgrown by vegetation, and yielded practically no fossils, which the lower four silt ridges did abundantly.

Among the fossils collected, the remains of wolverine, bison, deer, and mammoth were easily recognized on the spot.

All these fossils found were carried to convenient shelves on the base of the silt bluffs and marked by stakes driven into the ground, to be picked up and

FIG. 46.—Little Anyui River. Fourth elevated silt bank, showing camp. Up-river trip, September, 1914.

FIG. 47.—Little Anyui River. Sixth elevated silt bank, separated by slough from Anyui proper. No fossils found. Down-river trip, September, 1914.

taken to Nizhni Kolymsk on our return trip. This precaution proved to be quite necessary, as a thin crust of newly fallen snow covered the ground before we reached the settlement again.

The general aspect of these different elevated silt banks resembled very much that of similar places in Alaska and Yukon Territory. The tops of the high, steep ramparts were overgrown with moss, lichen, a few Arctic plants, and grasses—among them our own "Labrador tea"—and thin larches without any underbrush. The lower moist places of the surface exhibited an abundance of "niggerheads."

Through many deep, narrow, cross gullies, worn by erosion into these elevated silt beds, little streams of muddy water trickled into the river below.

Often there was no shelf at all at the base of these elevated silt beds. Sometimes the shelves were extremely miry, overrun by sticky mud avalanches and very difficult of access.

Fig. 48.—Big Anyui River. First elevated silt bank, looking up-stream, June, 1915.

Bedrock was nowhere observed. However, during the last third of the journey the current became rather suddenly swift and greatly obstructed further progress of the clumsy dory. A fine reddish gravel appeared on the river bars, mixed with quartz and slate pebbles, rapidly increa ing in size. As soon as the gravel appeared, small fossils began to show on the river bars, while the mud flats below had been entirely bare of such. On the last camping place reached, fossils were found on the bars, and other elevated silt ridges apparently bordering the river farther above were noticed.

Finally the advanced season and lack of supplies compelled us to return. Approximately 50 versts above the mouth of the Little Anyui, we were directed by a lonesome half-breed fisherman—the only human being we met on this river—to a connecting slough which took us into the Big Anyui.

There we heard from another settler of three fossil banks farther above on the Big Anyui, but could not examine them at the present time. The winter was too near. I resolved, however, to return at the earliest opportunity.

We reached Nizhni Kolymsk September 29 with our last provisions and the first permanent snow. Two weeks later winter was upon us in good earnest and the broad Kolyma was frozen over solidly.

FIG. 49.—Big Anyui River. Second elevated silt bank near center, looking up-stream. June, 1915.

FIG. 50.—Tundra silt facing ocean. Notice amount of driftwood in this little gully. The mammoth skull was found about 300 yards from the beach. Between Cape Big Baranoff and Chaun Bay. August, 1915.

During the long winter months I had no opportunity whatever for further research.

The breaking up of the ice in 1915 was exceptionally gentle and early. By the middle of June the usual spring freshet, following the break-up, had so far subsided that I thought it feasible to make another attempt to revisit the fossil places examined the previous fall and to extend my explorations to the elevated silt beds reported to be on the Big Anyui River.

This time I hired a "carbass," one of the light fishing boats of the natives, and set out on June 17, 1915, accompanied by the photographer of the party.

All the elevated fossil banks on the Little Anyui were overhauled once more carefully with the exception of the last two that had yielded no fossil material before and were not likely to do so now. This time only a few scattered insignificant fossil remains could be found. All these places were practically as bare as I had stripped them the previous fall. The reason is evidently this: All these silt ridges were freezing fast when I left them late in September,

FIG. 51.—Tundra beach near Chaun Bay. Fossils found here, August, 1915.

1914. The power of the sun, still feeble, had not yet been able to thaw them, nor had the water, running only such short time again, been able to undermine them. Therefore, no recent slides had occurred and no new fossil remains had been brought to light.

We hurried downstream again, entered—by the same connecting slough mentioned above—the Big Anyui and went up river. In general appearance this river is practically an exact counterpart of the Little Anyui.

Approximately 60 versts above the mouth of the Big Anyui a first elevated silt ridge, two versts in length and about 80 feet high, was encountered on the left river bank. Fifteen versts farther on a second one of the same dimensions appeared on the same side. And finally, another 15 versts beyond and facing the river likewise on the left bank, a third silt ridge of about the same height but only half the length was met with. The general appearance of these frozen bluffs did not in any way differ from that of similar places on the Little Anyui described above.

From the second ridge on upward the heretofore rather sluggish river current quickened perceptibly and quite suddenly. Again pebbles and small fossil remains appeared on the bars, formerly composed only of very fine alluvial matter.

All these three places yielded a moderate amount of fossils. These remains are now all in the possession of the United States National Museum.

At midnight, on July 1, we returned to Nizhni Kolymsk, and five days later our schooner left on the return trip. I reached Nome on September 17, and Seattle on October 9.

Between Cape Big Baranoff and Chaun Bay a few more fossils were added to the collection. Some of them were found on the base of the elevated tundra silts facing the ocean, on many places between mountain ridges. The elevations of this tundra beach differ greatly according to locality. The surface of

FIG. 52.—Tundra beach near Chaun Bay. This picture shows detail of central part of figure 51, which compare. Fossils found here.

the frozen tundra was in August, 1915, overgrown with luxuriant Arctic grasses and herbs. The driftwood found along the beach comes from distant localities and has been brought down by the large rivers of the north. In many instances it is even undoubtedly of American origin.

Some of these fossils—among them a fairly complete mammoth skull—were found in little cross gulches dug by small water courses.

Mr. J. W. Gidley, in charge of fossil mammals in the National Museum, reports that the collection of bones sent in by the Siberian expedition contains a few fine specimens together with a considerable number of isolated bones which are valuable for study and comparison. They all indicate a late Pleistocene age, as the bones of many of the forms represented can with difficulty be distinguished from those of species still living in that region.

The animals represented in this collection are as follows: Mammoth (*Elephas primigenius*), bison, caribou, horse (two or more species), rhinoceros, musk-ox, wolverine, and wolf.

The prize specimen of the collection is a finely preserved, almost complete skull of *Elephas primigenius*. It is of especial interest in that this is the only skull of the Siberian mammoth in any of our American museums.

COLLECTING FOSSIL ECHINODERMS IN THE OHIO VALLEY

The explorations for fossil echinoderms during the summer of 1915, conducted under the supervision of Mr. Frank Springer, associate in paleontology in the U. S. National Museum, were limited to two areas of Silurian rocks in the Ohio Valley from each of which much valuable material was procured for the study of certain definite problems. In southern Indiana Mr. Herrick E. Wilson, under Mr. Springer's direction, spent a number of weeks quarrying for Niagaran echinoderms, particularly crinoids, in the vicinity of St. Paul where numerous outcrops of the Laurel limestone occur. The object of this work was to secure as many specimens as possible for comparisons of this peculiar fauna with those from European Silurian rocks. Not only was much material obtained by the quarrying operations, but all of the local collections of fossils were purchased for Mr. Springer so that the Museum, which hitherto had practically no fossils from the Laurel limestone, is now in possession of a splendid general collection of fossils from this particular formation.

The second area of exploration was in west Tennessee along the Tennessee River where Mr. W. F. Pate spent some weeks in searching for the peculiar crinoidal bulb, *Camarocrinus*, and the associated crinoid, *Scyphocrinus*, both of which Mr. Springer has proved to belong to the same organism. Mr. Pate was successful in finding several localities where excellent specimens of the *Camarocrinus* and *Scyphocrinus* were associated. Much material was secured and the specimens will be used in the preparation of Mr. Springer's monograph upon this group of crinoids.

GEOLOGICAL WORK IN PENNSYLVANIA AND VIRGINIA

Dr. Edgar T. Wherry, assistant curator of the division of mineralogy and petrology, U. S. National Museum, by arrangement with the U. S. Geological Survey, continued his studies of the geology of the Reading quadrangle in eastern Pennsylvania for a month during the summer. He completed the areal mapping of the Cambrian and Ordovician rocks of the region, and has transmitted to the Survey the manuscript of a report upon his work. He also mapped Cambrian and Triassic formations on the Quakertown and Doylestown quadrangles, which lie to the east of the Reading.

A brief visit was made to a newly discovered cave near Lurich, Virginia, where the cave marble was reported to be of economic importance. This view proved to be unjustified, but some unusual stalactitic formations were found, two specimens of which were obtained for the Museum collections.

GEOLOGICAL SPECIMENS FROM NEW ZEALAND

By an arrangement with Prof. Joseph P. Iddings, the Institution was enabled to secure during the year, a number of boxes of rock

FIG. 53.—A typical Buggi's house at Toli Toli, Celebes.
Photograph by Raven.

material and fossils from New Zealand and Tahiti, where Prof. Iddings was engaged in geological work during 1915. This material is a valuable addition to the Museum's collections for study and comparison.

EXPEDITION TO BORNEO AND CELEBES

Mr. H. C. Raven's material from Celebes alluded to in last year's exploration pamphlet [1] was received early in 1915. It includes 464 mammals, 870 birds, 50 reptiles, and some miscellaneous specimens.

[1] Smithsonian Misc. Coll., Vol. 65, No. 6, pp. 23-25.

FIG. 54.—The *Alnoer* anchored off Soemalata, Celebes. Photograph by Raven.

FIG. 55.—At Soemalata, Celebes. Photograph by Raven.

FIG. 56.—A Celebean lemur (*Tarsius*).
Photograph by Raven.

FIG. 57.—Skull of the Babirusa, a pig peculiar to Celebes and adjacent islands.
Collected by Raven.

The mammals and birds are of great value to the Museum as the first adequate representation of a fauna that has particular interest in connection with previous work on other parts of the Malay Archipelago. Some of Mr. Raven's Celebean photographs, also that of the skull of a babirusa, which he collected, are here reproduced (figs. 53 to 57). Early in the summer Mr. Raven returned to America and spent several months on vacation and in preparing for further explorations in Celebes and other parts of the East Indies. Doctor Abbott has generously offered his continued support to this work. Mr. Raven left Washington for the east by way of Japan and Singapore, about the middle of October. Two months later he reported from Buitenzorg, Java, that he was making good progress toward the collecting ground.

EXPLORATIONS IN CHINA AND MANCHURIA

Mr. Arthur de C. Sowerby has been very active in China and Manchuria. Early in the year he made a short trip to the recently opened hunting reserve, about 60 miles northeast of Peking, north of the Eastern Tombs, and south of Jehol. Here, he writes, "I found a well wooded district which I am convinced contains a lot of new stuff. The best thing that I got was a series of squirrels of a species quite new to me. They are striped like chipmunks, but have a thick, soft, much more grayish fur. They are almost entirely arboreal in habits, living in holes in oak trees. These squirrels are very active and take enormous leaps from one tree to another, though they cannot be said to 'fly.' There is no cheek pouch as in the chipmunks." He also obtained an interesting hare, and a cat, *Felis euptilura*, not previously represented in the Museum by a good specimen. The squirrel is a representative of a group hitherto unknown in northeastern China. It has been described as a new species under the name *Tamiops vestitus*.

In March and April Mr. Sowerby visited the Tai-pei-shan district of southern Shensi with the special object of observing the race of Takin, a large goat-like animal, peculiar to that region. "I am pleased to say," he writes under date of May 29, "that I have a fine bull Takin (*Budorcas bedfordi*) for you which I shot at 300 yards range. It is an enormous animal." The skull of this individual is shown in figure 58. He further obtained a female of the Chinese musk deer, now becoming very scarce as the result of excessive hunting by the natives; also a few interesting small mammals including four pikas, small, lemming-like animals related to the hares. "The little pikas simply swarmed above an altitude of 8,000 feet, and it was only because I was exhausted with the difficulty of the country

Fig. 58.—Skull of the South-Shensi Takin. Collected by Sowerby.

and the hard work entailed in hunting the Takin that I did not collect more."

During July, August, and September an important expedition was made to the lower reaches of the Sungari River and the I-mien-po district in north Manchuria. Of his experiences Mr. Sowerby writes: "Had a fearful trip this time owing to floods, insect pests, and dysentery; still I have some 70 or so mammals, 35 birds and a good collection of fish. I have the skull of a good black bear. The skin went bad owing to our being delayed by Russian police. Also I have a good hide and skull of a wapiti, besides series of various small mammals" Of the specimens obtained, only a small package sent by mail has been received in Washington. It includes three species not hitherto represented in the Museum collections.

FIG. 59.—The *Eagle* in winter quarters at Nizhni Kolymsk. Photograph by Amory.

December and January found Mr. Sowerby at Shanghai and on the Yangtzee. He visited the Sikawei Museum to see the collections of Chinese large mammals that formed the basis of the writings of Heude. As this is the first time that these specimens have been examined by anyone acquainted with present-day methods in the study of mammals the result of Mr. Sowerby's observations will be awaited with much interest. They must, however, be reserved for a later report.

GERRIT S. MILLER, JR.

WORK BY COPLEY AMORY, JR., IN EASTERN SIBERIA

In June, 1914, Mr. Copley Amory, Jr., a collaborator of the National Museum, joined the party accompanying Captain John Koren to the northeast coast of Siberia. The party left Seattle on June 24 and reached Nome, Alaska, in July. A photograph of the *Eagle*, the schooner in which they sailed, appeared in last year's report on explorations (fig. 25).[1] The same boat is here shown (fig. 59) in winter quarters. Collecting in Siberia began on July 31 at Emma Harbor, the innermost part of Plover Bay. A view of the harbor and its surroundings is given in figure 60. After a week's work here the party went north through Bering Strait and then west along the north coast to Nizhni Kolymsk near the mouth of the Kolyma River. They arrived here about the end of August and established

FIG. 60.—Emma Harbor, Siberia. Photograph by Amory.

permanent headquarters. Large collections were made at Nizhni Kolymsk during the autumn and winter, while from this point as a base special trips were undertaken up the Little Anyui River (September 6 to 16, November 9 to 26, and December, 1914), up the Kolyma to Verkhni Kolymsk (March and April, 1915), and to the foothills of the Tomushaya Mountains west of Verkhni Kolymsk (May, 1915). In August and September Mr. Amory with the *Eagle* made the return voyage to Nome.

As his part of the results of the expedition Mr. Amory turned over to the National Museum 365 mammals, 264 birds, and various miscellaneous specimens principally of plants, fish, and birds' eggs. Most of this material was prepared by Mr. Amory himself, though

[1] Smithsonian Misc. Coll., Vol. 65, No. 6, p. 26.

various members of the expedition contributed to the collections of both mammals and birds. At present the Amory collections are being

FIG. 61.—Chookchees in their "kayaks," skin-covered boats used by the men in hunting aquatic animals, especially seals. Photographed by Amory near Cape North.

studied with every prospect of important results. Among the mammals about 25 wild species are represented. These are of particular interest as furnishing opportunity to compare the many Alaskan species well represented in the Museum with their nearest Asiatic

FIG. 62.—Tungus family breaking camp in foothills of Tomushaya Mountains. They ride their reindeer and use no sleds (sleds in foreground belong to Amory). Note similarity of lodge structure to that of Chippewa and Montagnais Indians. Photograph by Amory.

FIG. 63.—On the trail between Sredni and Verkhni Kolymsk, showing the two methods of winter travel on the upper Kolyma. Except the first pair each reindeer is tied to the sled in front of it.

relatives. The skull and antlers of the moose shown in figure 64 present a striking example of the similarity which exists between

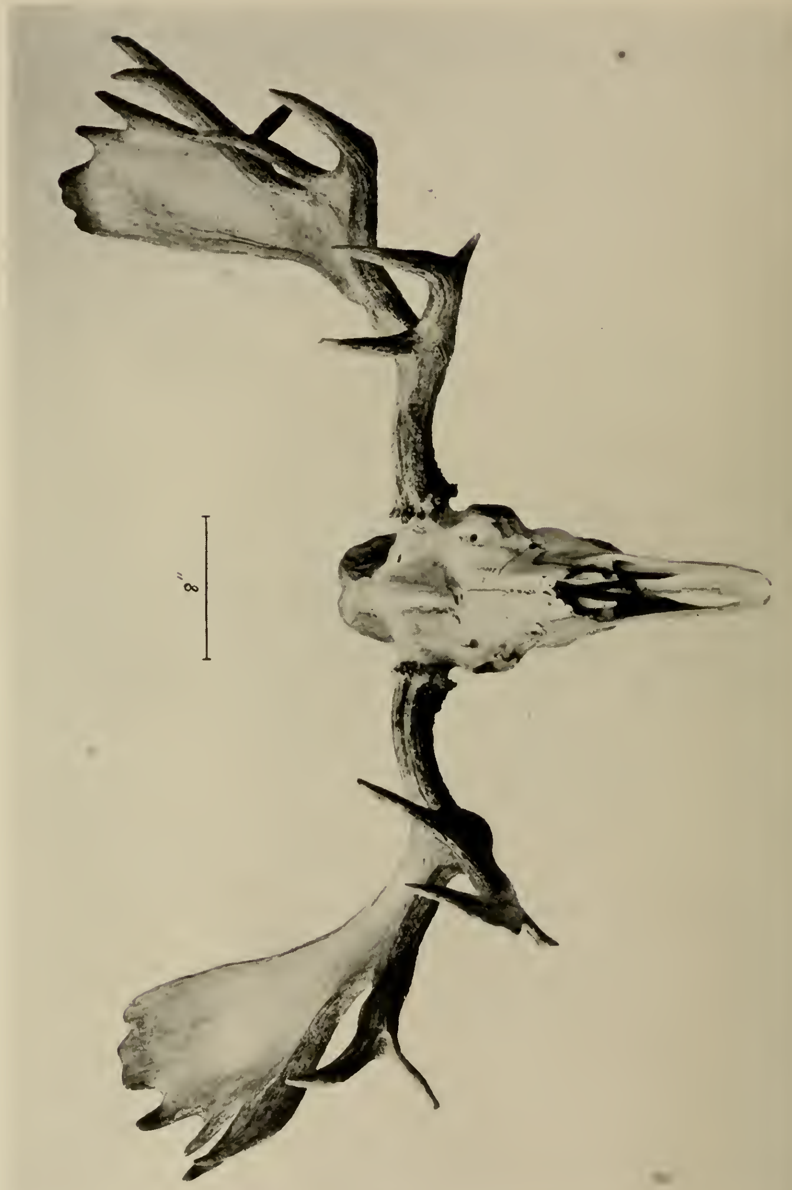


Fig. 64.—Skull of the East-Siberian Moose. Collected by Amory.

Asiatic mammals and their better-known American representatives. Several interesting photographs contributed by Mr. Amory are also reproduced.

GERRIT S. MILLER, JR.

FIG. 65.—At the fur market at Pontilayka, 40 versts northwest of Nizhni Kolymsk. The large men are Chookchees. Their reindeer parkas are covered with drill parkas on which the breath does not frost. Photograph by Amory.

FIG. 66.—Chookchees in a walrus skin "umiak" near Cape Yakan. Note that this boat is not overloaded, although there are at least 14 people aboard. Photograph by Amory.

EXPERIMENTS WITH CERIONS ON THE FLORIDA KEYS

The Bahama Cerion Colonies planted on the Florida Keys were examined by Dr. Bartsch this year between June 18 and 30. A more detailed report of the status of the various colonies was published in the Year Book No. 14 of the Carnegie Institution of Washington, pages 194-196.

A large number of adult specimens of the first generation of Florida grown individuals were found, and these show much more

FIG. 67.—Noddy terns (*Anous stolidus*) on their nesting ground, Bird Key, Tortugas.

fully than the scanty material available last year did, that this first generation has responded to the new conditions in a remarkable manner. The facts which were pointed out in a paper by Dr. Bartsch, Publication No. 212 of the Carnegie Institution of Washington, pages 203-212, plates 1-8, have been fully substantiated and materially added to by the data obtained this year.

A new experiment was started in the transplantation of 307 specimens of the Florida tree snail *Liguus fasciatus* to the Tortugas, one set of which was planted on Garden Key within the Fort, and two on Loggerhead Key.

As in previous years records on the birds observed on the Florida Keys and the southern portion of the peninsula were kept, and these observations have been published in the Year Book No. 14 of the Carnegie Institution for 1915, pages 197-199. The past two years have yielded a list of 76 species to which 13 were added this year, bringing the total list of birds noted to date to 89.

FIG. 68.—Sooty terns (*Sterna fuscata*) on their nesting grounds, Bird Key, Tortugas.

BIOLOGIC STUDY OF CHESAPEAKE BAY

In October, 1915, the United States Bureau of Fisheries began a hydrographic and biologic study of Chesapeake Bay. The work being carried out under the direction of Mr. Lewis Radcliffe with the aid of the Fisheries steamer *Fish Hawk*.

Two cruises were made in 1915. On the first, which extended from October 25 to October 28, Mr. Wm. B. Marshall, assistant curator, division of marine invertebrates, represented the National Museum, while on the second, which covered the period from December 2 to 6, Mr. Clarence R. Shoemaker of the U. S. National Museum took part. During the first cruise observations were made at 30 stations, that is, 8,336 to 8,365 inclusive. These stations extended from the lower bay to the mouth of the Patapsco River, while during the second cruise 35 stations were examined, Nos. 8,366 to 8,390 inclusive, which approximately covered the same parts of the bay examined during the first trip. The efforts of the members of the Museum staff were directed to the securing of bottom samples and bottom life, the hydrographic work being done by the representatives of the Bureau of Fisheries.

Fig. 69.—Looking out through Gregerie Channel, Danish West Indies, where much dredging was done.

The results of these two cruises indicate a remarkable scarcity of animal life, the washing of an entire dredge haul frequently yielding only a handful of shells, worms, and small crustaceans. The bottom material consisted chiefly of mud in a semi-fluid condition, which appears to be discouraging to animal life. A few notable exceptions were encountered in what one might term garden spots in which a decided concentration of living organisms was encountered. No shore collecting was done.

EXPEDITION TO ST. THOMAS, DANISH WEST INDIES

Mr. C. R. Shoemaker of the division of marine invertebrates, spent the two months from the middle of June to the Middle of August,

FIG. 70.—Collecting in Morning Star Bay, Danish West Indies.

FIG. 71.—Edge of Water Island, Danish West Indies, where much shore collecting was done.

1915, in the Danish West Indies, under the auspices of the Carnegie Institution of Washington, D. C., securing collections of corals and other marine invertebrates.

The collecting was done in the open water, bays, and channels at St. Thomas, St. John, and St. James. The deeper waters were explored by means of dredging from a motor boat, while native divers, working from the heavy West Indian row boats, were used for collecting in the shallow waters. In addition to this, much shore

Fig. 72.—Drift Bay, Danish West Indies, where many fine corals and sponges were collected.

collecting was done. Owing to the very strong and constant trade wind, work on the exposed reefs was in many cases made impossible by the heavy surf. Collecting in the protected bays, however, was most successful, as a great variety of bottom was to be found in many of them.

While the chief aim of the expedition was to secure as complete a representation of the coral fauna as possible—and this aim met with considerable success—fine collections of other marine invertebrates were also obtained, including protozoa, sponges, hydroids, medusæ, alcyonarians, anemones, bryozoans, starfish, sea urchins, holothurians, annelids, crustaceans, mollusks, and ascidians. Collections were also made on land whenever opportunities offered, including insects, mollusks, reptiles, and batrachians.

This expedition has enriched the collections of the National Museum by about five thousand specimens, which it is hoped will throw considerable light on the correlation of these islands in the West Indian complex.

CACTUS INVESTIGATIONS IN BRAZIL AND ARGENTINA

Dr. J. N. Rose, associate in botany, U. S. National Museum, (at present connected with the Carnegie Institution of Washington in the preparation of a monograph of the Cactaceae of America), accompanied by Mr. Paul G. Russell, of the U. S. National Museum, continued the botanical exploration of South America during the summer of 1915, spending over five months in travel and field work in Brazil and Argentina.

Bahia, Brazil, was the first place visited, which city served as a base for collecting trips into the interior of the State of Bahia. One of these was to the town of Joazeiro, located about three hundred miles north northwest of Bahia, and lying in a typical cactus desert, although this region is traversed by the large Rio São Francisco. Notwithstanding the fact that this stream is full the entire year, little or no attempt is being made to use the water for irrigation purposes. The country is of that type known as "catinga," and resembles in a remarkable way the deserts of the West Indies; indeed, the genera of plants are in many cases the same, though the species are distinct. Here was seen the "carnuba," or wax palm, from which is obtained the wax utilized in making records for phonographs. Near Joazeiro is the Horto Florestal, or "forest garden," a government experiment station in charge of Dr. Leo Zehntner, who rendered great assistance in the study and collection of the cactuses of the region.

After making short stops at various stations in returning to Bahia, a trip was made to Machado Portella, a small town about 175 miles west and a little south of Bahia, the terminus of a little narrow gauge railway. This is also a semiarid region, and proved exceedingly interesting botanically. The next side trip was to Toca da Onça, still farther south, on the edge of a thick tropical forest, and in a region much more humid than the northern part of the state.

About six weeks were then spent in beautiful Rio de Janeiro and vicinity. Here, even in the city itself, a botanist finds a great deal to interest him, for the trees are covered with epiphytic cactuses, mostly of the genus Rhipsalis, and within the city itself rises the picturesque Corcovado, a thickly wooded mountain on whose slopes are found many rare ferns and tree-inhabiting cactuses. The Jardin Botanico in this city is one of the finest in the world. Over

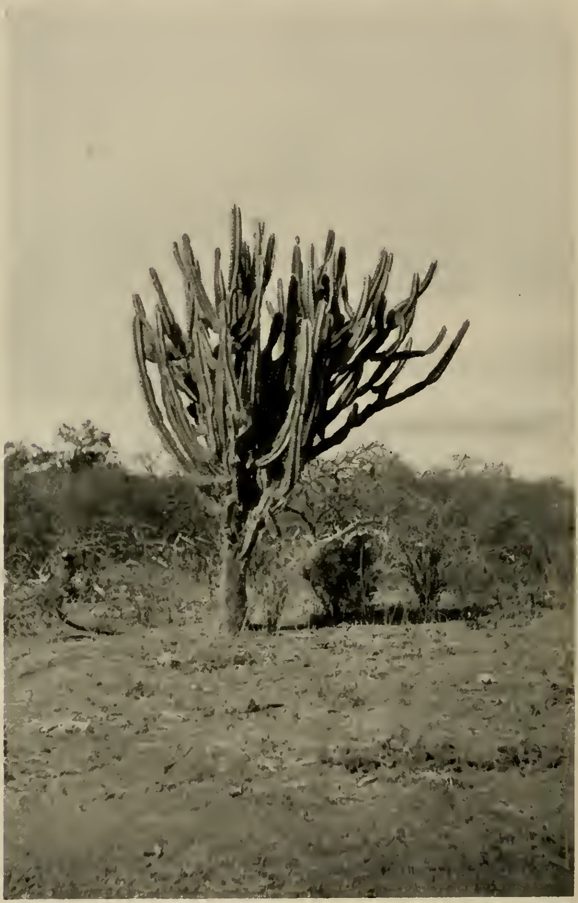


FIG. 73.—*Cereus jamacaru* DC., near Joazeiro, Brazil, one of the largest cacti in the State of Bahia, Brazil. Photograph by Russell.

two hundred species of palms from all parts of the tropics are here grown in the open, besides many other rare tropical plants. In another section of the city, in a fine large park called the Quinta Boa Vista, is the Museo Nacional, where a number of rare cactuses were found in the herbarium.

FIG. 74.—Transportation on the Rio São Francisco near Joazeiro, Brazil. Photograph by Russell.

FIG. 75.—Slopes of Mount Itatiaya, the highest mountain in Brazil, showing *Araucaria braziliana* A. Rich., in the foreground. In the distance the morning mists hide the valley. Photograph by Russell.

From Rio de Janeiro an ascent of Itatiaya, the highest mountain in Brazil, was made, and on the very top, 10,000 feet above the sea,

FIG. 76.—The wax palm, in the State of Bahia, Brazil, from which is obtained "carnuba," the wax used in the manufacture of phonographic records. Photograph by Russell.

was found a small cactus with beautiful rose colored flowers. Excursions were also made to Cabo Frio, to Ilha Grande, and to the islands in the Bay of Rio de Janeiro. A few days were spent in

FIG. 77.—The avenue of palms in the Botanical Garden at Rio de Janeiro, Brazil. Photograph by Russell.

the Organ Mountains, near Petropolis, the summer home of the wealthiest classes of Rio de Janeiro. This range of mountains merits a more thorough biological exploration than has been hitherto undertaken.

Fig. 78.—*Cereus Forbesii* Först., from the desert region near Cordova, Argentina. Photograph by Russell.

Proceeding southward, a day was spent at Santos, Brazil, the world's greatest coffee center. Buenos Aires was visited next, although but little time was spent in the city. Several visits were made to the fine suburb of La Plata, where resides Dr. Carlos Spegazzini, the leading authority on Argentine cactuses.

From Buenos Aires a trip was taken across Argentina to Mendoza, a city situated near the foot of the Andes, in a region favorable to the growth of succulent plants. From there a short excursion was made to Portrerillos, Argentina, on the railway which leads to Valparaiso, Chile. Many very interesting plants were found in both these places.

In the city of Cordova, Argentina, northwest of Buenos Aires, the cactus collection of Dr. Frederick Kurtz was found to contain some rare types, which were very kindly submitted for examination and study. In this vicinity, as well as in the neighboring town of Cosquin, many cactuses were collected on the semiarid peneplain.

In addition to good sized collections of cactuses, consisting of living, herbarium, and formalin specimens, moderately large collections of insects, shells, diatoms, and other natural history specimens were obtained. In all about 8,000 herbarium specimens were obtained and over 90 cases, large and small, of living plants were sent back to the United States. The living collection is now on exhibition at the New York Botanical Garden.

The expenses of this expedition were chiefly borne by the Carnegie Institution of Washington and the New York Botanical Garden.

SHELL MOUNDS ON THE PACIFIC COAST

While serving as representative in charge of the exhibit of the Institution at the Panama-Pacific International Exposition, Dr. Walter Hough had an opportunity to examine some of the shell mounds which are numerous around San Francisco Bay. In this work he was aided by Prof. T. T. Waterman and Mr. E. W. Gifford of the University of California. A large mound in West Berkeley which had been sectioned by grading for factory sites, leaving a mass which appeared to be the central portion, and presenting a face 12 feet in height, was selected for operations and enough work was done to secure data as to its strata of accumulation, human, animal, and art contents. Within three feet of the base under ashes were found the skeletons of several infants. This find was considered noteworthy, a similar deposit not having been found before. Artifacts were not common in this section of the mound. There were found plummets, sinkers, hammers, grinding stones, awls, antler wedges, and rarely obsidian blades.

ARCHEOLOGICAL RECONNOISSANCE IN WESTERN UTAH

Previous to June, 1915, our meager knowledge of the archeological remains in western Utah had been gleaned mostly from casual notes in the official reports of early government geologists, surveyors, and army officers attached to frontier posts. Very few scientific excavations had been attempted and almost nothing had appeared in print regarding their results. The cultural relationship between the builders of the ancient Utah dwellings, remains of which consisted primarily of mounds, and the prehistoric pueblos and cliff-dwellings of southeastern Utah and the adjoining sections of Colorado, New

FIG. 70.—Small storage bins in rectangular adobe dwellings at Beaver City, Utah.

Mexico and Arizona, furnished a much mooted question, a solution of which seemed highly desirable. The preliminary task of securing definite and first-hand information regarding these mounds was commenced in May, 1915, by Mr. Neil M. Judd, of the National Museum, who, under the auspices of the Bureau of American Ethnology, remained in Utah six weeks, engaged in researches that extended the entire length of the state.

Mr. Judd began his reconnoissance at Willard, on the northeastern shore of Great Salt Lake. Years of continued soil cultivation had quite leveled the dozen or more mounds once noted at this place; only one remained in the spring of 1915 in a comparatively undisturbed condition. Excavations in this mound disclosed the remains of a very primitive structure, the roof of which had consisted, apparently, of logs that rested upon the ground and leaned against crosspieces supported by four vertical posts surrounding the fireplace. The adjacent timbers composing the roof had in turn supported layers, respectively, of willows, grass, and clay. This structure had been circular in form and was probably not more than 15 or 16 feet in diameter.

Dwellings of the same type were discovered near Beaver City, in Beaver County, in close proximity to larger structures whose walls were made of adobe and whose flat roofs had consisted of heavy

FIG. 80.—Walls and fireplace of a large adobe structure at Beaver City, Utah.

beams covered with willows, grass, and clay in succession. The artifacts recovered from these two types of dwellings differ but little and indicate a close relationship, both in time and in culture, between their respective builders.

One large mound at Beaver City, which was completely excavated, contained 15 rectangular rooms and a circular structure which has been identified as a kiva or ceremonial chamber similar to those associated with prehistoric habitations throughout the San Juan drainage. Of the 15 rectangular rooms, only four were contiguous; the walls of all had been constructed of adobe mud, pressed into place while in a plastic condition. No indication of the use of adobe bricks or of large adobe blocks could be found. In the northern portion of the mound four distinct levels of occupancy

FIG. 81.—Petroglyphs near the southern end of Little Salt Lake in Iron County, Utah.

were exposed, each bearing fireplaces and other remains of habitations. Careful examination of the artifacts from these superimposed levels failed, however, to show that their inhabitants were other than those who had occupied the lower houses or that any considerable period of time had elapsed between the occupancy of the lowest and the uppermost levels.

Similar dwellings were unearthed near Paragonah, in Iron County. Owing to lack of time no effort was made to study the houses concealed by the larger mounds; the four small elevations examined contained only individual rooms which differed but little from those

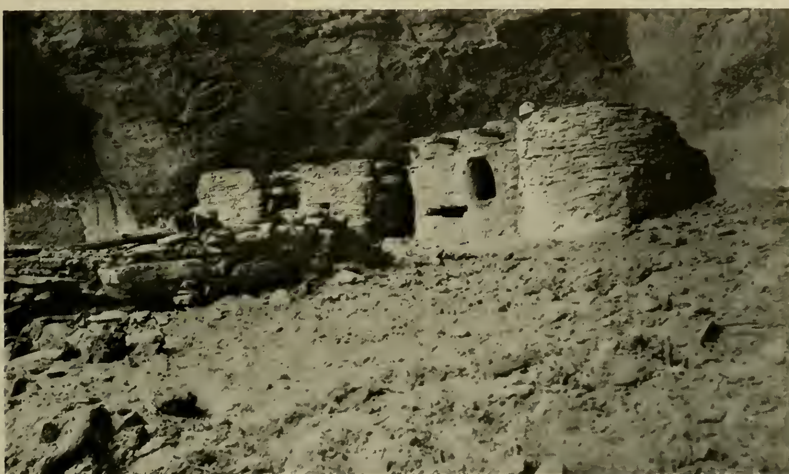


FIG. 82.—Small cliff-village in Cottonwood Canyon, near Kanab, Utah.

near Beaver City. Twenty years ago more than 100 mounds were counted at this place; today, only a few remain, the others having been recently razed and the artifacts they contained scattered over the newly plowed fields. While it is impossible to check this destruction, since the mounds are upon privately owned land, it is not yet too late to determine the architectural peculiarities of the primitive houses over which the mounds have accumulated and to gauge the degree of culture to which the ancient inhabitants had attained.

One day was spent near St. George, in the southwestern corner of the State, a region which received much attention from Dr. Edward Palmer, of the National Museum, between the years 1870 and 1876. The vast increase in the number of cultivated acres has brought about the destruction of most of the formerly abundant archeological remains, only a few small and isolated house sites being now visible.

Few ruins were noted along the road that connects St. George with Kanab, in Kane County. This section is extremely arid and no effort was made to visit the isolated mounds and cliff-houses reported by

Fig. 83.—Caves in limestone formation in Whalen Canyon, showing evidence of occupancy by primitive peoples.

cowboys as existing upon the mesas both north and south of Short Creek. It is believed that close examination will disclose structures similar to those near Beaver City and Paragonah, but probably constructed with stone instead of adobe—the availability of laminate sandstone would naturally have led to its use by primitive peoples.

After leaving Kanab, Mr. Judd spent one day in Cottonwood

FIG. 84.—Pits and fractured stone at the so-called "Spanish diggings" in Wyoming.

FIG. 85.—Fractured stone surrounding the aboriginal quarries known as the "Spanish diggings" in Wyoming.

Canyon, investigating a number of caves which contain evidences of prehistoric occupancy. In one of these were several circular rooms, the walls of which had been constructed with masses of adobe, reenforced by bunches of rabbit-brush or the young twigs of sage. On the rear wall of this same cave were many representations of mythological beings, painted in red, white, brown, and yellow.

Another cave in this canyon contained the ruins of four unconnected cliff-houses and a subterranean kiva measuring 14 feet in diameter. The fact that the four houses of this small cliff-village were entirely detached is quite novel and may lead to extensive revision in prevailing theories regarding the origin of the great communal houses built by prehistoric peoples south and east of the Rio Colorado.

Several caves in Cave Canyon are now flooded with water, but bear unmistakable evidence of having been formerly occupied by

Fig. 86.—Tipi circles or old camp-sites on the hills overlooking Willow Creek, Wyoming.

primitive peoples. Exposed mounds in Johnson Canyon, about 15 miles east of Kanab, indicate the sites of rectangular dwellings similar to those near Beaver City, with the exception that stone was freely employed in the construction of the walls.

Mr. Judd's preliminary examination of the archeological remains in western Utah shows that at least three distinct types of prehistoric habitations formerly existed; that artifacts found in the two types first mentioned indicate a close cultural affinity between their builders, and that the second and third types possess many characteristics in common, together with an unmistakable cultural relationship with the pre-Puebloan ruins scattered widely throughout the southwest.

After leaving Salt Lake City on his return journey to Washington, Mr. Judd made a hurried visit to the " Spanish Diggings," a series of aboriginal quarries on the Dry Muddy, a branch of Willow Creek, in northern Platte County, Wyoming. These pits take their name from a local belief, still prevailing, which credits the Spanish conquerors with having made the excavations in their untiring search for gold. Although but one day was spent in the Willow Creek basin, it is quite evident that the "Spanish Diggings" are nothing more than pits left by the aboriginal inhabitants of the region in their efforts to obtain suitable stone from which arrow-points, blades, and other chipped artifacts might be made. Most of the quarries are in exposures of fine-grained, bluish quartzite and may be traced over an area nearly 50 miles square. In every valley and upon almost all the low hills which divide the stream courses are countless tipi circles, the former camp sites of wandering bands of Indians, in and about which are innumerable chipped scrapers, blades, etc., and vast quantities of artifacts rejected during the manufacturing process, all of stone quarried from such exposed rock masses as the "Spanish Diggings."

TRIP TO THE CHIPPEWA INDIANS OF MINNESOTA

In May of 1915, Dr. Aleš Hrdlička, curator of the division of physical anthropology in the U. S. National Museum, made a rapid but rather extended trip over the White Earth and Leech Lake Reservations in Minnesota, under the auspices of the Department of Justice.

The object of this trip was to determine, as far as possible, the extent of full-bloods and mixed-bloods in the tribe, and especially to pass on the status in this respect of certain families and individuals.

About five years ago the United States Congress passed a law enabling mixed-blood Indians to alienate their land and timber, but did not sufficiently define what constituted a mixed-blood, that is, how he could be safely recognized as such in every instance before the law. As soon as this law was passed the local lumber companies and white settlers took full advantage of the situation, with the result that in a few years hundreds of Indian families and individuals were practically destitute, and those who were induced to sell included not only the easily recognizable mixed-bloods, but also quite a number of those who claimed to be full-bloods, or who could not by any ordinary means be recognized as having any white blood in their veins. Moreover, in some of these cases the sale of the timber or land by the Indians was obtained by misrepresentation and even by actual fraud.

The full-blood Indians, however, and those who could not be legitimately recognized as mixed-bloods, were under the protection of the United States Government. They had no right or power to alienate their property without the Government's consent; and when the attention of the authorities was called to the wholesale deprivation of the Indian of his land and timber, due steps were taken not

FIG. 87.—Chippewa mixed-blood, French-Indian, looking strikingly like a Japanese.

only to prevent the continuation of such deprivation but to recover for the Indian all property that was taken from him illegally. Commissions were appointed to investigate the conditions; the Indians were thoroughly questioned as to their genealogy and blood mixture, and in the course of years hundreds of actions were brought before the courts for the recovery of their property.

As these cases proceeded and the defense developed, it became evident that the most urgent and important problem was to determine in many of the contested cases who was, and who was not, a full-blood Indian. There was no difficulty in this respect where the amount of white blood was considerable or the mixture fairly recent; but in many instances the mixture first took place many generations ago, and the proportion of white blood in the present representatives of some such families is so small that it is difficult, if not impossible, to determine the degree of white infusion by ordinary observation.

It was with a view of assisting, as far as possible, in the solving of the problem as to who are full-bloods and who are mixed-bloods among the Chippewa, that Dr. Hrdlička was asked to visit the reservations; and he undertook the task with the expectation of coming in

Fig. 88.—A family of Chippewa mixed-bloods, Leech Lake. All the individuals are mixed, but in some the proportion of white blood is small.

contact with many interesting conditions which usually are not directly related to regular anthropological work.

The method of procedure was to drive from dwelling to dwelling over the reservations, and to examine the Indians whose blood status was in doubt by all the means at the disposal of the anthropologist, practicable in field work of this nature. Particular attention was directed to the skin of the body, especially that of the chest, to the hair and eyes, physiognomy, and a number of other features, such as the nails, gums, and teeth, which may be of assistance in determinations of this nature. Furthermore, stress was laid on the examination, in all important cases, of all the living members of the family, for it frequently happens that the brothers and sisters of an individual throw more light on his blood status than does the examination of his own person.

The results of the work need be mentioned in this place only very briefly. It was found that mixture is very prevalent in the tribe. Most of this mixture dates far back, and taking in account the effects of the changed mode of living of the Indians, which has resulted in some lightening of the skin, it is frequently difficult to determine; yet it was found that there are certain signs by which in a large majority of cases a quite definite judgment can be reached on this question. The most difficult cases were found to be the old people, in whom the hair has changed to some extent through age and neglect, the skin is modified by exposure, the teeth are lacking

Fig. 89.—Chippewa birch-bark lodge, White Earth Reservation. These lodges, the shape of which reminds one so much of the Mongolian and Siberian "yurtas," are now very scarce among the White Earth Chippewa.

or worn down, and the eyes, due to various affections as well as age, are in a more or less unsatisfactory condition for examination.

On the whole there is no question but that a detailed anthropological examination in cases of this nature could be of considerable assistance to the law. It would readily show the true full-bloods, with a very large majority of the mixed-bloods; and the small percentage then remaining would consist almost exclusively of aged individuals whose status could probably be readily adjusted to legal requirements by some sort of compromise.

Scientific results of the work, on the other hand, would probably prove disappointing. The obtainable knowledge as to the nature and time of the admixture is very limited; the members of the families are widely scattered; conditions are complicated by former polygamy; and there are many blends which doubtless follow some laws of heredity, but the complexity is too great to be unraveled by such investigations as are possible on the great and sparsely populated reservation, and with people who, due to their limitations, can be of but little assistance to the anthropologist.

THE NACOOCHEE MOUND IN GEORGIA

In pursuance of a plan for cooperative archeological research by the Bureau of American Ethnology and the Museum of the American Indian of New York, Mr. F. W. Hodge, Ethnologist-in-charge, early in July joined Mr. George G. Heye of the museum mentioned, in the excavation of the Nacoochee Mound in White County, northeastern Georgia, permission to investigate which was accorded by the owner, Dr. L. G. Hardman.

The Nacoochee Mound is an earthwork built by the Cherokee Indians, who occupied it until early in the 19th century. The name "Nacoochee," however, is not of Cherokee origin, or at least it is not identifiable by the Cherokees as belonging to their language, and by no means does the word signify "the evening star" in any Indian tongue, as one writer has claimed.

The summit of the mound, which had been leveled for cultivation about 30 years ago, measured 83 feet in maximum and about 67 feet in minimum diameter; the height of the mound above the adjacent field was 17 feet, 3 inches, and the circumference of the base 410 feet. These measurements, however, are doubtless less than they were at the time the mound was abandoned by the Cherokee, as all the dimensions have been more or less reduced by cultivation, the slope at the base particularly having been plowed away for several feet.

It was the custom of the Indian tribes of the South, and especially throughout the valleys of the Mississippi and its tributaries, to erect mounds for various purposes, namely, to serve as a site for the domicile of the chief or for the "town-house" of the settlement, as a burial place of the dead, or merely as a place of refuge during periods of flood. The Nacoochee Mound was reared both for domicile and for cemetery purposes, and was composed of rich alluvial soil from the surrounding field. The excavations determined that the mound was not built at one time, but evidently at different periods as circumstances demanded. This was shown plainly by the stratification of the mound soil, the occurrence of graves at different depths with undisturbed earth above them, the presence of fire-pits

Fig. 90.—The Nacoochee Mound from the south. The summer-house on the summit was erected about 30 years ago.

Fig. 91.—Forty-foot trench, 4-foot level. View looking north.

or of evidences of fires throughout the mound at varying levels, and by the finding of a few objects derived from the white man in the upper part and in the slopes of the mound, but not in the lower levels. From this last observation it is evident that the occupancy of the mound extended well into the historical period, a fact supported by the memory of the grandparents of present residents of the Nacoochee Valley who recalled the mound when the Cherokee Indians still occupied it and the surrounding area.

Fig. 92.—Trench, east side of mound. View from the south. The lowermost part of the excavation shows the base of the mound.

The fact that the mound was used for burial purposes is attested by the finding of the remains of 75 individuals during the course of the excavations, the graves occurring from slightly beneath the summit to a depth of about 19 feet, or below the original base of the mound. These graves, with few exceptions, were unmarked, and in most instances were not accompanied with objects of ceremony or utility. The exceptions were those remains with which were buried stone implements, shells or shell ornaments, a smoking pipe, a pottery vessel, or the like. The skeletons were found usually with the head pointed in an eastwardly direction, and were all in such a greatly decomposed condition that it was impossible to preserve any of them for measurement and study, the bones in most cases consisting of only a pasty mass.

As mentioned above, most of the burials were unmarked. The exceptions consisted of two graves encased and covered with slabs of stone, both unearthed near the very base of the mound. One of these stone graves contained a skeleton the bones of which were largely of the consistency of corn-meal, owing to the ravages of insects; but what was lacking in the remains themselves was more than compensated by the finding, near the skull, of a beautiful effigy

FIG. 93.—Sectional view of fire-pit 10 feet in length, showing indurated ash.

vase of painted pottery, the only piece of painted ware, whole or fragmentary, found in the entire mound. The occurrence of this type of vessel and the presence of the stone graves at the bottom of the mound suggest the possible occupancy of the site by Indians before the settlement of the Cherokee in the Nacoochee Valley.

Perhaps the most remarkable feature of the mound was the large number of smoking pipes of pottery, mostly broken, but in many forms and of varying degrees of workmanship. Some of the pipes are of excellent texture and are highly ornamented with conventionalized figures of birds, etc., or marked with incised designs. Another feature of the mound was the great amount of broken pottery found, especially in the refuse at the base and covering the slopes.

FIG. 94.—A flexed skeleton in the Nacoochee Mound, showing ornaments buried therewith.

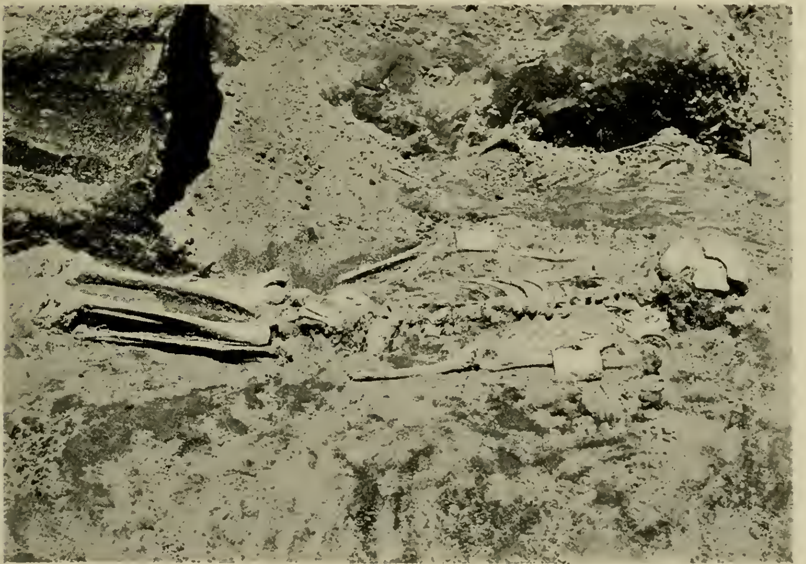


FIG. 95.—One of the burials found in the Nacoochee Mound. Note the copper arm-band, and the beads at the neck.

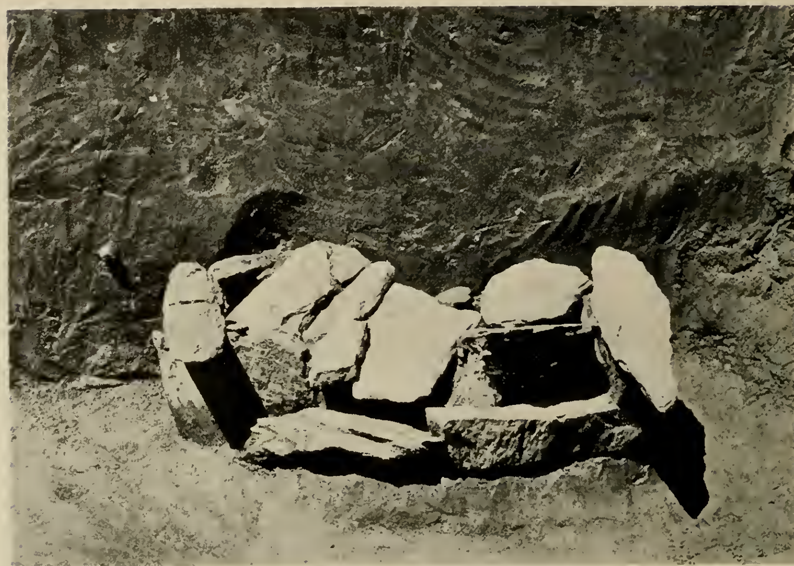


FIG. 96.—Stone grave above the bottom of the mound.

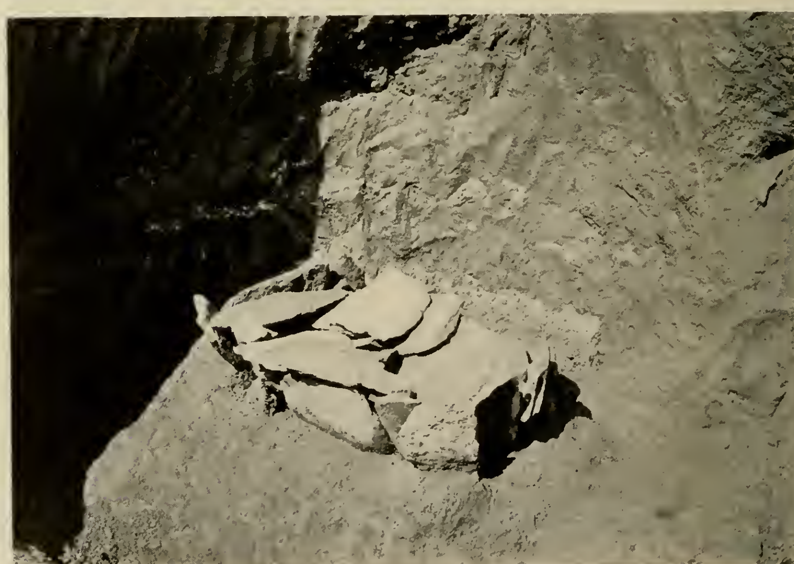


FIG. 97.—Stone grave near the bottom of the mound.

FIG. 98.—Painted effigy vase found with a skeleton in a stone grave at the base of the mound.

FIG. 99.—Copper axe in handle found with one of the burials at the base of the mound.

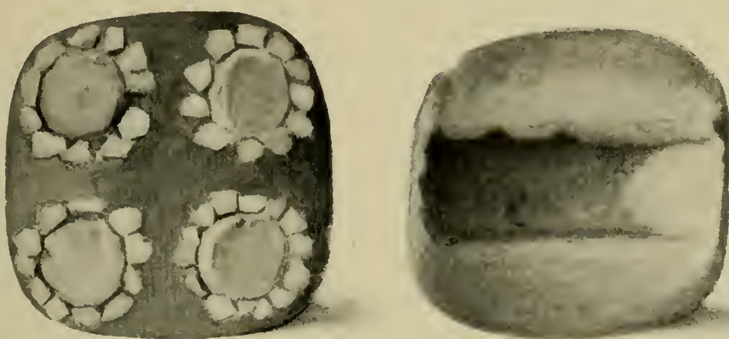
This pottery is chiefly of fine texture, although some of the cooking vessels are of coarse ware. With the exception of the painted vessel above noted, the only ornamentation applied by the makers of the pottery consists of incised and impressed designs, the latter conferred usually with a paddle of clay or wood, or worked out in the moist ware, before firing, by means of a pointed tool, a spatula, a piece of cane, or a shell.

PREHISTORIC REMAINS IN ARIZONA, NEW MEXICO, AND COLORADO

One of the most interesting historical monuments protected by the Government is the ruin of the old mission church of San José de

Fig. 100.—Ruin of San José de Tumacacori, Arizona. Photograph by Fewkes.

Tumacacori, situated on the Santa Cruz River, south of Tucson, Arizona. There were formerly several of these churches along the banks of this river, one of which, the nearest to Tucson, is called San Xavier del Bac. This building is still in use, having been repaired and enlarged to accommodate the inhabitants of the neighboring village of Papago Indians. A few miles south of San Xavier are remains of the old settlement Tubac, and the walls of the fort and former Indian town. Still farther south, about 20 miles from Tucson, stand Tumacacori (fig. 100) and the mounds of the adjacent prehistoric settlements. Although the old church is protected from vandalism, the foundations of the walls, undermined and exposed to the elements, are sadly in need of repair. Unless something is done to prevent its crumbling walls from falling, after a few years little will remain of this fine example of Spanish mission architecture of the 18th century. The façade and dome are still fairly well preserved; the main walls, roof of the cupola, and mortuary chapel are still standing, and a few hundred dollars judiciously expended would save for posterity this precious relic of the past. Evidences of the walls of a prehistoric compound formerly inhabited by the Indians of that region may be traced near the mission and mounds indicating massive aboriginal buildings are visible. These ought to be excavated and repaired. Dr. Fewkes made a trip to the above mentioned missions in January, 1915, in order to study the distribution of prehistoric settlements now in ruins on the Santa Cruz, one of the gateways



a *b*

FIG. 101.—Turquoise mosaic (*a*, front; *b*, back) from Mimbres Valley, New Mexico. Original 0.8 inch square. Heye Collection. Drawing by Mrs. R. E. Gamble.

of early communication between Mexico and southern Arizona. He regards the region west of the Santa Cruz as one of the most important unworked ethnological and archeological fields in the Southwest. Little has been recorded on the prehistoric remains in this region and there is still much to be learned of the modern inhabitants whose culture has been little modified by the influence of civilization and who still preserve many of their ancient dances and secular customs.

The slightly known ruins of this region were found to be of practically the same type as Casa Grande on the Gila, suggesting a southern extension of this type of architecture into Mexico. The prehistoric mounds would well repay systematic excavation, and would yield much material bearing on the diffusion of culture of the ancient people of our Southwest. The object of the visit was a reconnoissance, which was successfully completed. There are large mounds indicating compounds of considerable size between Casa Grande and Vekol, near Quijotoa, and at the Kwahadt settlements.

Having made the brief reconnoissance above mentioned, Dr. Fewkes returned to Deming, New Mexico, and undertook an examination of ruins along the Mimbres River, inspecting various archeological sites as far north as Silver City. He obtained by purchase valuable additions to collections of the characteristic pottery of this

d

a *b* *c*

Fig. 102.—Decorated pottery from Mimbres Valley, Heye Collection. *a*, unidentified animal; *b*, bee; *c*, *d*, unidentified composite animals.

region, from Oldtown and elsewhere (figs. 102-111). One of the most striking objects examined is a rare turquoise mosaic with four figures representing flowers (fig. 101). The culture of the Mimbres Valley as shown by archeological data is distinctive, with no likeness to that of the lower Gila, but connecting that of the upper Gila with Casa Grandes in Chihuahua. The prehistoric culture of Mimbres Valley, like that of the Santa Cruz, is destined to play an important rôle in determining diffusion of Southwestern culture.

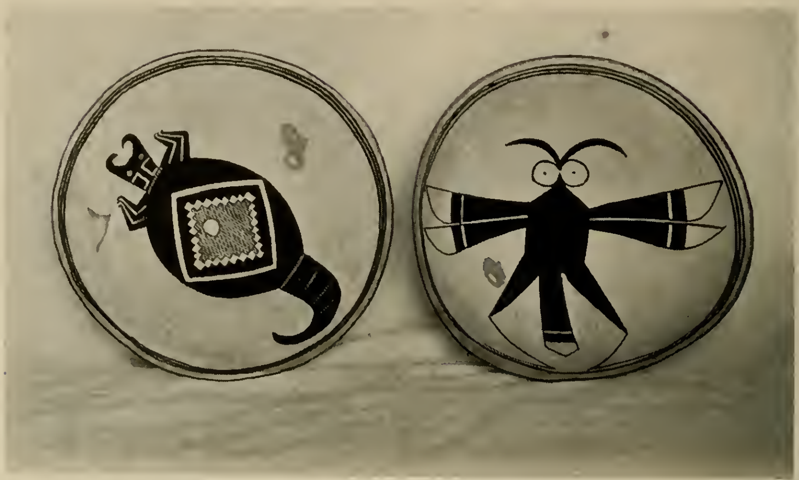
Important work was carried on by Dr. Fewkes during the last year in the Mesa Verde National Park, where the Department of the Interior is cooperating with the Smithsonian Institution in the excavation and repair of cliff-houses and other prehistoric ruins, to increase *d*

a *b* *c*

Fig. 103.—Decorated pottery from Mimbres Valley, Heye Collection. *a*, bird; *b*, turtle; *c*, bear; *d*, reptile.

a *b*

Fig. 104.—Decorated pottery from Mimbres Valley, Heye Collection. *a*, unidentified animal holding unknown object (see *b*, fig. 107); *b*, bear.

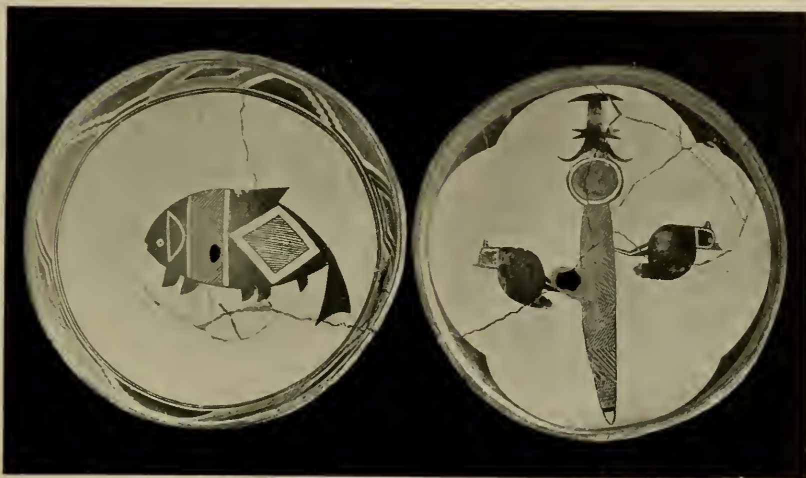


a *b*

FIG. 105.—Decorated pottery from Mimbres Valley, Heye Collection. *a*, unidentified insect; *b*, dragonfly.

a *b*

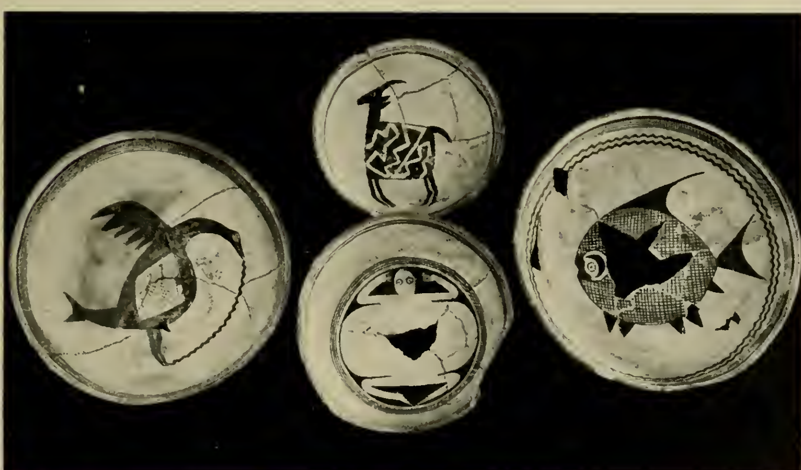
FIG. 106.—Decorated pottery from Mimbres Valley, Heye Collection. *a*, animal with head and body of antelope and tail of fish; *b*, measuring-worm, with rainbow symbol.



a *b*

FIG. 107.—Decorated pottery from Mimbres Valley, Heye Collection. *a*, fish; *b*, birds on unidentified object (see *a*, fig. 104).

c



a *b* *d*

FIG. 108.—Decorated pottery from Mimbres Valley, Heye Collection. *a*, bird; *b*, frog; *c*, mountain sheep; *d*, fish.

c

a b

FIG. 109.—Decorated pottery from Mimbres Valley, Heye Collection. *a* and *b*, dancing figures; *c*, bird.

a b

FIG. 110.—Decorated pottery from Mimbres Valley, Heye Collection. *a*, animal with head of antelope and body of insect; *b*, mountain lion.

their value to students and render them more attractive to visitors. The field work last summer (1915) was devoted to a large building situated on the point (fig. 112) opposite Cliff Palace, and to Oak-tree House, an adjacent cliff-dwelling in the neighboring canyon. This work was unusually successful in that it revealed a new type of prehistoric building 121.7 feet long by 340 around the north or semicircular side. This ruin, to which the name Sun Temple has been given, is considered one of the most mysterious structures in the

FIG. 111.—Bird and larval insect from Mimbres Valley, Heye Collection.

Southwest. It was completely excavated, the fallen earth and stones were removed, and the walls thoroughly repaired, the most improved methods being adopted for their preservation from the elements. The ground plan shows an original building and an annex, shaped like a capital letter **D**. Adjoining the southwest corner of the annex, on the outside, were built two walls forming an enclosure identified as a shrine, the floor of which is formed by the upper face of the southwest cornerstone of the building. In this floor is a fossil palm, suggesting a symbol of the sun, which has given the name to the ruin.

The mound (fig. 113) covering the ruined walls of the Sun Temple dates back to 1555, as indicated by a cedar tree having 360 annual "rings" which was found growing on the top of the highest wall. There is no way of telling how much earlier the mound was formed or how many years before it became a mound the foundations of the building were laid. It is, however, believed that worship at the sun shrine undoubtedly antedated the construction of the building.

FIG. 112.—Sun Temple from point across Fewkes Canyon, Mesa Verde National Park, Colorado. Photograph by T. G. Lemmon.

The Sun Temple was probably built by the neighboring cliff-dwellers and is regarded as more modern than Cliff Palace. The unity of plan shown in the Sun Temple (fig. 115) indicates union of several clans in its construction and the existence of a higher social organization than at Cliff Palace. It was intended for a ceremonial building with a secondary purpose of storage and refuge in time of trouble, but shows evidence that it was never finished.

A cliff-ruin called by guides Willow House, but which might better be known as Oak-tree House, is a typical cliff-dwelling of about the same age and culture as Cliff Palace. It is situated in

FIG. 113.—Sun Temple, Mesa Verde National Park, Colorado, before excavation, from southwest corner. Photograph by E. E. Higley.

FIG. 114.—North wall of Sun Temple, Mesa Verde National Park, Colorado, looking east from annex. Half excavated. Photograph by Fewkes.

Fewkes Canyon, Mesa Verde National Park, under a perfectly arched natural roof, below the mysterious ruin above mentioned. Oak-tree House is not referred to in Nordenskiöld's classic on the "Cliff Dwellers of the Mesa Verde," and has not been figured nor described by other archeologists, although it presents several very exceptional architectural features. This oversight may be due in part to the fact that it was practically inaccessible previous to last summer (1915). Notwithstanding its neglect by archeologists this ruin is of no mean size, having had at least six circular subterranean ceremonial chambers, and 25 rooms, some of which were habitations, indicating the existence of a population of at least six clans. Its ground plan shows that it occupied the whole floor of a large cave; the houses were in places four stories high.

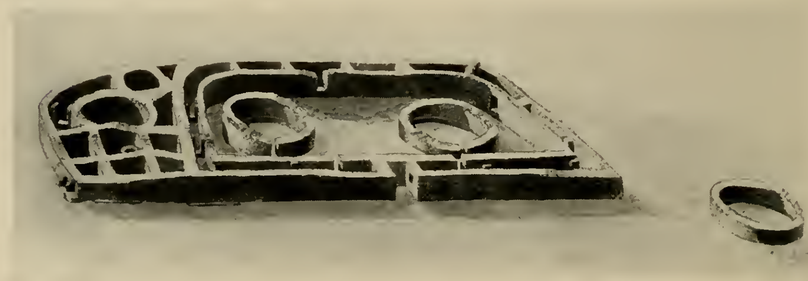


FIG. 115.—Birdseye view of Sun Temple, Mesa Verde National Park, Colorado, looking northeast.

At the close of the work on the Sun Temple, above mentioned, the rooms of Oak-tree House were cleaned out, and the walls repaired and put in condition for permanent preservation. Ladders were placed in position to afford descent from the rim of the mesa to a pathway made on the talus on which it stands. This descent is a somewhat difficult task, but once accomplished it offers beautiful views of Cliff Palace and other ruins down Soda Canyon, as far as Mancos River.

Perhaps the most unusual ceremonial room of Oak-tree House (fig. 117) is a kiva shaped like the letter D, in which there is a rectangular chamber between the firehole and the south wall. This chamber communicates with the outside by means of a vertical flue and opens into the main room by two passageways in a wall, corresponding to the deflector of other kivas. Another exceptional feature of Oak-tree House is the presence in the rear of the cave of a circular room,

Fig. 116.—View of Sun Temple, Mesa Verde National Park, Colorado, from the east. Photograph by Fred Jeep, with east wall added by W. H. Holmes.

FIG. 117.—Oak-tree House, Mesa Verde National Park, Colorado.
Photograph by T. G. Lemmon.

the walls of which are not constructed of masonry but of willow twigs and sticks covered with adobe plastering, a feature quite common in the cliff-house walls in northern Arizona, but very rare on the Mesa Verde. This is supposed to be a survival of a pre-Puebloan style of architecture. A small collection of artifacts was made in the course of the repair of Oak-tree House. Among the objects found were two beautiful specimens of typical black-and-white-ware pottery. The so-called snow-shoe (fig. 118) is rare, and the head-rest (fig. 119) exceptionally well made.

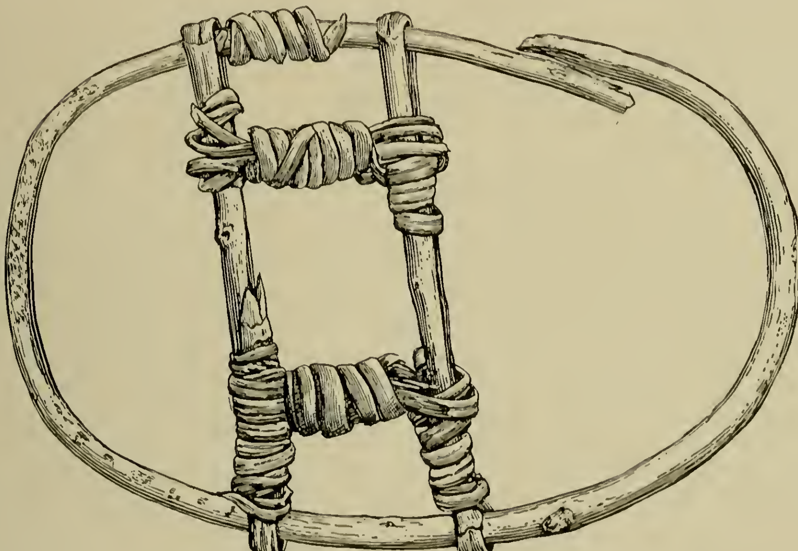


FIG. 118.—"Snow-shoe" from Oak-tree House, Mesa Verde National Park, Colorado.

Following the trail along the north side of the same canyon in which Oak-tree House is situated, the visitor comes to a remarkable ruin called Painted House, which, like Sun Temple on the cliff above, presents a ground plan and architectural features different from any yet described in cliff-dwellings. Like the Sun Temple it appears to have been built for religious ceremonies, but it is quite different in character. Painted House has a long room or court, possibly an open dance plaza or a covered ceremonial room, the north side of which is formed by the vertical cliff of the rear of the cave. At each end of this long room there are rooms with massive walls, that on the east being connected with the court by passageways, too wide for ordinary cliff-house doorways. The walls of one of the rooms of the western group are plastered, and decorated with a procession of animals and men painted in red. Two of the human figures, unfortunately mutilated within the last six years, suggest phallic beings still personated by the Hopi, a similarity which implies that the Mesa Verde cliff-dwellers had a cult like that of the

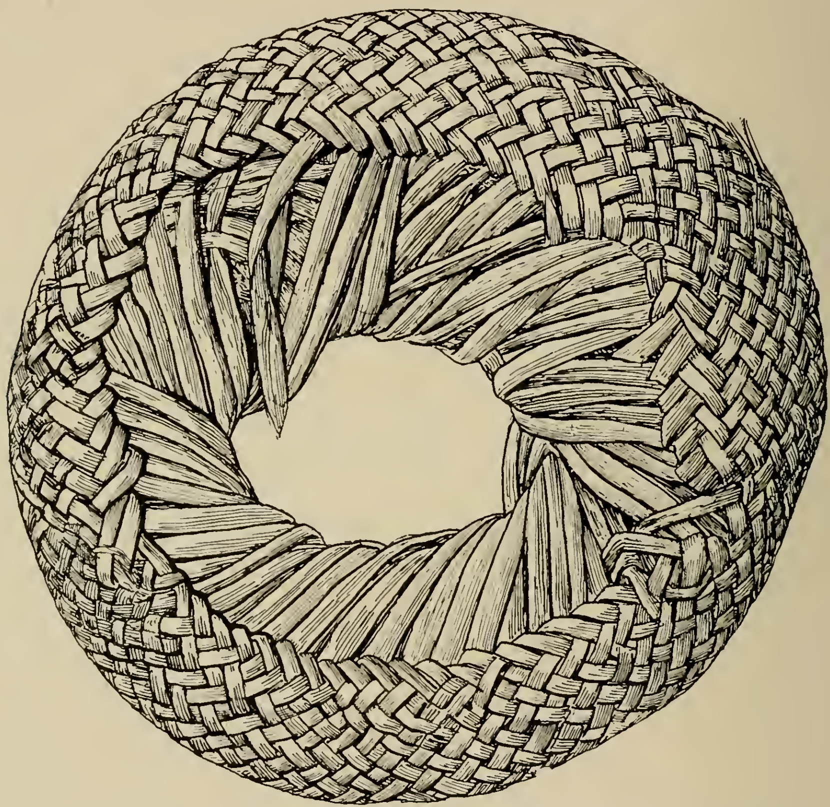


FIG. 119.—Head-rest from Oak-tree House, Mesa Verde National Park, Colorado.

Hopi, and as phallic rites and personages are pre-eminently associated by the latter with New-fire ceremonies, it may be that the cliff-dwellers of Painted House practised the same or similar rites.

The specialization of these two great buildings for ceremonial purposes and the evidences of the former existence of a considerable population nearby, seen in the size of Cliff Palace and other cliff-houses in the neighboring caves, impart peculiar interest to the study of the distribution of aboriginal culture characteristics of the Mesa Verde National Park.

Information has been brought from time to time to the attention of the Smithsonian Institution that there exists in the northern part of Texas a large ruin known as the Buried City of the Panhandle. The name suggests that this may be a community dwelling, and it has occurred to several students that this " city," if such exists, marks the eastern extension of the Pueblo area. In order to determine the truth of this report Dr. Fewkes visited northwestern Texas and examined certain Indian remains along Wolf Creek, a tributary of the Canadian

FIG. 120.—Sandstone dyke, often mistaken for an artificial wall. Rockwall, Texas.

River, said to be the location of the " city." Sites of aboriginal camping places, probably of nomadic Indians, were found in this locality, but no remains of walls or pottery suggestive of Pueblo occupancy. There are no signs of a " Buried City of the Panhandle " in the region visited.

Archeologists often have their attention called to sand dykes which are locally mistaken for artificial walls. The attention of Dr. Fewkes was directed to what appeared to be a prehistoric artificial wall situated in the suburbs of Rockwall, in Rockwall County, near Dallas, Texas. In order to determine its true character he visited this " wall " and found that it was not constructed by man, but belonged to those natural formations known to geologists as sand dykes. Its resemblance to an artificial wall is so close that for many years it was supposed to be the wall of a prehistoric dwelling (see fig. 120).

ETHNOLOGICAL RESEARCHES IN OREGON AND WASHINGTON

During the summer of 1915 Dr. Frachtenberg continued his investigations of the languages, traditions, history, and ethnology of the

Fig. 121.—Louis Kenoyer, the last of the Atfalati.

various tribes of Oregon and Washington. He began the year's work in the month of July with a trip to the Yakima Reservation, Washington, where, with the assistance of Louis Kenoyer, he revised the Atfalati (Kalapuya) manuscript material which had been collected by the late Dr. Gatschet in 1877. This material, comprising 421 manuscript pages, consisted of vocables, stems, grammatical forms, and ethnological and historical narratives, obtained in the Atfalati dialect. The revision of this material marked the completion of the work on the Calapooya (Kalapuya) languages which Dr. Frachtenberg began during the previous summer. It may not be out of place here to mention the fact that Louis Kenoyer is the last surviving member of the Atfalati (or Wapato Lake) tribe of the Kalapuya family.

During the latter part of August Dr. Frachtenberg attended the

FIG. 122.—Thomas Payne, the present nominal Chief of the Quileute.

first Indian Fair, which was held at Siletz, Oregon, by the various Indian tribes living at that agency. During this trip 52 Athapascan and Shastan songs were collected.

In the month of November Dr. Frachtenberg commenced his ethnological researches of the Chimakuan family. Up to the present writing a preliminary survey of the morphological and syntactic structure of the Quileute language had been made, and 30 native myths and tales were collected.

The Chimakuan family was originally composed of three distinct tribes living in the northwestern part of Washington. These tribes were the Chemakum, Quileute, and Hoh. The Chemakum tribe has disappeared entirely; while the Quileute and Hoh tribes are represented by approximately 350 individuals living at the Lapush Agency, in Clallam County, Washington.

FIG. 123.—A group of Quileute Indians, members of the Shaker Church.

A singular feature of the material life of these Indians, to which attention may be called here in passing, has been observed in the fact that in former days they were actually hunting whales in the ocean instead of eating the meat of whales that drifted ashore. As far as our knowledge goes, the Nootka of Vancouver Island are the only other Indian tribe that ever engaged in the actual hunting of whales in the ocean.

WORK AMONG THE FOX AND SAUK INDIANS

In June, 1915, Dr. Michelson left for the West to resume his work among the Fox Indians of Iowa. He remained at Tama till about the middle of August, where he devoted his time mainly to securing ritualistic origin myths. These myths, particularly those

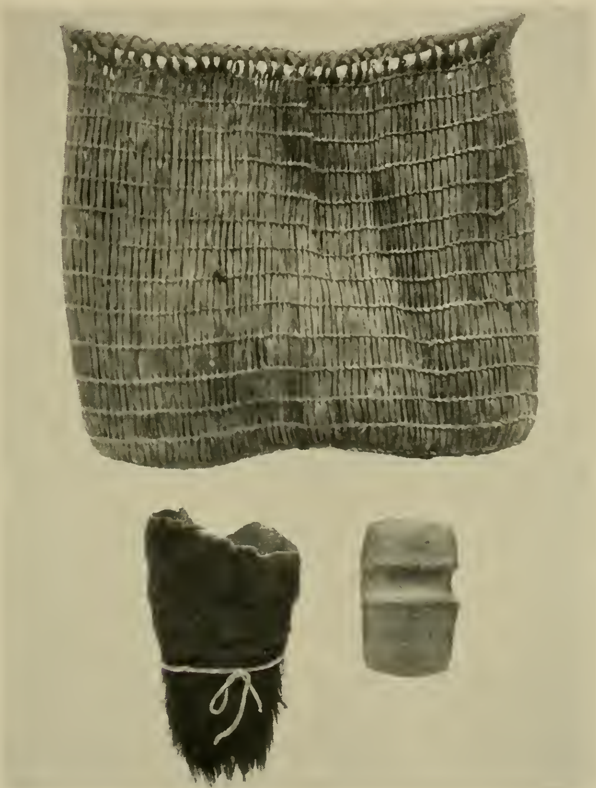


FIG. 124.—Stone ax and wrapping of bear hide, belonging to a sacred pack of the Fox Indians.

appertaining to clan ceremonies, are extremely valuable inasmuch as the existing ceremonies which the myths account for, cannot be witnessed in their entirety. It is clear that these myths were invented long ago to account for the existing ceremonies. In this way is obtained knowledge of one part of Fox ethnology which otherwise would be a blank.

In August Dr. Michelson left for Oklahoma to work among the Sauk and Fox of that state. Here he spent his time mainly in obtaining translations of the myths noted above, as the Fox informants, being extremely conservative, wrote out the myths in the

Fig. 125.—Chief of Fox Indians, Pushitoniqua (Old Eye).

current syllabary with the understanding that these would be translated elsewhere. At the same time the Sauk social organization and the Sauk systems of consanguinity received attention. It appears that the regulations regarding membership in the tribal dual are quite complex, and it will be some time before the matter can be cleared up. The work on the Sauk system of consanguinity shows that Morgan's Sauk and Fox schedules need revising. Dr. Michelson returned to Washington about November 1.

STUDIES AMONG THE CAYUGA INDIANS

Mr. J. N. B. Hewitt, ethnologist, with the efficient aid of Mrs. Mary Gibson, widow of the late Chief John Arthur Gibson, completed the long text in Cayuga of the O'ki'we, being the history and the ritual of the Feast of the Dead which is in charge of the women of the tribe. With the same assistance Mr. Hewitt also finished work on a selected list of Mohawk verbs by supplying each with a Cayuga synonym. Then with the aid of Mr. Richard Hill he was able to correct and elucidate certain moot points in the Mohawk and other texts of the Ritual of the Mourning and Installation Council, and especially to confirm a conjecture as to the reconstruction of a portion of a ritual which had been quite lost and forgotten, namely, the dramatization of the so-called Six Songs, in which these songs are sung by a chief impersonating the dead chief.

STUDY OF INDIAN MUSIC

The study of Indian music was continued by Miss Frances Densmore during the season of 1915. The first reservation visited was that of Fort Berthold, North Dakota, where she resumed, under the auspices of the Bureau of American Ethnology, a study of music of the Mandan and Hidatsa, commenced in 1912 under the auspices of the State Historical Society of North Dakota. A competent interpreter for each language was secured, and the work was conducted along more intensive lines than during the previous visit.

One of the principal subjects investigated was the custom of eagle-catching, which is common to both tribes and which, though scarcely to be called ceremonial, is closely associated with their beliefs in the power of the supernatural. The Mandan tradition of the origin of this custom, together with the songs connected with its fetish (the wolverene), was obtained from the only man living who inherited them. It is understood that no other person has the right to sing these songs, and the ownership of songs is held inviolate on this reservation. Miss Densmore visited an eagle trap which is said to have been in disuse for about 70 years. Upright in the ground beside it was a bone that had been used to hold bait for the eagles. This bone was identified as one of the upright vertebræ of a buffalo, and on it could be discerned traces of red paint.

The legend of the origin of the flute was also obtained by Miss Densmore, and its melody recorded phonographically. The Society of the Creek Women among the Mandan was also studied, and its

FIG. 126.—Hidatsa whistle played by owner.

FIG. 127.—Old Mandan earth lodge.

songs were recorded by a member of the society. Other distinctively Mandan songs are those connected with the spring-time custom of "purifying the corn," several songs of the last corn priest being recorded by his daughter. Mandan songs sung by women in their gardens were obtained from two aged women of the tribe, most of them being plaintive songs concerning absent or slain warriors.

FIG. 128.—Modified form of Mandan earth lodge.

FIG. 129.—Entrance to old Mandan earth lodge.

The Hidatsa material, in addition to that pertaining to the custom of eagle-catching, chiefly concerns war and the various societies, many songs of these classes being recorded. The songs of the Mandan and Hidatsa, on being transcribed, are found to be of a simpler type than those of the Chippewa and Sioux which have been analyzed.

Specimens of the musical instruments collected among both tribes include a drum, the rattles used by certain societies, and a whistle resembling a flageolet but without finger holes, on which a wide range of tones can be played (fig. 126). Specimens illustrating the material culture of the tribes were collected, and photographs illustrating their dwellings and daily occupations were made (figs. 127-130).

A new phase of Miss Densmore's investigations consisted in the making of pitch-discrimination tests. This was done by means of

FIG. 130.—Mandan woman tanning a hide at entrance of earth lodge.

a set of 11 tuning forks, the fundamental fork having a pitch of 435 vibrations (*a* above middle *c*, international pitch), and the remaining forks being tuned respectively, ½, 1, 2, 3, 5, 8, 12, 17, 23, and 30 vibrations higher. These tests were made on both Mandan and Hidatsa Indians and the results recorded.

After leaving the Fort Berthold Reservation Miss Densmore visited the Standing Rock Reservation in North Dakota and the White Earth Reservation in Minnesota for the purpose of making similar tests among the Sioux and the Chippewa. The results of these tests show that some Indians have a pitch discrimination of three vibrations, or one-eighteenth of a tone, while others can discern only an interval of five vibrations, or one-eleventh of a tone. The method used in these tests is that of Prof. C. E. Seashore, of the State University of Iowa, who kindly examined the record of the tests and expressed the opinion that the abilities shown by these Indians are about as good as would be found among average American whites under similar conditions.

OSAGE WAR RITES[1]

In the month of March, 1915, additional information was secured by Mr. Francis LaFlesche, ethnologist, from Xu-thá Wa-*t*oⁿ-iⁿ, concerning the *T*se-dó-ga Iⁿ-dse gens version of the great Osage war rites. This information consisted mostly of certain parts of the rites arranged in metrical form for the purpose of reciting at the ceremonies. This arrangement is called wi′-gi-e, or a recitation. The wi′-gi-e are as follows:

1. Wi′gi-e *T*oⁿ-ga has 584 lines and covers 20 typewritten pages without the translations. The wi′-gi-e tells of the coming of the people of the *T*si′-zhu from the sky to the earth and of the origin of the various symbolic articles used in the ceremonies of the war rites, as well as of the gentile symbols from which personal names are adopted.

2. Wa-zhó-i-ga-tha Wi′-gi-e has 406 lines and covers 15 typewritten pages without the translations. This wi′-gi-e deals with the various heavenly bodies that the people of the *T*si′-zhu of the Seven Fireplaces adopted for their gentile symbols. These heavenly bodies are:

1. Mi, the Sun. 2. Mi′-oⁿ-ba, the Moon. 3. Mi-*ká*-*k*'e Hoⁿ-ba doⁿ, the Morning Star. 4. Mi-*ká*-*k*'e Hoⁿdoⁿ, the Evening Star. 5. Wá-ba-ha, travois, Ursa Major. 6. Mi-*ká*-*k*'e U-*k*i-tha-ç'iⁿ, the Double Star. 7. Ta-*p*á, Deer's Head, Pleiades. 8. *T*a Thá-bthiⁿ, the Three Deer. 9. Mi-*ká*-*k*'e Zhu-dse (Red Star), the North Star. 10. Shoⁿ′-ge A′-ga-*k*'e e-goⁿ, Dog at the Side, Canis Major.

3. *K*i′-noⁿ Wi′-gi-e has 63 lines and covers two typewritten pages without translations. It relates to the symbolic painting of the members of the *T*si′-zhu of the Seven Fire-places when about to go to the ceremony of the Ni′-*k*i-e degree of the war rites. It refers back to the time when the rites were being formulated. The people asked of one another what they should use for symbolic painting. Then they gathered four stones upon which they put a great pile of dry wood. This they set on fire and the flames that leaped upward

[1] The italic letters in the Indian names indicate peculiarities of pronunciation which it is unnecessary to explain in this brief account.

cast a reddish light upon the darkened sky and upon the people themselves. This reddish light they adopted for their symbolic color and for the color of the symbolic shields which they wear on their breasts when they go to war. They also made it to represent the sun which was their gentile symbol of life.

Besides these wi′-gi-es Xu-thá Wa-*to*ⁿ-iⁿ gave the ritual of the Ni′*k*i-e degree of his gens, which has four wi′-gi-e and five songs.

In the month of September, 1915, at Mr. LaFlesche's invitation, Xu-thá Wa-*to*ⁿ-iⁿ visited him on the Omaha Reservation, at which time he gave the wi′-gi-e and songs recited and sung by the *T*se-dó-ga Iⁿ-dse gens at the Wa-shá-be A-thiⁿ, war ceremonies, together with a detailed description of the ceremonial forms. A description of the Wa-shá-be A-thiⁿ was secured from Wa-xthi′-zhi of the Iⁿ-gthoⁿ′-ga gens, but ceremonial etiquette restrained him from giving the parts that belonged to the *T*se-dó-ga Iⁿ-dse gens. The wi′-gi-e given by Xu-thá Wa-*to*ⁿ-iⁿ are as follow:

1. Wi′-gi-e of the Sacred Fire, 77 lines.
2. Wi′-gi-e relating to certain symbolic articles made by the gens, 400 lines.
3. Wi′-gi-e of the Sun and the Moon, 17 lines.
4. Wi′-gi-e of the Sacred War-club and the Buffalo Bull, 26 lines.
5. Wi′-gi-e of the Elk, Puma, Bee, Black Ant, etc., 58 lines.
6. Wi′-gi-e relating to the Cleaning of the Sacred Pipe, 47 lines.

Following are the songs given by Xu-thá Wa-*to*ⁿ-iⁿ:

1. Hiⁿ′-noⁿ-xpe Ga-xe Wa-thoⁿ, Song 1, four stanzas; Song 2, four stanzas; Song 3, one stanza; Song 4, three stanzas; Song 5, four stanzas; Song 6, six stanzas.
2. Wa-*ts*′é-the Wa-thoⁿ, Song 1, eight stanzas.
3. Wa-*ts*é Wa-thoⁿ *T*oⁿ-ga, Song 1, five stanzas; Song 2, four stanzas.
4. *T*si-ú-thu-gi-*p*e Wa-thoⁿ, Song 1, twelve stanzas.

The wi′-gi-e and songs that have been recently secured from Xu-thá Wa-*to*ⁿ-iⁿ, with explanatory notes, have not yet been put together and typewritten. On account of other work in process, pertaining to the Osage rites, it will be some time before these can be taken up.

While presenting this report, word has been received that Xu-thá Wa-*to*ⁿ-iⁿ died in December, 1915. (See portrait, fig. 131.) A member of the Tse-dó-ga Iⁿ-dse gens informed Mr. La Flesche that the portion of the tribal rites committed to his gens had died with Xu-thá Wa-*to*ⁿ-iⁿ. This would have been true but for the fortunate circumstance that last September all that the old man knew of the rites belonging to his gens was secured. This material, together with a paraphrase of one of the wi'-gi-e obtained from *Pá*-thi^n-wa-we-xta in 1912, makes possible a fair presentation of the rite.

Fig. 131.—Portrait of Xu-thá Wa-to^n-i^n, an Osage.

ETHNOLOGICAL WORK AMONG THE NATCHEZ, CREEK, AND CHICKASAW INDIANS

Dr. John R. Swanton was in the field for about two months during 1915, from toward the end of September until well after the middle of November. The first two weeks and the last week were devoted to work among the few remaining Natchez Indians and the recording

FIG. 132.—Watt Sam, one of the three surviving speakers of the Natchez language, and his home.

FIG. 133.—Hilibi square ground and ball post, near Hanna, Oklahoma.

of texts and other linguistic material from one of the three Indians still able to speak the Natchez language. One hundred and thirteen pages of text with interlinear translations were secured.

About three weeks were spent among the Creek Indians, recording myths and obtaining additional ethnological information. About 80 pages of myths were obtained in English, and in addition 33 pages of native text from a young Creek Indian able to write in his own language.

During the remainder of the time Dr. Swanton made a preliminary visit to the Chickasaw in order to learn how much of their ethnology can be recovered. Not much time was spent in any one place, but a

FIG. 134.—"Stomp ground" in the Cherokee country, Oklahoma. There are seven seats, one for each of the seven Cherokee clans. The Natchez Indians living among the Cherokee have a similar ground.

considerable list of Chickasaw clans was secured and some additional notes were obtained regarding various matters connected with the ancient culture of the tribe.

WORK AMONG THE INDIANS OF CALIFORNIA AND ARIZONA

Mr. John P. Harrington became a member of the staff of the Bureau of American Ethnology February 20, 1915, and devoted the rest of the year to the study of the Chumashan and Yuman Indians of California and Arizona, establishing headquarters for the convenience of his field studies at the Southwest Museum in Los Angeles and at the Panama-California Exposition in San Diego, where he was granted facilities by the courtesy of these institutions. Results of researches conducted by him before entering the service of the Bureau have been elaborated and necessary additional material has been obtained.

On May 29 Mr. Harrington went to Santa Inés mission where he found among the old records preserved at the mission a manuscript bearing the title, "Padron que contiene todos las Neofitas de esta Mision de la Purisima Concepcion con expresion de su edad, y partida de Bautismo segun se halla hoy dia 1° de Enero de 1814," by Father Mariano Payeras. This document, which appears to have been unknown to historians, is of the greatest value for the study

FIG. 135.—A Yuma fiesta.

of the Indians of La Purisima and Santa Inés. A copy of it was made for the Bureau and a large amount of other material was extracted from the archives of the mission. While at Santa Inés Mr. Harrington succeeded in locating the sites of some of the former rancherias mentioned in the records of the mission.

On June 19, Mr. Harrington proceeded to Arroyo Grande, where he worked for a week with a poor, sick old woman, the sole survivor of the San Luis Obispo Indians. The importance of the immediate rescuing of her language and the other information which she can furnish can hardly be overestimated.

The latter part of July and the month of August were spent in San Diego working with a Chumashan informant. The period from September 1 to December 31 was spent at San Diego and Los Angeles in the elaboration of the San Luis Obispo and other material.

Interesting results of the work are the finding of the existence of totemic clans among the Indians of the Chumashan stock and the determination of the genetic relationship of Chumashan and Yuman.

EXPERIMENTAL FLIGHTS WITH THE ORIGINAL LANGLEY AERODROME

The trial flights with the original Langley aerodrome (built 1898-1903), which were begun in May, 1914, under the direction of Mr. Glenn Curtiss, to determine whether the machine was fundamentally

FIG. 136.—Langley machine in launching condition on skates on Lake Keuka, March 9, 1915.

correct in design and construction, were continued in 1915 at Lake Keuka, New York.

Toward the end of February, 1915, the machine was mounted on three elastic skates preparatory to launching it from the ice on Lake Keuka, with its original motor and as nearly as possible in its original condition. When thus assembled for flight it weighed without pilot 955 pounds, including five gallons of gasoline and the necessary oil and water. The aeroplane frame and wings were on March 2 taken on a tug boat 12 miles down Lake Keuka to where the ice was thick, and placed upon the ice under the brow of a wooded hill whose shelter made it easier to wing and unwing the machine in the wind.

FIG. 137.—Langley machine ascending from the ice on Lake Keuka in March, 1915.

FIG. 138.—Langley machine in flight over Lake Keuka, May 20, 1915.

Short flights were made from the ice. On March 10, after a stationary propeller test on the ice showing a thrust of less than 300 pounds, the aeroplane was headed down the lake against a wind of

FIG. 139.—The Column of Progress at the Panama-Pacific Exposition, 1915. Photograph by Walcott.

six miles per hour for a trial flight. She ran over the lake at fair speed with but four cylinders working. The poise on the ice was steady. After a short run the rear skate arose clear of the ice; then the front skates of the machine were sustained in the air for some 75 feet, as shown by the measured breaks in the traces on the ice. The machine then landed gently on the ice owing to the falling off of the motive power.

In May and June several short test flights were made over the waters of Lake Keuka as shown in figure 138.

Fig. 140.—Nearer view of the Column of Progress at the Panama-Pacific Exposition, 1915. Dedicated to aviation; Langley tablet on west side. Photograph by Butman.

The accompanying photographs, figures 139 and 140, show the Langley Tablet on the Column of Progress, dedicated to aviation at the Panama-Pacific Exposition, 1915.

FOG CLEARING INVESTIGATIONS

With the aid of a grant from the Smithsonian Institution, a committee of electrical engineering experts under the general direction of Mr. F. G. Cottrell continued during 1915 the investigations begun by the University of California in cooperation with the United States Lighthouse Service, relative to the clearing of fog by means of electrical precipitation. In a preliminary report read at the first meeting of the committee, Prof. Ryan of Stanford University, says, "Science has established the fact that all dust and fog particles in the open atmosphere are electrified and subject to dispersion or precipitation. It is apparent, therefore, that a source of very high direct voltage with facilities for control and application may be of inestimable value in certain quarters and seasons for clearing fog away from a street, from along a passenger railway, from around the landing stages of a ferry, or possibly about or in advance of a ship under headway at sea."

The clearing of fog differs from the treatment of smoke and fumes in several respects, principally in that the smoke particles must plainly be actually deposited on the electrodes to bring about the desired effect, whereas in treating fog, it is only necessary to cause coalescence of the minute particles into larger ones to give much greater transparency, even disregarding the more rapid settling of the larger drops. However, other difficulties are to be expected in the problem of clearing fog, such as the conditions arising from the continual immersion in the wet atmosphere. What is chiefly needed for an intelligent conception of the problem is actual first-hand experience in handling these and other unusual conditions.

A great deal has been learned during the year about the electrical technique of the problem, and although days of suitable fog conditions have been extremely scarce, on the rare occasions of actual trial, very perceptible clearing for a short distance around the high tension wires was obtained as the fog swept past.

STUDIES IN SOLAR RADIATION

The Mount Wilson Station of the Astrophysical Observatory was occupied by Messrs. Abbot and Aldrich from May to October, 1915, and numerous measurements of solar radiation were made there. During June unusually many days were marred for these observations by cirrus clouds, but the later months were uncommonly fine. In October almost every day proved suitable for the work.

As in former years a principal object of these investigations was to detect and measure changes in the amount of solar heat. Results of the now fully reduced work of 1913 and 1914 show that in 1913 (a time of extremely low solar activity as indicated by the numbers of sun-spots, faculæ, etc.), the sun's output of radiation was nearly

FIG. 141.—Observing station of Astrophysical Observatory on Mount Wilson with new tower telescope. Photograph by Abbot.

three per cent below normal, and that with the return of activity in 1914, the output of radiation rose to about one per cent above normal. The work of 1915, not yet fully reduced, seems to indicate that high values will be found to prevail in this year also.

Fluctuations of solar radiation from day to day, while noted, appear to have been less marked in 1914 than in earlier years.

The need is very urgent that other observing stations in remote regions of the earth take up the daily measurement of solar radiation in cooperation with the Astrophysical Observatory. Preferably not less than four stations in relatively cloudless regions, widely separated, should be engaged in this work. The variation of the sun is established. Its influence on terrestrial climate and conditions of growth of vegetation cannot be well determined unless the results of the Astrophysical Observatory are verified and supplemented by prolonged routine observing at several cooperating stations.

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The Ordáz and Dortal Expeditions in Search of El-Dorado, as Described on Sixteenth Century Maps

(With Two Maps)

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THE ORDÁZ AND DORTAL EXPEDITIONS IN SEARCH OF EL-DORADO, AS DESCRIBED ON SIXTEENTH CENTURY MAPS

By RUDOLF SCHULLER

(With Two Maps)

I. OVIEDO'S HUYAPARI MAP

In the second volume of Oviedo's "Historia Géneral y Natural de las Indias," [1] there is a facsimile of a small map illustrating several early explorations of the Orinoco or Huyapari [2] River (see fig. 1).

This map is Oviedo's own work,[3] and is plainly drawn but bears no date. It contains, however, various historical and descriptive legends, which enable us to establish the year when it must have been made.

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[1] Madrid: Imprenta de la Real Academia de la Historia. 1852.

[2] No doubt the names Orinoco and Huyapari, or Juyapari and Oya-pari, are of Indian origin; cf. Oviedo, II, lib. XXIV, cap. III, p. 216[a]. Orin-oco plainly contains the Betóya word "oco" ("water," "river"). Humboldt says it is a Tamanaco word; cf., for example, Oyap-oc(o), Sinar-uco (oco), Guarico, Orit-uco, Tin-oco, Guarit-oco, Urit-uco, and many other similar names of rivers in the great Orinoco basin.

[3] Loc. cit., cap. XV, p. 265[b], "Porque la pintura califica mucho y dexa mejor entender las cosas de la geographia, juntamente con la verdadera relaçion dellas, *quise poner aqui la figura* del rio de Huyapari, y los rios que en él entran." "Because a drawing enables us to understand more clearly the geography of a region I have here inserted a map."

This was written at the close of the year 1541, or, perhaps, in 1542; cf. loc. cit., cap. XVI; and cap. XV, where Oviedo states explicitly: "The governor Dortal himself told me . . . ." [and a few lines below] "where six years ago this governor had ordered his lieutenant, Alonso de Herrera, with 200 men . . . . to sail up the river Huyapari."

See also, "Historia coro-graphica, natural y evangelica de la Nueva Andalucia, provincias de Cumaná, Guayana y Vertientes del Rio Orinoco; dedicada al Rei N. S. D. Carlos III." Por el M. R. P. fr. Antonio Caulin dos vezes Provincial de los observantes de Granada, etc., Madrid, 1779, p. 150[b].

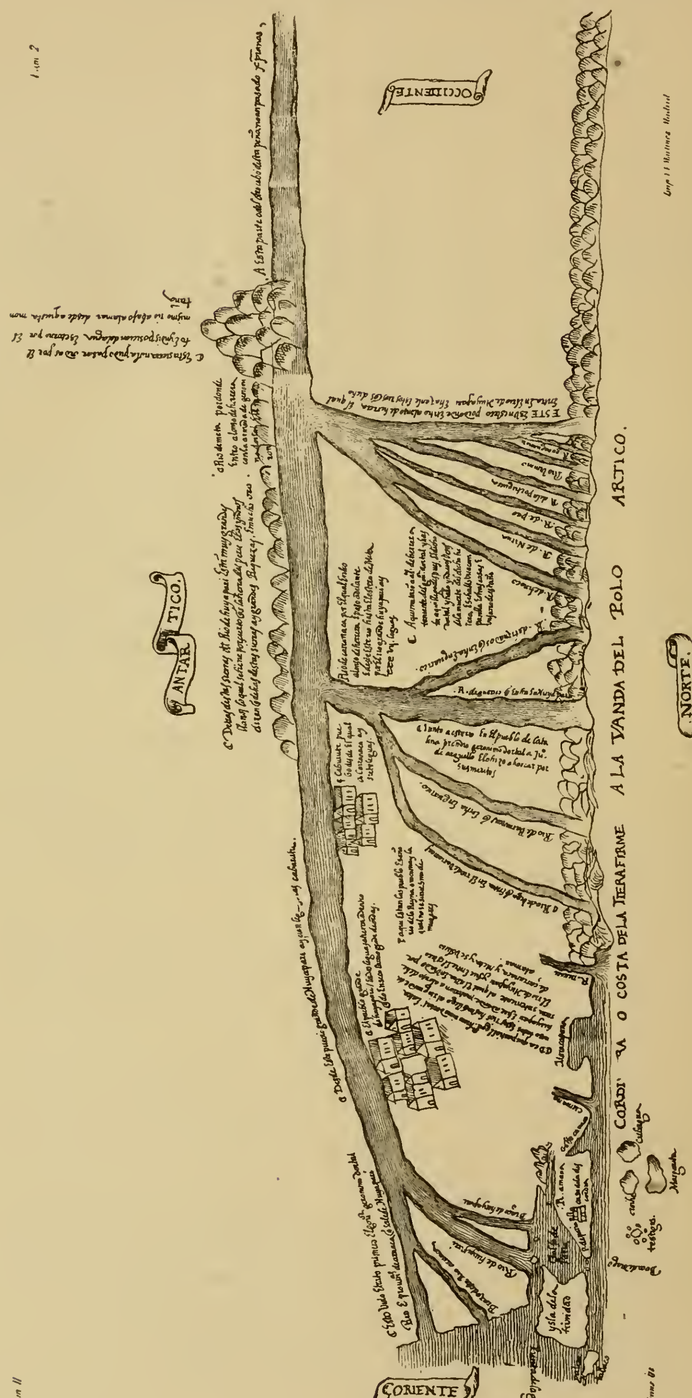
OCCIDENTE
ANTARTICO
NORTE
ORIENTE
O COSTA DELA TIERAFIRME A LA VANDA DEL POLO ARTICO

FIG. 1

Two of these inscriptions refer to the exploring expedition of the famous conqueror Diego de Ordáz[1] which set out from Paria on June 23, 1532. With 280 men, 18 horses, and one mule he arrived at the Indian village of Huyapari.[2]

The first legend, on the right of the Indian village depicted on the map, runs thus: "El pueblo grande de huyapari E a dos leguas a tierra adentro q(ue) do En seco la canoa gra(n)de de ordas" ("The large village of Huyapari is situated two leagues inland from the Orinoco River"—to which Oviedo added mention of the accident to Ordáz's large canoe after his return from the expedition in search of the Meta-El Dorado[3]—"Ordáz's large canoe remained [here] on dry [land]").

The second legend, above the mountains in the upper right-hand part of the map, reads: "Esta sierra no la pudo pasar ordas por El foE yndisposicion del agua E se torno por El mismó rio abajo a la mar desde aquesta montaña." ("Ordáz could not pass this chain of mountains[4] [by the river, on account of] the bad condition of the water[5] and from this mountain he returned down the same river to the sea.")

And, to the west of the mountains on the map, we read: "A Esta parte o del otro cabo desta peña no an pasado xpianos" ("To this side, or the other end of this rock, Christians had not [yet] come").

These two inscriptions unquestionably refer to the disastrous expedition up the River Orinoco to the "rapids," near the mouth of the Meta, undertaken by Ordáz in the second half of the year 1532, and this evidently led Harrisse[6] to believe that the map was

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[1] Native of Castro Verde in the Kingdom of León. Herrera: Historia General, etc., Madrid, 1601, Dec. IV, libro X, cap. IX, p. 275. We see him as early as 1515 in Cuba; cf. "Probanza hecha á petición del almirante D. Diego Colón," etc. Villa de San Salvador, Febrero 16, 1515; in "Colecc. Docs. Inéditos" ["De los Pleitos de Colón," II], 2d serie, T. núm. 8. Madrid, 1894, pp. 61-87.

Herrera: Dec. II, libro VI, cap. XVIII, ". . . . i que Diego de Ordás reconociò el Bolcàn de Tlascala [Popocatepetl], cosa para los Indios mui admirable" (edit. of 1726) (". . . . and that Diego de Ordás explored the Tlascala volcano, a feat greatly admired by the Indians").

[2] Properly termed Aruacay, according to Oviedo, loc. cit.

[3] Oviedo, loc. cit., pp. 217-218; especially p. 218^b.

[4] It means that they could not overcome the powerful and rapid currents produced by the narrowing of the river-bed between the mountains.

[5] The low level during July and August.

[6] "Cartographia Vetustissima," No. 200 (sic), instead of 202; in "Discovery of North America," etc., London, 1892, pp. 588-589.

made in that same year. But it can easily be shown that this date is irreconcilable with all known historical events.

Above all, I would observe that the author of the sketch-map could not have learned all those details of Ordáz's eventful exploring expedition before early in the spring of 1533, as it was not until that time that Oviedo met at Santo Domingo Gerónimo Dortal, the treasurer, and several other members of the Ordáz expedition, from whom, according to his own statement,[1] he obtained information concerning the vain attempt to reach the Meta-El Dorado. Therefore, even if the map bore no further indication as to the time when it was made by Oviedo, the only acceptable date, from this fact alone, would be the year 1533.[2]

Fortunately, however, there are other legends on the map relating to several expeditions up the River Orinoco after the ill-fated voyage by Ordáz, which prove that Oviedo's map must have been made ten or twelve years after the date suggested by Harrisse, the foremost authority on American cartography.

Students of early American history cannot help wondering how it was possible that Harrisse took no notice at all of the inscriptions connected with the expeditions of Alonso de Herrera and Governor[3] Gerónimo Dortal, the former treasurer of Ordáz's enterprise.

After the unsuccessful attempt to discover the long sought Meta-El Dorado by sailing up the Orinoco, Ordáz was compelled to leave the village of Huyapari for Cariaco, where he established a small fort,[4] which he named Sant Miguel de Paria. Thence he went to Cumaná, a province on the mainland opposite the pearl island, or "Cubagua," where he expected to meet Herrera, his lieutenant, with the rest of the expedition. Finally Ordáz and Dortal reached the town of Nueva Caliz in Cubagua, where they found Alonso de

[1] Loc. cit., cap. IV, p. 224[b], "Despues vino á esta cibdad de S. Domingo el thesorero Hieronimo Dortal, del qual y de otros que en todo lo que es dicho se hallaron *fui informado* . . . ." ("Afterwards came to this city of Santo Domingo the treasurer Herónimo Dortal, by whom, and by others who were present at all that is said, I was informed . . . .").

[2] This assertion is corroborated also by the following statement: ". . . . cansados [companions of Ordáz] de sus trabaxos se passaron con los otros de Cubagua, porque avia dos años que padesçian desde que salieron de España . . . ." (". . . . Tired of these troubles, they went with these others of Cubagua, because two years of suffering had passed since they left Spain . . . ."). Loc. cit.

Ordáz set sail from San Lucar de Barrameda on October 20, 1531; loc. cit., cap. II, p. 212[a].

[3] Only after 1533.

[4] Perhaps on September 28, 1532.

Herrera imprisoned by order of Governor Antonio Sedeño. The same fate met Dortal, and Ordáz, weak in health, weary and powerless, sailed in May, 1533, for Santo Domingo and thence to Spain, where he intended to protest at court against Sedeño's illegal interference with the projected settlement on the coast of Cumaná, which Sedeño arbitrarily claimed was within his jurisdiction. Ordáz died during the voyage across the ocean.[1]

Gerónimo Dortal, after being released from prison, addressed a letter to the Emperor, "giving him an account of his services rendered in the government of Cubagua and asking him for mercy."[2]

Early in the summer of 1533 Dortal was in the town of Santo Domingo, where he met Oviedo; and in the following autumn he was in Spain "asking for the same position formerly held by Ordáz."[3] That he was most successful in his "claim," is proved by the letters patent entered into between him and the Crown, on October 25, 1533.[4] By virtue of this land-grant, or "capitulación," he was appointed governor of Paria. Early in 1534 he organized the new expedition, and on August 18, 1534,[5] set sail from San Lucar de Barrameda. In the autumn of the same year he was again in Paria.

Alonso de Herrera, after his release from prison by order of the royal Audiencia of Santo Domingo, was in charge of the fort of San Miguel of Paria, and immediately recognized Dortal as governor and superior, notwithstanding his solemn pledge of faith to Antonio Sedeño.[6]

Shortly after his arrival, Dortal equipped a new expedition for the purpose of searching for the famous Meta-El Dorado, under the

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[1] Oviedo, cap. IV, p. 224ª—Herrera, Dec. V, libro I, cap. XI, p. 24 (ed. of 1728), ". . . . and other people said he died in Castile . . . ."

[2] Dated from the pearl island (Cubagua), January 28, 1533; in "Colecc. Docs. Inéditos," Tomo XII. Madrid, 1869, pp. 46-48.

A further proof that Oviedo could not have learned before February, 1533, what happened to the expedition.

[3] Oviedo, loc. cit.

[4] Archivo General de Indias, 139-1-2, Tomo III°, ff. 59-61 r.

[5] Oviedo, at that time also in Spain, met him again in Seville, cf. loc. cit., cap. VII, p. 236ª, " . . . . yba por procurador desta nuestra cibdad de Sancto Domingo y desta Isla Española . . . ." ("I have been there as procurator of this our city of Santo Domingo and of this island of Hispaniola").

[6] ". . . . con quien quedó conçertado en Cubagua, ... porque le prometió de la hazer alcayde de la fortaleça que avia de haçer en la isla de la Trinidad . . . ." (". . . . with him he had made arrangements . . . . because he promised to appoint him alcaide of the fort which he intended to establish on the island of Trinidad"). Oviedo, loc. cit., p. 232ª.

command of the intrepid but unscrupulous Alonso de Herrera. The itinerary of Herrera's ill-fated voyage is described on Oviedo's map as follows:

"Este Ès vn estero por donde entro alonso de herrera El qual Entra En Elrio de Huyapari È hazenle Èstos rios q(ue)s dicho." ("This is a swamp where Alonso de Herrera entered and which empties into the River Huyapari; it is formed by the aforesaid rivers.")[1]

Further, in the angle formed by the Huyapari and Carranaca rivers, we read: "Rio de carranaca por El qual Èntro alonso de herrera[2] È passo adelante È deste(!) Èste rio hasta Èl estero de Meta por Èl grande huyapari ay XXXVII leguas" ("River Carranaca where Alonso de Herrera entered and went farther on and from this river to the Meta swamps, up the great river Huyapari, it is 37 leagues").[3]

Facing the mouth of the swamp there is the following legend: "Rio de meta por donde Èntro alonso de herrera con la armada de geroni (*sic*) no(!) dortal È le mata ron" ("River Meta, where Alonso de Herrera entered with the fleet of Gerónimo Dortal; and they killed him").[4]

Finally, the last legend to be considered in connection with this disastrous exploring expedition appears at the left of the Tinoco River on the map. The legend reads: "Aqui mataro[n] a al° de herrera[5] teniente del gou[or] dortal y has ta aqui llego despues Èl dicho dortal y hallo yndicios veros de la muerte del dicho he rera È se hallo

[1] The affluents are as follows: "R. de tinoco, R. de Nirua, R. de pao, R. dela portuguesa, Rio viminio, R. guuaguanari.

[2] The elegia IX, canto I, of Juan de Castellanos' "Elegias de varones ilustres de Indias," does not at all refer to Herrera's expedition in 1535, as is erroneously asserted by the untrustworthy Chilean writer José Toribio Medina, "Notas" to "El Descubrimiento del río de las Amazonas," pp. 273-274.

[3] Oviedo, II, cap. IX, p. 245[a], 'from the Gulf of Paria to the village of Caburutu, 150 leagues; from San Miguel de Neveri, a small town founded by Dortal in 1536, on the coast of Maracapana, to the said village, 40 leagues; and from San Miguel to the mouth of the river Huyapari, 120 leagues of sea-coast."

[4] Loc. cit., libro XXIV, cap. VII, p. 240[a].

Medina, l. c., settles the matter in a very summary manner, saying flatly: "Verificada en 1535, fue dirigida á las regiones que se extienden al norte del Amazonas" (sic!!) ("Organized in 1535, [the expedition] was directed to the regions situated to the north of the Amazon River").

[5] He was wounded with a poisoned arrow, cf. loc. cit., and see p. 247[a], where is given a detailed account of the preparation of urari, or curari, by the Carib Indians.

vna cam panilla E otras cosas E vn jarro de estaño" ("Here they killed Alonso de Herrera, lieutenant of Governor Dortal; and to this place came afterwards the said Dortal and found true marks of the death of the aforesaid Herrera; and there were found among other things, a little bell and a tin cup").[1]

This legend, of course, refers, as will be shown later, to two chronologically distinct expeditions into the interior of the country.

In 1536, about a year after Herrera's death, Governor Dortal organized a second exploring expedition,[2] in the course of which he discovered the domain of the female cacique Orocomay, an independent community of Indian women, similar to those described by Father Gaspar de Carvaxal in the narrative of the discovery of the River Amazonas by Francisco de Orellana in 1542.[3]

This social phenomenon, not always correctly interpreted by writers,[4] has not yet been observed in South America, but in the "Kulturkreis" of the Carib-aruáque.

The domain of Queen Orocomay is located on Oviedo's map between the Huyapari and the Barrancas, an affluent of the Carranaca River, and is given the following legend: "P[or] aqui Estan los pueblo[s] E señorio de la Reyna (!) orocomay la qual no se sirue[5] sino de mugeres" ("Here are the villages and domain of Queen Orocomay, who employs only females").[6]

During this voyage Dortal had to contend with a mutiny led by Alderete and Aguilar, two of his officers; and he was finally compelled to return to the coast, where a new danger threatened him.[7]

[1] Oviedo, loc. cit.

[2] "Y segund el mismo Hierónimo Dortal me dixo . . . ." (". . . . and according to what I was told by H. Dortal himself . . . ."), loc. cit.; cap. X, p. 247[a].

[3] "Descubrimiento del Río de las Amazonas, según la relación hasta ahora inédita," etc., de Fray Gaspar de Carbajal. Sevilla, MDCCCXCIV, pp. 66-67.

[4] "Zur südamerikanischen Amazonensage." Von Dr. R. Lasch; in "Mitteil. der K. u. K. Geogr. Gesellsch. in Wien." 190, pp. 278-289. Dr. G. Friederici "Die Amazonen Amerikas." Leipzig, 1910.

[5] The verb has in this combination a double meaning.

[6] Oviedo, II, libro XXIV, cap. X, p. 247[b].

[7] El mismo ano [15]36, venido Ortal á quejarse de los suyos que se le alzaron, é de 170 leguas tierra adentro le mandaron con los oficiales Reales á la costa de la mar . . . ." ("The same year, 1536, Ortal came to complain about his men who had revolted against him and obliged him, together with the Royal officers, to return 170 leagues from inland to the coast"); cf. "A la Sacra Real Magestad del Emperador nuestro Señor, los oidores de su Real Audiencia de Santo Domingo á 31 de Diciembre de 1538," in "Colección de Docs. Inéditos." Tomo I. Madrid, 1864, p. 553.

Antonio Sedeño, as we have already seen, hostile ever since the time of Ordáz to any attempt at colonizing on the opposite shores of the mainland, had unexpectedly landed on the coast of Maracapana, with the unmistakable intention of seizing Dortal, his hated rival. Dortal, however, having been informed in time, by some friends, of Sedeño's presence at the town of San Miguel, fled to Cubagua; and shortly after to Santo Domingo, where he notified the "Audiencia" of the armed invasion of that peaceful colony. The Royal Court ordered him, accompanied by Johan de Frias, "juez de comision," to return to his settlement, November, 1536.[1]

Sedeño died in the meantime near the River Tiznados.[2]

At the beginning of the year 1540, Dortal led his second reconnoitering expedition into the interior of Venezuela.[3]

The two legends relating to his last expedition are as follows: "De aqui partio El gou^or^ hieronimo dortal E atra ueso todos Estos rios hasta q[ue] llego al rio grande de huyapari E fue adonde mataron a alonso de herrera su teniente al qual El avia Enviado por El rio de Huyapari y fue Entre El estero de çarranaca y Meta y se voluio a la mar" ("From here Governor H. Dortal started and crossed all these rivers until he reached the great river Huyapari; and he went to the place where A. de Herrera, his lieutenant, was killed, whom he had ordered [to go] by the river Huyapari; and it happened [Herrera's death] between the swamp of Çarranaca and Meta; and he (Dortal) returned to the sea").

The second inscription relates the capture of Juan de Argüello, one of the principal instigators of the above mentioned seditious movement against Dortal. It reads: "Junto a este rio En el pueblo de Catalina prendio geronimo dortal a Ju^a^ de arguello E lo hizo ahorcar por sus meritos" ("Near that river (the Guarico), in the village of Catalina, G. Dortal seized Juan de Argüello, and had him hanged according to his merits").

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[1] Oviedo, II, libro XXIV, cap. X, p. 249[b]; and cap. XII, p. 253 ss; cap. XIII, p. 259[a]. ". . . Dortal . . . . me certificó en presençia de algunos hombres prençipales . . . ." ("Dortal . . . . told me in the presence of some leading men . . . .").

[2] Caulin, op. cit., p. 159. Rio de los Tiznados means: "river where they found tattooed Indians."—Carbajal, p. 70—"they came painted black all over (tiznados), for this reason we called that place province of the negroes."

[3] Oviedo, cap. XIV, p. 262[b] ". . . . en el mes de junio de 1541, avia mas de un año que no se sabia del gobernador Dortal" (". . . . in June, 1541, it was more than a year since they had had news of Governor Dortal").

This act of summary justice, notwithstanding the fact that Argüello was a notorious thief,[1] was, however, considered as exceeding the power of the governor, and Dortal was dismissed shortly afterward. He married in the town of Santo Domingo in 1546.[2]

Finally, special mention should be made of the inscription concerning El-Dorado, which is, of course, also on Oviedo's map, connected with the Inca Empire: "Detras destas sierras d[e]l Rio de Huyapari Esta[n] muy grandes llanos lo qual se tiene por çierto q[ue]s la tierra del peru E los yndios dizen q[ue] detras destas sierras ay grandes Riquezas. E mucho oro" ("Beyond these chains of mountains of the river Huyapari, there are vast plains which are believed to be the land of Peru, and the Indians say that beyond these chains of mountains there are great treasures, and much gold").

The influence of El-Dorado[3] and other similar traditions of genuine Indian origin,[4] on the cartography of South America during the second half of the sixteenth century, has not yet been studied with the care and attention which such an important historical and geographical question deserves.[5]

On the map, generally ascribed to Sir Walter Raleigh,[6] and made about 1595,[7] we can see El-Dorado, Epuremei,[8] and that wonder-city of Great-Manóa placed in the very vicinity of the legendary "Lake

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[1] Loc. cit., p. 263.

[2] Loc. cit., cap. XVI.

[3] Synonymous with which are: Machifaro, or Machipalo; Epuremei, Eupana, La gran ciudad de la Manoa, which presumably gave origin to the legend of the lost Inca cities somewhere in the virgin forests beyond the Andes.

[4] Notwithstanding the corrupt and often exaggerated form in which most of these traditions came to us, the principal elements are, after all, more or less identical in the different versions.

[5] A special chapter will be reserved for this most interesting question in my work on the "Origin and Development of the Early Cartography of America."

[6] Reproduced by Paul Vidal de la Blache, "La Rivière Vincent Pinzon," Paris, 1902.

[7] The map mentioned in the "officio" of the Duque is Raleigh's chart, but not that of capitão André Pereira, as is erroneously believed by several Brazilian historians; cf. "Annales da Bibl. Nac. do Rio de Janeiro," Vol. 26. Rio de Janeiro, 1905; "Documentos para a historia da Conquista e Colonisação da costa de leste—oeste do Brazil" (separate), pp. 179-183.

[8] Very often named also Evpana; cf. the planisphere of Bartholomeu Velho, 1561, on parchment, 4 sheets. Florence, Reale Instituto de Bellas Artes. Reproduced by Barão de Rio Branco (José da Silva Paranhos), "Frontières entre le Brésil et la Guyane Française." "Atlas." Paris, Lahure, 1900, No. 14.

of Manóa." The latter is undoubtedly identical with the mythological "Lake of Parima"[1] in the Carib-aruáque traditions.

Notwithstanding its roughly sketched character, Oviedo's map of the Huyapari River is a very important historical document, which, for that early time, shows fairly exact knowledge of the hydrographic conditions in the interior of the present Republic of Venezuela, especially in the western region, between longitude 67° and 69°. Most of the names given to rivers and places on his map are still in use, particularly those along the coast, and also the names given to the islands by the first discoverers between 1498 and 1500.[2]

In conclusion, there can be not the slightest doubt, I believe, that Oviedo's Huyapari map was drawn after 1542.

II. THE SPANISH ANONYMOUS MAP, ABOUT 1560

The map shown in figure 2 was first reproduced in facsimile by the editor of the "Cartas de Indias," with the following title: "Mapa de los rios Amazonas, Esequibo ó Dulce y Orinoco y de las comarcas adyacentes" ("Map of the rivers Amazon, Esequibo or 'Dulce' (sweet water river) and Orinoco; and the adjoining parts"). We need not take up the question as to whether or not it is reproduced in the original size or whether the original contains the title given above.

The map bears neither name of the author nor date. Judging from the handwriting and from some of the inscriptions relating to different historical events, it was doubtless made in the second half of the sixteenth century. And therefore, I think, the year 1560, ascribed to the map by the editors of the "British Guyana Boundary Arbitration,"[3] was accepted also by the learned Brazilian historians Barão de Rio Branco[4] and Dr. Joaquim Nabuco.[5]

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[1] The great Paro, meaning a powerful Indian chief, and sometimes "great river," or "lake," also plays an important part in the Indian traditions of Northwestern Bolivia and Eastern Perú; and it is, of course, etymologically, related to *Pari*-(i)ma; Huya-pari, Machi-paro, and others.

Ima, or ema, in Aruáque signifies "mouth of a river"; cf. Abur-ema (Chiriqui) discovered by Columbus on his fourth voyage (1502-1504).

A river termed Aburema is mentioned also by Henri Coudreau "La France Equinoxiale," etc. II. Paris, 1887, p. 63.

[2] Third voyage of Columbus, 1498.
First voyage of Hojeda (-Cosa-Vespucci), 1499-1500.
First voyage of Guerra-Peralonso Niño, 1499-1500.

[3] "Venezuela." Baltimore, 1898. Atlas, No. 76.

[4] Loc. cit., No. 13.

[5] "Frontières entre le Brésil et la Guyane Anglaise." "Atlas." Paris, 1903, No. 4.


MAPA DE LOS RIOS AMAZONAS, ESEQUIVO Ó DULCE Y ORINOCO Y DE LAS COMARCAS ADYACENTES.

Fig. 2

The author, surely a Spanish professional chart-maker, used for the compilation of the map, at least as far as concerned the rivers Esequibo and Orinoco, data which he must either have obtained direct from explorers of these rivers, or else he may have simply copied an original chart to which, presumably, he afterwards added several of the inscriptions.

The fancy representation of the course of the Amazon River, on the contrary, was, ostensibly, depicted from one of the numerous derivatives of the Sebastian Cabot Mappa Mundi of 1544.[1]

Two of the legends relate to the Ordáz expedition in 1532. The first is placed, approximately, in the region which on Oviedo's map is occupied by the Indian village Huyapari, and runs as follows: "esto q[ue] mo Ordas. año. 1536" ("This was burned [by order of] Ordáz in 1536"). This refers to that shameless outrage committed by Ordáz before he started up the Orinoco, in the village of the Indian chief Baratu-baro.[2] For some trifling reason the cruel discoverer ordered the village to be burned, and over 120 of the defenceless Indians perished in the flames.[3]

The second legend, at the foot of the chain of mountains in the interior, and to the left of the rapids, where Ordáz was compelled to abandon his project, reads: "Aqui llegó ordas co[n] sus naujos y no pudo passar por vn salto q[ue] el rio haze e[n] la sierra y volujose año 1536[4] murio en la mar camjno de Castilla" ("Ordáz reached this place with his vessels and was unable to sail farther, on account of a fall formed by the river in the mountains, and he returned, 1536. He died at sea on the voyage to Castille").

That the dates of the historical events are the chart-maker's weak point, can be seen also in the following inscription which refers to Orellana's memorable voyage down the Amazon River in 1542: "Año de 1546[4] baxo este rio abaxo Orillana. mas q[ue] mjll leguas y fue a españa y bolujo co[n] la gouernacio[n] do[n]de se p[er] dio co[n] todos los qu[e] co[n] el yua[n] por entrar por el rio a riba(!) q[ue] es gra[n] parte anegadizos e auja salido este del peru co[n]

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[1] Diego Homen, 1558. British Museum, Add. MSS. 5415A, reprod. by Rio Branco, loc. cit., No. 11. Diego Homen; 1568, ibid. No. 17[a]; Atlas of Bartolomé Olives, Vatican, Codex Urbinas, 283; ibid. No. 15.

[2] It is a very interesting fact that names of Indian chiefs and of rivers are often identical, as f. i., Baratu-baro, Juan-ico, Tari-pari, or Turi-pari, and so on.

[3] Oviedo, II, p. 216.

[4] Originally, "1536!" See the emendation on the accompanying photograph of this map.

go[n]çalo piçarro q[ua|n|do| descubrio la canela[1] y muriero[n] de ha[m]bre la mayor p[ar]te de los q[ue] co[n] el fuero[n]" ("In the year 1546 [instead of 1542] Orellana sailed down this river[2] over 1,000 leagues, and went to Spain; and having been appointed governor he returned to this river, where he, with all his companions, almost perished in sailing up the river, which in great part is marshy; and he had started from Perú with Gonzalo Pizarro, when the latter discovered the province of cinnamon; and most of those who went with him died of hunger").

Gonzalo Pizarro left Quito at the close of February, 1541, for the "pais de la canela."[3] On February 2, 1542, Orellana and his companions reached the Curaray, an affluent of the River Napo, and on Sunday, February 11, began the voyage down the river at present called "de las Amazonas."

The latest geographical datum in the anonymous map is the legend on the coast of the present Brazilian Guyana, which briefly relates the fate of the Portuguese colonizing expedition led by Luis de Mello in 1554: "Ano (!) de 1554. dia de S. Martin.[4] Se perdio. en esta costa al est. ala boca del marañon. Luis de Mello. portugues co[n]. 600. ho[m]bres q[ue] lleuaua en. 6. naujos sin torm[ent]a sino q[ue] surgiero[n] a la noche en. 7. braças. y de noche baxo el agua y q[ue]-daro[n] en seco" ("In the year 1554, on St. Martin's day, Luiz de Mello, a Portuguese, was lost on this coast, westward of the mouth of the Marañón, and with him 600 men in six vessels; [they were lost] not in a gale, but on account of anchoring at night in seven 'braças' (each of 2.20 m. of water), which on the following night ebbed, leaving them on dry land").[5]

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[1] "El Pais de la Canela." Por D. Márcos Jiménez de la Espada; in "El Centenario." Revista Ilustrada, etc. T. III. Madrid, 1892, pp. 437-457 (illustr.).

[2] Carbaxal, op. cit., p. 55, ". . . . y nos dijo como entre ellos habian dos mujeres blancas, y que otros tenian indias y hijos en ellas: estos son los que se perdieron de Diego de Ordás . . . ." ("And told us that there were two white women among them (Indians); and that others (Spaniards) have Indian women and children with them. They are those who were lost on the Ordáz expedition"); cf. Castellanos, l. c., where he relates the shipwreck of J. Cornejo.

[3] Another version of the "El-Dorado."

[4] Probably November 11.

[5] For further details, see F. A. de Varnhagen (Vizconde de Porto Seguro), "Historia Geral do Brasil." Second ed. (Wien, s. d.), tomo I, p. 261; and cf. also "Tractado Historico," etc., by Gabriel Soares de Souza, whose account, in part, differs from that of the former.

Interesting observations on the topography of the coast northward of the mouth of the Amazon, or Marañón, are contained in the legend placed on the coast of the "tierra de paragotos[1] amigos de Aruacas":[2] "toda esta costa hasta la ysla dela trinjdad como corre es baxos de arena y lama. y anegadi zos. 20 leguas la tierra adētro. q[ue] no ay puerto[3] p[ar]a nauio grande. ni au[n] p[ar]a verga[n]tin sino co[n] gra[n] difficultad" ("Along this coast as far as the island of Trinidad, there are shallows of sand and mud, and swamps, extending over twenty leagues inland; there are no seaports for large vessels, and even small ones can enter only with great difficulty").

"Guyana. ay oro guanj" ("Guyane. There is gold *guani* [low carat]"), reads a legend placed in the valley formed by two short chains of mountains situated between the rivers Cuyramo and Caroni, two southern tributaries of the Orinoco.

About four degrees north a long chain of mountains runs from the Orinoco uninterrupted, in a southeasterly direction across the interior, almost to the northern mouth of the Amazon.

The region where on other maps is generally shown the legendary lake of Manóa, is here occupied by the following inscription:

"esta sierra viene del reyno y del peru es alla en el peru rica de plata en el reyno de oro. y por aqui esta lo q[ue] dice[n] el dorado" ("This chain of mountains extends from the kingdom [of New Granada] and from Perú; in Perú it is rich in silver; and in the kingdom it is rich in gold; and this is what they call El-Dorado").

This strange geographical conception, a result of the influence of the Indian legend on early American cartography, prevails on most maps made in the second half of the sixteenth century.[4]

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[1] Oto is the typical termination of Carib clan-names; cf. Cumanag-oto; Purue-oto and many others.

[2] "Arruans," as quoted by Goeldi, is incorrect; cf. "Memorias do Museu Paraense de Historia Nat. e Ethnographia." I. "Escavaçœs archeologicas em 1895." [Pará] 1900, p. 34, 2d ed., Pará, 1905, l. c.

Goeldi is a genuine representative of the Tupi-mania.

[3] Therefore the stereotyped observations of "anegadizos" "no visto" "visto de lexos" on the early American maps.

[4] And even on several original charts of the seventeenth century, as on those made by the brothers João and Pedro Teixeira. The most interesting graphic representation of El-Dorado appears on a manuscript chart of the lower course of the Amazon River, drawn by one of the Teixeira, about 1625 to 1630. The photographs in original size of that as yet unpublished chart are preserved in the Schuller Collection at the Library of Congress, Washington. Neither of the modern bibliographers furnishes exact data on these two Portuguese cartographers.

Finally, there is a legend concerning early communication between the Amazon and Esequibo rivers, probably by the headwaters of the latter and those of the Rio Branco, an affluent of the Rio Negro: "Yayua caciq[ue] Aruaca Año. 1553, subio por el rio de es[e]quibo arriba co[n] 4. piraguas. y las passo a cues tas la sierra y dio a la otra v[er]tie[n]te en otro Rio y por el fue a dar en el rio gra[n]de de las amazonas. y hallo ta[n]ta ge[n]te q[ue] se bolujo" ("Yayua, Aruáque chief, in the year 1553 went up the Esequibo with four piragua,[1] and carried them over the mountains; and on the other side he reached another river, by which he went down to the great Amazon; and he found [there] so many people, that he returned").

The geographical nomenclature, especially the names of the rivers between the Amazon and Orinoco, differs materially from that of other maps of the same period.

Starting from the northern mouth of the "Amazónas," or Marañón, we find there the following rivers: R.[io] Cureti (Corrent-ine);[2] R. Beruisca (Berbisce?); R. Magnay . . . . (?); R. Mirari; R. Capaname; R. duce (!) (Esequibo); R. Baruma, cacique caçurama);[3] R. Moruca, cacique gumapõyma y Aruare cacique; R. Guaynj (Wa-*ini*, We-*ene*), cacique Jeraya coyma; R. Guayanepe; and R. Barimea (Bari-ma), cacique orejón (=long ear).

The Aruáque there occupy the shores, and the interior of the country is inhabited by the Carib(es). The line traced from the mouth of the river Barima to the Berbisce seems to indicate the border of their respective habitats.

So many details on a relatively early map strengthen the belief that the anonymous author must have had before him original information, probably obtained from one of the El-Dorado expeditions,[4] undertaken in the second half of the sixteenth century.

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[1] Canóa and pirágua are two genuine Carib-aruáque words, notwithstanding all said against this view by Professor Leo Wiener, of Harvard University.

[2] Ine, ene, in Aruáque, "water," "river"; papam-ene is the Aruáque name for the Amazonas. Pinzón in 1500 learned the name "Maria-(Paria)," or "Marina-(Parina)-tam-balo (=palo =falo =paro =faro), which seems to be the Carib designation for that river.

The origin of the name Marañón from the Portuguese Maranhãõ is unsupported.

[3] On that river probably was situated the village of the chief mentioned above.

[4] Archivo General de Indias, Sevilla; 139-1-2, Tomo III°: "De oficio. Rio Marañon—Desde 20 de Maio de 1530 hasta 21 de Febrero de 1539"; and especially: 139-1-1, Tomo 1° and Tomo II°; cf. also the pen sketch map, of about 1550, 145-7-7. Ramo 5.

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Hodgkins Fund

ON THE DISTRIBUTION OF RADIATION OVER THE SUN'S DISK AND NEW EVIDENCES OF THE SOLAR VARIABILITY

(With One Plate)

BY
C. G. ABBOT, F. E. FOWLE, and L. B. ALDRICH

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Fig. 1

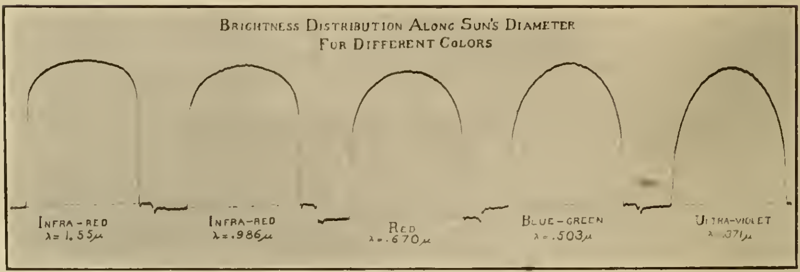

Brightness Distribution Along Sun's Diameter
For Different Colors
Infra-red
λ = 1.55μ
Infra-red
λ = .986μ
Red
λ = .670μ
Blue-green
λ = .503μ
Ultra-violet
λ .371μ

Fig. 2

Hodgkins Fund

ON THE DISTRIBUTION OF RADIATION OVER THE SUN'S DISK AND NEW EVIDENCES OF THE SOLAR VARIABILITY

By C. G. ABBOT, F. E. FOWLE, and L. B. ALDRICH

(With One Plate)

Referring to the Annals of the Astrophysical Observatory,[1] we gave there the results of earlier investigations of the distribution of radiation over the sun's disk, and some indications of a variability of this distribution which might be associated with variation of the sun's total radiation. This work was done in Washington prior to the year 1908. When the new observing station of the Smithsonian Institution was constructed upon Mt. Wilson in 1909, provision was made for the erection of a tower to be used for a tower telescope for the continuation of such observations. It proved impossible to equip a tower telescope until the autumn of the year 1913, when apparatus was hastily arranged and operations were begun on September 9, 1913. The tower was improved both in its rigidity and in the mountings of the apparatus for the research in 1914 and 1915, and is now regularly used on all days when solar-constant observations are made.

In figure 1 (pl. 1) is given a general view of the tower telescope upon the observing station at Mt. Wilson. Owing to the bold situation of the station, it is impossible to get a photograph of the apparatus except by climbing a tall pine tree at some distance away, and the trees intervening are some obstacle to a satisfactory presentation of the installation.

Figure 3 is a diagram of the construction of the tower telescope and its relation to the spectro-bolometer. *A* and *B* are the mirrors of the coelostat, from which a beam of sunlight passes downward to the 30-centimeter (12-inch) concave mirror *C* of 23 meters (75 feet) focal length. Thence the beam passes up to the plane mirror *D*, which reflects the image to focus at *E* near the floor of the observing chamber. At *F* is a small plane mirror at the angle of 45°, which reflects the beam through the slit *G* of the spectro-bolometer *G H I*. At *J K*, outside the observing chamber, is the coelostat used for the ordinary solar-constant observations.

[1] Vol. 2, Pt. 3, and Vol. 3, Chap. 7.

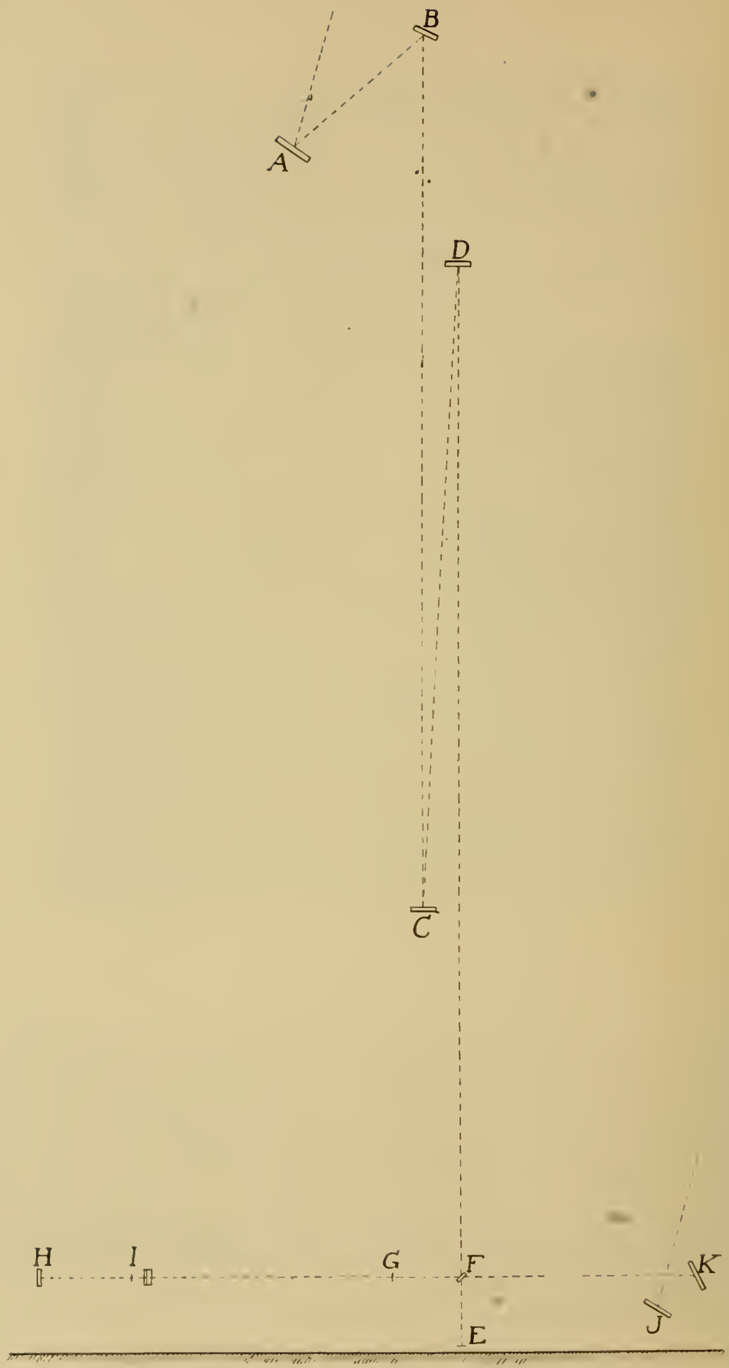


FIG. 3.—Diagram of tower telescope and spectro-bolometer

The reader will understand that the beam from the coelostat *A B*, or that from the coelostat *J K*, may be brought to the spectro-bolometer, according as the 45° mirror *F* is in place or withdrawn. The former is the condition for observing the distribution of light over the sun's disk, the latter the condition for observing the solar constant of radiation.

As explained in the publications already cited, we allow the sun's image to drift across the slit of the spectro-bolometer by the diurnal motion of the earth, thus avoiding all sources of error associated with inequalities of the transmission of the optical apparatus of the tower telescope. For it is obvious that during a single such period of drift the telescope is always directed to the same point of the sky, and treats whatever object passes that point with impartiality, whether it be the sun's limb, center, or the light of the sky itself. We regard this feature as very favorable for exact results, and much preferable to the arrangement used by some investigators, in which the observing apparatus is shifted about from part to part of the solar image, and the results may be affected by inequalities of transmission of the optical apparatus to these different parts of the image.

On the other hand, we are thereby limited to an east and west course across the sun's disk, and this hardly ever coincides with the solar equator. However, it seems clear that a comparison of the mean of a great number of observations taken during a large part of one year with that of a great number of similar observations covering the same part of another year, would certainly be fairly comparable irrespective of the various presentations of the sun during these intervals. It is by no means so clear, without further investigations which we hope to undertake next year, that short-period changes of the distribution of radiation along a solar diameter may not be associated with changes of distribution depending on latitude in the sun. Such investigations as have been made on this point heretofore relate, we think, only to total brightness or total radiation. Pickering's[1] experiments indicated that the contrast of visual brightness along a polar diameter exceeds that along the equatorial, so that for total visual brightness at 95 per cent out on the radius the equator is brighter in the ratio of about 56 to 53. Pickering expressed doubt as to whether this difference is solar or from experimental error. The more numerous investigations of Langley[2] seem to have shown clearly that differences of contrast in total radiation between the equatorial and polar diameters of the sun are negligibly small, probably

[1] Proc. Amer. Acad. Arts Sci., Vol. 10, p. 428, 1874.

[2] Comptes Rendus Sept. 6, 1875.

far less than 1 per cent. Hence it seems probable that the influence of changes in the inclination of the solar equator as affecting our investigations is inappreciable.

Figure 2 (pl. 1) shows a number of drift curves at selected regions of the spectrum chosen to indicate the differences of form which are found, depending on wave lengths. As discovered by earlier investigators, and hitherto abundantly confirmed by ourselves, the contrast of brightness between the center and the edge of the sun is greatest for short wave lengths, and diminishes as one comes to the red and infra-red.

We have two principal objects in this research: First, to repeat our earlier determination of the distribution of light along the diameter of the solar image; second, to detect fluctuations of distributions from year to year and from day to day, if any, and to compare them, if found, with fluctuations of the radiation of the sun as determined in our solar-constant investigations.

On each day of observation we are accustomed to take 14 drift curves, two each at seven different wave lengths, as follows: 0.3737μ, 0.4265μ, 0.5062μ, 0.5955μ, 0.6702μ, 0.8580μ, and 1.008μ. In the reduction of observations, we proceed as stated on pages 154 and 155 of Vol. 3 of our Annals, from which we quote as follows:

"We have determined the rate of descent in the plate carrier of the photographic plates on which the curves are recorded, and have determined from the Nautical Almanac the time required for the sun's disk to pass the meridian. From these data we have determined the distance along the plate corresponding to the width of the sun's diameter. This distance has been regarded as the true width of the U-shaped curve, and all the measurements of ordinates of this curve have been made at certain round-numbered fractions of the corresponding solar radius.

"To illustrate: On June 8, 1908, the sidereal time required for the sun's semidiameter to pass the meridian was $1^m\ 8.72^s$. The corresponding mean solar time for the passage of the diameter is 2.284^m. On this date the photographic plate descended 3.978 centimeters per minute. Hence, the diameter of the sun expressed on the photographic plate is 9.086 centimeters. Measurements were made at the center and at 10 places on either side of it, making 21 places in all, at distances from the center of the U-shaped curve which correspond to certain fractions of the solar radius from the center of the sun's disk.

"In further reduction of the observations, the mean values of the measurements on each curve for the advancing and following limbs of the sun were taken. Then, in order to standardize the observations (for it is to be remembered that the bolographic curves depend for their ordinates on the sensitiveness of the galvonometer, the clearness of the sky, and the sun's zenith distance, all of which vary from day to day), the sums of the mean measurements at the center (given half weight) and at 2/10, 4/10, 55/100, and 65/100 radius, were taken. All the measurements were divided by this sum and thus expressed in terms of a unit five times the mean height of the central part of the **U**-shaped curve.

"For illustration: On June 8, 1908, the following measurements were made on a curve corresponding to wave length 0.501μ. Taking the sum, 40.96, of the first five places (giving the central place half-weight) and dividing this sum into the mean values at the several places on the curve, we have the following values:

TABLE (53) 1.—*Illustrative of reduction of drift curve observations*

Distances from center:	*cm.*										
Linear	0.00	0.91	1.82	2.50	2.95	3.41	3.75	3.98	4.18	4 32	4.41
Fractional	0.00	0.20	0.40	0.55	0.65	0.75	0.825	0.875	0.92	0.95	0.97
Heights:											
Advancing limb	9 80	9.69	9.16	8.74	8.41	7.61	6.96	6.35	5.65	4.70	3.60
Following limb	....	9.69	9.26	8.81	8.36	7.68	7.03	6.37	5.58	4.78	4.16
Mean	2×4.90	9.69	9.21	8.775	8.385	7.645	6.995	6.36	5.615	4.74	3.88
Ratio, mean height to 40.96	.1196	.2366	.2249	.2142	.2047	.1866	.1708	.1553	.1371	.1157	.0947
Ratio to central height [1]	1.0000	.9862	.9379	.8932	.8536	.7781	.7123	.6476	.5717	.4825	.3949

[1] The lowest line of the table is added in view of its interest, but is not used in the reductions. It is based on the standard central value .1199 found from 104 curves. It will be further explained.

"The following table contains the standard reduction values for many wave lengths. It corresponds to the next to the last line of table above, represents the mean of many days of observation, and is used in preparation of the tables which follow it.

AUXILIARY STANDARD REDUCTION VALUES

TABLE (54) 2.—*Mean distribution of radiation along radius of solar disk*

Wave length	Number of observations	Distance from center as fraction of radius									
		0.00[1]	0.20	0.40	0.55	0.65	0.75	0.825	0.875	0.92	0.95
μ											
0.386	3	0.1233	0.2417	0.2283	0.2110	0.1953	0.1750	0.1560	0.1367	0.1190	0.1030
0.433	39	.1227	.2400	.2275	.2126	.1978	.1789	.1588	.1430	.1251	.1104
0.456	89	.1207	.2380	.2273	.2136	.2007	.1826	.1644	.1487	.1298	.1136
0.481	74	.1201	.2371	.2267	.2141	.2018	.1851	.1683	.1532	.1359	.1198
0.501	104	.1199	.2362	.2267	.2145	.2026	.1864	.1704	.1559	.1397	.1240
0.534	104	.1192	.2353	.2265	.2150	.2041	.1888	.1736	.1602	.1443	.1306
0.604	72	.1182	.2339	.2262	.2158	.2062	.1929	.1798	.1679	.1533	.1403
0.670	41	.1173	.2324	.2255	.2168	.2081	.1965	.1844	.1737	.1596	.1476
0.699	64	.1171	.2319	.2255	.2169	.2085	.1970	.1856	.1751	.1618	.1492
0.866	51	.1160	.2302	.2248	.2178	.2113	.2021	.1926	.1837	.1726	.1621
1.031	30	.1149	.2293	.2246	.2185	.2126	.2042	.1955	.1875	.1775	.1677
1.225	43	.1148	.2284	.2240	.2188	.2139	.2068	.1987	.1914	.1824	.1737
1.655	26	.1138	.2268	.2235	.2198	.2163	.2111	.2051	.1996	.1928	.1856
2.097	25	.1134	.2260	.2236	.2202	.2169	.2123	.2075	.2024	.1965	.1900

[1] On half the scale of other columns.

"The values in the table just given are a standard of reference, and the values obtained at these wave lengths on any day of observation are comparable with them as soon as reduced to the form given in the next to the last line of table 53.

MEAN DISTRIBUTION OF RADIATION ALONG THE SOLAR RADIUS FOR DIFFERENT WAVE LENGTHS

"The following tabular summary of the distribution of brightness of different wave lengths along the diameter of the sun's disk has been obtained in the manner just described from numerous observations made between November 1, 1906, and January 1, 1908. Profs. Schwartzchild and Villager determined the distribution of radiation along the diameter of the sun for the very short wave length, $\lambda = 0.323\mu$, by photographic observations made after silvering the objective of their telescope.[1] In this way they observed only with the ultra-violet rays transmissible by silver. The following table includes the mean of observations of Schwartzchild and Villager:

Table (55) 3.—*Mean distribution of radiation along radius of solar disk*

[Intensity at center as unit.]

Wave length	Number of observations	Distance from center as fraction of radius									
		0.00	0.20	0.40	0.55	0.65	0.75	0.825	0.875	0.92	0.95
μ											
0.323	......	1.0000	0.960	0.897	0.835	0.775	0.690	0.600	0.530	0.452	0.382
0.386	3	1.0000	.9797	.9258	.8556	.7920	.7097	.6326	.5543	.4826	.4177
0.433	39	1.0000	.9780	.9271	.8663	.8060	.7290	.6471	.5827	.5098	.4499
0.456	89	1.0000	.9857	.9416	.8848	.8314	.7564	.6810	.6160	.5377	.4706
0.481	74	1.0000	.9871	.9438	.8914	.8401	.7706	.7007	.6378	.5658	.4988
0.501	104	1.0000	.9850	.9454	.8945	.8449	.7773	.7106	.6501	.5826	.5171
0.534	104	1.0000	.9870	.9499	.9018	.8561	.7919	.7282	.6720	.6053	.5478
0.604	72	1.0000	.9894	.9568	.9129	.8722	.8160	.7606	.7102	.6485	.5935
0.670	41	1.0000	.9906	.9612	.9241	.8769	.8376	.7860	.7404	.6803	.6292
0.699	64	1.0000	.9902	.9629	.9261	.8903	.8412	.7925	.7476	.6909	.6371
0.866	51	1.0000	.9922	.9690	.9388	.9108	.8711	.8302	.7918	.7440	.6987
1.031	30	1.0000	.9978	.9774	.9508	.9251	.8886	.8507	.8159	.7904	.7298
1.225	43	1.0000	.9948	.9779	.9530	.9316	.9007	.8654	.8336	.7944	.7565
1.655	26	1.0000	.9965	.9820	.9657	.9504	.9275	.9012	.8770	.8471	.8155
2.097	25	1.0000	.9965	.9858	.9709	.9563	.9361	.9149	.8924	.8664	.8374"

We now give the mean distribution of radiation along the solar radius for different wave lengths as found by the observations of 1913. The tables here given are conformable to tables 54 and 55 of Vol. 3 of the Annals. They relate, however, to other wave lengths.

[1] Astrophysical Journal, Vol. 23, pp. 284 to 305, 1906.

TABLE 4.—*Auxiliary standard reduction values of 1913*

Wave length	Number of observations	Distance from center as fraction of radius										
		0.00	0.20	0.40	0.55	0.65	0.75	0.825	0.875	0.92	0.95	0.97
0.3737	84	0.1219	0.2401	0.2278	0.2 23	0.1978	0.1781	0.1589	0.1413	0.1217	0.1053	0.0852
0.4265	81	.1218	.2399	.2282	.2124	.1978	.1787	.1595	.1431	.1245	.1084	.0946
0.5062	87	.1193	.2360	.2269	.2147	.2032	.1878	.1717	.1576	.1410	.1262	.1126
0.5955	82	.1179	.2335	.2261	.2161	.2065	.1935	.1802	.1681	.1536	.1402	.1276
0.6702	83	.1168	.2319	.2258	.2170	.2086	.1972	.1856	.1747	.1617	.1495	......
0.8580	82	.1156	.2297	.2247	.2182	.2118	.2027	.1932	.1847	.1741	.1642	......
1.0080	78	.1152	.2290	.2246	.2186	.2126	.2046	.1960	.1881	.1781	.1689	......

TABLE 5.—*Standard distribution of radiation along radius of solar disk, 1913*

Wave length	Number of observations	Distance from center as fraction of radius										
		0.00	0.20	0.40	0.55	0.65	0.75	0.825	0.875	0.92	0.95	0.97
0.3737	84	1.0000	0.9841	0.9344	0.8708	0.8113	0.7305	0.6518	0.5796	0.4992	0.4319	0.3495
0.4265	81	1.0000	.9848	.9368	.8719	.8120	.7336	.6548	.5874	.5111	.4450	.3883
0.5062	87	1.0000	.9891	.9510	.8998	.8516	.7871	.7196	.6605	.5909	.5289	.4719
0.5955	82	1.0000	.9902	.9589	.9165	.8757	.8206	.7642	.7129	.6514	.5946	.5411
0.6702	83	1.0000	.9927	.9666	.9289	.8930	.8442	.7945	.7479	.6922	.6400	......
0.8580	82	1.0000	.9935	.9719	.9438	.9161	.8767	.8356	.7989	.7530	.7102	......
1.0080	78	1.0000	.9939	.9748	.9488	.9227	.8880	.8507	.8164	.7730	.7331	......

CHANGES OF DISTRIBUTION FROM YEAR TO YEAR

We have compared the distribution for 1907 with that for 1913. It was at once apparent that a change of distribution had occurred. Inasmuch as the year 1913 was a year of absolute minimum of sun spots such as has not been equaled for almost a century, it seemed well to use the distribution obtained in 1913 as a standard of reference.

Imagine tables to be formed for other years, similar to that which we have just given for 1913. Imagine, further, that we divide each number of the table for another year by the corresponding number of the table for 1913. There results, for each wave length, a series of values. Having adjusted the values so that smooth curves to represent them would give zero departures at the center of the sun's disk, the actual values, starting near unity at the center of the sun's disk, run to numbers slightly smaller or larger than unity as we approach the edge of the disk, according as the distribution in the given year shows a greater or a less contrast of brightness between the center and the edge than that which prevailed in the standard year 1913.

In the following table (6) are given the results of such comparisons for the years 1907 and 1914. It was necessary to reduce the observations of 1907 to the wave lengths employed in 1913 and 1914. This was accomplished by plotting the tabular values on a very large scale and interpolating for the proper wave length. The 67 observations of 1914 which are here represented were obtained between June 12 and October 5. Other observations of 1914 are not as yet reduced.

TABLE 6.—*Comparison of distribution values of other years with results of 1913*

Year	Wave length	Distance from center as fraction of radius									
		0.00	0.20	0.40	0.55	0.65	0.75	0.825	0.875	0.92	0.95
1907	0.4265	1.0033	0.9996	0.9966	0.9992	0.9992	0.9981	0.9967	0.9929	0.9903	0.9918
1907	0.5062	1.0017	.9991	.9970	.9978	.9968	.9930	.9936	.9920	.9926	.9888
1907	0.5955	1.0005	.9997	.9976	.9971	.9956	.9928	.9919	.9915	.9902	.9909
1907	0.6702	1.0018	.9989	.9958	.9953	.9938	.9916	.9892	.9898	.9837	.9840
1907	0.8580	1.0000	1.0000	.9978	.9956	.9946	.9930	.9922	.9904	.9865	.9809
1907	1.0080	.9986	1.0012	.9991	.9986	.9990	.9966	.9962	.9936	.9933	.9906
	Mean	1.0010	0.9997	0.9973	0.9973	0.9965	0.9942	0.9950	0.9934	0.9894	0.9878
1914	0.3737	1.0005	0.9990	0.9983	0.9977	0.9963	0.9957	0.9939	0.9955	0.9943	0.9926
1914	0.4265	.9998	1.0002	.9987	.9985	.9983	.9973	.9962	.9966	.9946	.9939
1914	0.5062	1.0002	.9996	.9994	.9990	.9984	.9973	.9972	.9976	.9964	.9956
1914	0.5955	1.0000	1.0000	.9997	.9995	.9992	.9987	.9978	.9977	.9966	.9975
1914	0.6702	1.0006	.9999	.9991	.9988	.9985	.9977	.9966	.9968	.9961	.9970
1914	0.8580	.9996	.9998	.9999	.9989	.9983	.9985	.9981	.9979	.9975	.9990
1914	1.0080	.9997	1.0000	.9999	.9996	.9997	.0992	.9990	.9991	.9992	1.0008
	Mean	1.0001	0.9998	0.9993	0.9988	0.9984	0.9978	0.9970	.9975	0.9964	0.9966

The results just given are indicated graphically in figure 4. Ordinates are ratios of the mean ordinates of drift curves for 1907 and 1914 compared to those of 1913 taken as standards. Abscissæ are positions along the solar radius, starting from zero at the center of the disk and running to 1.000 at the limb.

It appears that greater contrast prevailed in the years 1907 and 1914 than that which prevailed at sun-spot minimum in 1913; because when all the curves are reduced to equality at the center of the solar disk, they indicate lower values at the limb in the years 1907 and 1914 than in 1913. The differences are exceedingly small, although so unmistakable. Thus the average departure at 92 per cent on the radius is but 1 per cent in 1907 and but 0.36 per cent in 1914.

We have considered whether these differences are due to experimental error, but three considerations seem to us to oppose this view. First, no significant change in the apparatus or methods of experiment occurred between 1913 and 1914. Second, the fluctuations of contrast from day to day are correlated with fluctuations of the solar constant from day to day, as will appear below from very numerous cases occurring in 1913 and 1914. This being so, it is reasonable to expect also a fluctuation of contrast from year to year, if the solar radiation fluctuates from year to year. Greater values of solar radiation prevailed in 1907[1] and 1914 than those prevailing in 1913. Hence it is not surprising to find that the contrast of brightness was greater in both the years 1907 and 1914 than it was

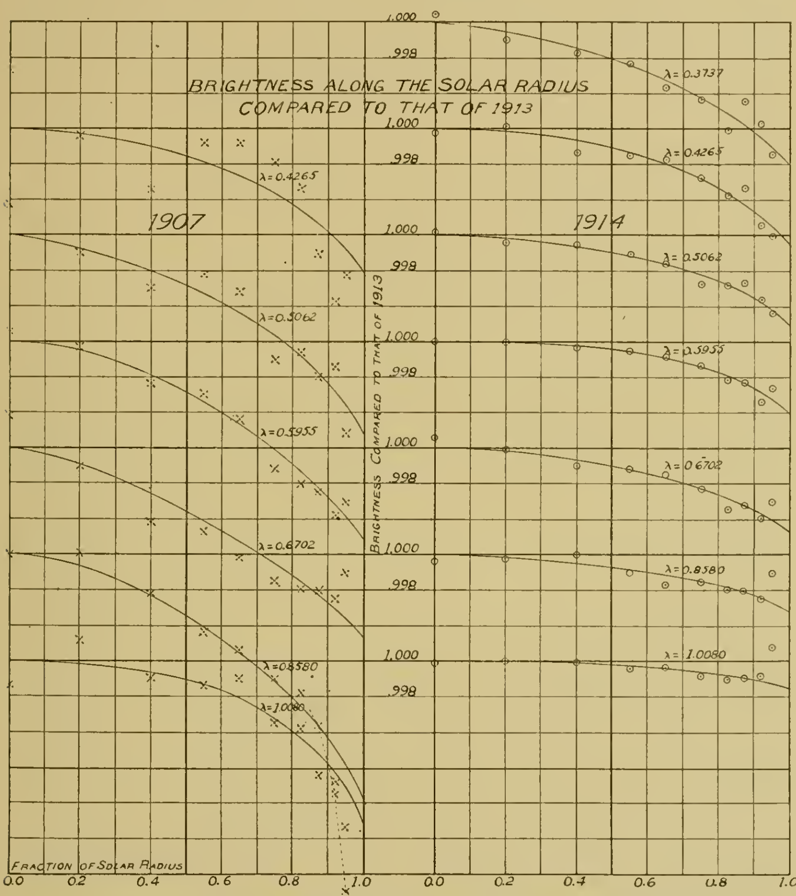


FIG. 4.—Variability of distribution of sun's brightness from year to year

in the year 1913. Third, there seems to be a correlation of change of contrast with change of wave length. This relation does not appear clearly from the results of 1907, but figure 4 shows that these results are subject to large experimental error compared with the

[1] This statement regarding 1907 is based on the dependence between solar-constant values and sun-spot numbers indicated by figure 16 of Vol. 3 of our Annals. Few solar-constant determinations were made in 1907.

results of 1914. A slightly different weighting of two discordant points on each of the curves for wave lengths 0.4265, 0.5062, 0.6702, and 1.008 μ in the curves for 1907 would bring them all (excepting that at wave length 0.8580 μ) into harmony with the conclusions about to be stated. Confining attention to the more accurate observations of 1914, the change of contrast is greater for short wave lengths than for longer ones, in the proportions indicated by the following table (7):

TABLE 7.—*Deviations of contrast of mean results of 1914 from standard form of 1913. (Derived from mean curves)*

Wave length	μ 0.3737	μ 0.4265	μ 0.5062	μ 0.5955	μ 0.6702	μ 0.8580	μ 1.0080
Fraction of radius.							
0.50	0.0020	0.0010	0.0009	0.0004	0.0010	0.0007	0.0002
0.90	0.0062	0.0046	0.0035	0.0026	0.0035	0.0023	0.0010

Figure 5 shows graphically the dependence of the 1914 departures of contrast on the wave length. The evidence of future years will be required to show whether the irregularities of the curves of figure 5

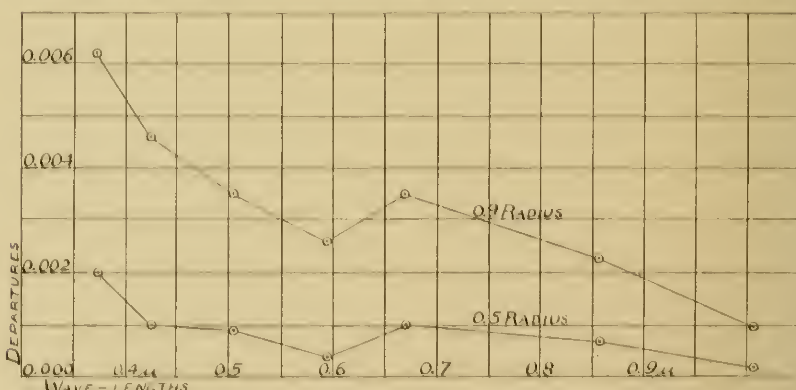


FIG. 5.—Dependence of brightness variability on wave length

are accidental or solar, but of the reality of the increase of departures attending decrease of wave length there seems to be little question.

CHANGES OF DISTRIBUTION FROM DAY TO DAY

We now pass to a consideration of changes of contrast from day to day. Still using the mean distribution of 1913 as a standard, we took logarithms of the values and subtracted these from the corresponding logarithms for the individual days. We then plotted the resulting logarithms as ordinates, and the positions on the solar disk radius as abscissæ. In this way we obtained for each day of observation seven plots, or pairs of plots, in which the slant of the representative lines indicated the departure from the standard mean condition of solar contrast, at seven different wave lengths. In the 1913 reductions we combined the pairs of check values before plotting, but kept them separate in the 1914 reductions.

Figure 6 shows the results of two days of comparison which are typical of the two different classes of results obtained on the various days. On September 22, 1913, the curves run generally upward, indicating a less contrast than the mean, while on October 20, 1913, the lines run generally downward, indicating a greater contrast than the mean. Some curves on each day, to be sure, run counter to the general trend of the day, but these divergences are reasonably to be regarded as often due to accidental error. A change of atmospheric transparency of 1 per cent during the single minute of time at which the central part of the sun's disk is crossing the slit of the spectroscope would account for the divergences shown by wave lengths 0.6702 and 1.008 μ on September 22. Still more probably the discrepancy may be accounted for by a temporary shift of less than a millimeter in the zero of the bolometric curve either at the beginning, middle, or end of the runs.

We desired to obtain for each day's observation a single value which would be typical of each day's departure of contrast from the general mean. While logarithmic curves of departures are not always smooth, and while there is no physical reason on which to base a prediction of the form which they ought to assume, still in general the curves are tolerably represented by straight lines. We have regarded the inclination of the best representative line for each logarithmic plot as a fair indication of the departure of contrast for that day and that wave length. There are seven wave lengths observed on each day of observation, and we might have taken the simple mean value of the tangents of the inclination of the logarithmic lines as the index of the departure for the given day. But it appeared that the departures were greater, the smaller the wave lengths, so much so that the simple mean would give entirely too much weight to the shortest wave length of observation. Accordingly, a system of weights has been determined by comparing the magnitudes of the departures at the different wave lengths. The numbers for 1913 and 1914 were obtained independently from the data for those two

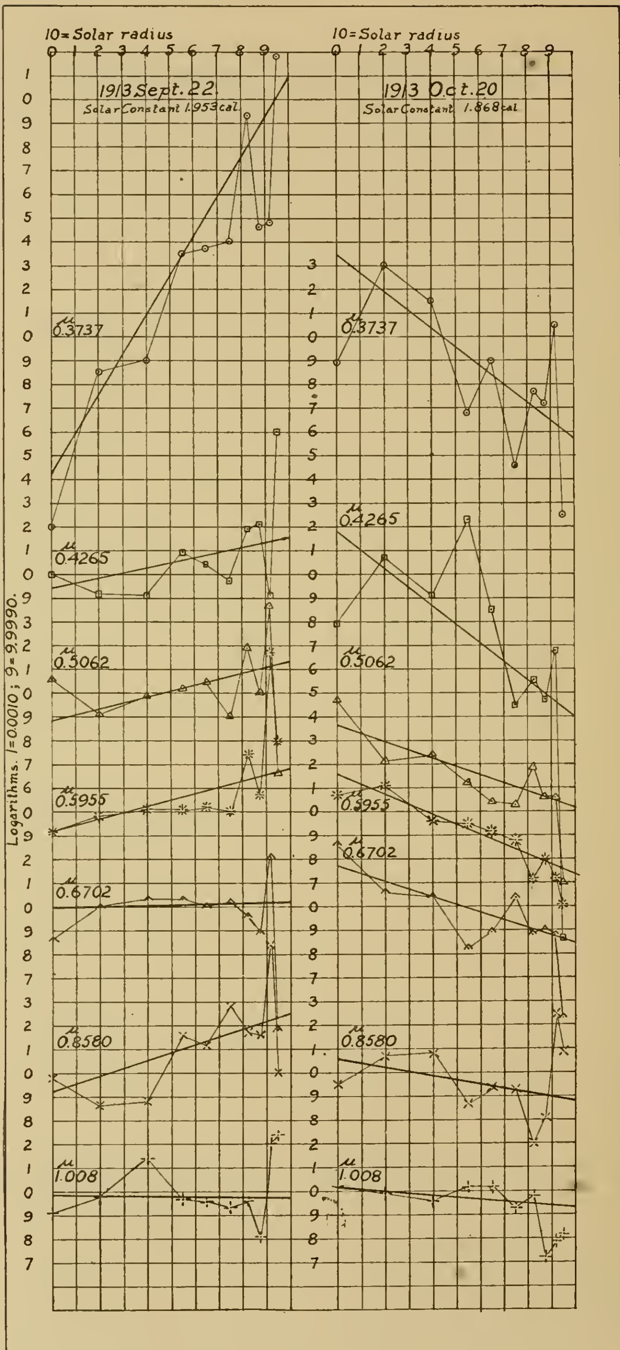


FIG. 6.—Variations of solar contrast from day to day

years, and they differ somewhat from each other.[1] The weights for the two years were not smoothed by wave lengths. They are as follows:

TABLE 8.—*Adopted weights*

Wave length	0.3737	0.4265	0.5062	0.5955	0.6702	0.8580	1.0080
1913 values	0.33	0.79	1.39	1.00	1.32	1.47	2.17
1914 values	0.42	0.59	0.62	1.00	0.63	1.00	1.67

For the purpose in view, the differences between the two sets of weights are of little significance. The numbers are, on the whole, very like those which might be derived from figure 5.

We have made two different reductions of the data. In one, we multiplied the tangents for each day by the appropriate multiplier taken from the preceding table, and having taken the mean of the weighted tangents, we thus obtained for the given day a value representing the average weighted departure from the standard condition of distribution, as determined by observations at seven different wave lengths. In another reduction, we omitted the wave lengths 0.3737 and 1.008 μ and took the simple mean of the tangents for the other wave lengths. We omitted these two wave lengths in consideration of the fact that the accidental error at 0.3737μ is unduly large, owing to the smallness of galvanometer deflections there; and also that the changes of contrast at wave length at 1.008μ are relatively small compared with the accidental error there.

The following tables (9 and 10) give the solar-constant and solar-contrast numbers for the years 1913 and 1914. The values given must be regarded as preliminary and subject to minor changes before final publication.

As so much depends upon the values for 1913, a great deal of attention has been paid to the remarkable decrease of the solar-constant values which occurred on and after September 24, 1913. Not only did the solar-constant values fall off at this time, but also a change in the contrast values occurred. If we divide all the days in which solar-contrast values were obtained in 1913 into two groups,

[1] It may be significant in view of what follows to note that the weights obtained for 1913 depended on the relative amounts of the deviations of individual wave lengths on different days, while the weights obtained for 1914 depended rather on the relative deviations for these wave lengths found from the year as a whole, compared to 1913 as a whole.

TABLE 9.—*Observations of the year 1913*

Date	Solar Constant	Grade	Solar Contrast: All λs	Grade	Omitting λ= .3737μ and λ=1.008 μ	Grade
July 16	1.928	Vg+	....	....	....	....
23	1.935	Vg−	....	....	....	....
24	1.911	Vg+	....	....	....	....
Aug. 3	1.928	E	....	....	....	....
4	1.916	E−	....	....	....	....
5	1.958	E	....	....	....	....
6	1.913	Vg−−	....	....	....	....
9	1.957	E−	....	....	....	....
10	1.954	Vg−	....	....	....	....
11	1.921	Vg−	....	....	....	....
12	1.940	Vg	....	....	....	....
13	1.927	Vg	....	....	....	....
14	1.955	E−−	....	....	....	....
15	1.922	E−	....	....	....	....
16	1.877	Vg+	....	....	....	....
17	1.913	E	....	....	....	....
18	1.958	Vg+	....	....	....	....
19	1.859	Vg+	....	....	....	....
20	1.987	Vg+	....	....	....	....
21	1.910	Vg−	....	....	....	....
28	1.968	G+	....	....	....	....
Sept. 2	1.963	G	....	....	....	....
3	1.933	E+	....	....	....	....
4	1.907	G−	....	....	....	....
5	1.905	Vg	....	....	....	....
6	1.901	Vg+	....	....	....	....
7	1.950	Vg++	....	....	....	....
8	1.897	Vg++	....	....	....	....
9	1.936	Vg+	+ 38	P+	+33	P
10	1.930	E−	+ 12	G	−13	G+
11	1.912	E	− 21	Vg−	0	Vg
14	1.907	E−	+ 42	G	+38	G
15	1.899	Vg+ ?	+ 48	G	+39	G
16	1.912	Vg −	+101	P	+54	G−
17	1.938	G+	+ 83	G	+79	G+
18	2.000	Vg	+ 47	Vg−	+67	Vg−
19	1.954	Vg+	+ 62	G	+29	G
P. M. 21	1.915	Vg++	+ 29	G−	+19	P
22	1.953	Vg	+ 49	Vg−	+46	G+
P. M. 24	1.928	E	+138	Vg−	+43	(Omitting λ=.5062) Vg
25	1.881	Vg	+ 28	G+	+12	G+
26	1.849	E	− 15	G+	−05	Vg−
27	1.894	E	− 23	G−	−26	G
28	1.855	E+	+ 18	Vg	−13	Vg
29	1.882	E+	− 54	Vg	−49	Vg+
30	1.907	G+	+ 11	P	−19	P
Oct. 1	1.869	Vg	....	....	....	....
3	1.966	Vg−	+ 11	G+	+19	Vg−
6	1.835	Vg	−107	G+	−68	Vg−
7	1.878	E	− 51	G−	−62	Vg−
8	1.804	G+	− 28	G	−25	G
9	1.806	G	....	....	....	....
11	1.852	E+	− 36	G	−24	G+
12	1.893	E+	− 07	Vg−	+ 4 or −24	G+
13	......	......	....	....	....	....
14	1.861	E	+ 03	Vg−	+16	Vg−
15	1.831	E	− 43	G	−20	G
17	1.907	E−	− 43	G	−29	G+
19	1.873	E+	− 30	G−	−38	G−
20	1.868	E	− 81	G+	−88 or −64	G+
21	1.912	E−	− 02	G−	+04	G−
22	1.893	Vg+	+ 24	G−	+30	G−
23	1.871	E	+ 22	G	+01	G
24	1.882	E	0	Vg−	+16	Vg−
25	1.850	E	− 01	G+	−26	G+
26	1.871	Vg+	+ 29	G+	+20	G
27	1.914	G	− 22	G	−27	G
28	1.830	E−	+ 04	G	+15	G+
31	1.867	Vg+	+ 52	G−	+44	G−
Nov. 4	1.852	E+	+ 65	P+	+09	P+
5	1.818	E+	− 13	G	−43	G
7	1.888	Vg+	− 34	G	−11	G
8	1.902	E	+ 53	G+	+31	G
9	1.918	Vg−	+ 35	G−	+27	G−

Table 10.—*Observations of the year 1914*

	Date		Solar Constant	Grade	Solar Contrast All λs	Grade	Omitting λ= .3737μ λ=1.008 μ	Grade
	June	12	1.977	G+	....	....	....	....
		13	1.943	E−	− 14	G	− 51	G−
		14	1.944	E−	− 52	G+	− 65	G+
		15	1.979	E+	− 13	Vg	− 72	G+
		16	1.938	E	− 21	Vg−	− 40	G+
		19	1.916	Vg	− 34	G	− 43	G+
		20	1.954	E−−	− 38	G	− 54	G−
		21	1.918	E	− 40	E−	− 57	Vg+
		22	1.975	E−	− 16	Vg−	− 37	Vg−
		23	1.943	E+	+ 2	Vg−	− 27	Vg
		24	1.936	Vg−−	− 38	G+	− 32	G+
		25	1.958	Vg	+ 17	Vg−	+ 8	Vg
		26	1.966	E	− 7	G	− 21	G
		30	1.981	Vg+	− 9	Vg−	− 17	G+
	July	1	1.973	E	− 48	G+	− 55	G+
		2	1.947	E−	− 37	G−	− 65	G−
		17	1.932	E	− 13	Vg−	− 34	G+
		18	1.901	E	− 64	G+	− 83	G+
		19	1.951	Vg+	− 64	G+	− 34	G+
		20	1.949	Vg−	− 39	Vg−	− 47	Vg−
		21	1.968	E	− 60	G	− 87	G
		22	1.950	E+	− 55	Vg	− 33	Vg
		23	2.004	Vg+	− 41	G+	− 36	G+
		26	1.934	Vg++	− 11	G+	− 24	G
	P. M.	27	1.948	E−	− 25	G+	0	G
		28	1.968	Vg+	− 39	Vg+	− 66	Vg+
		29	1.921	Vg−−	− 59	G+	− 82	G+
a		30	2.031	Disturbed	− 46	Vg	− 46	Vg
a	Aug.	1	2.062	weather	− 56	G	− 45	G
a		2	1.966	Sky streaked	+ 3	Vg−	+ 6	G+
a	P. M.	5	2.099	with cirri	− 20	G	− 12	G
		7	1.989	Vg	− 56	G	− 30	G
a		8	1.945	Exceptional humidity	+ 6	G	+ 13	G
		9	1.987	E−	− 25	Vg	− 49	Vg
		10	1.949	E	− 88	G+	−104	G+
		11	1.987	E+	− 27	Vg−	− 26	Vg
		12	1.962	E−	− 38	G−	− 70	P
		14	1.952	Vg+	− 49	P	− 79	P
		17	1.923	E−	− 80	Vg	− 63	Vg−
		18	1.937	Vg	− 23	P+	− 34	P+
		19	1.935	E−	− 43	G−	− 76	G−
		20	1.969	G	− 32	G−	− 56	G−
		21	1.947	E+	− 34	G	− 59	G
		22	1.942	E	− 40	Vg	− 73	Vg
		23	1.975	E+	− 43	G−	− 77	P+
		24	1.928	G−	− 59	G−	− 78	G−
		26	1.934	E	− 37	G	− 81	G
		27	1.951	Vg+	− 27	G−	− 26	G
		28	1.940	E	− 38	G	−118	G
a		29	1.779	Disturbed weather	− 27	G−	− 48	G−
a		30	2.057	Sky streaked				
a		31	1.987	with cirri	−130	G−	−133	G−
	Sept.	1	1.915	E	−106	Vg−	−134	Vg−
		2	1.948	E	− 63	G+	− 81	G−
		3	1.942	E	−107	Vg	−121	Vg−
		4	1.949	E+	− 86	G	−108	G+
		6	1.921	E+	− 82	G	−109	P+
		7	1.944	G+	− 81	G	−109	G
		8	1.958	E−	− 53	G−	− 93	G−
?		9	1.932	Vg	−109	G	−174	G
a		10	1.954	E−	− 87	P	−119	P+
		11	1.946	Vg	− 18	G−	− 54	G−
		12	1.936	Vg	− 44	G	− 86	G
		13	1.922	E+	− 22	G	− 53	G
		14	1.954	E	− 58	Vg	− 69	Vg
		15	1.965	E−	− 34	G+	− 46	G
		16	1.951	E+	− 53	G−	− 73	G−
?		19	1.921	Exceptional humidity	− 18	Vg	− 36	Vg−
		20	1.936	E	− 19	Vg−	− 65	Vg
		21	1.960	E	− 62	G+	− 90	G+

TABLE 10.—*Observations of the year 1914* (Continued)

Date	Solar Con-stant	Grade	Solar Contrast			
			All λs	Grade	Omitting λ= .3737μ λ=1 008 μ	Grade
Sept. 22	1.915	Vg+	− 24	G	− 58	G
23	1.985	E	....	....	....	....
28	1.941	E+	− 48	G+	− 98	G+
Oct. 2	1.956	G−	....	....	....	....
? 4	1.939	E(?)	− 48	G	− 44	G
9	1.947	E	− 17	G−	− 24	G−
10	1.961	G	....	....	....	....
11	1.940	E	....	....	....	....
12	1.951	Vg+	....	....	....	....
13	1.946	E+	....	....	....	....
14	1.933	Vg	....	....	....	....
15	1.973	Vg+	....	....	....	....
16	1.946	Vg	....	....	....	....
18	1.960	E−	....	....	....	....
19	1.949	E	....	....	....	....
20	1.955	E+	....	....	....	....

prior to and succeeding September 23, respectively, we find as follows:

TABLE 11.—*Comparison of results before and after Sept. 23, 1913*

Observation Period	Solar-constant numbers		Solar-contrast numbers	
	Above 1.895 cal.	Below 1.895 cal.	Positive	Negative
Sept. 9 to Sept. 22	11	0	10	1
Sept. 24 to Nov. 9	8	24	15	17

Not only was this date critical with regard to solar-contrast and solar-constant values, but a marked change in the distribution and total amount of the water vapor in the atmosphere took place. The values of precipitable water in the atmosphere determined by Fowle's method were far above the normal until September 23, and from then to the end of the period of observation generally about normal or a little below. A similar change is indicated, but not in so great a degree, by the observations with the wet and dry thermometers. The temperature also fell at the same critical time. These changes are shown by the following table (12):

TABLE 12.—*Mean Mt. Wilson precipitable water, pressure of aqueous vapor and dry bulb temperatures during observing periods*

Observation Period	Precipitable Water	Pressure Aqueous Vapor	Temperatures
	mm	*mm*	*c*
Sept. 9 to Sept. 22...........	10.5	5.52	23.0
Sept. 24 to Oct. 7............	5.2	3.52	13.6
Oct. 8 to Oct 21	5.2	3.22	15.4
Oct. 21 to Nov. 9.............	5.0	4.30	17.1

It is to be regretted that at this very time, when all these changes were occurring, we made a radical change in the observing apparatus, for on September 23 we substituted for the bolometer which had been in use on Mt. Wilson since 1905 the bolometer which was employed in the Mt. Whitney and Algerian expeditions. We made this change because the Algerian bolometer was less subject to prejudicial influence from wind. But had we known how many other changes were occurring at the same time, it is certain that we would not have made a change of apparatus too. We have thought it necessary, on account of this, to investigate very thoroughly the merit of the solar-constant determinations succeeding September 23, and we find the following facts to verify their accuracy.

First, empirical determinations of the solar constant from pyrheliometry and psychrometry at Arequipa in Peru [1] indicate that the values subsequent to September 23 were lower than those prior to that date, and by about the same amount as do the Mt. Wilson observations. Second, we have determined an empirical formula for the solar constant from Mt. Wilson pyrheliometry and psychrometry. This formula has been worked out solely by the use of observations of 1910, 1911, and 1912, and does not depend in any way on bolometric observations of 1913, except that we chose days of the earlier years for which the precipitable water had values comparable with those of 1913. This formula gives the same change in solar-constant values at about September 23 that is indicated by the bolometric work itself. Third, we felt a suspicion that the determinations of the water-vapor absorption in the bolographic work might be interfered with by some change in the excellence of the definition of the spectroscope. Instead of employing with the usual constants Mr. Fowle's method of determining these absorption effects in the bolographs, from measurements on the band $\rho\sigma\tau$, the areas of the absorption bands were actually measured on many plates, just as we did formerly in all our bolographic reductions, and we thus determined new constants applicable to the last part of 1913. But no substantial change occurred in our conclusion regarding the fall of the solar-constant values on and after September 24.

We therefore see no reason to doubt that the days from September 9 to the end of 1913 are as homogeneous as any other series of our measurements, and we believe that the great drop of the solar-constant which is indicated to have occurred just after September 23 is a real one.

[1] See "Arequipa Pyrheliometry," Smith. Misc. Coll., Vol. 65, No. 9.

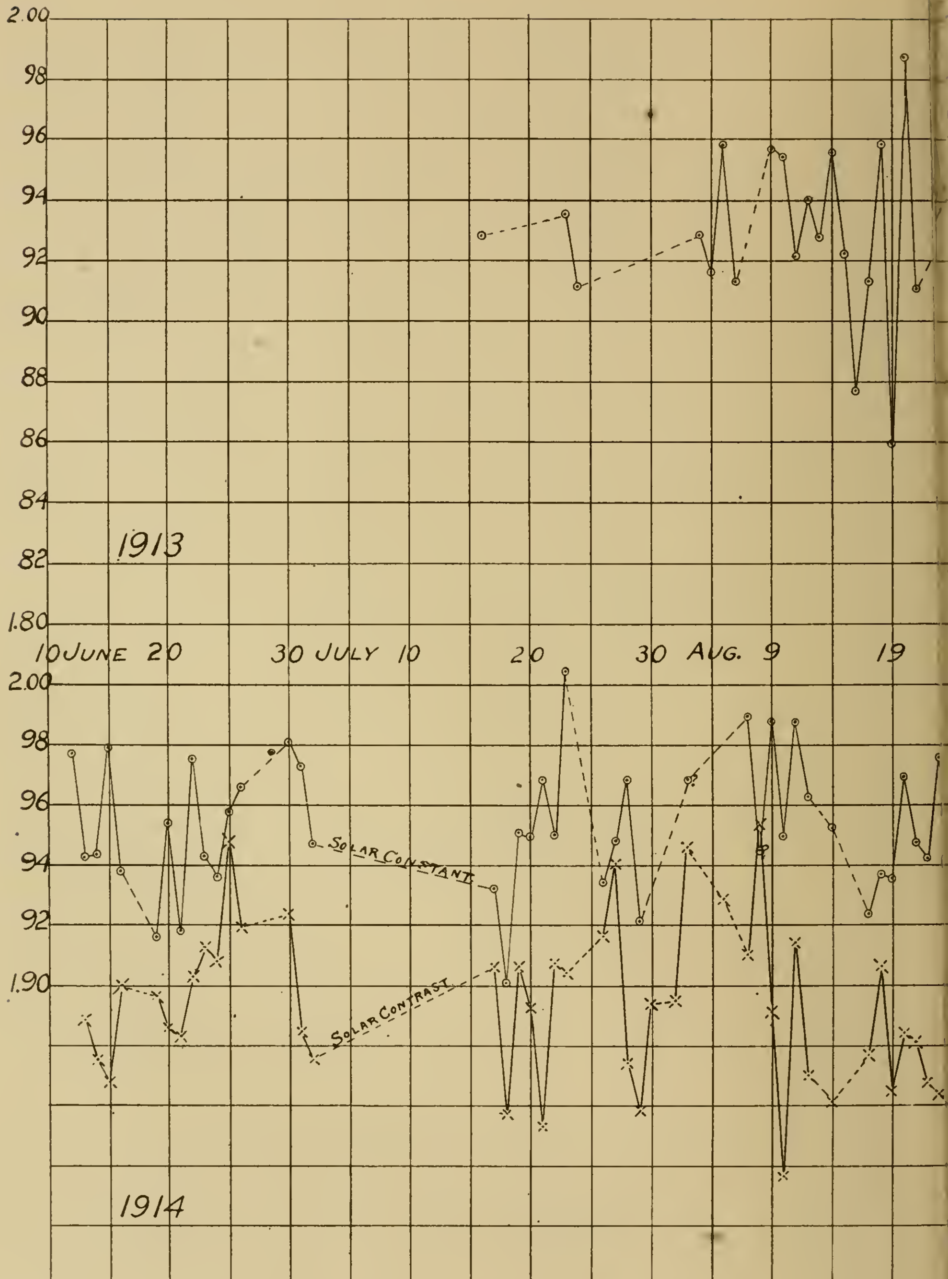
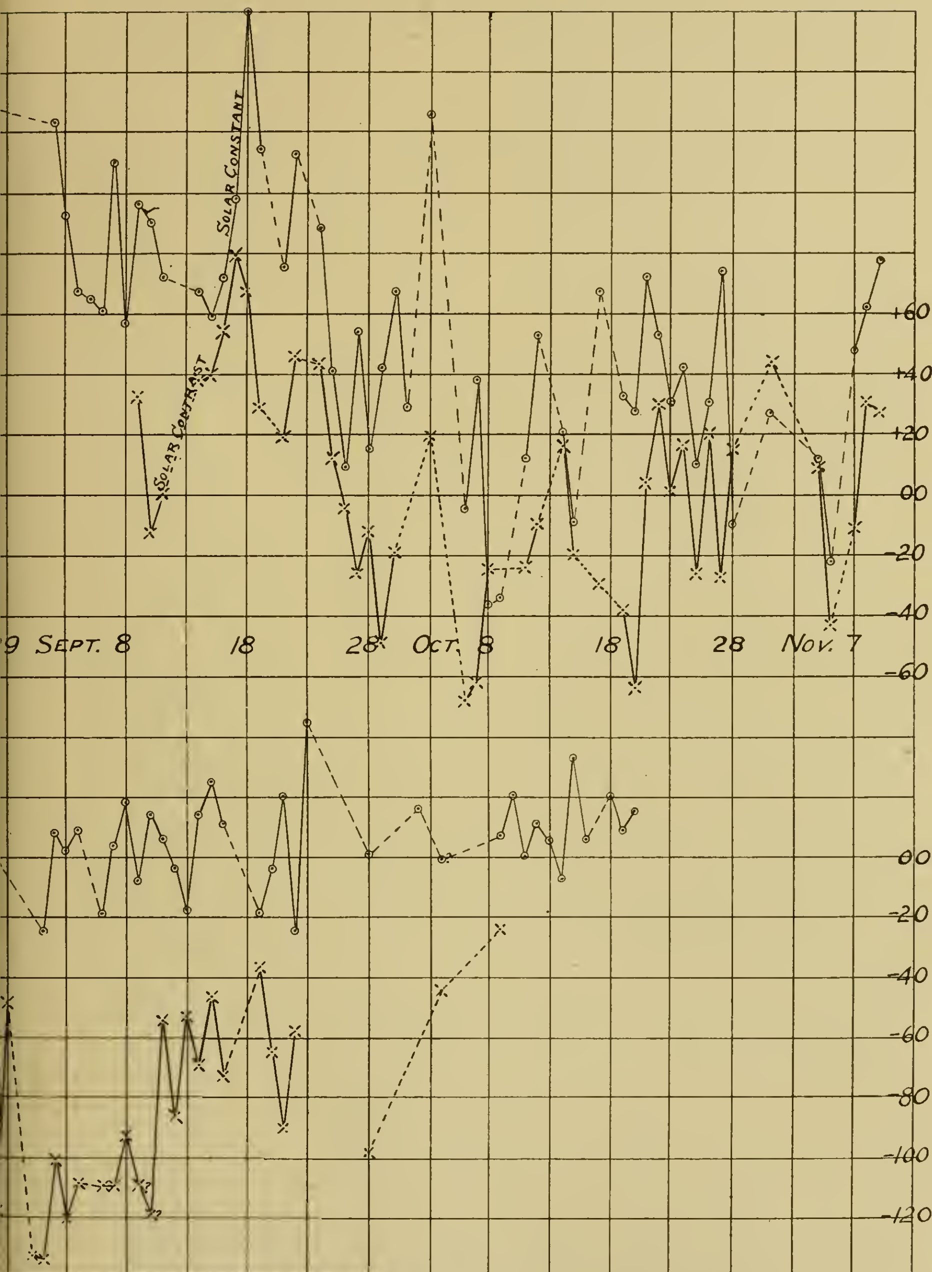
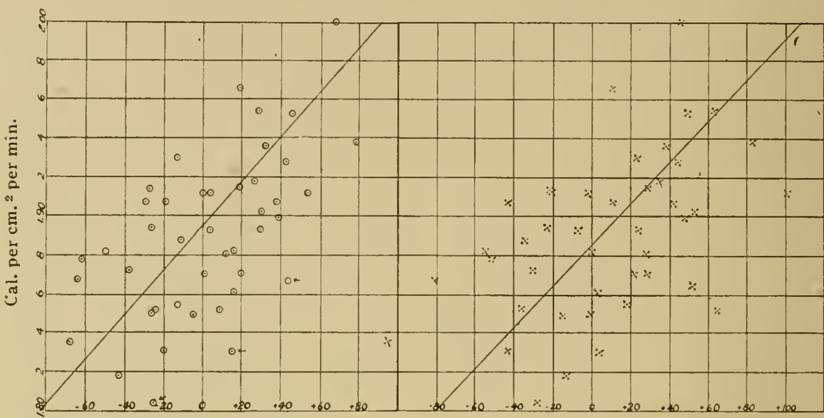


FIG. 7.—Variability of the sun in the years 1913 and 1914. Circles represe



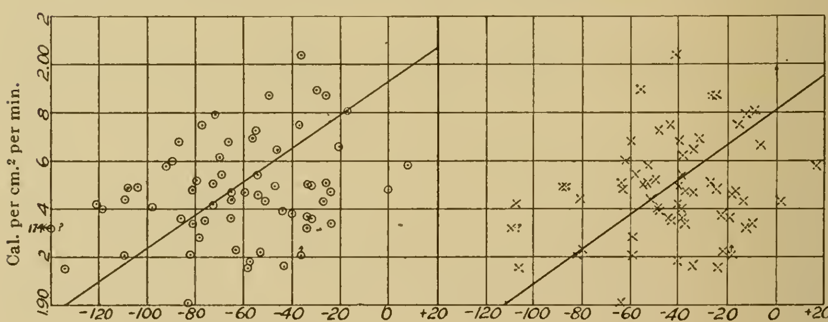
ily solar-constant values. Crosses represent daily solar-contrast numbers

Figures 7, 8, and 9 show the solar-constant values and the solar-contrast values of 1913 and 1914 plotted as functions of the time and also as functions of each other. From figures 8 and 9 the



Contrast numbers.

FIG. 8.—Variations of solar constant and solar contrast in 1913[1]



Contrast numbers

FIG. 9.—Variations of solar constant and solar contrast in 1914[1]

increase of the solar-constant values by 1 per cent corresponds to an increase of solar-contrast values of 1913 and 1914 as follows:

Year	Change of Solar Constant	Change of Solar-Contrast Number
1913:	+1 per cent :	+17
1914:	+1 per cent :	+29

[1] Circles represent simple mean contrast numbers, omitting wave lengths 0.3737 and 1.008μ. Crosses represent weighted means of all wave lengths. Arrows indicate that a certain probability exists that the points marked should be moved in the direction shown.

The factors of correlation (omitting $\lambda=0.3737$ and 1.008) are as follows:

$$1913:\ r=0.601\pm0.067$$
$$1914:\ r=0.213\pm0.080$$

The reader will recall that the method of deriving these contrast values is such that algebraically increased contrast numbers correspond really with decreased solar contrast.

Let us now restate these logarithmic results in ordinary terms. Imagine that the spectroscope was dispensed with, and that the contrast of brightness was determined for the solar radiation as a whole, and not for particular wave lengths. Let us further suppose that all the drift curves so obtained during 1913 and 1914 were reduced to unit intensity at the center of the solar disk. We should then find, still confining ourselves to a consideration of the short-period variations, that in 1913 an increase of 1 per cent in the solar constant of radiation corresponds with a decrease of the ordinate of the drift curve at 92 per cent out on the radius of 0.35 per cent.

The results of 1914 indicate a larger ratio of change of contrast compared to change of solar constant than those of 1913. This may be possibly a real difference caused in the sun, but it should be noted that the range of variation in 1914 was so small that the error of the determination of this ratio is much larger than it was in 1913. It is probable that the numerous values which will be found from observations of 1915 will enable us to give a more satisfactory conclusion on this point.

We now come to the consideration of the question why the ratio of change of contrast from year to year with respect to change of solar constant differs in its sign from the ratio of change of contrast from day to day with reference to the corresponding change in the solar constant. As stated above in years when the solar constant was high the solar contrast was greater than usual, while, as just stated, during 1913 and 1914 short-period temporary increases of the solar constant of radiation were attended by decrease in the solar contrast. This indicates two causes at work in the sun. We are inclined to suggest the following hypothesis.

Attending the long-period changes of solar activity indicated by prevalence of sun spots, faculæ, prominences, etc., there is, it may be assumed, a change of the effective solar radiating temperature. Higher effective radiating temperatures should prevail at times when increased solar activity brings faster the hot material to the surface to radiate. It is clear that if the solar temperature was zero, the contrast of brightness would be zero, and the higher the temperature, the higher the contrast and the higher the solar constant of radiation.

Turning now to a consideration of the short-period changes, it was the older view that the difference of brightness between the center and the edge of the solar disk was produced by an absorbing atmosphere or envelope. We prefer, however, to regard the decrease of brightness toward the edge of the sun as mainly a consequence of decreased effective temperature of the radiating surface. We suppose that the depth to which one looks at the center of the solar disk is very considerable, and that the limit of it is reached when the molecular scattering cuts off the ray. The same quantity of molecular scattering will be found in a very much less radial depth near the edge of the sun, because the line of sight there is oblique, so that a comparatively thin layer viewed obliquely will furnish the necessary number of molecules to cut off the radiation.

But while holding these views, we admit that the escape of radiation depends also on the transparency of the outer solar envelope. If now the transparency of this envelope increases, the solar constant of radiation must increase also; but the percentage increase of the intensity of solar rays will be greatest near the edge of the sun, where the path in these imperfectly transparent layers is longest. Thus it would happen that increased transparency of the outer solar layers would produce at the same time increased values of the solar constant of radiation and decreased contrast of brightness between the center and edge of the sun.

The two contrary effects we have been discussing may sometimes neutralize each other, but it is not to be expected that they will exactly neutralize each other for all wave lengths. Hence, we may find, with very high values of the solar constant of radiation, a contrast almost exactly, on the whole, equal to that which prevailed in the mean in the year 1913, but the different wave lengths may differ slightly in their behavior, some indicating a greater contrast than the mean of 1913, others less.

In our former publications on this subject (see Vols. 2 and 3 of the Annals) we have already considered the possibility of short-period irregular fluctuations of contrast and arrived at opposite conclusions from the two sets of data then published. Both sets of data, however, are so far inferior in accuracy to those we are now publishing that we withdraw altogether those former conclusions in favor of the ones which we now advance.

SUMMARY

We have repeated at Mt. Wilson, in 1913 and 1914, with improved apparatus, the determinations of the distribution of brightness along the solar diameter described in Vols. 2 and 3 of the Annals of the Astrophysical Observatory. More than 40 days' determinations were secured in 1913 and more than 80 in 1914.

The results agree closely with those obtained at Washington in 1907 for all wave lengths for which a comparison is possible.

There are, however, slight but significant differences between the mean results of different years. Taking 1913 as the standard year, greater contrast of brightness between the sun's center and edge was found in 1907 and 1914 than in 1913. We incline to connect these changes with solar activity, greater contrast prevailing along with greater solar radiation at times of high solar activity.

Besides these long-period changes there appear to be small changes of contrast from day to day, correlated with the changes of the solar radiation heretofore discovered by us. For this type of changes increased contrast is associated with decreased solar radiation.

We are thus led to consider two causes of change existing in the sun. One, going with increased solar activity, we regard to be increased effective solar temperature, which naturally produces increased radiation and increased contrast. The other, altering from day to day, we regard to be increased transparency of the outer solar envelopes, which naturally produces increased radiation but decreased contrast.

All these changes are greater for shorter wave lengths.

APPENDIX

A correction.—In a recent letter to Mr. Abbot, Professor F. H. Bigelow has called attention to the misrepresentation of his views in foot-note 1 on page 28 of our paper "New Evidence on the Intensity of Solar Radiation Outside the Atmosphere."[1] Professor Bigelow states that he has carefully avoided using Wien's displacement law as the basis of an estimate of the solar temperature. He has used instead a consideration of the general form of the solar spectrum energy curve.

We regret having made this error. The note as it now stands seems to us to represent fairly the position of Mr. F. W. Very.[2] In order to adapt it to Professor Bigelow's position we should require to make the following changes:

In lines 4 and 5 of our note strike out the words "they determine the wave length of maximum energy, and from it."

In line 16 strike out the words "position of the maximum of energy" and substitute the words "form of the solar energy curve outside the atmosphere."

In lines 26 and 27 strike out the words "position of maximum energy in its spectrum," and substitute the words "form of its energy spectrum distribution."

Strike out lines 32 to 41, inclusive.

As thus modified the main thesis of our note is as follows: Estimates of the solar constant of radiation based on estimates of the solar temperature involve: (1) The extrapolation of radiation laws thousands of degrees beyond the temperature to which they have been experimentally verified; (2) the assumption that the sun radiates like a "black body" in the face of experimental evidence that it does not; (3) dependence on the accuracy of the determination of the form of the solar-spectrum energy curve outside our atmosphere, which is a result of difficult and uncertain investigation. In short such estimates are not determinations of the solar constant, but are merely elaborate tissues of speculation. On the other hand we base our determination on sound and simple theory checked and verified at every point and applied nearly a thousand times under the most diverse circumstances, with closely agreeing results.

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[1] New Evidence on the Intensity of Solar Radiation Outside the Atmosphere. By C. G. Abbot, F. E. Fowle, and L. B. Aldrich. Smith. Misc. Coll., Vol. 65, No. 4, June 19, 1915.

[2] Am. Jour. Sci., 4th Ser., Vol. 36, 609, 1913.

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PHONETIC TRANSCRIPTION OF INDIAN LANGUAGES

REPORT OF COMMITTEE OF AMERICAN ANTHROPOLOGICAL ASSOCIATION

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PHONETIC TRANSCRIPTION OF INDIAN LANGUAGES

REPORT OF COMMITTEE OF AMERICAN ANTHROPOLOGICAL ASSOCIATION

The following report is based on several meetings held in New York in January, 1913, April and May, 1914, and January, 1915, by a quorum of the committee of the American Anthropological Association, charged with the drawing up of a phonetic system for transcribing Indian languages, consisting of F. Boas, Chairman, P. E. Goddard, and E. Sapir, Secretary, further on correspondence with the remaining member of the committee, A. L. Kroeber.

GENERAL PRINCIPLES

It is essential that each simple sound be consistently represented by the same symbol.

These symbols, as far as possible, should be those associated in past use with sounds similar to the ones they are chosen to represent.

For the sake of appearance and to avoid distracting the attention of the reader, mixture of fonts and unusual characters should be avoided unless indispensable.

In texts accompanied by interlinear translations all characters and marks of punctuation not strictly phonetic, such as capitals, commas, and periods, should be eliminated excepting, however, symbols introduced for facilitating grammatical analysis.

In order to reduce the cost of publishing texts, only such diacritical marks and accents as are essential for adequate transcription should be employed.

Where a uniform and fairly adequate system has already been employed in the recording of a particular language, it will usually be best to continue its use in further work with that language to facilitate comparisons and to avoid confusion. For purposes necessitating the comparison of different languages and requiring phonetic accuracy the more rigid system should be applied.

The committee considers that the needs to be met by a phonetic system for transcribing American languages are several. For the specialist who wishes to analyze and discuss the sounds of a language a very considerable number of symbols and a variety of modifying accessories in the form of diacritical marks and accents are necessary.

Such an elaborate system proves too complicated for students who are less thoroughly trained in phonetics and therefore less discriminating in their perception of sounds. For the recording and printing of large bodies of texts, a too elaborate and detailed system is expensive and often impracticable. The main objects to be secured in a large series of texts are a full vocabulary and ample illustrations from which the range in the meanings of words and phrases can be deduced. It is not necessary that words recurring many times in such texts be transcribed each time by symbols indicating all their phonetic features. It is, however, necessary that each phonetic unit be unmistakably distinguished from all others.

The committee has been led, therefore, to submit a comparatively simple system of transcription adapted to the ordinary purposes of recording and printing texts. To provide for the recording and discussing of the complex and varied phonetic phenomena encountered in American linguistics, a fairly detailed and comprehensive system has been provided. It is necessarily of such character that it can be employed only by a specialist in phonetics. By its aid it is to be hoped that the phonetic features of all of the extant North American languages may be discussed and compared.

A. RULES FOR THE SIMPLER SYSTEM

I. VOWELS

1. *Quality.*—It is important that each vowel having a distinct quality or timbre be represented by a definite character. Since the Latin alphabet has only five vowel characters, it will usually be necessary to supply others. For a full system of vowels the use of Greek characters is recommended. Since these are not always available and present other difficulties in their use, Roman characters with a diacritical mark above the letter, particularly macron (*ā*), may also be utilized. The following symbols are recommended:

a, as in English *father*.	α, as in English *but*.
ä, as in English *hat*.	
e, as in English *fate*.	ε, as in English *met*.
i, as in English *pique*.	ι, as in English *pin*.
o, as in English *note*.	ɔ, approximately as in English *not* (better as *o* in German *voll*).
u, as in English *rule*.	υ, as in English *put*.

These values correspond exactly to the recommendations of B (see p. 9). If it is desired to avoid Greek characters, *ɔ*, and *ä*, the following alternate system is recommended:

a, as in English *father.*	á, as in English *but.*
ă, as in English *hat.*	
ē, as in English *fate.*	e, as in English *met.*
ī, as in English *pique.*	i, as in English *pin.*
ō, as in English *note.*	o, as in English *not* (better as *o* in German *voll*).
ū, as in English *rule.*	u, as in English *put.*

For vowel qualities due to mixed positions, such as the umlauted *o* and *u* in German, two dots above the letter are recommended (*ö*).

The obscure vowel, found for instance in English *a* of *idea,* may be rendered by *ə* (turned *e*).

Vowels of any timbre as determined by the shape of the mouth cavity may be further modified by the addition of the resonance chamber of the nose. Such nasal quality in vowels (as in the French nasalized vowels) may be indicated by adding beneath the letter a hook turning to the right (*ą*).

It is to be understood that if only one of the qualities usually associated with a roman letter occurs in the language in question, that letter is to be used without a diacritical mark (similarly, *o* is to be used instead of turned *c* (*ɔ*) if there is only an open *o* in the language).

2. *Duration.*—The duration or quantity of vowel sounds, often an essential matter, may be indicated by placing a mark after the vowel. It is recommended that a turned period (*a*·) or a colon (*a*:) be used for vowels long in duration, and a breve (*a*˘) for those unusually short. It is important that these marks be used after the vowels to avoid confusion between duration and quality or timbre, since they are not necessarily connected, as is generally assumed to be the case in English.

3. *Pitch.*—In certain languages vowel sounds are distinguished from each other by definite variations in pitch. When such variations of pitch are essential, the acute accent over the vowel (*á*) should be used for high pitch, and grave (*à*) for low pitch, the circumflex (*â*) for falling pitch, and the inverted circumflex (*ǎ*) for rising pitch. When it becomes necessary in the recording of a language to use these accents to represent pitch, similar diacritical marks for quality over the vowels are best avoided.

4. *Weak vowels.*—Vowels which are of full duration and strength but not voiced, such as whispered vowels, may well be represented by small capitals. When vowels are slighted in the force of enunciation, but are voiced, exponent vowels should be used (*w*ⁱ).

5. *Stress.*—Where variations in stress are prominent they may be indicated by placing the acute accent (ʹ) after the vowel. Secondary

accents may be indicated by the grave accent (`). It should be remembered that stress accent is exceptionally marked in English and that it is less pronounced and plays a less important rôle in many American languages. Unless the indication of stress is necessary to distinguish one word from another, it need not be printed each time a word appears in texts.

II. CONSONANTS

1. *Stops.*—The consonants that are usually known as stops, those in which the stream of breath is completely checked for a moment by a closure of the mouth passage, are classified in various ways.

Various organs or parts of organs are employed: both lips, the tip of the tongue against the teeth or palate, the back of the tongue against the palate, the back of the tongue against the velum. The sounds resulting from the release of the contact of these various mouth parts have well-known and distinct qualities, such as the bilabial sounds of *p* and *b*, the dental sounds of *t* and *d*, the palatal sounds of *k* and *g*, and the velar sounds, not found, however, in English.

Various modifications of these stops uttered in the four positions are recognized, and may be grouped in definite series. If the vocal cords are not closed and are not in operation during the uttering of the consonant, it is known as a surd. If the vocal cords are closed and vibrating during the entire time occupied in articulating the sound, it is a sonant. In many Indian languages sounds occur that to the English ear appear now a surd and now a sonant. These stops are called intermediates, and should be consistently represented by definite symbols. Small capitals of the sonant symbols are recommended for these. The ordinary *b, d, g,* may be used when only intermediate surds and not sonants occur. Surd consonants are frequently followed by a strong expiration of breath, and are called aspirated in consequence. Unaspirated surds are usually difficult to distinguish from intermediates.

Many Indian languages have a series of stopped consonants quite foreign to European ears. In addition to and during the usual closure of the mouth characteristic of the particular sound, there is a closure of the glottis. The air thus confined in the mouth is compressed and escapes with abruptness when the stop is released. These glottalized consonants may be indicated by following apostrophe (*p*').

The following system of recording the stopped consonants is recommended:

	Sonant	Intermediate	Surd	Surd aspirated	Glottalized
Bilabial	b	ʙ	p	pʻ	p'
Dental	d	ᴅ	t	tʻ	t'
Palatal	g	ɢ	k	kʻ	k'
Velar	g̣	ɢ̣	q or ḳ	qʻ or ḳʻ	q' or ḳ'

Labialized and palatalized palatals and velars may be indicated respectively by adding *y* and *w* to the consonantal characters. Thus *gy* represents palatalized *g*, *ky'* glottalized palatalized *k*, and *qw* labialized velar *k*.

2. *Nasals.*—Sounds having closures at the same points and involving the same mouth parts may be uttered with the passage through the nose unimpeded. They may be continuously sounded through the nose or only released through the nose by a lowering of the velum. The following characters will ordinarily be found to be adequate: bilabial, *m;* dental, *n;* palatal, *ñ;* velar, *ṇ̃.*

3. *Spirants.*—Consonants of another sort derive their chief distinctive qualities from the agitation of the mouth parts which by their approximation at certain points form definite strictures in the mouth passage. They are called spirants or fricatives. They fall generally into the same classes and series obtaining for stop consonants. When considered as to the organs involved in their production they are bilabial, labio-dentals (lower lip against the upper teeth), interdentals (tip of the tongue on the points of the upper teeth), dental sibilants (the tip of the tongue just back of the upper teeth), palatal sibilants (the fore part of the tongue with its tip turned down approaching the fore part of the palate), palatals (the back of the tongue approaching the palate), velar (the back of the tongue approaching the velum).

These spirant sounds may be and usually are both surd and sonant for each position. Less frequently they are glottally affected. The following characters are recommended:

	Sonant	Surd	Glottalized
Bilabial[1] / Labio-dental	v	f	f'
Interdental	ϑ	θ	θ'
Dental sibilant	z	s	s'
Prepalatal sibilant	j	c	c'
Palatal	γ	x	x'
Velar	γ̣	x̣	x̣'

4. *Affricatives.*—A series of sounds closely related to the spirants are generally called affricatives. Initially they are like stops, except

[1] Both forms are not likely to occur in the same language and *v* and *f* may be used for either. Proper definition should be given.

that they are released through the mouth positions of the corresponding spirants into which they immediately merge. It has been customary to write them with two letters, as if they were compound sounds. Were sufficient characters available, it would be better to make use of a single symbol. For practical reasons it is recommended that the following combinations be used:

	Sonant	Surd	Glottalized
Bilabial	bv	pf	pf'
Interdental	dϑ	tθ	tθ'
Dental	dz	ts	ts'
Prepalatal	dj	tc	tc'
Palatal	gγ	kx	kx'
Velar	g̣γ̣	qx or ḳx	qx' or ḳx'

5. *Semivowels.*—Closely associated with the bilabial and palatal spirants are two sounds produced with less evident agitation of the approximated surfaces. These are the semivowels, *w* and *y*. They are frequently voiceless, when a small capital ʏ may be used and an italic *w*, since small capital is not sufficiently distinct from lower case *w*.

6. *Trills.*—At various points where the mouth passage is constricted a mouth part may be bodily vibrated. When the tip of the tongue is turned up toward the palate and allowed to vibrate in a current of air, *r*-like sounds are produced. The tip of the velum, the uvula, may be caused to vibrate in a similar manner, resulting in the uvular *r* heard in some parts of Germany and France. The following symbols are recommended: tongue tip, sonant *r;* surd ʀ (small capital) ; uvular, sonant *ṛ;* surd ʀ̣.

The surd velar *r* is hardly to be distinguished from the surd velar spirant, since the uvula may vibrate in the surd spirant also.

7. *Laterals.*—The consonant sounds so far discussed are occasioned by the release of stops, or by narrow passages in the middle line in the mouth. There are other sounds made at the side of the mouth between the teeth and the edge of the tongue. The best known is an *l* sound found in English and all European languages. It is a sonant and is given a part of its quality at least by a movement of the side of the tongue similar to that of the tip of the tongue in the *r* sounds.

In many of the American languages there are lateral spirants made between the side of the tongue and the upper teeth. The spirant quality is pronounced only when surd. The sonant spirants approximate the "liquid" or trilled *l* of English. These lateral spirants may be preceded by a closure forming an affricative similar to the medial affricatives. The symbols recommended are the following:

	Sonant	Surd	Glottalized
Lateral trill	l		
Lateral spirant		ł or ʟ[1]	ł' or ʟ'
Lateral affricative	dl	tł or tʟ	tł' or tʟ'

8. *Glottal.*—In American languages a peculiar hiatus is frequently found between vowels, and a similar cessation of the breath precedes and follows vowels. This closure is of the glottis, and is in all probability caused by the folding of the epiglottis over the glottis, as is the case in swallowing. It is recommended that the apostrophe (') be used. As noted above, this glottal closure also occurs with glottalized consonants.

A glottal spirant, evidently caused by the agitation of the relaxed vocal cords during the forcible expiration of the breath, does not differ particularly from the *h* of English. Strong aspiration should be indicated by *h*, weak aspiration by breathing (ʻ).

B. RULES FOR THE MORE COMPLETE SYSTEM

DIACRITICAL MARKS USED INDEPENDENTLY

1. As a sign for long vowel or consonant, it is recommended that the inverted period (·) be used after a letter. For more than ordinary length, a colon (:) may be used after a letter. Thus, *a*· would denote long *a*; *a*: would denote excessively long *a*. Excessive length of non-grammatical significance, such as is often made use of for rhetorical purposes, may be expressed by plus (+). Characters without explicit signs of length are to be considered as short. Excessive shortness of vowels is to be indicated, where it seems advisable to do so, by a small superior breve (˘) immediately after the letter. It is to be recommended that it be printed small and close to the preceding letter, so as not to sprawl the word.

2. Main and secondary stress accents are to be indicated by acute (´) and grave (` ) respectively, which are to be placed after the vowel or syllabic consonant affected. Where an accent and a mark of length apply to the same vowel, it is recommended that the two symbols be united into a single symbol, so as to avoid sprawling the word. Thus, ´· ` · and `·.

3. A period on the line is to be used between characters normally forming diphthongs or affricatives, when it is desired to indicate that each of the sounds represented has its own (syllabic) value. Thus,

[1] Small capital ʟ.

a.i is non-diphthongal *a* plus *i, ai* being the corresponding diphthong. Similarly, *t.s* is the non-affricative *t* plus *s*, corresponding to the affricative *ts*.

4. Hyphens should not be used for phonetic purposes. They may, however, be used to indicate morphological analysis. Where, in continuous text, it seems advisable to indicate somewhat loosely affixed elements (prefixes and suffixes not thoroughly welded with stem) by means of hyphens, double hyphens may be used at the ends of lines to indicate a break in the word not meant to be of morphologic significance.

VOWELS

5. Pitch accent, where indicated at all, should be expressed by means of diacritical marks over the vowel. These diacritical marks are also to be used over sonant continuants (such as *l, m, n, w, z*) where these bear the pitch accent. The fundamental difference between the system of pitch accent here recommended (the same as has been fully described by Father W. Schmidt in various articles in "Anthropos") and that of indicating stress is that the diacritical marks for the former stand immediately above the letter, whereas those for the latter follow. High pitch is to be indicated by an acute accent (´) over the letter; low pitch is to be indicated by a grave accent (`) over the letter; falling accent from high to low is to be indicated by a combination of the acute and the grave, i. e., by the circumflex accent (ˆ); rising accent from low to high is to be indicated by a combination of the grave and acute accents, i. e., by the inverted circumflex accent (ˇ). When it is necessary to indicate middle pitch, this may be done by a vertical line above the vowel (ˈ).

6. Voiceless vowels, that is, aspiration with definite vocalic timbre, should be indicated by means of small capitals of corresponding vowels.

7. Nasalization should be expressed by means of a hook, turned to the right, placed under the vowel or voiced continuant. Thus, nasalized *a* is indicated by *ą*. This device may also be employed to indicate semi-nasalized consonants. Thus, *b̨* would indicate semi-nasalized *b*, acoustically midway between *b* and *m*.

8. What might be rather vaguely termed subsidiary or weakly articulated vowels of various sorts are to be expressed by means of superior or inferior characters. Rearticulations (such as often occur in Indian languages, e. g., *a·ᵃ* in Takelma), vocalic glides, murmured or echo vowels pronounced with feeble energy, yet not

entirely voiceless (such as often occur in America after glottal stops), vocalic resonance of preceding consonants, and whispered vowels are all to be expressed by superior or inferior vowels. The exact usage of superior or inferior vowels should be carefully explained in the key in every case, so as to avoid possible confusion. If it is desired to distinguish between vocalic timbres and weakly articulated voiceless vowels on the one hand and vocalic glides and weakly articulated voiced vowels on the other hand, superior vowels (^{a}) may be used for the former, inferior vowels ($_a$) for the latter.

9. The representation of vocalic qualities here recommended attempts to combine, as far as possible, the requirements of ordinary usage with the demands of a consistent scientific system. The phonetic analysis serving as a basis of the system has been taken from Sweet's "Primer of Phonetics."

The five vocalic symbols serving as a starting point in this system are: *a,* pronounced as in German *Mann; e,* pronounced as in French *été; i,* pronounced as in French *fini; o,* pronounced as in German *so;* and *u,* pronounced as in German *gut.*

Roughly speaking, the Greek forms of these letters indicate the open (Sweet's wide) forms of the same sounds. For Greek omikron, which would be easily confused with *o,* inverted *c* (ɔ) is substituted. Thus, upsilon (υ) represents *u* of English *full;* turned *c* (ɔ) represents *o* of German *voll;* epsilon (ϵ) represents *e* of English *met;* iota (ι) represents *i* of English *it;* alpha (α) represents *u* of English *but.* According to Sweet's phonetic analysis, *a* is the wide form of α, but general usage demands the retention of *a* for the value here recommended. The principle of simplicity (see last paragraph of A, I, 1) will, in most cases, involve considerable simplification of this system. Thus, where but one form of *i*-vowel is in use, the simple symbol *i* will be used for either the close or open variety.

Rounded forms of front vowels are to be indicated by the umlaut (¨) over the corresponding rounded back vowels. Thus, *ü* indicates the vowel of German *kühl* or French *lune; ö* represents the vowel of German *schön* or French *bleu;* ϋ represents the first vowel of German *Mütze;* ɔ̈ represents the first vowel of German *Götter.*

The use of the umlaut may be extended to indicate high-back-unrounded vowels, the corresponding high-front-unrounded vowels being taken as points of departure. Thus, ï and ϊ represent the high-back-unrounded representatives of *i* and ι, in other words, the unrounded forms of *u* and υ. Both of these sounds occur, for example, in Shoshonean.

A natural extension of the system, as developed up to this point, is the use of a single dot over a vowel to indicate articulations midway between front and back, that is, all vowels belonging to Sweet's "mixed" category. Thus, *u̇* represents the vowel acoustically midway between *u* and *ü*, an example of which is *u̇* of Swedish *hus.* To avoid confusion with ordinary *i*, the superior dot of the *i* of this series should be printed a little to the left (*ı̇*).

For the low-back-narrow-rounded vowel (the English *aw* of *law*), omega (ω) may be used; the corresponding low-front-narrow-rounded vowel, the *eu* of French *peur*, is indicated by ω̈, which thus falls in line with *ü* and *ö*. The vowel midway in position between ω and ω̈ is ω̇.

For the other vowels of Sweet's scheme no specific symbols are recommended as yet.

An obscure vowel of undefined quality may be represented by turned *e*, i. e., *ə*.

CONSONANTS

10. Small capitals are to be regularly used to indicate voiceless forms of consonants ordinarily voiced (lateral continuants, trilled consonants, nasal continuants). Thus, ʟ, ᴍ, ɴ, and ʀ indicate voiceless *l, m, n,* and *r*, respectively. In the case of stops and spirants, where distinct characters are used for corresponding voiced and voiceless forms, the small capital is to be used to indicate a surd-sonant intermediate (intermediate consonants here include voiceless consonants pronounced with stress ordinarily characteristic of sonant consonants, also surd consonants that are sonant at the moment of release). Thus, ɢ indicates the intermediate between sonant *g* and surd *k*; similarly, ᴢ (slightly higher than lower case *z*) indicates the consonant intermediate between *s* and *z*, equivalent to J. O. Dorsey's turned *s*.

Weakly articulated or barely audible consonants, also consonantic glides, are to be represented by superior letters; thus, Malecite ^{p}m– and Wyandot –^{n}d–.

11. A point beneath the consonant is regularly used to indicate a point of articulation posterior to the standard point of articulation adopted for the simple character. Thus, *ḍ* represents a *d* pronounced with the tip of the tongue articulating against the palate back of the alveolar ridge, that is, the cerebral *d*. Similarly, *ḳ* may be used to indicate a velar *k*.

A semicircle beneath the letter (̫) is regularly used to indicate a point of articulation in front of the standard one adopted for the sound indicated by the simple character. Thus, *ṱ* represents dental *t*, as in Slavic; *g̭* indicates prepalatal *g*.

12. Four main types of articulation are recognized for the stopped and affricative consonants of each position; the sonant, the surd, the intermediate (indicated by small capital forms of letters representing sonant stops), and aspirated surd (represented by the sign of aspiration (ʻ) following the symbol for voiceless surd stop). Other types of consonants involving synchronous articulations will be discussed below.

13. Three main positions are recognized for stopped consonants: the bilabial, the linguo-dental or linguo-alveolar, and the linguo-palatal or guttural. The sonant of the first position is indicated by *b*, its corresponding surd by *p*, intermediate by B, aspirated surd by *p*ʻ. The voiced nasal continuant of this series is represented by *m*, its voiceless form by *M*; the semi-nasal stop may be indicated by *b̨*.

14. In parallel fashion, *d*, *t*, D, and *t*ʻ indicate corresponding consonants of alveolar position (the tip or blade of the tongue and the alveolar ridge are here taken as the standard point of articulation for the linguo-dental and linguo-alveolar consonants). *ḓ*, *ṱ*, Ḓ, *ṱ*ʻ indicate the corresponding sounds for the true dental series. *ḍ*, *ṭ*, Ḍ, and *ṭ*ʻ indicate the corresponding sounds for the cerebral series.

The voiced and unvoiced nasals for the three positions defined above are respectively *n*, N; *ṋ*, Ṋ; *ṇ*, Ṇ.

15. Between the alveolar and guttural consonants is a set of dorsal consonants, produced by the upper surface of the tongue articulating against the forward part of the palate. Such consonants are indicated by Greek letters. The four stops parallel to those enumerated for the preceding positions are δ, τ, Δ, and τʻ; the corresponding nasals are ν and small capital ν (inasmuch as capital ν is identical with English *N*, it is recommended that the lower case ν be used in somewhat enlarged form).

δ̭, and correspondingly for the other characters of the series, would indicate dorsal consonants produced by articulating with the middle surface of the tongue against or just back of the teeth; δ̣, and correspondingly for the other characters of the series, would indicate dorsal consonant produced by articulating with the middle surface of the tongue against the back part of the palate.

16. The symbols, *g*, *k*, G, and *k*ʻ indicate the guttural consonants produced by articulating with the back of the tongue against the posterior part of the palate; the position given by *g* of English *good*

may be taken as the standard. The corresponding voiced nasal (*ng* of English *sing*) is indicated by *ŋ*; its voiceless form by *ɴ*.

The front palatal series (illustrated by *k* of English *kin*, or still more markedly by the anterior palatal *k*-sounds of several West Coast languages) is represented by *g̑*, *k̑*, *ɢ̑*, *k̑'*; and the corresponding nasals by *ŋ̑* and *ɴ̑*.

The back palatal series, produced by the back of the tongue articulating against the velum, is represented by *g̣*, *ḳ* (or *q*), *ɢ̣*, and *ḳ'*; the corresponding nasals are *ŋ̣* and *ɴ̣*.

17. The rounded voiced bilabial spirant, or semivocalic *u*, is to be represented by *w*; its voiceless correspondent, *ƕ* (i. e., as used in transcriptions of Gothic for *hw*). Unrounded bilabial spirants (Eskimo *f* and *v*, according to Kleinschmidt's orthography) are to be represented by *φ* (voiceless) and *β* (voiced). The dento-labial spirants are respectively represented by *f* and *v*.

The interdental spirants (*th* of English *thick* and *then*) are to be indicated respectively by the two forms of Greek theta, *θ* (voiceless) and *ϑ* (voiced). The spirants corresponding to the various *t*-sounds are to be represented by *s* and *z*; variations of position may be indicated as in the case of *t*-sounds, *s* and *z* representing the ordinary alveolar sibilants, *s̑* and *z̑* the dental sibilants, and *ṣ* and *ẓ* the corresponding cerebral sibilants. Dorsal sibilants may be represented by *σ* (voiceless) and *ζ* (voiced), which symbols, however, need be used only when it is necessary to distinguish explicitly between dorsal and apical sibilants; as in the case of the other sibilants, forward and backward points of articulation may be indicated by *σ̑*, *ζ̑*, and *σ̣*, *ζ̣*, respectively.

The spirants corresponding to the various *k*-series are to be represented by Greek *χ* (or *x*) and *γ*, which correspond in position to *k* and *g*. The prepalatal spirants are to be indicated by *χ̑* (as in German *ich*) and *γ̑* (*y*, pronounced as in English *yes*, will be the ordinary symbol for the voiced spirant of this position, but it will be convenient sometimes to use the symbol *γ̑* for a voiced spirant of the same or slightly posterior position of non-vocalic effect); for *χ̑* may, where convenient, be substituted *x̑*. The back palatal spirants are *χ̣* and *γ̣*, for the former of which may, where convenient, be substituted *x̣*.

Spirants that are intermediate, as regards voicing, between typical surd and sonant spirants, may be represented by small capitals of the corresponding characters for voiced spirants.

Any spirant may be nasalized, to indicate which the hook, as usual, is employed. Thus, *z̨* would represent the *z* of English *seal*, but nasalized.

18. The sibilants of thickish quality (English *sh* and *z* of *ship* and *azure*) are to be represented by *c* (voiceless) and *j* (voiced). Forward and backward articulations of these sounds are respectively represented by *c̭*, *j̭*; *c̣*, *j̣* (cerebral *c*-sounds).

19. Affricatives, that is, consonantal diphthongs consisting of stop followed by spirant of identical position, should always be written analytically, that is, both stop and spirant should be represented. Thus, *pφ* is the voiceless affricative of unrounded bilabial position; *dz* is the voiced affricative of *t*-position. The same manner of writing applies to affricatives the spirantal element of which is a *c*-sound.

If the stop and following homorganic spirant do not form an affricative but preserve their individuality, a period is to be put between them; thus, *t.s.*

20. All lateral sounds are to be indicated by *l* or *l*-like characters, the standard *l* being defined as an apical voiced *l* of alveolar position; the corresponding voiceless sound is ʟ or *ł*. The corresponding dental and cerebral *l*-sounds are *l̯*, ʟ̯, (*ł̯*); and *ḷ*, ʟ̣, (*ł̣*), respectively.

Dorsal *l*-sounds are to be indicated by λ (voiced) and small capital lambda, ᴧ (unvoiced). Forward and backward articulations of dorsal *l* may be represented by means of λ̭, ᴧ̭; and λ̣ (this would be the back-*l* found in many Slavic languages), ᴧ̣.

Lateral affricatives, that is, *t*- or *k*- stop merging into lateral spirants, should be indicated analytically as in the case of all affricatives. *tł* and *dl* would be the normal characters used for the voiceless and voiced dorsal lateral affricatives, while the systematic rendering of these sounds is τᴧ and δλ. *kł*-sounds may also occur.

Nasalized laterals can be indicated by *l̨* and correspondingly for other *l*-sounds.

21. All rolled consonants (*r*-sounds), whether markedly trilled or not, are to be indicated by *r* or *r*-like characters. *r* indicates a voiced tongue-tipped rolled consonant in alveolar position; *r̯* is the corresponding sound of dental position; *ṛ* the cerebral *r*. The corresponding voiceless consonants are respectively ʀ, ʀ̯, and ʀ̣.

The uvular *r* is to be indicated by Greek rhō (ρ); the corresponding voiceless uvular *r*-sound is to be represented by small capital (ᴘ), which is best printed as small capital italic *p*: *ᴘ*.

If it is necessary to distinguish untrilled (or weakly trilled) from markedly trilled *r*-sounds, a macron is to be put above the character to indicate the latter type. Thus, *ṝ* denotes strongly trilled cerebral *r*.

Nasalization, as usual, is to be expressed by the hook beneath a character. Thus, ρ̨ indicates nasalized uvular *r*.

22. Aspiration, as already indicated above in treating of aspirated surds, in serving as a consonantal release or concluding a syllable after a vowel, is to be indicated by breathing (ʽ). Aspiration as an independent consonant is to be indicated by *h* when strong, by breathing (ʽ) when weak.

Nasalized breath may be represented by ʽ̨ or *h̨*. Nasalized breath with definite vocalic timbre may be indicated by putting the sign for aspiration under the vocalic character: thus, *ı̨*. Voiceless stopped consonants with nasalized breath release and continuance of oral contact during release may be indicated by putting the sign for nasalization under the character for the stopped consonant: thus, *p̨*. The peculiar strangulated-sounding *h*-sounds found in Nootka and Arabic may be indicated by *ḥ*.

23. The glottal (epiglottal) stop is to be indicated by an apostrophe, ʼ. Broken vowels, that is vowels cut in two by a glottal stop, may be rendered *aʼa* or *aʼ*^{a}, and correspondingly for other vowels; the latter orthography is to be employed when the postglottal part of the vowel is weakly articulated (murmured or whispered).

A simple glottalized consonant, that is, a voiceless consonant pronounced with simultaneous closure of the glottis, and whose release also is simultaneous with that of the glottal closure, may be indicated by putting the ʼ over the character; thus, *p̓* indicates a glottalized *p* (such consonants are found in Southern Paiute and in Delaware). *pʼ*, and correspondingly for other consonants, indicates a consonant whose release is immediately followed by a glottal closure.

A common type of glottalized consonant in American languages is the so-called "fortis." These consonants are generally pronounced with simultaneous glottal closure and with glottal release subsequent to that of the oral release. We may distinguish here between the simple glottalized stop and the true fortis produced with very high pressure and accompanying increased muscular tension of the articulating organs, which gives to the sound its abrupt exploded character. It is recommended that the orthography already in use (namely, *p!*, and correspondingly for other consonants) be retained for the true fortis; *p̓* (and correspondingly for other consonants) should be used to indicate the more weakly articulated glottalized consonant of this type.

A "glottal trill," that is, a vowel broken up by a rapidly succeeding series of glottal closures (German "Knarrstimme"), may be indicated by putting the apostrophe over the vowel. Thus, *a̓* is glottally trilled *a*.

A peculiar strangulated-sounding glottal stop found in Nootka, and bearing the same relation to the ordinary glottal stop that *ḥ* bears to *h*, may be indicated by ʼ̣ .

24. Special modifications of consonants may be brought about by synchronous articulations, that is, by the simultaneous action of some other part of the speech apparatus than is primarily involved in the production of the consonant. Nasalized and glottalized consonants, two types of such "doubly articulated" consonants, have already been discussed. Aside from glottalization, all such synchronous articulations should be indicated by diacritical marks beneath the character or by closely following inferior characters. This method seems preferable to indicating them by means of superior characters, as in this way confusion is avoided with consonantal glides.

Labialized consonants, that is, consonants pronounced with simultaneous lip-rounding, are to be indicated by means of inferior *w* closely following the character. Thus, l_w indicates an *l* pronounced with markedly rounded lips; similarly, k_w indicates a *k* with simultaneous lip-rounding (not to be confused, of course, with *kw*).

Palatalized consonants, that is, consonants modified by the simultaneous articulation of a large part of the surface of the tongue against the palate (in other words, by the tongue taking *y*-position), are to be indicated by closely following inferior *y*. Thus, n_y indicates a palatalized dental *n*. The ordinary so-called "palatal" *l* and *n* are probably best considered as palatalized dorsal *l* and *n* and should thus, strictly speaking, be indicated by λ_y (Italian *gl*) and ν_y (Italian *gn*); l_y and n_y would, however, be the normal methods of representing these consonants.

In some languages a vowel or consonant may be given a distinct velar or guttural resonance, due to the fact that during the production of the sound an approximation is made of the tongue and velum or tongue and posterior palate to velar or guttural closure without such closure being actually attained. No symbol is expressly recommended here for gutturalized and velarized sounds, but these sounds, where noted, should be definitely indicated in some way.

25. If a consonant forms its own syllable without a preceding or following vowel, that fact may be indicated by placing a small circle under the character. Thus, *n̥* indicates syllabic *n*, as in English *button* (*bα'tn̥*).

Vowels, based on H. Sweet.

1. high-back-narrow ï (e.g. Southern Paiute paγï$^{\varepsilon}$ "fish")	7. high-mixed-narrow ı̇ (e.g. Welsh un)	13. high-front-narrow i (e.g. French fini)	19. high-back-wide *ï* (e.g. Southern Paiute pïva$^{\varepsilon}$ "in which place")	25. high-mixed-wide *ı̇*	31. high-front-wide ι (e.g. English bit)
2. mid-back-narrow α (e.g. English but)	8. mid-mixed-narrow (e.g. German Gabe)	14. mid-front-narrow e (e.g. French été)	20. mid-back-wide a (e.g. German Mann)	26. mid-mixed-wide (e.g. English butter)	32. mid-front-wide *e* (e.g. English men)
3. low-back-narrow (e.g. Cockney park; French pâte)	9. low-mixed-narrow (e.g. English sir—Sweet)	15. low-front-narrow (e.g. English air)	21. low-back-wide (e.g. Norwegian mat)	27. low-mixed-wide ȧ (e.g. Portuguese cama; practically French patte)	33. low-front-wide ä (e.g. English man)
4. high-back-narrow-round u (e.g. German gut)	10. high-mixed-narrow-round u̇ (e.g. Swedish hus)	16. high-front-narrow-round ü (e.g. French lune)	22. high-back-wide-round ʋ (e.g. English put)	28. high-mixed-wide-round ʋ̇ (e.g. Takelma ʋ̇gι "give me!")	34. high-front-wide-round ʋ̈ (e.g. German Mütze)
5. mid-back-narrow-round o (e.g. German so)	11. mid-mixed-narrow-round ȯ	17. mid-front-narrow-round ö (e.g. French peu)	23. mid-back-wide-round ɔ (e.g. German voll)	29. mid-mixed-wide-round ɔ̇	35. mid-front-wide-round ɔ̈ (e.g. practically German Götter)
6. low-back-narrow-round ω (e.g. English law)	12. low-mixed-narrow-round ω̇	18. low-front-narrow-round ω̈ (e.g. French peur)	24. low-back-wide-round (e.g. English not—Sweet)	30. low-mixed-wide-round (e.g. Swedish upp)	36. low-front-wide-round

	Stops					Spirants			Affricatives			Nasals		Laterals			Lateral Affricatives			Rolled Consonants		
	Surd	Sonant	Intermed.	Aspir.	Glottalized	Surd	Sonant	Glot.	Surd	Sonant	Glot. *	Surd	Sonant	Surd	Sonant	Glot.	Surd	Sonant	Glot.	Surd	Sonant	Glot.
Bilabial (rounded)	p_w	b_w	$ʙ_w$	p_wʽ	p̓$_w$, p_w!	ƕ	w	* ƕ!	pƕ	bw	pƕ!	$ᴍ_w$	m_w									
Bilabial (unrounded)	p	b	ʙ	pʽ	p̓, p!	ϕ	β	ϕ !	pϕ	bβ	pϕ !	ᴍ	m									
Dento-labial						f	v	f !	pf	bv	pf !											
Interdental						θ	ϑ	θ !	tθ	dϑ	tθ!											
Linguo-dental	ṱ	ḓ	ᴅ̭	ṱʽ	ṱ̓, ṱ !	s̭	z̭	s̭ !	ṱs̭	ḓz̭	ṱs̭ !	ɴ̭	ṋ	ł̭, ʟ̭	ḽ	* ł̭!	ṱł̭	ḓḽ	* ṱł̭!	ʀ̭	r̭	* ʀ̭ !
Linguo-alveolar	t	d	ᴅ	tʽ	t̓, t !	s	z	s !	ts	dz	ts !	ɴ	n	ł, ʟ	l	ł!	tł	dl	tł!	ʀ	r	ʀ !
Cerebral	ṭ	ḍ	ᴅ̣	ṭʽ	ṭ̓, ṭ !	ṣ	ẓ	ṣ !	ṭṣ	ḍẓ	ṭṣ !	ɴ̣	ṇ	ł̣, ʟ̣	ḷ	ł̣!	ṭł̣	ḍł̣	ṭł̣!	ʀ̣	ṛ	ʀ̣ !
Dorso-dental	τ̭	δ̭	Δ̭	τ̭ʽ	τ̭̓, τ̭ !	σ̭	ζ̭	σ̭ !	τ̭σ̭	δ̭ζ̭	τ̭σ̭!	Ʋ̭	ν̭	Λ̭	λ̭	Λ̭!	τ̭Λ̭	δ̭λ̭	τ̭Λ̭ !			
Dorsal	τ	δ	Δ	τʽ	τ̓, τ !	σ	ζ	σ !	τσ	δζ	τσ!	Ʋ	ν	Λ	λ	Λ!	τΛ	δλ	τΛ!			
Dorso-palatal	τ̣	δ̣	Δ̣	τ̣ʽ	τ̣̓, τ̣ !	σ̣	ζ̣	σ̣ !	τ̣σ	δ̣ζ	τ̣σ!	Ʋ̣	ν̣	Λ̣	λ̣	Λ̣!	τ̣Λ	δ̣λ	τ̣Λ !			
Anterior c-sounds	(τ_y)	(δ_y)	(Δ_y)	(τ_yʽ)	(τ̓$_y$, τ_y!)	c̭	j̭	c̭ !	ṱc	ḓj	ṱc !	($Ʋ_y$)	(ν_y)	(Λ_y)	(λ_y)	(Λ_y !)	($\tau\Lambda_y$)	($\delta\lambda_y$)	($\tau\Lambda_y$!)			
Mid c-sounds	(t_y)	(d_y)	($ᴅ_y$)	(t_yʽ)	(t̓$_y$, t_y!)	c	j	c !	tc	dj	tc !	($ɴ_y$)	(n_y)	($ł_y$, $ʟ_y$)	(l_y)	($ł_y$!)	($tł_y$)	(dl_y)	($tł_y$!)			
Posterior c-sounds	(ṭ$_y$)	(ḍ$_y$)	(ᴅ̣$_y$)	(ṭ$_y$ʽ)	(ṭ̓$_y$, ṭ$_y$!)	ç	j̣	ç !	ṭc	ḍj	tc !	(ɴ̣$_y$)	(ṇ$_y$)	(ł̣$_y$, ʟ̣$_y$)	(ḷ$_y$)	(ł̣$_y$!)	(ṭł$_y$)	(ḍl$_y$)	(ṭł$_y$!)			
Anterior palatal	k̭	g̭	ɢ̭	k̭ʽ	k̭̓, k̭!	x̭	γ̭ ;y	x̭!	k̭x	g̭γ	k̭x!	Ŋ̭	ŋ̭				k̭ł	g̭l	k̭ł̭!	ρ̭	ρ̭	ρ̭!
Mid-palatal	k	g	ɢ	kʽ	k̓, k !	x	γ	x!	kx	gγ	kx!	Ŋ	ŋ				kł	gl	kł!	ρ	ρ	ρ!
Back palatal, velar	ḳ (q)	g̣	ɢ̣	ḳʽ	ḳ̓, ḳ !	x̣	γ̣	x̣!	ḳx	g̣γ	ḳx!	Ŋ̣	ŋ̣				ḳł	g̣l	ḳł!	ρ̣	ρ̣	ρ̣!
Glottal	ʼ			ʼʽ		ʽ, h	a (any vowel)		ʼʽ											(ȧ)		
Laryngeal	ʔ			ʼʽ		ḥ	(any vowel with laryngeal resonance)		ʼḥ													

* Glottalized aspirants, affricatives, laterals, lateral affricatives, and rolled consonants may also be designated by superscript ʼ. See glottalized stops.

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THE PYRANOMETER—AN INSTRUMENT FOR MEASURING SKY RADIATION

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THE PYRANOMETER—AN INSTRUMENT FOR MEASURING SKY RADIATION

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The instruments we are about to describe are the result of investigations begun under a grant from the Hodgkins Fund in 1913. They are derived in principle from the highly successful pyrheliometer of K. Ångström.[1] In that instrument there are two strips of blackened manganin, one of which is shaded from the solar radiation, the other exposed. The shaded strip is heated by an electric current whose strength can be graduated until the temperatures at the back of the two strips are equal, as shown by means of thermo-elements attached to the rear of the two strips. When the equality of temperature is brought about, as shown by zero deflection of the galvanometer, it is assumed that the energy of radiation absorbed in the exposed strip is equal to the energy of the electric current dissipated in the shaded one. To eliminate errors the uses of the strips are reversed, so that the formerly shaded strip is exposed to radiation, and the formerly exposed strip is shaded and heated by the electric current.

In another instrument of K. Ångström, called by his son the pyrgeometer,[2] a pair of blackened manganin strips alternate with a pair of polished gold-plated ones, and the whole grid of four strips, arranged centrally nearly in the plane of the surface of a nickel-plated box, is exposed to the night sky. The bright strips lose very little heat by radiation, while the black ones lose comparatively a good deal, and so the effect is to cool the blackened strips with respect to the bright ones, and this state of affairs is indicated by means of thermo-elements attached to the series of strips. It is provided that the electric heating current can be used to warm the blackened strips until their temperature is restored to that of the bright strips as indicated by the zero of the galvanometer. This instrument was not regarded by its inventor as a primary instrument, and following his

[1] Astrophysical Journal, Vol. 9, page 332.
[2] Smithsonian Misc. Coll., Vol. 65, No. 3, page 28.

procedure the constant of such instruments is determined by exposing them within inclosures of constant-lower-temperatured walls.

It might appear that the pyrgeometer could also be employed in daytime to determine the radiation scattered from sunlight by the sky, if at such times the sensitive strips were covered by a hemisphere of glass to cut off exchange of rays of long wave lengths. In such a case the heating current would require to be applied to the bright strips rather than the black ones. This use of the instrument is, however, defeated by the fact that the absorption coefficient of the bright strips for sky-light is not even approximately zero, and varies greatly with the wave length, especially in the blue and violet and ultra-violet parts of the spectrum.

It was our purpose to devise a standard instrument for measuring the solar radiation scattered inward by the sky in daytime, and it was our hope that the instrument suitable for this purpose should also be applicable to the measurement of nocturnal radiation as well. We began experiments for this purpose in 1912; and now, after having devised and constructed six different forms of instrument, we have satisfied ourselves that the last two types are very satisfactory for the purpose.

The name Pyranometer,[1] selected for the instrument we have devised, is taken from Greek words (πῦρ, fire; ἀνά, up; μέτρον, a measure) signifying that which measures heat above. The name was chosen with reference to the fact that the instrument is designed to measure the energy of radiation to or from a complete hemisphere lying above the measuring surface.

PYRANOMETER A. P. O. 6

Referring to the accompanying illustration, figure 1 is a side view; figure 2, looking down from above; figure 3, an attachment not used in measuring total sky radiation, but employed when it is desired to restrict the measurements to the sun alone; figure 4, a cross section taken at right angles to the view presented in figure 1 and omitting the wooden base and apparatus for shading the sun. In figure 5 are details showing the arrangement of the sensitive strips and thermo-couples. The instrument shown is the sixth form we have devised. In the fifth form there is but one sensitive strip instead of two as shown here. The fifth form of instrument is more sensitive than the sixth form, but has a certain source of error which was to a

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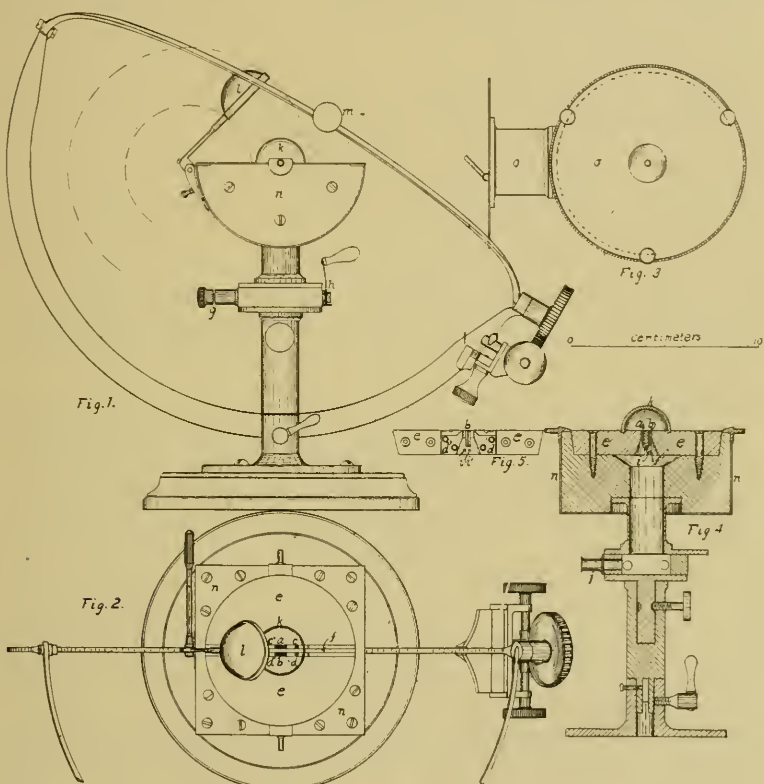
[1] We make our acknowledgments to Miss M. Moore and to Dr. Casanowicz for advice in selecting this name.

considerable extent avoided in the sixth form, of which more will be said hereafter.

A and *B* are strips of manganin, each exposing surfaces 6 mm. long and 2 mm. wide. The strips are bent through 45° at the ends of the exposed portion and soldered with great care on to the lower parts of the split copper blocks *C*, C^1, *D*, D^1, in such manner that the solder goes exactly to the bend where the manganin strip becomes



exposed. The strips *A*, *B*, are situated in the center of the polished nickel-plated copper block *E* and are separated the one from the other by the copper strip *F*. Electrical insulation between the strips *A*, *B* (with their attached copper blocks *C*, C^1, *D*, D^1), and the plate *E* and strip *F* are provided by means of thin vertical separating strips of mica, coming exactly to the common surface of the plate *E* and manganin strips *A*, *B*. Conductors (not shown) run from the blocks *C*, C^1, *D*, D^1, to the switch *H*, and thence to the pair of binding posts *G*, of which only one of the two appears in figure 1. Between the switch *H* and the blocks *C*, C^1, *D*, D^1, the electrical current for heating the strips *A*, *B*, divides into two. Appropriate resistances are placed in the two circuits, so that although the strip *B* is ten times as thick as the strip *A*, and has a correspondingly smaller electrical resistance, compensation is provided by means of the said electrical resistances so that the current divides in the proper proportion to heat the strip *A* at exactly the same rate as strip *B*.

The two U-shaped thermo-elements, *I*, I^1, are arranged in series, with their warm and cold junctions respectively attached by thin waxed paper to the back of the strips *A* and *B*, so that the difference of temperature (if any) between the strips *A* and *B* is indicated by means of a galvanometer connected into circuit with them by means of a flexible conductor (not shown in the figure) which enters the instrument by means of the tube *J* shown in figure 4. We employ tellurium-platinum for the thermo-elements on account of the great thermo-electric power of this combination, the non-corrosion of platinum by melting tellurium, and the small thermal conductivity of tellurium. The difficulty of forming tellurium into the U-shaped elements shown was at first considerable, but was overcome after some practice.

The principle of operation of the instrument may now be understood. Radiation falling simultaneously upon the strips *A* and *B* communicates to each the same quantity of heat; but the rise of temperature after a steady state is produced thereby is different in the two because the strip *B* is ten times as thick as the strip *A*, and so its thermal conductivity to the ends is greater. Hence a deflection of the galvanometer occurs. This deflection is balanced, after again shading the strips, by means of an electric current divided between the strips *A* and *B* so as to produce equal heating effects in each. By suitable adjustment the deflection of the galvanometer which was produced by the absorption of radiation is reproduced by the heating of the electric current. In these circumstances the energy of the electric current transformed into heat in either strip is equal to the energy of the radiation absorbed by either strip. The instrument is primarily designed to measure radiation on a horizontal surface, but it can be used in any position.

The remaining details of the instrument will be easily understood. *K* is an optically figured hollow hemispherical screen of ultra-violet crown glass 25 mm. in diameter and 2 mm. thick, whose purpose is to admit direct or scattered solar radiation, but to prevent the exchange of long wave-length radiation between the manganin strips and the sky. A nickel-plated shutter, *L*, is provided for shading the instrument from the sun or sky. A small metal screen, *M*, subtending 0.0011 hemispheres, is mounted on an equatorial axis operated by a worm-wheel arrangement. This screen is used to shade the sun from the strips, in case it is desired to measure the sky alone, and not the sun and sky in combination. A nickel-plated box, *N*, enclosing a wood block in which lies the plate *E*, is provided to keep the copper plate *E* from external disturbances of temperature by wind currents. Around this box *N* fits a nickel-plated cover, *O*, shown in figure 3, for use in observing the sun alone, in making comparisons with the pyrheliometer. When the cover shown in figure 3 is employed, the equatorial mounting of the sun-screen *M* is removed, and the worm attachment is used for rotating the solar cover box *O*, just described.

The following data were used to determine the constant of Pyranometer A. P. O. 6:

	Cm.
Length of strips between soldered portions	0.623
Width of thin strip (mean of 5 places)	0.198
Width of thick strip (mean of 5 places)	0.201
	Ohms
Electrical resistance of thin strip	0.2740
Electrical resistance of thick strip	0.0369
Electrical resistance in series with thin strip	0.819
Electrical resistance in series with thick strip	0.364
Assumed absorption of the lamp black	0.98
Assumed transmission of the glass hemisphere (allowing for 2 reflections with index of refraction, 1.5)	0.92

(Thickness of strips determined by weighings approximately 0.00034 and 0.0030 centimeters).

(Resistance of the two thermo-couples in series 30 ohms).

From these data the current in the thin strip is $\frac{.401}{1.494}$ times the current in the outside electrical heating circuit. Hence the current squares are as 0.0719 to unity. Hence the constant of the instrument (when glass covered) is

$$K = \frac{.0719 \times .2740 \times 60}{4.185 \times 0.623 \times 0.198 \times 0.98 \times 0.92} = 2.54,$$

so that the energy of radiation corresponding to a given heating current C measured in amperes is 2.54 C^2 calories (15° C.) per cm.^{2} per minute. If used at night without glass for measurement of long-wave rays, the constant should probably be taken at

$$2.54 \times \frac{92}{100} \times \frac{98}{95} = 2.41.$$

The reader will perceive that the instrument may be used for the sun alone, the sun and sky in combination, the sky alone by day; or by removing the glass screen *K* it may be used for nocturnal radiation. We have not as yet employed the instrument much for the measurement of nocturnal radiation nor have we as yet compared its readings under that arrangement with the radiation of enclosures at different temperatures. We hope to make such experiments in future. We have made numerous comparisons between the instrument as arranged for day observations and the pyrheliometer. A series of observations of this kind, interspersed by readings on the whole sky, is shown in table I. A close agreement with the results of Pyrheliometer A. P.

TABLE I.—*Summary of Results of March 31, 1916*
North Tower, Smithsonian Institution

Sec. Z	Pyranometer A. P. O. No. 6				Pyrheliometer A. P. O. No. 9 (Calories)	Pyrheliometer A. P. O. No. 9 / Pyranometer A. P. O. No. 6.
	Sky alone Glass on (Calories)	Sun and sky Glass on (Calories)	Sun alone Glass on (Calories) (x Sec. Z)	Sun alone* No glass on (Calories) (x Sec. Z)		
1.340 (A. M.)	.....	.....	.....	1.232	1.218	.988
1.330 (A. M.)	.....	.....	.....	1.084†	1.193	1.10†
1.235 (P. M.)	.1783	1.150	(1.200)	.....	(1.190)	(.991)
1.383	.....	.....	1.013	.....	.998	.984
1.400	.....	.....	.995	.....	.990	.995
1.420	.....	.....	.949	.....	.983	1.035
1.435	.....	.....	.975	.....	.987	1.011
1.485	.....	.....	.....	1.000	.993	.993
1.502	.....	.....	.....	1.019	1.020	1.001
1.545	.....	.....	.....	.947	.964	1.018
1.564	.....	.....	.....	.956	.967	1.011
1.665	.1978	.....	.....	.....	.....	.....
1.689	.1703	.....	.....	.....	.....	.....
1.730	.1757	.....	.....	.....	.....	.....
1.768	.....	.635	(.830)	.....	.....	.....
1.802	.....	.640	(.875)	.....	.....	.....
1.874	.1463	.....	.....	.....	.....	.....
1.897	.1500	.....	.....	.....	.....	.....
2.050	.....	.....	.780	.....	.775	.994
2.097	.....	.....	.798	.....	.770	.966
2.280	.1359	.....	.....	.....	.....	.....
2.338	.1359	.....	.....	.....	.....	.....
2.415	.....	.404	(.660)	.....	.....	.....
2.480	.....	.388	(.648)	.....	.....	.....
2.567	.1220	.....	.....	.....	.....	.....
2.943	.....	.....	.668	.....	.6825	1.021
3.055	.....	.....	.702	.....	.680	.969
3.280	.....	.....	.608	.....	.6325	1.040
3.420	.....	.....	.633	.....	.6493	1.024
3.760	.0851	.....	.....	.....	.....	.....
3.90	.....	.2471	(.613)	.....	.5706	(.930)
4.05	.0945	.....	.....	.....	.....	.....
4.45	.....	.....	.....	.504	.5220	1.034

General mean 1.006
Omitting observations Nos. 2 and 18 .... 1.005

* Constant of instrument different from preceding column, allowance being made for the removal of the glass.
† Ammeter probably stuck.
() Result on sun obtained by subtracting sky from sun and sky combined.

O. 9 is found for all altitudes of the sun when the pyranometer readings are reduced to vertical incidence. This confirms the accuracy of the instrument for observations of the entire sky.

PYRANOMETER A. P. O. 5

As stated above, we employed but one sensitive strip in Pyranometer A. P. O. 5, embedding the cool junctions of the thermo-elements in the copper plate *E*. This form is several times as sensitive as Pyranometer A. P. O. 6, so much so that we employed with it a potentiometer current to bring the very large galvanometer deflections to zero, and then balanced the potentiometer current by heating the strip. Unfortunately, a defect of this pyranometer is a secondary deflection, caused by the warming of the portion of the plate *E* under glass as soon as the shutter is opened. This secondary deflection was found very large, sometimes even as great as a quarter of the primary one. Its direction was sometimes in one sense, sometimes in the other, for reasons that we have not fully understood. There is, however, a method of reading whereby this source of error is very nearly eliminated. It was noticed that when heating the strip with the electric current no secondary deflection occurred, and the primary deflection was complete in 20 seconds. When heating by radiation a nearly complete temporary halt of the deflection occurred at about 20 seconds after exposure, before the secondary deflection appreciably manifested itself. Hence we balanced the radiation deflection exactly on the 20th second by the potentiometer current, closed the shutter, waited two full minutes for restored zero conditions, and then balanced the potentiometer deflection by the heating current.[1] Under these conditions the error is practically negligible, and on account of its great sensitiveness Pyranometer A. P. O. 5 is regarded as a valuable instrument.

Its constant is determined as follows: Length of strip, 0.628 cm.; width, 0.294 cm.; electrical resistance, 0.300 ohms. Radiation = KC^2 where $K = \frac{0.300 \times 60}{4.185 \times 0.628 \times 0.294 \times 0.98 \times 0.92} = 25.9.$

We have employed this Pyranometer A. P. O. 5 in numerous measurements of radiation from the sun, sun and sky, sky alone, and

[1] The secondary plate heating effect is not wholly absent from the two strip form of Pyranometer No. 6, but it is very greatly reduced in its percentage importance. To entirely eliminate it, however, we have found it necessary to close the shutter 30 seconds after opening, and then to wait at least one minute before balancing with the electric current.

new fallen snow. In comparisons with the pyrheliometer it gave very nearly equal results when corrected to vertical incidence. The reflecting power of snow for combined sun and sky rays was found to be 70 per cent.

Some of the results found from the measurements with Pyranometer A. P. O. 5 are given in table II. We draw attention to the results on cloudy and partly cloudy days, which indicate that the sky light as a whole, on days when it is cloudy but not thick enough to rain, is of the order of two or three times the intensity of the sky light excluding the direct sun on clear days.

The pyranometer is a very handsome instrument as constructed by Mr. Kramer. It may be used readily by anyone equipped with the

TABLE II.—*Summary of Readings of February, 1916. North Tower, Smithsonian Institution, Pyranometer A. P. O. 5*

Date	Sec. Z	Sky alone. (Calories)	Sky and sun. (Calories)	Sun alone. Calories (x Sec. Z)*	A. P. O. 9 Calories†	A. P. O. 9 / Pyranometer No. 5	Kind of sky
1916 Feb. 17.	2.33	.224	....	....	....	....	Sky 4/5 cloudy.
	2.495	.274	....	....	....	....	3/4 cloudy.
	2.84	....	.313	....	....	....	(Sun mostly hidden.)
	3.00	.165	....	....	....	....	1/2 cloudy.
	3.10	....	.296	....	....	....	(Cirro-cumulus.)
Feb. 18.	2.045 A. M.	.157	....	....	....	....	Lower 30° all cloudy. Upper 60° 1/2 cloudy.
	2.015	.210	....	....	....	....	Lower 30° all cloudy. Upper 60° 1/3 cloudy. Sun shining through thin haze.
	1.905	.306	....	....	....	....	Lower 30° all cloudy. Upper 60° 2/3 cloudy. Sun shining.
	1.710 P. M.	.192	....	....	....	....	Lower 30° 9/10 cloudy. Upper 60° 1/5 cloudy. Sun clear but hazy.
	1.720	....	.728	....	....	....	Upper clouds increasing. Sun still clear.
	1.750	.263	....	....	....	....	Upper 60° 3/4 cloudy. Sun covered by clouds.
Feb. 21.	1.750 A. M.	.1060	....	....	....	....	Light cirri in southern half of sky, partly covering sun. Otherwise very clear.
	1.700	....	.800	(1.16)	....	....	Sky same, sun clear.
	1.683	.1266	....	....	....	....	Same.
	1.667	....	.952	(1.40)	....	....	Same. Cirri decreasing.
	1.570 P. M.	.1127	....	....	....	....	Few cirri low in south. Very clear.
	1.580	....	.992	(1.39)	(1.38)	.993	
	1.589	.1163	....	....	....	....	
	1.593	....	.962	(1.35)	(1.36)	1.008	
	3.60	.0780	....	....	....	....	Cloudless. Some smoke in west from fire at 2 hr. 45 min. at Bureau of Engraving.
	3.75	.0780	....	....	....	....	
	3.95	....	.313	(932)	(.912)	.979	
	4.13	....	.291	(890)	(.883)	.992	
	4.28	.0746			Mean...	...992	

* Values in this column obtained by interpolating for "sky alone," subtracting interpolated values from "sky and sun" and multiplying by secant Z.

† Values in this column obtained by plotting logarithmically seven readings of pyrheliometer A. P. O. 9 made at various times during the afternoon and interpolating from this plot values to correspond with values of secant Z.

auxiliary apparatus used with the Ångström pyrheliometer. Its readings on the sky and sun by day appear to be truly expressed in calories per square centimeter per minute, for in solar comparisons values found agree within experimental error for all zenith distances with those of our standardized pyrheliometers. We are undertaking further experiments to test its accuracy for long wave-rays such as compose nocturnal radiation. While we have hitherto employed only ultra-violet crown glass screens, it is obvious that such screens might be covered with stained gelatine, or other screens of special glass employed to restrict the measurements to special regions of spectrum, as might be desirable in botanical investigations. While the two strip form is preferable from its greater freedom from temperature disturbances, the single strip form is so much more sensitive that for observations in deep shade, as in a forest, it would be more suitable.

As in the case of the silver disk pyrheliometer, we are authorized to state that the Smithsonian Institution will undertake to furnish pyranometers at cost to those who are engaged in investigations which will be greatly promoted by the use of this instrument. The cost cannot yet be exactly estimated, but it will not exceed $150 for the pyranometer itself. This does not, of course, include a galvanometer, ammeter, or batteries. Suitable slide wire resistances will be included. If desired, an equatorial mounting additionally will be be furnished at cost, so that the instrument can be used as a pyrheliometer at right angles to the solar beam.

SUMMARY

The authors have designed and tested with satisfactory results an instrument for measuring solar and sky radiation by day and terrestrial radiation by night. Two forms of the instrument are described. Either form will be furnished at cost by the Smithsonian Institution to institutions or individuals doing important investigation which will be promoted by using the instrument.

SMITHSONIAN MISCELLANEOUS COLLECTIONS
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THREE NEW AFRICAN SHREWS OF THE GENUS CROCIDURA

BY
N. HOLLISTER

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THREE NEW AFRICAN SHREWS OF THE GENUS CROCIDURA

By N. HOLLISTER

Since the publication of Mr. Guy Dollman's synopsis of the African shrews of the genus *Crocidura*,[1] the East African specimens of this group contained in the United States National Museum, over 500 in number, have been critically examined. Three hitherto unnamed forms have been found in this collection. Of these, one was collected by the Smithsonian African Expedition, 1910; one by the Rainey African Expedition, 1912; and one was sent to the museum by Mr. H. J. A. Turner, of Nairobi.

CROCIDURA DAPHNIA, sp. nov.

Type from Gondokoro, Uganda. U. S. National Museum No. 164898, skin and skull of adult ♀ (teeth moderately worn). Collected February 19, 1910, by J. Alden Loring. Orig. No. 9009.

Description.—Like specimens of the brown phase of *Crocidura nyansæ* Neumann, but somewhat paler in color, the sides especially paler, and line of demarcation between color of upperparts and underparts more sharply drawn. Upperparts grayish buffy-brown or drab buff, with a pale cinnamon wash; sides paler, with a more buffy wash; hairs of side glands almost white; underparts yellowish buff, the chin, throat, and patches of new pelage buffy white; feet buffy-brown; tail blackish-brown above, lighter below, the hairs on basal third below whitish buff. The tail is closely haired and has many longer bristles on basal two-thirds. Skull and teeth essentially as in *nyansæ,* and size as in that form.

Measurements of type.—Head and body, 142 millimeters; tail vertebræ, 79; hind foot, dry without claws, 19. Skull (braincase broken): maxillary breadth, 9.4; palatal length, 12.8; length of mandible, 15.5; upper tooth row, entire, 13.6.

Remarks.—This new shrew is probably a connecting link between *Crocidura nyansæ* Neumann and *C. doriana* Dobson. It is the

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[1] Annals and Mag. Nat. Hist., Ser. 8, Vol. 15, pp. 508-527, May; pp. 562-575, June, 1915; Vol. 16, pp. 66-80, July; pp. 124-146, August; pp. 357-380, October; pp. 506-514, December, 1915; and Vol. 17, pp. 188-209, February, 1916.

species referred by Dollman[1] to *C. sururæ* Heller, of Lado, but it is quite a different form of the same group, larger and lighter colored. The Nile is apparently a barrier between these two forms and the specimens from Wadelai and Mongalla mentioned by Dollman under *sururæ* seem to represent this new species. Dollman mentions a very pale colored example of the *C. nyansæ* group from Unyoro as in some ways intermediate between *nyansæ* and the specimens from east of the Nile which he referred to *sururæ*. Two similar specimens from Unyoro (Hoima and Butiaba) in our collection indicate the strong probability of direct intergradation between these forms.

CROCIDURA PARVIPES NISA, subsp. nov.

Type from Kibabe, Kisumu, British East Africa. U. S. National Museum No. 182440, skin and skull of adult ♀ (teeth moderately worn). Collected January 20, 1912, by Edmund Heller. Orig. No. 5126.

Description.—A small, short-tailed form related to *Crocidura lutrella* Heller and to *C. parvipes* Osgood. Color almost precisely as in the type of *parvipes,* but upperparts slightly darker; tail darker, more blackish, above; and outer side of arms same color as upperparts of body, not whitish as in *parvipes.* Skull about same size as in *parvipes* but with heavier rostrum and wider palate, the unicuspid rows further apart; small upper unicuspid teeth of approximately same size and well overlapped, as in *parvipes.*

Measurements of type.—Head and body, 80; tail vertebræ, 38; hind foot, dry, 11.3. Skull: condylobasal length, 19.6; maxillary breadth, 6.9; breadth of braincase, 9.0; median depth of braincase, 5.3; mandible, 11.0; upper toothrow, entire, 8.9.

Remarks.—Only a single specimen of this new subspecies is in the collection. The locality from which it came is almost exactly half way between the widely separated regions, Lado Enclave and the Taita Hills district of southeastern British East Africa, which are the type localities of the only obviously closely related forms (*lutrella* and *parvipes*). The Field Museum of Natural History has kindly lent me, through Mr. W. H. Osgood, the type specimens of *Crocidura parvipes* and other African shrews for study in this connection. A specimen from Fort Hall, British East Africa, in the National Museum collection, which I refer to *parvipes* rather than to *nisa,* is clearly intermediate between the two.

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[1] Ann. and Mag. Nat. Hist., Ser. 8, Vol. 15, pp. 571-573. June, 1915.

The two forms most closely related to *C. p. nisa* (*parvipes* and *lutrella*) were placed by Dollman in different groups, *parvipes* in the *jacksoni* group, and *lutrella* in the *beiræ* (*hindei*) group. Both obviously belong with the *hindei*-like shrews with the massive maxillary processes and long, narrow rostra.

CROCIDURA SIMIOLUS, sp. nov.

Type from Kisumu, British East Africa. U. S. National Museum No. 197959, skin and skull of adult ♀ (basal suture obliterated but teeth little worn). Collected September 25, 1913, by H. J. A. Turner. Collector's No. 3.

Description.—Related to *Crocidura mutesæ* Heller and *C. suahelæ* Heller, but slightly larger than either of these forms. Upperparts of the type specimen uniform rich Prout's-brown, except on nose and tail which are much darker brown; underparts paler, grayish brown. Other skins from Kaimosi and Kibabe are darker than the type. Skull like that of *C. mutesæ* but larger, with larger teeth.

Measurements of type.—Head and body, 113; tail vertebræ, 60; hind foot, dry, 17. Skull: condylobasal length, 26.1; maxillary breadth, 8.3; breadth of braincase, 11.1; median depth of braincase, 6.4; mandible, 13.7; upper tooth row, entire, 12.3.

Remarks.—Four specimens of this new shrew are in the collection. All are from the vicinity of Kavirondo Gulf, in the Kisumu district, and were taken in localities where the larger *C. nyansæ* is common. Skins of this species might readily be confused with *nyansæ* or *kijabæ*, but specimens may be easily separated by the small skull and teeth. Young examples of *nyansæ* always have much larger teeth than adults of *simiolus*. The coast species, *C. suahelæ*, and the Uganda *C. mutesæ* were placed in widely separate groups by Dollman in his recent synopsis of the African species of *Crocidura*, but they are very closely related forms and are the nearest relatives of *C. simiolus*. While perhaps best placed for the present in the *fischeri* group, where Dollman considered *suahelæ* to belong, these three species show many characteristics of the *nyansæ* group, and approach in size the Lado form, *C. sururæ*.

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MAXONIA, A NEW GENUS OF TROPICAL AMERICAN FERNS

BY
CARL CHRISTENSEN
Copenhagen

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MAXONIA, A NEW GENUS OF TROPICAL AMERICAN FERNS

By CARL CHRISTENSEN, Copenhagen

While working with the genus *Dryopteris* I have had for examination several specimens of a fern which in my Index Filicum was called *Polystichum apiifolium* (Swartz) C. Chr. and later was referred to *Dryopteris* by Maxon.[1] Considering, however, that it differs widely from the common type of *Dryopteris*, Maxon placed it in a special subgenus, for which he created the new name *Peismapodium*. To me it was evident, upon very slight examination of a full-grown fertile specimen, that this fern should certainly not be placed in *Polystichum*, although in some respects it resembles *P. adiantiforme;* its proper place seemed to be in the genus *Dryopteris* and its alliance with such species as *D. amplissima, D. macrostegia, D. ochropteroides,* and a few others, which together form a very distinct group of *Dryopteris* characterized by a certain polystichoid habit and, generally, leathery leaves. On closer examination I have found, however, that in essential characters *P. apiifolium* is very different from the species mentioned, and that it represents an apparently monotypic genus of very great interest, since it is, in fact, a connecting link between *Polybotrya* and the group of *Dryopteris* species just mentioned.

The plant under discussion usually has decidedly dimorphic leaves, as has *Polybotrya*. They are borne on a very thick rhizome (2 to 3 cm. in diameter), which is clothed throughout with long, narrow, rufous scales and which climbs on trees (and cliffs?) as do those of *Polybotrya osmundacea, Polystichum adiantiforme,* and *Davallia canariensis*. Within the genus *Dryopteris* a similar rhizome is unknown, although that of *D. amplissima* has a certain resemblance to it. The sterile leaves are tri-quadripinnate, leathery, and of the same general habit as those of the species with which I have compared *P. apiifolium*. They are destitute of scales and hairs on the

[1] Contr. U. S. Nat. Herb. **13**: 39. 1909.

surfaces, while the axils of the secondary and tertiary rachises and the narrow furrows of the vascular parts above are more or less filled with a short rufous pubescence consisting of short, few-celled articulate hairs; a few similar hairs are found on the veins beneath. Thus, in pubescence the leaves agree perfectly with those of *Polybotrya osmundacea*, while the leaves of the species of *Dryopteris* and *Polystichum* above mentioned are scaly or differently hairy.

The fertile leaves also are very different from those of *Polystichum adiantiforme* and all species of *Dryopteris*. Their leafy parts are often so greatly contracted that the whole leaf resembles a mere skeleton consisting only of the vascular parts, which bear the sori. Thus the fertile leaf resembles not a little that of *Polybotrya osmundacea*, although usually it is not so much contracted. There is, however, a very important difference. The sori are confined to the veins and are indusiate, whereas in *Polybotrya* the sporangia are borne on almost the whole under surface of the fertile lobes and are not covered by an indusium. Most specimens seen have the leaves strongly dimorphous, but this character is not a stable one. I have two specimens, for example, in which certain parts of the leaves (mainly the upper half) are fertile, while the lower part is sterile; the fertile segments are not nearly so much contracted as is the case in the entirely dimorphous form.

The indusium of *P. apiifolium* is very peculiar, and unique in its development. This is seen very beautifully in a specimen from Jamaica (*Maxon* 2284a). In its first state the indusium is seen as a little protuberance on the back of a vein, sometimes immediately below its apex. This protuberance elongates toward the vein-tip and forms a pale linear body, parallel to the vein and raised above it. It soon broadens at its outer part, becoming spatulate; and as growth proceeds the margins bend downward and finally are firmly appressed to the parenchyma of the vein. In this state the indusium resembles much that of *Cystopteris* or sometimes that of *Davallia;* and now the first traces of the sporangia are seen on the vein immediately above the base of the indusium. This, however, continues its growth at the sides, scarcely at the apex, and thus soon becomes rounded at the outer edge, its shape being now nearly circular, with a short, cuneate base, its pedicel. Next the basal part of each side grows out into a rounded lobe, directed backward. The indusium has now become reddish brown, subreniform (the basal sinus being low only), and highly vaulted over the sporangia, around which it is appressed firmly to the parenchyma, while the edges themselves are bent upward. The two basal lobes now grow inward also and soon reach each other or, even, one may widely overlap the other. The now full-grown indusium is circular, apparently peltate, glabrous or with a few glands along the edges, and very persistent.

The characters mentioned—dimorphism, peculiar rhizomes, and the unique development and morphology of the indusium—are to me more than sufficient upon which to erect a new genus, which must stand between *Polybotrya* and certain species of *Dryopteris* grouped with *D. amplissima.* Granting that isomorphism is a more primitive character than dimorphism, the new genus represents a more recent type than *Dryopteris,* although it has not progressed so far as *Polybotrya,* with which genus it has most characters in common. It still shows such dryopteroid characters as having indusia and sporangia confined to the back of the veins. In its evolution from *Dryopteris* toward a more specialized type it has not progressed so far that all characters have become fixed. Thus the dimorphism generally ascribed to the species is, as mentioned, not a stable character. The occasional subdimorphous leaves point definitely to dryopteroid ancestors with isomorphous leaves.

It is a special pleasure to me to have got permission to dedicate this interesting new genus to Mr. William R. Maxon, Associate Curator of the U. S. National Herbarium, who has contributed very much to our knowledge of the ferns of tropical America by his excellent collections of these plants in Jamaica, Cuba, and Central America, and by numerous papers in which he has succeeded in unraveling with acumen several intricate groups of that difficult division of plants.

MAXONIA C. Chr., gen. nov.

TYPE: *Dicksonia apiifolia* Swartz, the only species known.

MAXONIA APIIFOLIA (Swartz) C. Chr., comb. nov.

Dicksonia apiifolia Swartz, Journ. Bot. Schrad. 1800[2]: 91. 1801.

Dryopteris apiifolia Kuntze, Rev. Gen. Pl. 2: 811. 1891; Maxon, Contr. U. S. Nat. Herb. 13: 39. 1909.

Aspidium ascendens Hew. Mag. Nat. Hist. II. 2: 463. 1838; Hook. Sp. Fil. 4: 32. *pl. 224.* 1862.

Polystichum apiifolium C. Chr. Ind. Fil. 578. 1906.

The type specimen of this species (Herb. Stockholm) was collected in Jamaica by Swartz and consists of sterile leaves only. Other specimens studied are:

Jamaica: Hollymount, Mount Diabolo, alt. 750 meters, *Maxon* 2284, 2284a, 2284b. Near Troy, alt. 600—660 meters, *Maxon* 2822; *Underwood* 2862, 2934. (All in U. S. Nat. Herb.)

Cuba: Ramón de la Sagra. (Herb. Berol.)

While the Cuban specimens are fully identical with subdimorphous ones from Jamaica, a plant from Guatemala is somewhat different. Still the differences are rather small and the plant must be regarded provisionally as a variety of this species:

MAXONIA APIIFOLIA DUALIS (Donn. Sm.) C. Chr., comb. nov.

Nephrodium duale Donn. Smith, Bot. Gaz. 15: 29. *pl. 4.* 1890.

This differs from the typical Jamaican plant in its very thick (4 cm.) rhizome, which is very densely covered with glossy, silky, rufous scales that are quite entire, while in the Jamaican plant the rhizome scales are finely toothed, especially toward their threadlike apex. The continental plant is, as a whole, of larger growth, and the fertile leaf is greatly contracted, with very large, distinctly reniform, pale brown indusia.

Guatemala: Pansamalá, Dept. Alta Verapaz, *von Türckheim;* distributed by John Donnell Smith as no. 1408. (The type specimens, U. S. Nat. Herb. nos. 831030, 831031.)

Copenhagen, April 10, 1916.

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THREE NEW MURINE RODENTS FROM AFRICA

BY
N. HOLLISTER

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THREE NEW MURINE RODENTS FROM AFRICA

By N. HOLLISTER

The following heretofore overlooked forms of murine rodents have been found in the collections made by the Smithsonian African Expedition in 1909 and 1910.

ARVICANTHIS ABYSSINICUS CENTROSUS, subsp. nov.

Type from Rhino Camp, Lado. No. 165167, U. S. National Museum, skin and skull of male adult (teeth moderately worn), collected January 21, 1910, by J. Alden Loring. Orig. No. 8817.

Subspecific characters.—Differs from *Arvicanthis abyssinicus rubescens* Wroughton of Uganda in its much darker color and larger teeth.

Color of type specimen.—General appearance of upperparts blackish gray, or blackish grizzled with grayish buff; hairs of back mostly broadly blackish at base, with subapical area of yellowish buff, and tip of black; mixed with these are numerous hairs wholly black in color. Rump and lower back slightly more reddish brown than head, shoulders, and forward parts of back; sides lighter than back, the undercolor paler and the buff rings on the hairs less yellowish. Underparts dark grizzly drab, all the hairs blackish at bases and with drab-gray tips. Ears well clothed with black and yellowish buff hairs, much the color of head and upper back. The buffy ochraceous nose and eye-ring are faintly marked. Hands and feet blackish brown, the feet with black centers. Tail bicolor, brownish black above, grayish buff below.

Skull and teeth.—Skull essentially as in *Arvicanthis abyssinicus rubescens;* teeth distinctly larger.

Measurements of type specimen.—Head and body, 129 millimeters; tail vertebræ, 114; hind foot, dry, without claws, 29. Skull: Condylobasal length, 31.2; zygomatic breadth, 16.5; interorbital breadth, 4.8; length of nasals, 11.7; length of mandible, 20.5; upper tooth row, alveoli, 6.9; lower tooth row, alveoli, 7.0.

Specimens examined.—Sixteen, all from the type locality.

Remarks.—This new subspecies of *Arvicanthis abyssinicus* resembles *A. a. nubilans* of the Kisumu Province, British East Africa, very much in color, but is a slightly smaller animal with a longer tail. The ranges of the two forms are separated by that of *A. a. rubescens,* which occupies the eastern side of the Nile system in Uganda, from Ankole to Gondokoro. The Nile appears to be an effective barrier between the ranges of the subspecies *rubescens* and *centrosus.* In Lado this new form ranges with *Arvicanthis testicularis jebelæ* Heller, but specimens can readily be separated from skins of that form by their much darker color, above and below (*jebelæ* has a white belly, sharply marked from the color of the flanks), and by the shorter tail.

DASYMYS HELUKUS NIGRIDIUS, subsp. nov.

Type from Naivasha Station, British East Africa, skin and skull of female adult (teeth moderately worn), collected August 20, 1909, by J. Alden Loring. Orig. No. 7054.

Subspecific characters.—Differs from *Dasymys helukus helukus* and *D. h. savannus* in larger size and darker color; skull and teeth larger. Fur long and silky.

Color of type specimen.—General color of upperparts brownish fuscous, darker on mid-dorsal line where there is considerable purple and green iridescence; paler and more brownish on sides, where the colors blend into the much lighter grayish buff of the underparts. The upperparts are everywhere speckled with fine lines of golden buff; underfur dark neutral gray. Head and cheeks brownish gray, with considerable of the greenish iridescence around eyes and between ears; ears dull seal brown. Underparts grayish buff, the hair long; neutral gray, tipped with olive buff. Hands and feet thinly covered with long hairs of brown, darker than in the neighboring forms. Tail closely annulated; the numerous hairs of brown above and buff below not covering the scales.

Skull and teeth.—Skull somewhat larger than in either of the neighboring forms, *helukus* and *savannus,* with higher sinciput, heavier rostrum, and greater interorbital breadth. Teeth larger.

Measurements of type specimen.—Head and body, 176; tail vertebræ, 162; hind foot, 36 (dry, without claws, 33.2). Skull: Condylobasal length, 38.4; zygomatic breadth, 20.1; length of nasals, 13.8; interorbital breadth, 4.7; upper tooth row, alveoli, 8.0; lower tooth row, alveoli, 7.6.

Specimens examined.—Nineteen from the type locality and one from the Aberdare Mountains at 7,000 feet.

Remarks.—This is the largest of the British East African forms of *Dasymys.* It is further distinguished by its very dark color (almost blackish in some lights), long, silky pelage, and larger skull and teeth. Skins of young, about half-grown animals, are especially dark as compared with the young of *Dasymys h. savannus.*

MUS BELLUS PETILUS, subsp. nov.

Type from Southern Guaso Nyiro River, British East Africa. No. 162397, U. S. National Museum, skin and skull of male adult (teeth much worn), collected June 28, 1909, by J. Alden Loring. Orig. No. 6450.

Subspecific characters.—Like *Mus bellus bellus* (Thomas) of Machakos, but with smaller, more slender skull.

Measurements of type specimen.—Head and body, 54; tail vertebræ, 44; hind foot, dry, without claws, 12.3. Skull: Condylobasal length, 16.1; zygomatic breadth, 8.4; breadth of braincase, 7.9; length of nasals, 7.0; length of mandible, 9.8; upper tooth row, alveoli, 2.9.

Specimens examined.—Three from the Southern Guaso Nyiro and one from Naivasha.

Remarks.—Compared with large series of specimens of the neighboring form, *Mus bellus bellus,* the specimens of the new subspecies *petilus* are sharply distinguished by their small, slender skulls. The color of the skins is as in true *bellus,* and therefore is very different from the color of *M. b. vicinus* and *M. b. enclavæ,* both of which have larger skulls, like true *bellus.*

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ON THE USE OF THE PYRANOMETER

BY
C. G. ABBOT AND L. B. ALDRICH

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ON THE USE OF THE PYRANOMETER

By C. G. ABBOT and L. B. ALDRICH

We described the pyranometer in an earlier paper.[1] Its purpose is to measure the radiation, originally a part of the solar beam, which reaches a horizontal surface by scattering from all parts of the sunlit sky: or to measure at night the loss of heat of a blackened horizontal surface by reason of its long-wave radiation toward the whole sky. The pyranometer may be used also to measure solar radiation. We published in our earlier paper a comparison between observations of solar radiation with the pyranometer and the pyrheliometer, and these showed almost exact agreement. As these measurements were made at various altitudes of the sun from about 10° upward, they indicated strongly the probable accuracy of the pyranometer for sky radiation, which comes from all angles.

Further use of the instrument has not diminished our confidence in its accuracy, but we have found it necessary to alter the method of reading with it. As stated in our earlier paper, the pyranometer is developed from the plan of the Ångström electrical compensation pyrheliometer. A thermo-electric couple connected to a moving coil galvanometer indicates differences of temperature between the two blackened metallic strips which form the receiving surfaces for radiation; and a heating current of electricity furnishes to these strips a quantity of energy whose measured intensity is the index of the intensity of the absorbed radiation. In our first observations we found that nearly 30 seconds must elapse after throwing on a heating current before a new state of temperature equilibrium becomes completely established, as shown by a steady state of the galvanometer. Accordingly we adopted the custom of waiting 30 seconds after each exposure to radiation, in order that the steady state might be reached, before recording the galvanometer deflection. At Mount Wilson our attention was drawn to a phenomenon unnoticed at Washington. When exposing the instrument to sunlit sky, through the glass hemisphere used to cut off long-wave rays, the deflection of the galvanometer came to a maximum within 5 seconds, and then con-

[1] Smithsonian Misc. Coll., Vol. 66, No. 7.

Smithsonian Miscellaneous Collections, Vol. 66, No. 11

tinually decreased for as much as a minute thereafter. The decrease in 30 seconds was a very considerable part of the whole sky-deflection. Our original method of reading thus proved quite arbitrary, for there was no reason to suppose the reading at 30 seconds after exposure was better than at 20 or 40 seconds. A similar drift of the galvanometer but very small relatively to the whole deflection, was observed after the lapse of about 20 seconds after exposure to the sun through the glass hemisphere. Whenever the glass hemisphere was removed, whether observing the sky by day or by night, or the sun, the deflection increased gradually for about 20 or 30 seconds, as with the heating current.

A clue was soon found. Generally if the sky is observed by day in Washington, with glass removed, almost no deflection occurs. The gain of heat to the blackened strips from scattered sun rays at Washington is almost equal to the loss of heat by emission of long-wave rays toward the sky. But if the observation is made on Mount Wilson, a large negative deflection occurs. At summer temperatures of observation the scattered sun rays at Mount Wilson are by no means equal in energy to the long-wave rays emitted toward the sky. Now it is well known that glass is a nearly perfect absorber of these long-wave rays, and hence is a nearly perfect radiator of them as well. But, on the other hand, the brightly polished metal cover, used as a shutter to the pyranometer, radiates almost nothing, being a nearly perfect reflector for long-wave rays. But the nickel plated cover absorbs about 30 per cent of the shorter-wave solar rays which meet it, and thereby is warmed, and warms the glass close below it by air convection. Now when the cover is removed the glass can cool rapidly by radiation, and as it is almost completely transparent to solar rays, it is hardly warmed at all by them. Hence the glass after exposure grows cooler than before, and as it subtends a full hemisphere, it tends strongly to reduce the temperature of the blackened strips below, thus causing the gradual decrease of the galvanometer deflection.

Having discovered the cause of error, the remedy was seen to lie in shortening the period of exposure so much that there would not be time for the glass to become appreciably cooled on the inside. We therefore began to investigate the behavior of the galvanometer with a view to observing the first swing instead of the permanent deflection.

As is well known to many readers, the time of swing of a moving coil galvanometer is shortest on open circuit, and increases as the external resistance in closed circuit diminishes, until at length no second swing occurs. Of two galvanometers tried by us both gave about 2 seconds' time of single swing on open circuit, but when closed on the pyranometer alone, one gave no second swing at all, the other a second swing of about 1/20 the magnitude of the first. By inserting 75 ohms or more resistance in series with the first galvanometer, it also gave a second swing, and the time of single swing of each galvanometer, when just giving a second swing, was about 4 seconds. Even with 75 ohms in series, the first-tried galvanometer gave about twice as much deflection as the other, but for several reasons we at length preferred the second one. This was a galvanometer by Rose, of Upsala, Sweden, made for use with the Ångström pyrheliometer. Its resistance is about 15 ohms. The resistance of the pyranometer is 30 ohms. When used with the pyranometer, whether with or without additional resistance of 200 ohms or less in series, the Rose galvanometer completes its first swing in about 4 seconds.

We next made tests with the heating current and with radiation at night to see if the first swing is proportional to the final deflection. We found this to be the case. We also found that both with the heating current and with nocturnal radiation, not only the first swing but the deflections, attained after 10, 15, 20, 25, and 30 seconds, maintained certain definite proportions to the final deflection, no matter what the strength of the current, or the intensity of the observed radiation. We also found that when proper allowance was made for the non-uniformity of sensitiveness of the galvanometer for large and small deflections, the deflections observed due to heating currents were exactly proportional to the square of the heating current employed.

These facts ascertained, the way seemed clear to avoid the source of error mentioned above, and at the same time to greatly increase the rapidity of reading the instrument, and also to avoid drifting of zero, so apt to occur in long exposures. In short for all daylight observations we adopted the plan of reading first swings, and of omitting exact adjustments of the energy of the heating currents to equal that of the observed radiation. Our present procedure in day work is as follows:

(1) On exposure to radiation, read the first swing of the galvanometer, and immediately close the shutter.

(2) After 30 seconds or more throw on a heating current sufficient to cause a deflection approximately equal to that from the radiation, and again note the first swing, and the exact strength of the heating current.

(3) Let D_R be the deflection due to radiation, D_C the deflection due to heating current, C the strength of current, and K the constant of the pyranometer. (For our pyranometer, A. P. O. No. 6, $K=2.54$.) Then the intensity of radiation $R=K\frac{D_R}{D_C}C^2$.

For the observation of nocturnal radiation we sometimes use the same method, but generally we effect an exact compensation of the nocturnal radiation by adjusting the heating current to reduce the galvanometer deflection to zero. In this way the temperature of the strips is brought back to the temperature of the air, and experience shows that even on windy nights the galvanometer is steady under these conditions. When the glass hemisphere is removed for night work, the constant of the pyranometer is decreased from 2.54 to 2.41. (See our earlier paper.)

When in the use of the pyranometer deflections are observed too large for convenient reading, a suitable resistance is used in series with the galvanometer. In new instruments a little switch is provided for this purpose and marked G. It provides three degrees of sensitiveness according as open or closed on one side or the other.

SAMPLE OBSERVATIONS MADE ON MOUNT WILSON

On the proportion borne by the deflections observed after fixed intervals to the final deflections due to different heating currents. Glass hemisphere on.

A. With German galvanometer. Resistance 58 ohms.

1. Current strength, 0.200 amperes. No extra resistance in circuit, and no definite first swing.

Time in seconds....	5	10	15	20	25	30	40	50	60	75
Deflection in cm ...	7.34	8.93	9.24	9.32	9.35	9.36	9.37	9.38	9.39	9.40
Proportion of final.	.781	.950	.983	.991	.993	.996	.997	.998	.999	1.000

2. Current 0.400 amp. Extra resistance 60 ohms. Deflections 20 to 23 cm.

Proportion of final.	.869	.967	.987	.994	.998	.999	.999	.999	1.000	1.000

3. Current 0.605 amp. Extra resistance 260 ohms. Deflections 20 to 23 cm.

Proportion of final.	.870	.966	.987	.993	.995	.999	.998	.999	.999	1.000

4. Current 0.802 amp. Extra resistance 560 ohms. Deflections 18 to 22 cm.

Proportion of final.	.820	.956	.987	.995	.997	.999	1.000	1.000	1.000	.999

B. With Swedish galvanometer.[1] Resistance 15 ohms.

1. Current 0.300. No extra resistance. Deflections 2.8 to 3.0 cm.

Time in seconds....	4	10	15	20	25	30	40	50	60	75
Proportion of final.	.915	.965	.984	.994	.994	.997	1.000	1.000	1.000	1.000

2. Current 0.385. No extra resistance. Deflections 4.6 to 5.0 cm.

Proportion of final.	.915	.965	.985	.995	.996	.998	1.000	1.000	1.000	1.000

From these experiments we see that the deflection attained after the first swing, or after any specified interval, is closely proportional to the final deflection whatever the strength of the heating employed. The final deflection is approximately attained in 20 seconds.

On the proportion borne by the deflection observed after fixed intervals to the final deflection, due to emission of nocturnal radiation. Glass hemisphere off.

A. German galvanometer. No extra resistance.

Time in seconds...............	5	10	15	20	25	Final
Deflection in cm.............	9.28	11.40	11.84	11.90	11.79	11.89
Proportion of final...........	.781	.959	.996	1.001	.992	1.000
Previous result with current...	.835	.960	.986	.993	.996	1.000

B. Swedish galvanometer.[1] No extra resistance.

Time in seconds...............	4	10	15	20	25	Final
Deflection in cm...............	1.90	2.00	2.02	2.06	2.05	2.09
Proportion of final...........	.910	.957	.967	.985	.981	1.000
Previous result with current...	.915	.965	.984	.995	.996	1.000

[1] We here read the first swing, which occurred in approximately 4 seconds.

From these experiments we see that after definite intervals the deflection due to emission of nocturnal radiation reaches sensibly the same proportions of its final value that occur when heating currents are observed. Hence we may conclude that the true deflection due to the radiation of the sun or the sunlit sky, if such deflections could be observed apart from the secondary cooling effects described above, would follow the same law of increase with lapse of time as does the deflection due to current. Thus if the one is observed when the first swing is complete, the other should also be so observed to yield comparable results.

On the degree of uniformity of the scale of the Swedish galvanometer.

A constant source of electromotive force having been provided, deflections of the galvanometer were observed when the following values formed the total resistances in the galvanometer circuit.

Resistance in ohms R	10014	6014	3514	2514	1614	1214
First swing D	2.32	3.99	6.96	9.81	15.42	20.70
Final deflection D_1	1.92	3.31	5.80	8.16	12.88	17.20
Ratio $\frac{D}{D_1}$	1.208	1.206	1.200	1.202	1.197	1.203
Product $D \times R$	23230	23970	24430	24630	24910	25150

From these experiments it appears that the first swing is closely proportional to the final deflection for all parts of the scale. But the scale is evidently far from uniform, and gives greater sensitiveness for large deflections.

On the proportionality between deflection and the square of the heating current applied to the pyranometer.

Test made with Swedish galvanometer, reading first swings.

Current square C^2	.0395	.1580	.3472	.6292
Deflection D	1.175	4.835	10.93	20.00
Ratio $\frac{C^2}{D}$	.3361	.3268	.3176	.3146
Sensitiveness factor from scale test S	(234)	241	247	251
Product $\frac{C^2S}{D}$	(788)	788	787	788

From these experiments it appears that when proper allowance is made for non-uniformity of the sensitiveness of the galvanometer scale, the deflection observed is exactly proportional to the square of the strength of the heating current applied to the pyranometer. Hence it follows that if a certain current C_1 produces a deflection D_1, and a certain radiation R produces a slightly different deflection D_2, the radiation R would be exactly compensated by a current C_2 such that $\frac{C_1^2}{C_2^2} = \frac{D_1}{D_2}$. This valuable result enables us to dispense with the tedious process of producing exact compensations.

On the method of observing in daytime with the pyranometer as illustrated by sample observations on Mount Wilson.

August 7, 1916

Time	Zero	First swing	Defl. D	Object	Current (C) amperes	C^2	$\frac{C^2}{Dc}$	Calories
$2^h 28^m 0^s$	11.00	14.26	3.26	Sky..........	......	......	......	0.137
	10.88	13.78	2.90	Current.......	.223	.0497	.0171	......
30 30	11.15	14.47	3.32	Sky...........	......	......	......	0.140
	11.28	14.48	3.20	Current.......	.231	.0534	.0167	......
33 30	14.98	21.96	6.98	Sun and sky...	......	......	......	1.240
	14.99	20.18	5.19	Current.......	.607	.368	.0709	.....
35 30	14.99	21.86	6.87	Sun and sky...	......	......	......	1.220
	14.92	20.30	5.38	Current.......	.610	.372	.0691	......

On the method of observing at night with the pyranometer as illustrated by sample observations on Mount Wilson.

August 7, 1916

Time	Compensating current C amperes	C^2	Calories
$7^h 55^m 0^s$	.285	.0810	.195
57 20	.280	.0782	.188
8 0 0	.281	.0789	.190

Note.—Quite windy, but the galvanometer remained steady when balance was reached.

On the comparison of solar readings by the pyranometer and pyrheliometer as observed on Mount Wilson.

Observations made with pyranometer A. P. O. No. 6 and secondary pyrheliometer A. P. O. No. IV. Results in calories per cm.² per min.

AUGUST 6, 1916. HOUR ANGLES 1^h52^m to 1^h37^m

Secant *Z*	1.160	1.148	1.137	1.132
Pyranometer × secant *Z*	1.462	1.464	1.471	1.451
Pyrheliometer	1.477	1.469	1.467	1.460
Difference	+ .017	+ .005	— .004	+ .009

AUGUST 7, 1916. HOUR ANGLES 5^h35^m to 5^h23^m

Secant *Z*	4.017	3.808	3.620	3.448
Pyranometer × secant *Z*	1.064	1.079	1.104	1.109
Pyrheliometer	1.067	1.077	1.087	1.118
Difference	+ .003	— .002	— .017	+ .009

From these experiments it appears that the pyranometer gives values of solar radiation comparable in accuracy with those observed with the pyrheliometer. As the results are of satisfactory accuracy at both great and small zenith distances, the pyranometer may be supposed to give accurate results on the sky, which involves all zenith distances.

DIRECTIONS FOR OBSERVING AND REDUCING OBSERVATIONS

Employ a galvanometer of not more than 60 ohms resistance giving a first swing within 5 seconds. If too sensitive diminish its deflection by a suitable resistance in series. Employ a heating current adjustable from zero to 0.8 amperes. If a storage battery is available it will be found the most satisfactory source to furnish the current, but dry cells may be used. A simple slide wire rheostat is required for nocturnal work. Employ an accurate ammeter for reading the current strength.

Daylight work.—Place the pyranometer on a level surface in the place where the intensity of radiation is to be measured. If the sun is sometimes to be shaded off, adjust the flat arc (which is the sunshade support) to lie north and south, set the arc to the latitude of the place, and set the shade to cast its shadow centrally on the pyranometer. The shade is to be turned forward as the sun goes westward. Employ the glass hemisphere in measurements of direct or scattered sun light. Remove it for nocturnal measurements. Be sure the glass screen has no dirt or finger marks upon it. (The glass may be cleaned by breathing upon it and while damp wiping with clean cloth or cotton.) When ready to observe, read the position of the galvanometer scale, open the shutter, read the first swing, close the shutter, wait a half minute, read the galvanometer, throw on a current suitable to give about the same swing, read the first swing, and read the current strength.

Let the deflection due to radiation be D_R, that due to current be D_C, the constant of the instrument be K (=2.54 for pyranometer A. P. O. No. 6 with glass on). Then the result in calories per cm.² per min. is $K \frac{D_R}{D_C} C^2$. Where there is non-uniformity of the galvanometer scale, as here, it is of course necessary that D_C shall not differ greatly from D_R. We generally form the quotient $\frac{C^2}{D_C}$ and take the mean of several values of it to use for neighboring values of radiation.

Night work.—The glass hemisphere is removed. When ready to read note the zero of the galvanometer. On opening the shutter a negative deflection occurs. The zero of the galvanometer is then to be restored by throwing on a suitable current, and adjusting its strength by means of the slide wire rheostat until exact compensation is reached. This should occupy not less than 30 seconds to enable the apparatus to reach a steady state. Read the current, C. The intensity of radiation is given by KC^2, where K is the constant of the pyranometer with glass removed. (For pyranometer A. P. O. No. 6, K is then 2.41.)

SUMMARY

Test experiments tend to verify the accuracy of the pyranometer. A new method of observing is described which conduces to more accurate results and to quicker operation. Sample observations are given, as made with the two-strip pyranometer No. 6 on Mount Wilson. The new method of observing is applicable, however, to the one-strip form of pyranometer described in our former publication,[1] and if used in the new way it is possible that this simpler form of pyranometer will prove equally accurate as well as more sensitive than the two-strip form.

[1] Smithsonian Misc. Coll., Vol. 66, No. 7.

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BONES OF MAMMALS FROM INDIAN SITES IN CUBA AND SANTO DOMINGO

(With One Plate)

BY

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BONES OF MAMMALS FROM INDIAN SITES IN CUBA AND SANTO DOMINGO

By GERRIT S. MILLER, Jr.

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Within the past few months the United States National Museum has received two collections of bones of mammals dug from kitchen middens in the island of Santo Domingo, West Indies. The first and most important consists of two hundred and forty-two specimens, representing probably about fifty individuals, procured at San Pedro de Macoris, by Mr. Theodoor de Booy for the Museum of the American Indian, Heye Foundation, New York City. A representative series has been presented to the National Museum by Mr. George G. Heye. The second was made during September, 1916, by Dr. W. L. Abbott in the caves near San Lorenzo where Gabb rediscovered the genus *Plagiodontia* about the year 1870. It consists of a dozen specimens all of which were given to the museum. Finally Mr. Heye has sent for examination part of a lot of bones collected at the "Big Wall," a former Indian village at Maisi, Baracoa, Cuba. These remains were found "scattered all through the site in conjunction with stone artifacts and fragments of pottery." All of this material proves to be of great interest on account of the light which it throws on the Antillean fauna that was associated with early man.

As lately as a year ago there existed wide differences of opinion as to the probability that the Antilles had ever been inhabited by a mammal-fauna of continental character.[1] Cope, in 1868, had pointed out that the geologically recent occurrence of a rodent (*Amblyrhiza*) as large as a Virginia deer on the island of Anguilla, whose area is only thirty square miles, indicated the former existence of a Caribbean continental area;[2] but this fact seems to have been generally lost sight of. It has all along been well known that bats occurred throughout the archipelago, but they were supposed to have flown

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[1] See "Some remarks upon Matthew's Climate and Evolution" by T. Barbour, with supplemental note by W. D. Matthew. Ann. N. Y. Acad. Sci., Vol. 27, pp. 1-15. January 25, 1916.

[2] Proc. Acad. Nat. Sci. Philadelphia, 1868, p. 313.

to the islands.[1] Chance or man might have accounted for the presence of a few raccoons, agoutis, and cricetine rodents, especially in the Lesser Antilles. The same was equally true of the hystricine rodents (*Capromys*) of Cuba and Jamaica. The Cuban ground-sloths were supposed to have been descended from ancestors which "arrived" from South America in the Miocene or from Central America in the Pliocene. The insectivore *Solenodon* of Cuba and Santo Domingo was so peculiar as to be scarcely within the range of speculation; while *Plagiodontia,* the indigenous rodent of Santo Domingo, lost since 1836, had almost passed out of mind.

In February, 1916, when recording Gabb's rediscovery of *Plagiodontia,* I said that the presence in the West Indies of three rodents so different from each other as *Plagiodontia, Capromys* and *Amblyrhiza* indicated the probability of a once-abundant Antillean representation of the hystricines.[2] Soon after my note was published I received from Dr. J. A. Allen his account of *Isolobodon portoricensis,* a previously unknown rodent from Porto Rico.[3] In August Mr. H. E. Anthony described[4] three further new genera of extinct Porto Rican mammals: a ground-sloth and two rodents, *Elasmodontomys* and *Neopsomys.* He also recorded (p. 194) a "fragmentary mandibular ramus, too incomplete for present determination, of a large hystricomorph rodent" apparently representing a peculiar genus. The material from Cuba and Santo Domingo adds still another genus of rodents from each island; it further includes the femora of two species not hitherto observed. All of these recently identified rodents are hystricine, while there is every reason to suppose that this is likewise the case with the undeterminable species. The number of well established Antillean genera has thus been increased within the year practically from two to eight, with the indication that at least one additional genus and perhaps more may be represented among the three[5] species (one from Porto Rico and two from Santo Domingo) whose status is now in doubt.

[1] That the geographic distribution of bats should not be regarded as primarily a question of flight has been pointed out by Dobson (Rep. Brit. Ass. Adv. Sci. for 1878, pp. 158-167), G. M. Allen (Bull. Mus. Comp. Zool., Vol. 54, pp. 175-176. 1911), and Andersen (Catal. Chiropt. Brit. Mus., Vol. 1, pp. lxxvi-lxxvii. 1912; see also Science, N. S., Vol. 36, pp. 526-527. October 18, 1912).

[2] Proc. Biol. Soc. Washington, Vol. 29, p. 47. February 24, 1916.

[3] Ann. New York Acad. Sci., Vol. 27, pp. 17-22. January 25, 1916.

[4] Ann. New York Acad. Sci., Vol. 27, pp. 193-203. August 9, 1916.

[5] The long bones (from Anguilla) of a supposed rodent about the size of an agouti described and figured by Cope (Smithsonian Contr. Knowl., Vol. 25, pp. 3-4, pl. 1, figs. 4-6. 1883) are excluded as evidently those of a housecat.

With the characters of so many genera known it becomes possible to gain some idea of the aspect of the Antillean hystricine fauna. The most noticeable feature of these genera considered as a group is their similarity to the Santa Cruzian and Entrerian rodents which Ameghino and Scott have described and figured. In no instance has the same genus been found in both the West Indies and Argentina or Patagonia; but the Antillean rodents thus far discovered never show such peculiarities that their remains would appear out of place among those of their extinct southern relatives, while as a whole they would at once be recognized as foreign to the present South American fauna. The large *Amblyrhiza* has teeth fundamentally more like those of the Entrerian *Megamys laurillardi* than like those of the living viscacha. Its plantigrade foot indicates relationship with the enormous extinct Patagonian rodents rather than with any existing saltatorial animals. Similarly the teeth of *Elasmodontomys,* in spite of their relatively small size, appear from Mr. Anthony's figures to be built on a plan identical with that of the molars of *Megamys patagonicus* (Entrerian), but with the same specialization of the anterior wall of each enamel loop that is seen in the simpler teeth of *Amblyrhiza.* In its peculiar outline and in the number and arrangement of the cross-ridges the upper premolar is not unlike the isolated teeth that formed the basis of the genus *Discolomys*[1] (Entrerian). On the other hand all the maxillary teeth of *Elasmodontomys* differ conspicuously from those of any known hystricine now living. In *Heteropsomys* the teeth are much like those of *Acaremys* (Santa Cruz) except that the crowns are more heightened. Teeth of this same type occur in the recent *Cercomys, Carterodon* and *Euryzygomatomys;* but the genus *Heteropsomys* differs from all the living spiny-rats in the form of the skull, most notably in the small size of the antorbital foramen. Of the newly-discovered Santo Domingan genus the only skull has the teeth so worn that their fundamental structure is no longer clear, but apparently this structure resembled that seen in the Santa Cruzian *Sciamys* rather than in any living echimyid. In the new genus from Cuba the teeth are, by all essential characters, exactly like those of the Santa Cruzian *Stichomys.*[2] Of the three known genera which still exist (if *Plagiodontia* has not been exterminated within the last few decades), *Capromys* has

[1] Particularly the specimen figured by Burmeister. Anal. Mus. Nac. Buenos Aires, Vol. 3, pl. 2, fig. 6. 1885. Ameghino, Mam. Fos. Argent., pl. 6, fig. 23. 1889.

[2] See Scott, Rep. Princeton Univ. Exped. Patagonia, pl. 65, figs. 17 and 19.

teeth based on the *Acaremys* plan, while *Plagiodontia* and *Isolobodon* have teeth with the same underlying structure as those of *Scleromys* (Santa Cruz), a type which recurs in the living *Abrocoma* and certain species now placed in *Proechimys*. Except that *Capromys* is represented on the mainland by the slightly different *Procapromys* of Venezuela, these three living genera stand alone as compared with all the nearly-related South American hystricines, both living and fossil, in their complete attainment of ever-growing teeth.

So far as can be judged from eight very distinct genera the Antillean hystricine rodents do not present the characters that would be expected in animals derived from South America during any period geologically recent. Neither have they the appearance of an assemblage brought together at different times by migration or chance introduction. On the contrary they suggest direct descent from such a part of a general South American fauna, probably not less ancient than that of the Miocene, as might have been isolated by a splitting off of the archipelago from the mainland. Of later influence from the continent there is no trace.

CANID. Species?

The left mandible of a canid with pm_2, pm_3 and pm_4 in place (No. 217139, U. S. Nat. Mus.) is among the specimens in the Cuban collection. It differs from the jaws of such Indian dogs as I have seen (both North American and South American) in the unusual width of the premolars and the complete absence of secondary cusps on all three of these teeth. A toothless left maxilla (No. 217130) from the same locality closely resembles the maxilla of a domestic dog's skull from pre-Columbian deposits near Lomas, Peru (No. 176386).

CAPROMYS PILORIDES (Say)

Represented by numerous skulls and leg bones from Big Wall.

CAPROMYS PREHENSILIS Poeppig

A right mandible and left femur from Big Wall are probably referable to this species.

ISOLOBODON PORTORICENSIS Allen

(Plate 1, fig. 3)

Macoris: 207 specimens (representing probably about 40 individuals): palate 1; lower jaw (right) 5, (left) 11; auditory bulla, 1; odd cheek teeth (mandibular) 22; lower incisor 1; scapula (left)

2; humerus (right) 18, (left) 8; radius (right) 2, (left) 2; ulna (right) 2, (left) 2; innominate (right) 7, (left) 3; sacrum 3; femur (right) 28, (left) 36; tibia (right) 28, (left) 25.

San Lorenzo: 2 left lower jaws.

On the basis of the present material, even after comparison with the numerous Porto Rican specimens kindly lent me by Dr. Allen, I am unable to find any character by which to distinguish the Santo Domingan *Isolobodon* from that of the neighboring island. This animal is by far the most abundantly represented of the mammals found in the Macoris deposits. It must have been common at San Lorenzo as well, for two of the three jaws which Gabb collected there and I recorded as *Plagiodontia* turn out to be *Isolobodon.* One of these specimens lacks all of the teeth while in the other the first and second teeth are lost and the third and fourth are broken away to below the alveolar level. Under these circumstances and before I had seen the description of *Isolobodon* I overlooked their true characters. Among the bones found at San Lorenzo by Dr. Abbott this genus is absent.

The tooth structure in *Isolobodon* is essentially like that of *Plagiodontia* except that the upper premolar retains a small antero-external reentrant fold, the reentrant folds in each of the molars and the main folds in the premolar are opposite, their tips coming in contact at middle of crown, and in the lower teeth the outer re-entrant angle is much deeper than those of the inner side. The cement in the teeth of *Isolobodon* is of a peculiarly open structure, showing conspicuous horizontal striation.

PLAGIODONTIA AEDIUM F. Cuvier

(Plate 1, fig. 4)

Macoris: 15 specimens (representing probably about 6 individuals): lower jaw (right) 1, (left) 1; humerus (right) 2, (left) 1; innominate (right) 1, (left) 1; femur (right) 2, (left) 4; tibia (right) 1, (left) 1.

San Lorenzo: 8 specimens (representing probably 3 individuals): anterior half of skull with complete dentition of right side, 1; left lower jaw, 1; innominate, 3; femur, 1; tibia, 2.

Measurements: No. 217112 (San Lorenzo): bregma to front of premaxillaries, 53.6; length of frontal along median suture, 26.6; least interorbital breadth, 19.0; breadth of rostrum across upper rim of premaxillaries, 12.8; diastema, 17.2; maxillary toothrow (alveoli), 21.0; crown of m^1, 5.2 x 4.8. No. 217126 (Macoris):

length of mandible, 58+ ; depth of mandible through articular process, 16.6; mandibular toothrow (alveoli), 23.8; crown of m_1, 5.8 x 5.6.

The material now at hand shows that the teeth of *Plagiodontia* were correctly figured by F. Cuvier. In the maxillary teeth the structure is uniform throughout the series though the size diminishes sensibly from first to fourth. The crowns are squarish in outline. From the postero-internal corner a narrow, parallel-sided reentrant fold extends diagonally across to near middle of anterior border. A similar fold parallel to the last extends backward from antero-external corner of crown and comes almost in contact with enamel of posterior border of tooth. No trace of other folds can be detected. In the mandibular teeth the premolar differs from the molars in the conspicuous narrowing of its anterior half. The pattern of all four teeth is fundamentally the same. On outer border there is one reentrant fold, directed slightly backward and extending less than half-way across crown. On the inner side there are two reentrant folds, each much longer than that of opposite side. The tip of the posterior inner fold comes nearly or quite in contact with that of outer fold. The obliquity of the folds in the upper teeth is so much greater than in the lower teeth that it produces an apparent lack of harmony between the two patterns. As I have already remarked the enamel patterns in both *Plagiodontia* and *Isolobodon* are specializations of a type like that found in the Miocene *Scleromys*.

BROTOMYS, gen. nov.

(Plate 1, fig. 1)

Type.—*Brotomys voratus* sp. nov.

Characters.—A spiny-rat about the size of *Proechimys canicollis;* skull differing from that of *Proechimys* and other living members of the group in the shorter rostrum and the greater breadth and depth of both rostrum and interorbital region; antorbital foramina very large, with no trace of secondary canal for nerve; posterior emargination of palate extending forward to middle of m^3; teeth weak, the roots of incisors producing no swelling on sides of maxillaries, the cheekteeth subterete, each with three poorly developed roots; toothrows nearly parallel; enamel pattern of pm^4 and m^1 (much worn) consisting of a single median reentrant fold from each side,[1] the tip of the outer fold curving back behind that of the inner.

[1] A minute enamel lake lies close to the inner extremity of the outer fold. This lake may indicate that the complete pattern is less simplified.

Remarks.—The genus *Brotomys* is remarkable for its combination of robust skull with weak teeth. It differs too widely from all of the existing genera to require any special comparisons. From the extinct *Heteropsomys* of Porto Rico (pl. 1, fig. 2) it is at once distinguishable by the relatively large antorbital foramina, horizontal anterior zygomatic roots, slightly emarginate palate, and perhaps by a more simplified enamel pattern.[1]

BROTOMYS VORATUS, sp. nov.

Type.—Anterior half of skull (lacking the nasal bones and second and third molars), No. 217117, U. S. National Museum, collected in kitchen midden at San Pedro de Macoris, Santo Domingo, by Theodoor de Booy. Presented by George G. Heye.

Characters.—As in the genus; measurements: distance from front of incisor to back of m^3 (alveoli), 26.6; palatal length, 25.4; palatilar length, 23.0; probable length of nasals, about 18; interorbital breadth, 14.6; palatal breadth including alveoli of second molars, 7.2; least breadth of palate between premolars, 2.0; least breadth of palate between posterior molars, 3.2; rostral breadth across nasal rim of premaxillaries, 9.2; depth at middle of molar series, 14.8; probable depth behind incisors, about 14; maxillary toothrow (alveoli), 10.0; crown of m^1, 2.2 x 2.4.

Specimens examined.—In addition to the type the following bones, probably representing about 6 individuals, all collected by Mr. de Booy at Macoris, appear to be referable to this species: humerus (right) 2, (left) 3; innominate (right) 1; femur (right) 3, (left) 2; tibia (right) 2, (left) 5.

BOROMYS, gen. nov.

Type.—*Boromys offella,* sp. nov.

Characters.—Similar to *Brotomys* but antorbital foramen with well developed secondary groove for nerve; roots of incisor producing an evident swelling on side of maxillary above neural groove; cheek-teeth relatively larger, but of same form and root-structure; enamel pattern of m^3 (and probably of all the other maxillary teeth) consisting of two narrow reentrant folds from each side, the extremities of all the folds reaching about to median line of crown.

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[1] For the opportunity to examine the skull of *Heteropsomys* and for permission to publish the photographs, I am indebted to Dr. J. A. Allen and Mr. H. E. Anthony, of the American Museum of Natural History.

Remarks.—Though resembling *Brotomys* in its general features the genus *Boromys* seems well characterized by the presence of the supplemental groove at base of antorbital foramen. Whether the teeth are actually as different from those of *Brotomys* as they appear must remain an open question until young individuals of both genera have been procured. That the patterns will prove to be identical seems improbable. In *Boromys* the median outer and median inner loops, corresponding to those present in *Brotomys,* are more deeply sunk into the crowns than the others; hence it is evident that a stage of wear would later be reached at which the structure in the two animals would be the same. But apparently at that stage the crowns of the teeth would be longer and less nearly terete in *Boromys* than in *Brotomys.* In reaching it a different course would be followed. The lake representing the antero-external loop in *Boromys* is larger and deeper than that representing the postero-internal loop, so that it remains well developed after the latter has disappeared. In *Brotomys* the only trace of a lake is in a position behind the median external loop and exactly opposite the tip of the median internal loop, therefore not in the place where the last remnant of a postero-internal loop should occur.

The enamel pattern of *Boromys* is identical with that of *Stichomys.* As compared with the Santa Cruzian genus the Cuban animal differs (a) in the more forward position of the zygomatic root relatively to the maxillo-premaxillary suture and the toothrow, (b) in the apparent shortness of the rostrum which results from this peculiarity of the zygoma, and (c) in the narrower palate (width of palate at pm^4 scarcely greater than that of alveoli). The concavity on posterior border of zygomatic root extends slightly beyond level of anterior surface of pm^4, while in *Stichomys* its most anterior portion is a little behind level of middle of this tooth.

BOROMYS OFFELLA, sp. nov.

Type.—Anterior half of skull (lacking the nasal bones, interorbital region and posterior termination of palate), No. 217138, U. S. National Museum. Collected in village site at Maisi, Baracoa, Cuba, by M. R. Harrington. Presented by George G. Heye.

Characters.—As in the genus; measurements: from front of incisor to back of m^3 (alveoli), 29.2; palatal breadth including alveoli of second molars, 9.0; least breadth of palate between premolars, 3.0; rostral breadth across nasal rim of premaxillaries, 8.2; depth at middle of molar series, about 17.4; maxillary toothrow (alveoli), 10.8; crown of m^1, 2.6 x 2.6.

Specimen examined.—The type.

RODENT. Genus?

The perfect left femur of an adult rodent collected by Mr. de Booy at Macoris is more slender than the corresponding bone in *Isolobodon* or *Plagiodontia,* the shaft is more compressed below, the great trochanter is narrower and the small trochanter is more abruptly emarginate on its lower border. In these peculiarities it is not approached by any individual among the numerous specimens by which the other genera are represented. As compared with the femur of *Brotomys* it differs chiefly in its much greater size (length to extremity of large trochanter 59.4 instead of 46; greatest diameter at middle 7 instead of 5.6; least diameter at middle 5.6 instead of 4.0). It may represent a large species of *Brotomys* or an unknown genus.

RODENT. Genus?

The incomplete right femur of a rodent collected by Dr. Abbott in a cave one-quarter of a mile from the shore at San Lorenzo probably represents another unknown species or genus. It is about the size of the femur last described, and the small trochanter is even more abruptly emarginate on its lower border. The striking peculiarity of this bone as compared with the femur in all the other Santo Domingan rodents is seen in the region lying between the upper surface of the small trochanter and the deepest portion of the digital fossa. The groove which occupies this area is usually not far from horizontal, that is, about perpendicular to the shaft of the femur. In this specimen it slopes upward at an angle of about 65°. The bone in question appears to be partly mineralized, while all the others in both collections seem essentially fresh.

TRICHECHUS sp.

A seacow is represented by a rib, a caudal vertebra, and the neural spine of a lumbar vertebra, all found at Macoris. The material at hand is not sufficient to make any positive determination possible.

EXPLANATION OF PLATE

(All figures natural size)

FIG. 1. *Brotomys voratus.* Type No. 217117, U. S. Nat. Mus., Santo Domingo. (de Booy.)

FIG. 2. *Heteropsomys insulans.* Type No. 14172, Amer. Mus. Nat. Hist., Porto Rico. (Boas.)

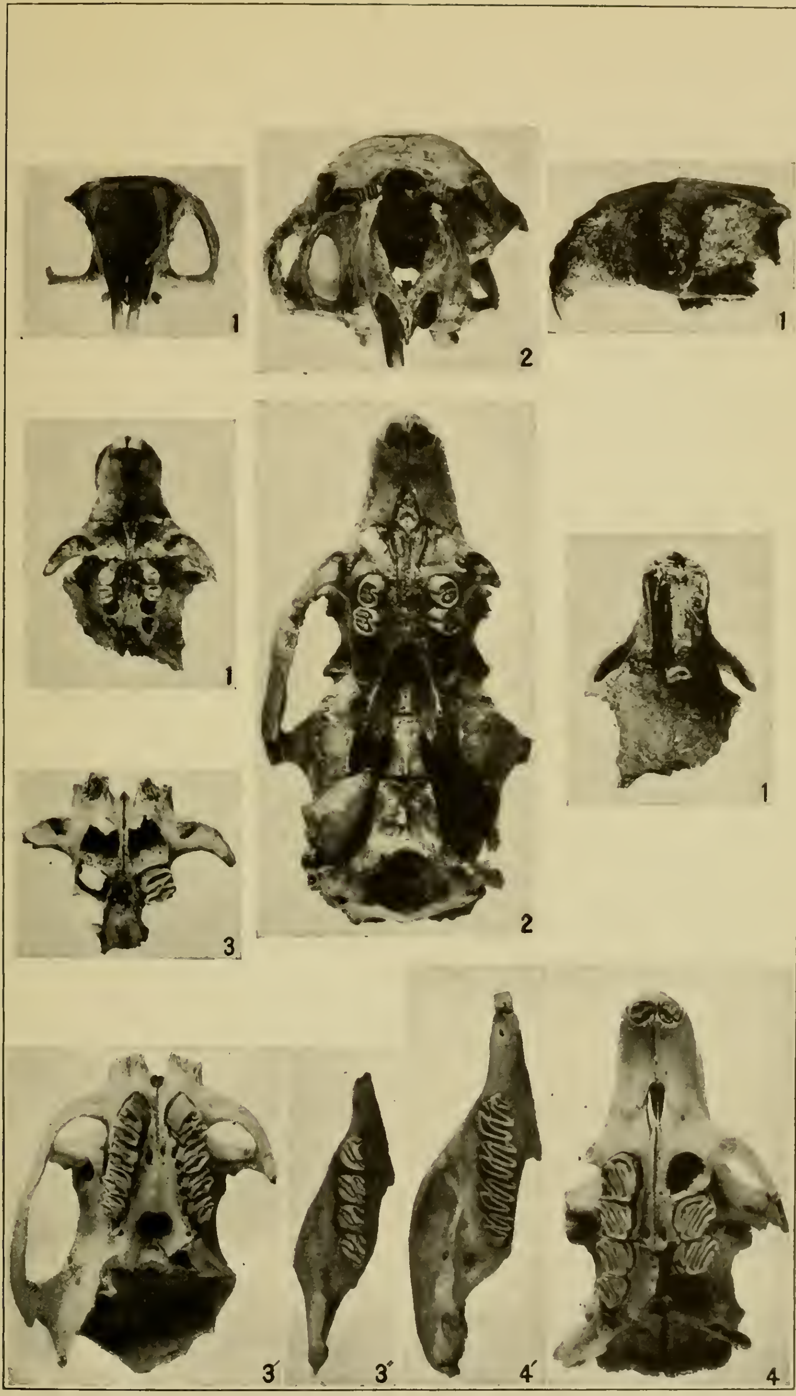
FIG. 3. *Isolobodon portoricensis.* No. 217118, U. S. Nat. Mus., Santo Domingo. (de Booy.)

FIG. 3'. *Isolobodon portoricensis.* No. 216595, U. S. Nat. Mus., Porto Rico. (Boas.)

FIG. 3". *Isolobodon portoricensis.* No. 217119, U. S. Nat. Mus., Santo Domingo. (de Booy.)

FIG. 4. *Plagiodontia aedium.* No. 217112, U. S. Nat. Mus., Santo Domingo. (Abbott.)

FIG. 4'. *Plagiodontia aedium.* No. 217126, U. S. Nat. Mus., Santo Domingo. (de Booy.)



1. BROTOMYS 2. HETEROPSOMYS 3. ISOLOBODON 4. PLAGIODONTIA

ALL NATURAL SIZE

SMITHSONIAN MISCELLANEOUS COLLECTIONS
VOLUME 66, NUMBER 13

THE TEETH OF A MONKEY FOUND IN CUBA

(WITH ONE PLATE)

BY
GERRIT S. MILLER, JR.

(PUBLICATION 2430)

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THE TEETH OF A MONKEY FOUND IN CUBA

By GERRIT S. MILLER, Jr.

(With One Plate)

In 1911 Ameghino described as *Montaneia anthropomorpha* a supposed new genus and species of American monkey from Cuba.[1] He based his account on a nearly complete set of mandibular teeth found associated with human remains in a cave near Sancti Spiritus. Dr. Louis Montané, the discoverer of these teeth, brought the specimens to Washington in December, 1915, and asked me to compare them with the South American material in the National Museum. On making this comparison we at once saw that the likeness of the Cuban teeth to those of *Ateles*, noticed by Ameghino,[2] amounted to such complete identity that in the absence of further evidence *Montaneia* could not be regarded as a distinct genus. The exact agreement in all essential characters between the type of *Montaneia* and an *Ateles* from Tehuantepec is shown by the accompanying photographs (plate 1). The only structural difference that can be observed is the unusual development in the Cuban specimen of the hypoconulid or "fifth cusp" in each of the molars, a peculiarity which caused Ameghino to see in the dentition a resemblance to that of man and the higher anthropoids.[3] Examination of numerous specimens shows that the hypoconulid in *Ateles* varies so much in size and distinctness that its degree of development must be considered as an individual or specific character and nothing more.

Ameghino remarks that the discovery made by Doctor Montané is noteworthy in view of the fact that no monkeys now occur in Cuba (p. 318). Not only do the islands of the Greater Antilles lack members of this group, but all[4] the living and recently extinct mammals yet found on them appear to be related to a South Ameri-

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[1] An. Mus. Nac. Buenos Aires, ser. 3. Vol. 13, p. 316.

[2] "Se parecen á los de *Ateles* y más todavía á los del hombre" (p. 318).

[3] "La conformación de las coronas de las muelas persistentes se parece á los monos antropomorfos y al hombre, y todavía más á este ultimo que á aquéllos" (p. 317).

[4] With the exception of the Jamaican *Oryzomys*, an animal whose history has almost certainly been different from that of the Antillean insectivores, ground-sloths, and hystricine rodents.

can fauna much older than any which is known to have included modern genera of monkeys. These circumstances, together with the facts that spider-monkeys are habitually tamed by the Indians in tropical America, and that the type of "*Montaneia*" was found in a cave used for human burial, make it seem probable that this particular set of teeth owed its presence in Cuba to man's agency. If this assumption were true it should be possible, so far as this can be done with such incomplete material, to identify the animal with some species now alive.

As the teeth of "*Montaneia*" differ specifically[1] from those of all the spider-monkeys in the National Museum I sent copies of the photograph here reproduced to Dr. J. A. Allen and to Mr. Oldfield Thomas. Dr. Allen could find no *Ateles* in the American Museum of Natural History that he would regard as probably conspecific with the animal whose teeth were represented. Mr. Thomas wrote under date of February 19, 1916, that a specimen in the British Museum collected at Nanegal, Ecuador, and supposed to be referable to *Ateles fuscipes* Gray, agreed "fairly closely" with the teeth of "*Montaneia*," though it did not show the unusual depth of the V-shaped notch on outer side of m_1 and m_2. As the notches in question appear to have been made somewhat unduly conspicuous by the lighting of the specimen when it was photographed, this discrepancy is probably not very important. While not willing, on the sole basis of the mandibular dentition, to assert specific identity between the Ecuadorean *Ateles* and the animal to which the Cuban teeth belonged, Mr. Thomas and Mr. Martin A. C. Hinton, who also compared the photograph with the specimen, did not regard such identity as impossible.[2] Nothing further seems needed to lead to the following conclusions:

That the teeth of the animal described by Ameghino as *Montaneia anthropomorpha* have no more than a superficial resemblance to those of the *Pongidae* and *Hominidae*.

That the generic name *Montaneia* Ameghino, 1911, must for the present be placed in the synonymy of *Ateles* Geoffroy, 1806.

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[1] The chief peculiarity is the large size. Measurements: canine, 5.4 x 6.8; height of canine from base of enamel on outer side, 11.6; anterior premolar, 5.0 x 5.4; median premolar, 4.0 x 5.0; posterior premolar 4.2 x 5.2; first molar, 6.2 x 5.2; second molar, 6.2 x 5.6; third molar, 6.0 x 5.4.

[2] "To say that *Montaneia* was probably or possibly conspecific with the Ecuador *Ateles* would be too strong, but I would not say it wasn't" (Thomas in letter dated March 23, 1916).

That while the specific name *Montaneia anthropomorpha* cannot now be referred with certainty to the synonymy of any known *Ateles,* the resemblance of the Cuban teeth to those of a specimen from Ecuador makes eventual identification with a living species seem probable.

That without much doubt the presence of these spider-monkey's teeth in Cuba was due to the agency of man.

EXPLANATION OF PLATE

(Both figures natural size)

FIG. 1. *Ateles neglectus* Reinhardt. Tehuantepec, Mexico (No. 13858, U. S. National Museum).

FIG. 2. *Ateles* sp. Cuba. (Type of *Montaneia anthropomorpha* Ameghino.)

1. ATELES NEGLECTUS

2. TYPE OF "MONTANEIA"

SMITHSONIAN MISCELLANEOUS COLLECTIONS
VOLUME 66, NUMBER 14

Preliminary Survey of the Remains of the Chippewa Settlements on La Pointe Island, Wisconsin

BY
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(Publication 2433)

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PRELIMINARY SURVEY OF THE REMAINS OF THE CHIPPEWA SETTLEMENTS ON LA POINTE ISLAND, WISCONSIN

By PHILIP AINSWORTH MEANS

HONORARY COLLABORATOR IN ARCHEOLOGY, UNITED STATES NATIONAL MUSEUM

INTRODUCTION

In August, 1916, on the advice of Dr. Hrdlička, I visited La Pointe Island (now commonly called Madeline) with the intention of conducting archeological investigations on the site of the Ojibwa village on that island. For reasons which I shall touch upon in the body of this report it was impossible for me to do what I intended at that time. I spent, however, several days going over the site, consulting those who were best acquainted with the local history of the Ojibwa, and planning for future work.

While in the Chequamegon Bay region I received much kindness and help, for which I wish to tender grateful acknowledgment, from Mr. Clark, proprietor of the Knight Hotel in Ashland; from Mr. C. N. Cramer of Ashland; from the Messrs. Salmon of the "Old Mission," Madeline Island; from Mr. William C. Stone of Watertown, Wisconsin, and from Mr. G. F. Thomas of La Pointe.

LOCATION OF LA POINTE OR MADELINE ISLAND

The island is one of the archipelago known as the Apostle Islands, in Lake Superior. On the north and east the archipelago is bounded by the open waters of the Lake; on the west lies the Bayfield peninsula; on the south stretches Chequamegon Bay, on the southern shore of which is the city of Ashland. La Pointe Island lies toward the southern extremity of the group of islands. Its main axis runs from southwest to northeast. In length the island is about twelve miles, and approximately three miles in breadth. The major part of it is covered with old forest; the remainder is taken up by farms and summer resorts.

FIRST INHABITANTS OF LA POINTE ISLAND

We do not know who were the earliest inhabitants of La Pointe Island. The Chippewa have occupied it since 1490. A mound which may have been made by their predecessors exists in the thick, swampy woods east of the Old Mission. It is said to be rather small, made of earth and stones, and to have the shape of "a serpent." It was described by Mr. Stone as being 15 to 18 feet in length and 3 to 5 feet high. An old Chippewa Indian, whom Mr. Stone consulted on the point, was certain that it was not the work of his people. The writer was not able to visit the mound in person. Its presence on La Pointe Island is interesting. Neither Lapham (1855) nor Thomas (1894) reports any mounds so far north. There is a mere possibility that it was made by the Chippewa [1] but, more probably, its builders were an offshoot of the tribes to which must be attributed the numerous mounds farther south in Wisconsin.

MIGRATIONS OF THE CHIPPEWA (OR OJIBWA) AND THEIR HISTORY ON LA POINTE ISLAND, 1490-1620

The Chippewa belong, as is well known, to the great Algonquian linguistic family. Much of that stock dwelt around the Gulf of St. Lawrence, and there are traditions that the Chippewa themselves once lived in that region.[2] Warren, basing his knowledge on what was told him by an old " priest " of the Midewiwin (Grand Medicine Lodge), tells the following story of the westward migration of the Chippewa:

Starting from the region around the Gulf of St. Lawrence, the Ojibwa moved up the river, following the *megis* (sacred sea-shell), which was their guide. They stopped for a time at Mo-ne-aung, now Montreal. Eventually the megis guided them to the Sault Ste. Marie, called by them Bow-e-ting. At Michillimackinac the Ojibwa (who were not then known by that name) split into three separate but always allied divisions; the Ojibwa proper, the Ottawa, and the Potawatomi. The Ottawa moved somewhat eastward from the Sault; the Potawatomi moved south; the Ojibwa moved west. In historic times, at least, the Potawatomi dwelt near Lake Winnebago and Green Bay.[3] These three new tribes, as they became, always remained in friendly relations.

After their separation from the Ottawa and the Potawatomi, the Ojibwa stayed for a long time at Bow-e-ting (Sault Ste. Marie). Many of them remained there after the main body had gone on.

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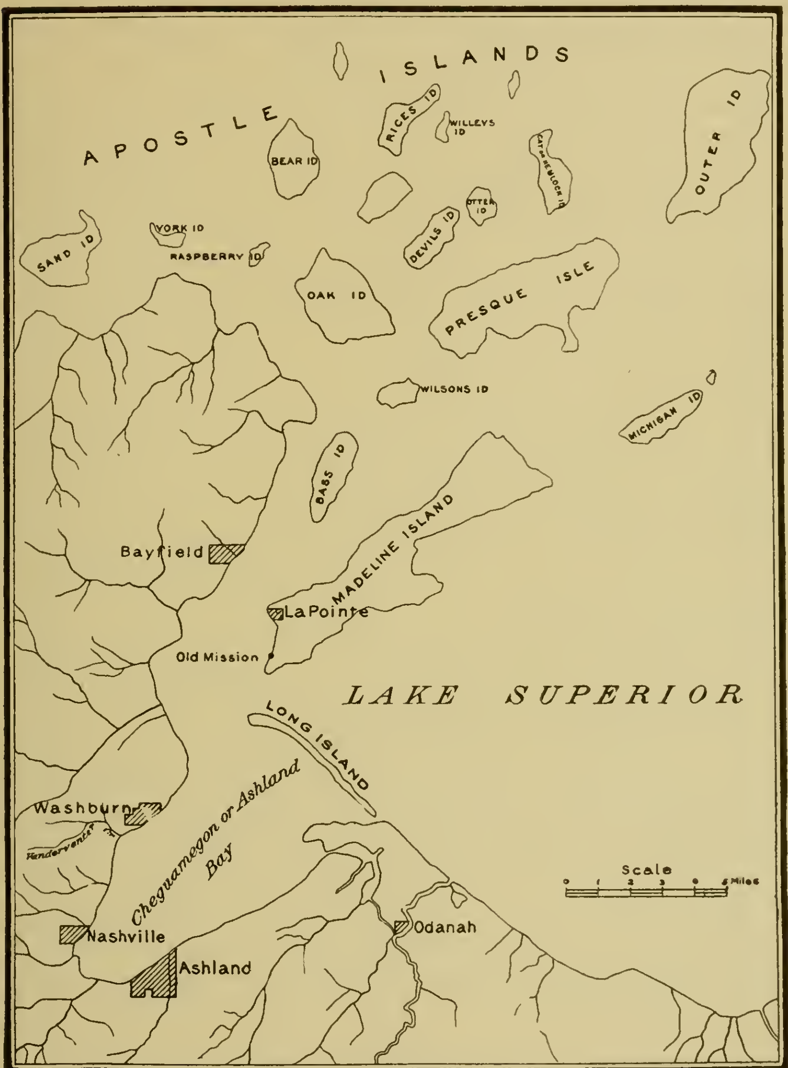
[1] According to Brinton, they occasionally built a mound " to celebrate some special event "—Brinton, D. G., Essays of an Americanist, Phila., 1890, p. 70.

[2] Cf. Warren, 1885, pp. 76-80; Powell, 1891. (Bibliographical references at end of paper.)

[3] Bulletin 30, Bur. Amer. Ethn., p. 290; Verwyst, 1886, p. 211; Jes. Rel. for 1640; Thwaites, 1908, p. 194.

The French name for the Ojibwa was *Sauteurs,* People of the Falls. Of those who separated, part went to the northern shore of Lake



MAP 1.

Superior; the remainder went west, until they reached the long, narrow sand-spit known as Shaug-ah-waum-ik-ong.[1] This place

[1] Warren, 1885, p. 86; Verwyst, 1895, p. 426.

is the narrow sandy island which forms the northern side of Chequamegon, or Ashland Bay. It is now called Long Island; formerly it was a peninsula connected with the mainland. It runs at a right angle to La Pointe Island.[1]

Upon this rather unsuitable site the Ojibwa built their first settlement in the Chequamegon Bay region.[2] The settlement took place, according to all authorities, about 1490. As the place was, at that time, a peninsula, it was open to the attacks of the Sioux and the Foxes, which tribes had replaced the Iroquois as enemies-in-chief of the Ojibwa.[3] Accordingly, the Ojibwa moved their chief village to Mon-ing-wun-a-kaun-ing (place-of-the-golden-breasted-woodpecker), now called La Pointe. There they established their principal village, though there were several other settlements along the shore of Chequamegon (Ashland) Bay.[4]

We may safely assume, then, that by or soon after 1500 a large Ojibwa town flourished on the area just indicated. This important community was menaced by the Sioux from the west and the Foxes from the south, but escaped destruction, and in the course of time numerous settlements were established by the Chippewa on the mainland, which served as outposts to the main village at La Pointe. War against their enemies occupied much of the Ojibwas' strength and time for generations.[5]

For about 120 years, from about 1500 to 1620, the Ojibwa lived uninterruptedly on La Pointe Island. About 1620, however, circumstances arose which led them to desert the place. There are two theories put forth to account for this desertion. One is that the branch of the Ojibwa who remained at the Sault (or possibly their kinsmen the Ottawa) received firearms at this time from the earlier French settlers, and, passing them on to their allies on La Pointe, enabled the latter to drive off their hitherto formidable enemies by means of their powerful new weapons, and progress over the mainland to the southward and westward. The other theory is that a craze for human flesh grew upon the medicine-men of the Ojibwa at La Pointe to such a degree that they even made use of

[1] See map 1, p. 3.

[2] This island is flat, sandy, sparsely settled, and not too much forested, offering every advantage to the archeologist. Finds from the northwestern end of the island would date from a very early prehistoric and an early historic period.

[3] Warren, 1885, p. 95; Verwyst, 1895, p. 430.

[4] Verwyst, 1895, p. 430.

[5] Warren, 1885, p. 92.

poisons and violence to meet their desires.[1] In time this abuse attained such proportions that parents were terrorized into giving up their children to the insatiable appetites of the shamans. At length, however, a father, braver than the rest, overcame his superstitious terrors and killed the shaman who had eaten his child. But the island came to be regarded as haunted by the Che-bi-ug, " Souls of the victims," and this belief grew, so that at last the site and the whole island were deserted.

Possibly both causes contributed to the abandonment of the site, though superstitious fear and unhappy conditions within the community would be sufficient for such a step. At all events, the island was completely deserted by all inhabitants about 1620. There were then already numerous Ojibwa villages around Chequamegon Bay and elsewhere on the mainland, and to these doubtless the La Pointe Chippewa went.

THE CHIPPEWA UNDER FRENCH CONTACT, 1634-1760

French knowledge of the existence of Lake Superior may be said to date from 1618. In that year one Étienne Brulé, a *voyageur* of Champlain's, reported the location of the Lake and also brought some copper from there.[2]

It was Jean Nicolet, however, who, in 1634-35, first came in contact with the Ojibwa of Sault Ste. Marie. News of his arrival quickly spread among the tribe.[3] In 1635 Champlain died, and a new Governor, Montmagny, was appointed, under whom exploration fell off. In 1641, however, Brébœuf and Daniel, two priests, visited the Sault, and in 1642 Jogues and Raymbault did likewise.[4]

In 1651 a very important event took place. According to Father Le Mercier, the fur-trade was begun in that year by a party of Indians.[5] The French were not slow to avail themselves of this chance for wealth, and the Company of the Hundred Associates was formed to carry on the trade.[6]

Groseilliers and Radisson were the first Frenchmen actually to enter the region of Chequamegon Bay. Warren declares (1885,

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[1] Warren, 1885, p. 109 ff.

[2] Neill, 1885, pp. 399-400; Parkman, 1886, p. 56.

[3] Neill, 1885, p. 400; Parkman, 1886, p. 166; Thwaites, 1908, pp. 22-31; Butterfield, 1881, pp. 35-74.

[4] Cf. Neill, 1872, p. 19; Parkman, 1886, p. 213; Bull. 30, Vol. 1, p. 278.

[5] Jesuit Relation for 1653-54.

[6] Thwaites, 1908, p. 34 ff.; Neill, 1885, p. 40; Jones, 1861, p. 165 ff.

pp. 121-122) that their first post was built on the eastern end of La Pointe Island. This is emphatically refuted by Thwaites[1] who, quoting Radisson, states that the fort then built by Radisson was on the mainland between the modern town of Washburn and the city of Ashland. In the winter of 1661-62 Groseilliers and Radisson penetrated Minnesota, returning to Chequamegon in the spring of 1662. At that time they built a second fort, probably on the point of Shaug-ah-waum-ik-ong, where the earliest Ojibwa village had been.[2]

In 1661 Father Ménard had established a mission among the Ottawa on Keweenaw Bay, but abandoned it before very long. Father Claude Allouez was sent, in 1665, to re-establish the mission, settling near the mouth of Vanderventer Creek, just south of modern Washburn. In a short time the name of "La Pointe du Saint Esprit" became attached to the whole of the present Bayfield peninsula.[3] At this time there were at Chequamegon Bay many Indian traders of the Ojibwa, Sauks, Foxes, Ottawa, and other tribes.[4] The labors of Father Allouez seem to have been ill requited, for he was relieved, in 1669, by Father Jacques Marquette. Soon after the arrival of the new missionary, the Ojibwa and the Sioux resumed their ancient hostility, and the former, together with Marquette, were driven to the Straits of Mackinaw. The first missionary period of Chequamegon Bay ended, then, in 1670.[5]

The fur-traders, however, met with a success never attained by the missionaries. In 1673 Sieur Raudin, or Radin, an agent of La Salle's, and Daniel Greysolon du Lhut, or Duluth, entered the western end of Lake Superior and explored it with a view to commercial enterprises.[6] Their trade languished after a time. In 1693 le Sueur was sent out to reopen du Lhut's old trade routes, notably the Bois Brulé-St. Croix route, in order that they might take the place of the better Fox-Wisconsin route which had been closed by the recently awakened hostility of the Foxes for the French. His many activities included a spectacular but commercially unprofitable copper mining, and also the construction of a fort and village on La Pointe Island.[7] I am sure from what I saw and heard on La Pointe Island that the

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[1] 1895, p. 401.

[2] Thwaites, 1895, p. 402 ff.

[3] Thwaites, 1895, pp. 403-4; map at page 419; Jes. Rel. for 1666-1667 and 1670-1671.

[4] Thwaites, 1895, p. 406; Bulletin 30, Vol. 2, 474.

[5] Parkman, 1887, p. 33; Thwaites, 1895, p. 406.

[6] Thwaites, 1895, p. 407 ff.; Appleton's Cycl., Vol. 2, p. 252, Article Du Lhut.

[7] Thwaites, 1895, pp. 408-411; Appleton's Cycl., Vol. 3, p. 698, Article Le Sueur.

site of this fort is in the large field on the southwestern end of the island. A description of this, the "French Fort Site," will be given later, together with a report on present conditions there. The fur-trade flourished under the French throughout the region from 1693-1756. There was a succession of French commandants, one of whom, Linctot, made peace between the Ojibwa and the Sioux about 1720.[1] In this long stretch of years the Ojibwa, who by now had returned to the island, passed through many changes. Their needs were elaborated and Europeanized; race intermixture occurred, and new forms of disease were introduced, together with a craving for whiskey. The anthropologist who wishes to study the Ojibwa in their primitive circumstances must, then, look behind this period.

From 1730-1744, the Chequamegon region was controlled by the Sieur La Ronde Denis and his son. They were not successful in their search for copper mines, but they built a forty ton sailboat which was the first on Lake Superior.[2] At that period the island was called Isle La Ronde.

In 1760-1761 the French fort on La Pointe was destroyed by some traders who were horrified by the crimes of a *voyageur* who, in that winter, had killed Joseph, a clerk, and his master, as well as Joseph's wife and child.

In 1765-66 Alexander Henry, a British trader, was vested with sole right to trade on Lake Superior. He associated with him in his business a young Frenchman named Jean Baptiste Cadotte.[3] During the same period (1760-1800) a Scotch-Irishman named John Johnston established himself near the old French fort at La Pointe Island, not far from the spot later occupied by the "Old Mission," and carried on trade with an Ojibwa village on the site of the modern Bayfield. Johnston married a daughter of the chief of La Pointe.[4]

The family of Jean Baptiste Cadotte, Sr., soon arose to prominence among the Chippewa. He married a girl of the tribe and lived with her at Sault Ste. Marie. His two sons, Jean Baptiste, Jr., and Michel, took up his business in 1796. In 1802 Michel moved to La Pointe, where he married Equaysayway, daughter of White Crane, chief of La Pointe.[5] Michel Cadotte occupied the site of the old French fort. His house, dismantled and dilapidated, remains to this day. He became an agent of Astor's American Fur Company, which

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[1] Thwaites, 1895, p. 411.
[2] Thwaites, 1895, p. 411; Butler, 1894, p. 87.
[3] Henry, 1809, p. 197 ff.
[4] Thwaites, 1895, p. 415.
[5] Thwaites, 1895, p. 415.

played an important rôle on the island in the first half of the nineteenth century. He died at La Pointe in 1837.

In 1818 Lyman Marcus Warren and Truman Abraham Warren arrived at La Pointe from western Massachusetts. Lyman Warren, also an agent for the American Fur Company, married a daughter of Michel Cadotte; he died in 1847. His son, William Whipple Warren, is our chief authority on the earlier history of the Chippewa.[1]

Although the wife of Lyman Warren was a Catholic, he invited missionaries of his own church (Presbyterian) to La Pointe. For the first time since the days of Allouez, missionaries were important in the lives of the Ojibwa. In 1831 the Rev. Sherman Hall arrived at La Pointe with his wife, who was a teacher. With them was their friend, Mrs. John Campbell, who acted as interpreter.[2] They built their mission about a mile north of the French fort. This building is now a part of an attractive summer hotel owned by the Messrs. Salmon who showed the writer so much kindness.

About 1830 the American Fur Company moved its village to the place where the La Pointe of our own day stands. The old anchorage (at the French Fort Site) was filling with sand, while the size of the boats used was steadily increasing.[3]

In 1845 most of the Ojibwa remaining on the island were moved over to the new La Pointe Reservation at Odanah, where they are to-day. The last representative of the Cadotte family was an old Indian whom Mr. Stone knew so well and from whom he received much information about the past of his tribe. This old man, Jean Baptiste Cadotte, 3d, died in 1913.

PRESENT CONDITIONS ON LA POINTE ISLAND AND PROSPECTS OF ARCHEOLOGICAL WORK ON THE ISLAND AND IN THE REGION OF CHEQUAMEGON BAY, WISCONSIN

When the writer went to La Pointe Island, Wisconsin, with the expectation of doing archeological work there, he found the present conditions unfavorable for work at just that time. The situation was this:

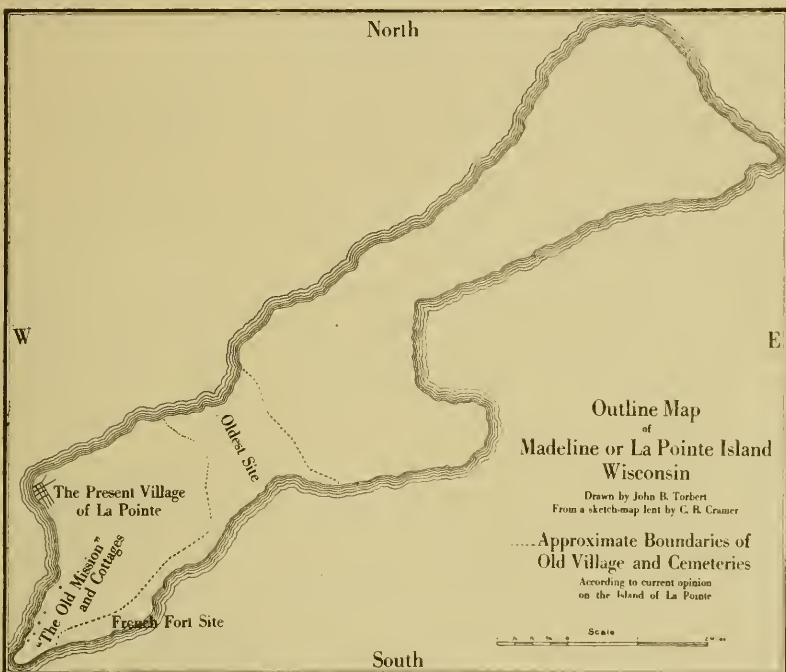
La Pointe Island is thickly settled, largely with a population of summer residents. A good-sized hotel (the "Old Mission") attracts many people there, and the half-breed Indian natives of the island largely support themselves by work connected with the hotel and its

[1] Thwaites, 1895, p. 416 ff.

[2] Thwaites, 1895, p. 419.

[3] Thwaites, 1895, p. 421.

dependent cottages. A goodly portion of the land in which lie the archeological materials is now given over to cultivation; the remainder of the ancient sites is still covered with dense woods. In places of the former sort, where the trees had been cleared off and the vegetal mold removed, it would have been simple enough to make excavations, were it not for the fact that standing crops of corn occupied the fields. The writer found it impracticable to buy the



MAP 2.

crops, and of course it was impossible to dig without destroying them. To wait until they had been harvested would have occupied many weeks. In the wooded portions of the sites the trees are very thick and the undergrowth is dense. It would be impossible to make satisfactory clearings without the aid of several laborers These were not then available.

The archeological sites on La Pointe Island will now be defined in chronological order. In the portion of this paper which deals with the history of the Ojibwa the importance of the several sites is dwelt on at greater length.

The oldest site is to be found covering a large area about two and one-half miles northeast of La Pointe village. The anciently occupied area extended from the southeastern shore to the northwestern shore at this point. (See map 2, p. 9.) By the year 1500, in all probability, the Ojibwa had established themselves in this area. They continued to occupy it and adjacent territory to the southwest until 1620. This territory to the southwest of the oldest site is referred to elsewhere in this paper as the "French Fort Site." Though geographically and chronologically a subdivision of the larger and older site northeast of it, the French Fort Site was occupied long after the oldest site had been deserted. In fact, the French Fort Site was the seat of the Ojibwa tribe until well along in the nineteenth century. The last, and the least important, Ojibwa site and burial ground on La Pointe Island is that immediately to the north of the "Old Mission." It is small, and, because recent and Christian, it is not of archeological interest.

Almost all of the oldest site is covered by woods. Some of it is in farms. Where fields now exist, the writer learned, the plentiful skeletal material is in fairly good condition owing to the fact that the sun dries out the sandy soil and the bones it contains. In the woods, conditions are probably less favorable, owing to roots and, above all, to dampness.

A serious difficulty on the island, however, is the question of labor. The mixed-bloods refuse to disturb the graves of their ancestors, and white laborers in the region of Chequamegon Bay were found to be few, expensive, and of doubtful quality.

Two or three miles south of the French Fort Site lies Long Island, where the Ojibwa first camped, about 1490. There are few trees upon Long Island, and the northwestern extremity of it, on which the village was, seems an ideal place for the archeologist. Because of its remoteness it is not, like the sites on La Pointe Island, liable to hostilities on the part of the half-breeds of La Pointe, who, Mr. Salmon assured me, would not hesitate to attempt a forcible prevention of excavations which they consider sacrilegious, at least on the more recent French Fort Site.

So much for present conditions on La Pointe Island and on Long Island.

The following table gives a brief chronological recapitulation of the various sites.

SYNOPSIS OF SITES OCCUPIED BY THE OJIBWA

First Site (about 1490-1500). The northwestern end of Long Island, then called Shaug-ah-waum-ik-ong. This site would yield very old objects.

Second Site (1500-1620). The region about two and one-half miles northeast of modern La Pointe village. This site was called Mon-ing-wun-a-kaun-ing. As it was occupied a long time, the occupied area gradually spread southwestwardly along the shore into the "French Fort Site."

Third Site (1620-1661). Just south of Washburn, probably at the mouth of Vanderventer's Creek. Other places were inhabited by the Chippewa at this time, also.

Fourth Site (1661-1662). On the northwestern end of Long Island.

Fifth Site. 1662-1693 was a period of uncertainty for the Chippewa. They were harassed by the Sioux, and were forced to wander about.

Sixth Site (1693-19th Century). The "French Fort Site" which, as has been said, was very old, was reoccupied during this period.

MATERIAL CULTURE OF THE OJIBWA

It may be well to note in this connection those aspects of the life and material culture of the Ojibwa which offer some indication of the class of objects that the archeologist may expect to find in excavating the various sites occupied by the tribe.

HOUSES AND GARDENS

The wigwams of the Ojibwa in their primitive periods were oval or oblong lodges, made either of birch-bark or of skins laid over a light framework of slender rods. The fastenings were thongs or certain rushes. The type persisted long after the Europeans had shown the natives how to erect more commodious houses of logs, and is still to be met with occasionally among some of the less civilized groups of the tribe.[1] The lodges had but one fireplace, and they were occupied by but one family. In other cases, however, long lodges with two or even three fireplaces existed. These accommodated as many as six families. Besides, there were the lodges of the Midewiwin.

The Ojibwa had gardens, even in the earliest periods. Pumpkins and maize were apparently the agricultural staples, if not the only vegetables grown, but wild fruits, wild rice, and maple sugar were

[1] A picture of a dome-shaped Chippewa (same as Ojibwa) house appears in Bulletin 30, Vol. 2, p. 131. See also illustration in Dr. Hrdlička's report on his trip to the Chippewa of Minnesota, in Explorations and Field-work of the Smithsonian Institution in 1915, Smithsonian Misc. Coll., Vol. 66, No. 3, fig. 89.

gathered in addition. Hunting and fishing were relied on to furnish the major part of the food.[1]

IMPLEMENTS, CANOES, ETC.

The Ojibwa were canoe-using people, which was a natural outcome of their environment. Some of the canoes built were of considerable size. These large canoes were often employed for carrying war-parties in the old days, and in later times they were used for carrying *voyageurs* and their merchandise. They were constructed in much the same manner as the wigwams, namely, of bark laid over a light framework, sewn together and calked with pitch. Dug-outs were not made by the Ojibwa, though used by some surrounding tribes.[2]

The Ojibwa were skillful makers of pipes, the material used being commonly a fine-grained, soft, reddish pipe-stone from the mainland. Mr. Stone presented an excellent example of such a pipe to the Wisconsin Historical Society a few years ago; it was about seven inches long and of fine workmanship. The writer was shown, by the farmer who now holds the "French Fort Site," several fragments of well-cut and polished pipes of similar nature. The cavity for the tobacco appeared to have been made by use of the sand-water-and-stick method; it was too narrow to permit the insertion of any other implement, and the striations caused by the sand were visible on the inside of the bowl.

The old Ojibwa made fire by the bow method. Pottery, decorated with simple incised designs, was used in cooking. These vessels as well as the various receptacles and utensils made of stone, birch-bark, and skins, were gradually discarded after the contact with whites was established.

The dress of the men consisted of a long coat or shirt of skins, and long leggings. The women wore a short garment of deerskin. Fringes, porcupine-quills, and feathers were employed for decoration. Fur robes were used in cold weather. Nose- and ear-ornaments were common. Moccasins, both low and high, were worn, and a long puckered seam running up the foot was distinctive of the Ojibwa moccasin [3] and gave the tribe its name.

[1] Cf. Gilfillan, 1901, p. 62; McKenney, 1827, p. 289 (picture), p. 418 (picture); Jones, 1861, pp. 71-73; Warren, 1885, pp. 40 and 97; Lahontan, 1905, p. 220; Carver, 1781, pp. 283-293.

[2] Thwaites, 1908, p. 18; McKenney, 1827, p. 200; Lahontan, 1905, p. 80.

[3] London, 1808-11, Vol. 2, p. 327; Jones, 1861, pp. 73-74 and 75-77; Carver, 1781, pp, 225-230; Warren, 1885, p. 36.

BURIAL CUSTOMS

When an Ojibwa died, his body was dressed in new and elaborate garments. He was then wrapped in strips of birchbark and, together with his best implements and weapons, was buried, his head to the west, the land of the future. In later times wooden coffins came into use. McKenney gives a picture which indicates that scaffold-burial was used, possibly during winter when the ground was frozen hard, for Ojibwa children. Though common in Dakota, it was probably rare among the Ojibwa.[1]

PICTOGRAPHY

The pictography of the Ojibwa was connected mostly with the Midewiwin and its rites. Brinton, however, mentions *adjidjiatig*, or grave-posts. Hoffman has discussed at length the nature and significance of the sacred bark records of the Midewiwin and figures several specimens of them.[2]

CONCLUDING REMARKS

From the foregoing, it would seem that archeological exploration of the oldest Chippewa burials on both Long and La Pointe islands will probably result in the recovery of considerable skeletal material which, in view of the extensive subsequent admixtures into the tribe of white and other blood, would doubtless prove of great value to science. Besides, there will doubtless be stone pipes, more or less pottery, and some stone implements including possibly some ceremonial forms, and there is a chance that some primitive tools of native copper may also be found. More perishable articles have of course by this time disappeared. In the burials dating from the time when contact with the French was established, there is a bare chance that a recovery may be made of medals, coins, or other articles which would serve to corroborate certain dates.

At all events, the La Pointe and surrounding sites must be regarded as among the best dated and, from the standpoint of anthropology, most valuable sites which await careful exploration in the northern states.

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[1] Loudon, 1808-1811, Vol. 2, p. 296; Carver, 1781, pp. 398-399; Jones, 1861, pp. 98-101; McKenney, 1827; Bulletin 30, Vol. 1, p. 946.

[2] Brinton, 1890, p. 228; Hoffman, 1891, p. 286; Carver, 1781, pp. 414-417; Belcourt, 1872, p. 232; Willis, 1859.

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THREE REMARKABLE NEW SPECIES OF BIRDS FROM SANTO DOMINGO

BY
J. H. RILEY

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THREE REMARKABLE NEW SPECIES OF BIRDS FROM SANTO DOMINGO

By J. H. RILEY

Dr. W. L. Abbott, the well-known traveller and collector, during the past summer and fall paid a visit to Santo Domingo, the Spanish-speaking portion of the Island of Haiti. He visited the highlands of the interior where few zoölogical collectors have ever penetrated and amongst the last shipment of birds received from this region the three following prove to be apparently undescribed. One is a white-winged crossbill, another is a song sparrow of the genus *Brachyspiza,* both belonging to genera that have never been reported from the West Indies, while the owl is closely related to a species found in Cuba and on the mainland, from which, however, it is very distinct.

These three birds, without question, are the most remarkable discoveries in West Indian ornithology in recent years.

ASIO NOCTIPETENS, sp. nov.

Type, U. S. National Museum, No. 249475, ♂ adult, Constanza, 4,000 feet, Santo Domingo, September 23, 1916. Collected by Dr. W. L. Abbott.

Similar to *Asio stygius* (Wagler) but much darker, with the lighter markings much restricted everywhere above and entirely disappearing on the interscapular region. Wing, 300; tail, 161; culmen from cere, 21 mm.

Remarks: Below, the differences are not so well-marked, but still the dark markings are darker than in *Asio stygius,* while the differences above are obvious. The type is the only specimen.

LOXIA MEGAPLAGA, sp. nov.

Type, U. S. National Museum, No. 249615, ♂ adult, El Rio, 4,000 feet, Santo Domingo, October 7, 1916. Collected by Dr. W. L. Abbott.

Similar to *Loxia bifasciata* (Brehm) but with a heavier and stouter bill and shorter wing.

Description: Head dusky, the feathers tipped with dull scarlet red and sulphine yellow; back dull black, the feathers washed with dull scarlet red and sulphine yellow; rump scarlet with some scattering lemon yellow feathers; upper tail-coverts dull black washed with dull scarlet; lores white with black stippling; auriculars, sides of neck, throat, and breast light grayish olive, the feathers tipped or washed with dull scarlet red and lemon yellow; belly dull grayish, vinaceous buff; flanks dusky, streaked with blackish and washed with pinkish and yellowish; under tail-coverts black, rather broadly edged with white and washed slightly with pinkish; tail dull black; wings dull black, the greater and middle coverts broadly tipped with white with a pinkish wash, forming two wing bands; the tertials also edged with white; under wing-coverts dusky, the feathers edged with whitish and with dark shaft streaks; the axillaries white, dusky at the base. Wing, 89; tail, 56; culmen, 18.5; tarsus, 17; middle toe, 12.5 mm.

Remarks: Besides the type Dr. Abbott took a female on the same day and while he found these birds more or less common in the pines, only succeeded in obtaining the pair. The female resembles the same sex of *Loxia bifasciata* but is smaller with a much stouter and heavier bill. From *Loxia leucoptera* the present species can be told at a glance by its heavier and much less attenuated bill.

BRACHYSPIZA ANTILLARUM, sp. nov.

Type, U. S. National Museum, No. 249605, ♂ adult, Constanza, 5,000 feet, Santo Domingo, September 23, 1916. Collected by Dr. W. L. Abbott.

Similar to *Brachyspiza capensis peruvensis* (Lesson) from the highlands of Costa Rica, but collar around hind-neck, edging of wings externally, back and flanks much darker, and the black patch on foreneck heavier. Wing, 67; tail, 63.5; culmen, 12; tarsus, 24; middle toe, 14.5 mm.

Remarks: Besides the type Dr. Abbott took two additional adult males, one adult female, and six immature specimens at the type locality and an additional adult male at El Rio, 4,000 feet.

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THE DETERMINATION OF METEOR-ORBITS IN THE SOLAR SYSTEM

BY
G. VON NIESSL
(Authorized Translation by Cleveland Abbe)

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THE DETERMINATION OF METEOR-ORBITS IN THE SOLAR SYSTEM

By G. von NIESSL

(Translation by the late Prof. Cleveland Abbe, with permission of the author and publisher, from the Encyclopädie der Mathematischen Wissenschaften, Band 6, Part 2, Heft 3. Dated Vienna, 1907.)

GENERAL THEORY

The orbits of those bodies which, by their entrance into the atmosphere, become incandescent meteors, have a planetary character in the solar system. They are conic-sections with the sun as one focus. That portion of the path revealed to us by observations is so short, that it must be assumed to be a straight line even in the most accurate determinations. Irregular movements that are conditioned by the shape of the body occasionally occur, but are here left out of consideration.

For all orbits that thus become visible, the smallest distance from the earth's center, or in geocentric phraseology, the perigee, is very small in comparison with the distance from the sun or the corresponding radius vector of the orbit of the earth, and can be neglected in comparison therewith. Hence, for the duration of fall the heliocentric radius vector of the meteor's path will be assumed as identical with that of the earth's orbit. Furthermore, since for the same reason, the collisions with the earth can be considered as identical with the passage of the meteor through one of the nodes of its path, therefore from the solar ephemeris for the date of collision we find directly the longitude and the radius vector of that node of its path.

The apparent location of the visible path of the meteor in the sky, depends parallactically on the location of the station of observation. It will, therefore, for the near-by meteors show greater apparent dislocation than for those more distant. Any point of the rectilinear path or its prolongation backwards, that is so far removed from all observing stations that their respective mutual distances no longer come into consideration, will be seen at the same point in the sky from all stations. This perspective point of divergence of the apparent paths instead of the true paths as seen from different places on the earth is the point of apparent radiation or convergence. This determines the geocentric direction of the observed rectilinear portion of the path. This is, however, except for the influence of the attraction of the earth, which can easily be allowed for, determined by the resultant of the velocity of the earth reversed and the true heliocentric velocity of the meteor. The projective direction of the latter motion as seen on the sky is the true radiation point or radiant which thus determines the true direction of the path of the meteor at the node.

Since the sun must lie in the plane of the orbit of the meteor this plane is determined by the radius vector to the sun and the direction of the orbit at its node, or by the great circle on the sphere that contains the points representing the sun and the true radiant.

But this latter also gives the angle that the true direction of the path makes with the radius vector at the node and thus all further elements of the orbit depend upon the velocity at this portion of the orbit, which must be determined either from the observations or from theoretical considerations.

The problem now before us consists, therefore, of two very different portions sharply separated from each other, of which the first is a geocentric problem, the second concerns the heliocentric conditions. These portions are:

1. The determination of the radiant point and of those quantities which are necessary for estimating the relative velocity.

2. The location of the orbit in the solar system.

With reference to the first part which contains the more difficult and complicated work, but whose results must be decisive as to the further results of the second part, the starting point and the aim can be different. The most important cases of the determination of the radiant are the following:

1. Examination of the path relative to the earth and of the radiant point by means of numerous observations of the same meteor from different places on the earth's surface (corresponding observations in the most general sense of the word).

2. Determination of the radiant by observations of several apparent paths belonging to the same radiant and seen from one station (one-place observations).

I. DETERMINATION OF THE RADIANT AND THE GEOCENTRIC VELOCITY

1. Numerous Observations at Different Places

Abundant experiences teach us that, depending upon the location of the orbit with reference to each individual place of observation, the beginning of the observed luminous streak is ordinarily not the same as observed everywhere, but that in this respect differences up to large angular arcs and up to hundreds of kilometers in linear measure can occur. We must except the cases with long enduring, sharply marked traces when the observations relate especially to these and not to the whole orbit.

In general the orbit may not be deduced by assuming the identity of the indicated initial points of visibility.

Since the true orbit does not differ appreciably from a straight line, the eye of the observer determines with it a plane which is a section or great circle of the celestial sphere. The so-called apparent orbits observed at different places can therefore be considered as arcs of great circles which, on being produced backwards (in the direction opposite to the course of the meteor), will indicate by their intersection the apparent radiant.

The determination of this apparent radiation point depends thus upon the fact that one intersection is given by many great circles that do not coincide but are given by the observations of the same meteor made at many places.

If now two sets of arcs of orbits are at hand the solution, whether by computation or by graphics, is so simple that it does not require further explanation. The problem is more complicated when numerous observations are to be united, and yet it is especially desirable, in fact important, to use a great excess of observations in order to determine the orbits of the great fire balls and meteorites for which we often have less accurate and partly also incomplete material. These are the typical cases to which the following explanations will principally relate.

The positions at which the planetary path of a large meteor is checked by the resistance of the air (the end of the orbit) is almost always so clearly shown by special phenomena that there is seldom any doubt as to the identity of this point. Ordinarily it is the one single point in the orbit of which this can be assumed with equal probability. Moreover, in reference to it, the near agreement among the observers is practically certain and occasionally the research is favored by observations of sound or even by the finding of pieces of fallen fragments of the meteorite.

The most accurate possible determination of the location and altitude of the end of the meteor's track forms in general a very important and generally indispensable preliminary to all further investigations.

There is no great geometrical difficulty in so solving the general problem that the three co-ordinates in space of the end-point, together with the spherical co-ordinates of the radiants, are obtained by the method of least squares from one system of equations. But such a solution, independently of the fact that it would be extremely tedious and have little importance, would only seldom lead to any useful result. It will therefore not be further considered here, but the determination of the end-point will be separately treated as a necessary preliminary work.

A. DETERMINATION OF THE GEOGRAPHIC CO-ORDINATES AND THE ALTITUDE OF THE END-POINT

There are good reasons why it will generally be useful to divide this problem into two parts, determining first the geographical locations and afterwards the linear altitudes. In certain cases the general treatment of the problem is necessary or at least appropriate. In order to determine all three unknown quantities the observations of three appropriate elements, including one apparent altitude angle, must be furnished by at least two places. The other two elements may be directions or azimuths and it is generally best that this should be the case. Evidently three azimuths are not sufficient if we wish to find the linear altitude, but on the other hand, the problem can generally be solved with three apparent altitudes. The determination of the geographical location merely by means of parallax in altitude will indeed be the only possibility if the parallax in azimuth is not given, for example, if the locations of the places of observation fall in the same vertical plane as the terminal point of the meteor's path.

Sometimes the observed altitudes are so uncertain that the accuracy of the result is diminished by combining them with the observed directions. If we have reliable azimuths with a sufficiently accurate parallax, then it is preferable to determine the location of the terminal point from these alone, whereby we assume that the spheroidal earth can be replaced with sufficient accuracy by a sphere of corresponding radius. We can with advantage make use of the following approximate method.

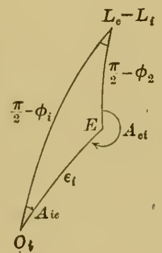
At the locations O_1, O_2. . . . on the earth's surface specified by the geographic co-ordinates L and ϕ, let observations be made of the azimuth A^*_{ie} of the terminal point E (L_e, ϕ_e) of the meteor's path.

First of all let approximate values L_o, ϕ_o of L, ϕ be found by some short, perhaps graphical, method, also let an approximate value H_o for the linear altitude H_e be sought out. Ordinarily these come, so to speak, of their own accord before the commencement of the real calculations, since in the gradual carrying out of the observations an approximate judgment must be formed of the location of the terminal points. In all important cases that are worthy of a more thorough treatment of the observations a preliminary idea of these quantities will soon be obtained.

With these approximate values we now compute approximate azimuths from O_i to E which will be denoted here by A°_{ie} and also those for the readily deducible directions from E to O_i which we shall denote by A°_{ei}. Furthermore, we find the approximate distances O_iE or the spherical amplitudes ϵ_i and approximately the apparent altitudes h_{ie}. The latter influence this determination only in so far as even quite crude approximations suffice when we do not desire to use observed quantities.

Finally we must form the numerical values of all the differences $A^{\circ}_{ie}-A^{*}_{ie}=\omega_i$. If now we assume $L_e=L_o+\Delta L_o$, $\phi_e=\phi_o+\Delta\phi_o$, in which ΔL_o and $\Delta\phi_o$ are the corrections to be determined for the preliminary co-ordinates of the terminal point, then if A_{ie} denotes the actual value of the azimuth we shall obtain from the equations

$$\tan\phi_e\cos\phi_i=\cot A_{ie}\ \sin(L_e-L_i)+\sin\phi_i\cos(L_e-L_i),$$
$$\tan\phi_o\cos\phi_i=\cot A^{\circ}_{ie}\sin(L_o-L_i)+\sin\phi_i\cos(L_o-L_i),$$
$$A_{ie}=A^{*}_{ie}+v_i\sec h_{ie},$$



in the usual way, the following set of equations for the errors:

$$v_i=o_i+a_ix+b_iy, \tag{1}$$

where $$x=\Delta L_o\cos\phi_o,\quad y=\Delta\phi_o,$$

$$\left.\begin{aligned} o_i&=\omega_i\cos h_{ie},\\ a_i&=\frac{\cos h_{ie}}{\sin\epsilon_i}\cos A^{\circ}_{ei},\\ b_i&=-\frac{\cos h_{ie}}{\sin\epsilon_i}\cdot\sin A^{\circ}_{ei}=-a_i\tan A^{\circ}_{ei}.\end{aligned}\right\} \tag{2}$$

The general factor $\cos h_{ie}$ is more important the more unequal the distances are, so also are the h_{ie}'s because the errors of direction usually attendant on such observations are not properly differences of azimuth, but small spherical arcs which correspond to very different azimuths according to the zenith distance.

From the equations (1), allowing different weights to the individual observations according to the method of least squares, we get ΔL_o and $\Delta\phi_o$ and therefore also L_e and ϕ_e with their mean errors.

The final azimuths are, therefore,

$$A_{ie} = A^*_{ie} + v_i \sec h_{ie}.$$

In case the v_i's are too large it is to be recommended that A_{ie} should be computed again directly from the final L_e and ϕ_e.

Of course we determine x and y in the units of the absolute term o_i. In this respect we can introduce various modifications according to circumstances.

If we designate by μ_i the spherical distance of the approximate terminal point $E_o(L_o, \phi_o)$ from the observed direction designated by A^*_{ie}, then we have approximately $\omega_i = \mu_i \operatorname{cosec} \epsilon_i$.

If we then put

$$\left.\begin{array}{l} \dfrac{\cos h_{ie}}{\sin \epsilon_i} = \sqrt{\gamma_i}, \\ \cos A^{\circ}_{ei} = a_i, \quad \sin A^{\circ}_{ei} = -b_i, \end{array}\right\} \quad (3)$$

we get

$$v_i = \sqrt{\gamma_i}(\mu_i + a_i x + b_i y), \quad (4)$$

and $\sqrt{\gamma_i}$ is a weight factor for the whole equation.

If we desire, for example, when reading from the chart for μ_i, as our unit a measure of length which shall then also hold good for x and y while the v's shall be given in degrees, so that in general the units may be taken to be one kilometer for altitude and one degree for azimuth, then the above-given equation for $\sqrt{\gamma_i}$ will still have to be multiplied by the following factor

$$\frac{1}{R \cdot \text{arc } 1^{\circ}} = \frac{1}{111 \cdot 35} = 0.0089807,$$

where the earth's radius is assumed to be $R = 6{,}380$ km.

It is easy to see that the coefficients a_i and b_i can, therefore, with advantage, be read off graphically, especially when the observations do not deserve the most accurate computational methods.

If we also find it advisable to use the parallax in altitude in the determination of the location of the terminal point (L_e, ϕ_e), which as we have already mentioned, is scarcely avoidable, then the approximate value H_o must be deduced more accurately and the consequent apparent altitude h_{ie} corresponding to the preliminary distance D_{ie} must be computed more carefully.

If $H_e = H_o + \Delta H_o$, and $\Delta L_o \cos\ \phi_o = x$, $\Delta\phi_o = y$, $\Delta H_o = z$ in longitude measure, while the corrections of the observed directions and the observed altitudes h_{ie} are given in degree measure and if we put

$$\left.\begin{aligned} (\tan h_{ie} + \sin \epsilon_i)\cos \epsilon_i &= K_i, \\ \frac{\cos^2 h_{ie}}{R \cdot \text{arc } 1^\circ \cdot \sin \epsilon_i} &= \sqrt{\gamma_i} \cdot \cos h_{ie} = F_i, \\ h_{ie} - h_{ie} &= n_i, \\ -F_i K_i \sin A^\circ_{ei} &= a_i, \\ -F_i K_i \cos A^\circ_{ei} &= b_i, \\ F_i &= c_i, \end{aligned}\right\} \tag{5}$$

then the error equations which we determine from the directions become

$$v_i = n_i + a_i x + b_i y + c_i z. \tag{6}$$

From these results again we obtain the normal equations and the unknown quantities.

This method should only be used with reliable altitudes and should only be applied when those deducted from stations in the neighborhood of the terminal point are to be compared with those further removed.

If we desire to determine the linear altitude of the terminal point separately on the basis of the geographical location of this point as already determined, then we usually combine the individual distances D_{ie} of the corrected terminal point with the corresponding observed apparent altitudes h_{ie} in order to obtain individual values of H_e from which an average value may then be determined. The distances do not need to be newly computed when they are known from previous work with reference to the preliminary terminal point, since they can easily be corrected from the corrections already determined, viz.: $\Delta L_o \cos \phi_o$ and $\Delta\phi_o$, and in fact with the help of the azimuth A_{ie} they can be easily reduced to the definitive point L_e, ϕ_e, for

$$\Delta D = -\frac{\Delta L \cos \phi_o}{\sin A^\circ_{ie}} = -\frac{\Delta\phi_o}{\cos A^\circ_{ie}}.$$

Since the reduction of the distance to the chord for such determinations of altitude is generally unnecessary, we can adopt

$$H_i = D_{ie} \frac{\sin\left(h_i + \frac{\epsilon_i}{2}\right)}{\cos(h_i + \epsilon_i)}. \tag{7}$$

If we put $h_i + \frac{\epsilon_i}{2} = h_i'$ then up to 10,000 kilometers the approximate height will be

$$H_i = D_{ie} \tan h_i' + \frac{1}{2R}(D_{ie} \tan h_i')^2, \tag{8}$$

even the first term is sufficient for several hundred kilometers. In consideration of the various uncertainties, the application of a correction for refraction will seldom be of any advantage, except that it may be done in cases of very large distances.

If we desire to consider the weight when we unite the individual determinations of the H_i's to an average value, then we must consider carefully the weights of the observed values of the h_i's that have been adopted, generally these weights cannot easily be estimated.

Large differences in the altitude above sea level of the individual places of observation are easily allowed for.

B. THE DETERMINATION OF THE APPARENT POSITION OF THE RADIANT

The data hitherto useful can be given in different forms, viz.:

1. The co-ordinates (A, h or α, δ) of the beginning and end of the apparent path.

2. Any two other points of the path, or even one point only, when it does not lie too near the assumed terminal point already well established. To this also belongs the indication of the direction of motion by means of some distant stars.

3. The apparent inclination to the vertical of a portion of the orbit at the terminal point, or the position angle with respect to the vertical. This I think can also be given for any other well-established portion of the path. In the case of paths that have a culminating point, the apparent altitude of the culmination is often sufficient, but the azimuth less frequently. Very often it is possible to utilize a determination, that is better than a mere estimate, of the apparent node of the orbit at the horizon or the apparent direction of motion with reference to some point in the horizon.

The utilization of the items mentioned under this latter subdivision No. 3, assumes that the terminal point has already been determined from other data. Sometimes, for instance, in the case of very short paths, these data are more useful than the co-ordinates of the beginning and end of the path. In such cases graphic sketches of the observed path are always a desirable addendum.

At first from the known position and altitude of the terminal point its apparent equatorial co-ordinates for the individual places or observations are calculated and in case 1 are taken instead of the observed, in case 2 they are taken for the co-ordinates of the unspecified terminal point.

In the cases mentioned under item 3, these computed co-ordinates serve for the two ends of the given apparent arc of the orbit. If N'

is the inclination of the apparent orbit to the vertical through the terminal point (A_e, h_e) in the incomplete observation as given, while N is the inclination to the horizon at the apparent node of the orbit and A_k, the azimuth of this node, then we have

$$\left.\begin{aligned} \cos N &= \sin N' \cos h_e, \\ \tan f &= \tan N' \sin h_e, \\ A_k &= A_e \pm f, \end{aligned}\right\} \tag{9}$$

where the plus or minus sign is taken according as the movement of the meteor is in the direction of increasing azimuth or in the opposite direction.

In a similar way the relations are obtained when the angle with the vertical at any other point of the orbital path has been observed, and for which either the azimuth or altitude or distance from the terminal point along the path must be given.

In cases 1 and 2 the two given points on the path are computed from the co-ordinates α_i', δ_i', and α_i'', δ_i'', and then for the great circle thus determined is computed the right ascension α_k of the ascending node on the equator, and the inclination J to the equator.

With $\dfrac{\tan\delta'}{\tan\delta''} = s$, we have

$$\left.\begin{aligned} \tan(\alpha' - \alpha_k) &= \frac{s \sin(\alpha'' - \alpha')}{1 - s\cos(\alpha'' - \alpha')}, \\ \tan J &= \frac{\tan\delta'}{\sin(\alpha' - \alpha_k)} = \frac{\tan\delta''}{\sin(\alpha'' - \alpha_k)}; \end{aligned}\right\} \tag{10}$$

α_k must thus be chosen so that the two equations for J are satisfied.

These determinations can be made rapidly and with sufficient accuracy by the use of a spherical net work or chart on the gnomonic projection and a correspondingly large scale.

This method is also to be used in the third case. Finally, every station of observation that furnishes usable data should employ a great circle drawn through α_k and J with the appropriate direction of motion to determine the radiant. If these apparent orbits were free from error, then by extending them backward, they would all intersect at the radiation point (a, d), that is to say the equation

$$\sin(a - \alpha_{ki}) \tan J_i = \tan d \tag{11}$$

would then be satisfied for each value of i from l to n.

But since this cannot be the case because of the errors of observation, we must apply corresponding corrections to the observed orbit paths. In doing this and ignoring certain exceptional cases, it will be assumed that the co-ordinates α'', δ'' remain unchanged and therefore that the corrections belong only to α', δ' (the initial point), or to a_k and J, which is brought about by a rotation around the apparent terminal point, α'', δ''. This rotation must be so made that

$$[p(\Delta\alpha'^2 \cdot \cos^2\delta' + \Delta\delta'^2)]$$

is a minimum for the necessary corrections $\cos\delta_i' \cdot \Delta\alpha_i'$ and $\Delta\delta_i'$, taking into consideration their respective weights p_i.

To this end, again just as in the case of the determination of the geographic co-ordinates of the terminal point, we proceed best by graphic methods. We adopt an approximate position for the point (a, d) which we can here designate by (a_0, d_0) and compute or graphically measure its normal distance Δ_i from each apparent orbital path a_{ki}, J_i.

If we regard Δ as positive, when (a_0, d_0) lies within the northern polar region of a_{ki}, J_i, and if we wish to find this distance as correctly computed, we use the following formula:

$$\sin\Delta_i = -\cos J_i \sin d_0 + \sin J_i \cos d_0 \sin(a_0 - a_{ki}). \qquad (12)$$

Now since the Δ_i's represent discrepancies, the corrections

$$\Delta a_0 \cos d_0, \ \Delta d_0$$

must be so determined that those shall be zero.

Putting

$$\left.\begin{aligned} \sin J_i \cos(a_0 - a_{ki}) &= \cos P_i, \\ \cos J_i \sec d_0 &= \sin P_i', \\ \Delta a_0 \cos d_0 = x, \ \Delta d_0 &= y, \\ \sin\Delta_i &= \Delta_i, \end{aligned}\right\} \qquad (13)$$

the condition for this is

$$o = \Delta_i - x\cos P_i + y\sin P_i'. \qquad (14)$$

In order to properly express the equations of error, we must still consider the fact that Δ, or the change of location that the provisional radiant must experience in order to fall in with the observed orbital path, *is not an observed quantity* since the corrected place to be obtained by the rotation is (α', δ'). Let ζ be the change that must be produced by the rotation, then we have

$$\frac{\sin\zeta}{\sin\Delta} \doteq \frac{\zeta}{\Delta} = \frac{\sin l}{\sin l'}, \qquad (15)$$

where l denotes the length of the arc from (α', δ') to (α'', δ''), l' that from (a_0, d_0) to (α'', δ'').

Therefore the factor $\frac{\sin l}{\sin l'} = \sqrt{g}$ is to be applied to the whole equation as the weight. If we omit this, then the short orbital paths have much too heavy a weight, since for these this ratio of the sines is a very small fraction.

If the apparent path be computed not by α', δ', but by the apparent inclination at the terminal point, we shall come nearest to the correct values of the weights if we assume the numerator as unity.

It is best moreover as a matter of course in all special cases to apply the indicated weight of the observed quantities.

The method here explained is based, as already stated, on the assumption that the terminal point can be located with sufficient accuracy to justify the assumption that the apparent positions α_i'', δ_i'' computed therefrom remain unchanged in determining the radiant. If this is not allowable, then the weight of the individual α_i'', δ_i'''s must be deduced from the average error in the determination of the location and altitude of the terminal point, and then an estimate must be made of the weight to be given the first point α_i', δ_i' of the orbit. The corrections for both points must then be determined as inversely proportional to the weights p' and p'', that is to say, the rotation of the apparent orbit is not around the point α'', δ'', but around that point in the orbit which is distant from this by the quantity $\frac{p'}{p'+p''} \cdot l$ and from α', δ' by a quantity $\frac{p''}{p'+p''} \cdot l$. If l'' represents the spherical distance of this division point from the assumed radiant a_0, d_0 then the factor becomes

$$\sqrt{g} = \frac{\sin \dfrac{p''l}{p'+p''}}{\sin l''}. \tag{16}$$

If we cannot or do not wish to determine the terminal point of the orbit beforehand, then in general the two points α', δ' and α'', δ'' must receive equal weights so that we must assume[1]

$$\sqrt{g} = \frac{\sin \dfrac{l}{2}}{\sin l''}. \tag{17}$$

If the radiant is determined from the final co-ordinates a, d, then for each place of observation the arcs from a, d to α_i'', δ_i'' will indicate, according to their positions, the improved apparent orbit. The normal projections of the point α', δ' on this arc afford us on one hand the improved apparent arc, and on the other hand the normal components of the errors of observation projected on the path. Those that lay in

[1] On the determination of the radiant from numerous observations without a previous determination of the terminal points, see also R. Lehmann Filhés "On the theory of the shooting stars, Berlin, 1878."

the direction of the path are of course indeterminate because of the inequality of the aspect. The correcting of α', δ' according to these suggestions is easily done, but is only necessary when the problem is sufficiently trustworthy to allow it to be applied to the determination of the altitude of the initial visibility and of the real length of the path.

C. THE LOCATION OF THE ORBIT RELATIVE TO THE EARTH; THE LENGTH OF THE PATH; THE ALTITUDE OF THE INITIAL VISIBILITY

If for the terminal point (L_e, ϕ_e), finally settled upon, the values for the azimuth and altitude of the radiant, referred to the horizon of the terminal point, are calculated from the equatorial co-ordinates of the determined radiant (a, d) with the aid of the meteor's time of fall corresponding to this meridian, then the first corresponds also to the azimuth of the linear meteor path, and the latter corresponds to its inclination relative to the horizon of the terminal point. The azimuth, which specifies the projection of the orbit upon the surface of the earth, can be taken from the chart or computed from the places above whose zenith the meteor passed, and the inclination in connection with the altitude of the terminal point gives the linear altitude which the meteor had at any point in its orbit above the earth's surface. In general we can neither speak of the true length of the meteor's path in the atmosphere, nor of the altitude of the beginning, because as has been remarked, observers very frequently catch different phases of motion. Since the length of the linear path in connection with the estimated duration allows us to deduce approximately the geocentric velocity, therefore the real orbital length must be obtained especially for those observations that give estimates of the duration. The altitude of the first visibility can then always be assumed to be that which results from the longest well-observed path.

In order to determine these quantities, however, all data are given as soon as the above-mentioned projection of the true orbit on the earth's surface and the inclination are well established. For each of the places of observation the corrected position (α', δ') of the first visible point in the orbit will now come into consideration. The corresponding azimuth then gives us the initial direction in the trajectory of the orbit, whence by the use of the inclination of the orbit to the horizon we get both the corresponding length of the orbit and the altitude of the meteor above this point.

D. THE GEOCENTRIC OR RELATIVE VELOCITY

If L_i and t_i are associated values of the length of the true orbit as computed from the observations and of the thence estimated interval of time in seconds required for the passage along this portion, then we have

$$\mathfrak{B} = \frac{L_i}{t_i} ,$$

which is the average relative velocity of the meteor as deduced from this particular observation, but affected with the great uncertainty that the estimate of duration almost unavoidably brings with it. An average velocity, because we must assume that the velocity cannot remain quite constant during the motion through the atmospheric strata.

If many associated data of L and t are at hand, we have to carefully consider whether, say, a single apparently very reliable estimate of t may be retained alone in connection with the value L corresponding to this observation, or whether an average value should be deduced, but of course always only in reference to associated data. We do not recommend combining the greatest length of orbit deduced from the earliest apparent visibility with the average of all the estimates of duration as is sometimes done, because generally many estimates occur among these that relate only to very short bits of the path.

In general it is best to determine the velocity for each pair (L, t) by themselves and then to take the average with or without giving attention to weight, but even the results of careful efforts to determine the weight are very often doubtful because of the frequent large overestimates of the duration, so that the sources of error are almost invariably on one side.

If there is no estimate of duration belonging to any of the segments of the path, then perhaps the average of the times may be combined with the average of all the L's.

Frequently long paths, passing chiefly through the higher layers of the atmosphere and also having their ends at great altitudes, give larger values for the velocity than shorter paths recorded in the lower strata. The answer to the question whether such results also represent quantitatively the retarding influence of the resistance of the atmosphere, or whether they result rather in an overestimate of the duration, which overestimate alters the result for short paths more than for long paths, needs further special study. The fact that individual results of observations certainly refer to particular well-ascertained definite limited higher or lower located parts of the orbit is therefore always very important and consequently must be most thoroughly investigated.

E. ZENITHAL ATTRACTION

The velocity and the radiant point must for further planetary computation be corrected for the influence of the earth's attraction which first increases and afterwards diminishes the approach to the zenith.

If z is the zenith distance of the estimated apparent radiant at the terminal point L_c, ϕ_c and v' the relative or geocentric velocity corrected for the attraction of the earth and z' the zenith distance corrected in the same way, then will[1]

$$v' = \sqrt{\mathfrak{V}^2 - 2gR},$$

where g is the acceleration due to gravity and

$$\left.\begin{aligned} 2gR &= 125 \cdot 18, \\ \tan \frac{\Delta_z}{2} &= \frac{\mathfrak{V}-v'}{\mathfrak{V}+v'} \tan \frac{z}{2}, \\ z' &= z + \Delta z, \end{aligned}\right\} \qquad (18)$$

where all quantities are expressed in kilometers.

The azimuth of the radiant suffers no change on account of zenithal attraction. The equatorial co-ordinates of the radiant are, however, to be newly computed with the help of this azimuth and the corrected zenith distance. When these are used in the following text for the computation of the planetary orbit, they will be designated by a' and d'.

2. The Observations of Different Meteors Belonging to the Same Stream from One Single Location on the Earth

When many apparent paths belonging to the same radiant are at hand which have been observed at only one place and within an interval that is not too long, and when the changes in the co-ordinates of the radiant during this interval are unimportant,[2] or have been taken into consideration, then these co-ordinates can also again be determined according to the fundamental theorem that the paths represent the most probable intersections of the respective great

[1] Schiaparelli, page 251.

[2] The zenith attraction causes a larger or smaller appreciable change in the location of the radiant together with the change in the zenith distance. This may be quite notable in the case of meteors that strike the earth with small velocity. Therefore we should combine into one determination only such observations as those that are not too far apart with respect to zenith distance of the radiant. In general, however, the dislocation in the position of the path increases with the solar longitude, but remains for several days together within the limits that have been indicated by the error of observation. The culmination of observations that cover a period of several weeks can in general only furnish approximate results. [Note.—Such results are of absolutely no value. C. P. Olivier.]

circles. On the other hand, we have, however, never absolute certainty that the paths taken into consideration do actually belong to the same radiant, wherefore the application of the rigorous method loses in value.

In the case of observations made at one place the geographic location and the altitude of the terminal point of a path cannot be given. Hence we do not have the correction to the terminal position α'', δ'' referred to in the appropriate portion of the previous section, which terminal position, therefore, is only of about the same value as α', δ'. Hence it is natural to distribute the corrections uniformly and to undertake the necessary rotation of the arc about the center of the orbit. The factor for the equation of error will therefore be $\frac{\sin \frac{l}{2}}{\sin l'}$ where l′ denotes the distance of the center of the orbit from the preliminary radiant point. Otherwise we may apply the same method as in the other case and indeed by the ordinary preferable graphic determination in which the observations are entered on squared paper.

R. Lehmann-Filhés[1] develops the method of deducing the apparent radiant for star shower observations made at one place, from the apparent paths each of which is determined by some point α, δ in the path and its position angle relative to the declination circle through this point. If the observer has a free choice of this point, then he will frequently fix it more accurately in the neighborhood of a star that is well known to him, and if the attention is not too much taken up by the exact locating of the beginning and ending of the path, then the direction of the path and thus also of the angular position is probably more accurately known than by locating each of the two points which, in observations made at one place, can only be approximately located, if in general we desire to consider them at all.

Equations 14 to 17, in which occurs the position angle P relative to the hour circle of the preliminary radiant a_0, d_0 and therefore not that determined for any other arbitrary point α, δ, can very easily be applied in this method of solution.

Let W be the angle of position determined for α, δ where these co-ordinates, therefore, must be indicated, then α_k can be found at once from

$$\left.\begin{aligned} \tan(\alpha-\alpha_k) &= \tan W \cdot \sin\delta, \\ \sin P' &= \frac{\cos\delta}{\cos\delta_0}\sin W, \\ \cos P &= \frac{\cos(a_0-\alpha_k)}{\cos(\alpha-\alpha_k)}\cos W. \end{aligned}\right\} \quad (19)$$

[1] R. Lehmann-Filhés, Astr. Nachr. 96 (1880), p. 241.

If we substitute this value in the above-mentioned equations, then they become at once modified appropriately for the proposed solution.

It may finally be noted that in the case of observations made at one place the zenithal attraction for the correction of the radiant can only be determined hypothetically, for we must use the zenith of the terminal point which is unknown, and we must know the relative velocity. For this latter the place of observation can be adopted and no great error will result. Instead of the unknown velocity, we generally use the geocentric velocity corresponding to the parabolic orbit.

II. COMPUTATION OF THE ORBIT RELATIVE TO THE SOLAR SYSTEM

The co-ordinates of the apparent radiant a', d' freed from zenith attraction, and relative to the ecliptic, will be designated by λ', β'. These and the relative geocentric velocity v' are found by the combination of the heliocentric motion of the meteor with the velocity v in the direction indicated by the analogous co-ordinates λ, β combined with the magnitude and direction of the heliocentric motion of the earth at the node of the meteor's orbit. λ, β determine the *true* radiant point and v is the *heliocentric* velocity at this point. The very unimportant influence of the earth's rotation on its axis can here be left out of the consideration.

As the unit for the measurement of v and v' when no other kind is noted, we use the velocity of the earth at its mean distance from the sun. The quantities expressed in kilometers will be reduced to this unit with sufficient accuracy by dividing by 29.59.

For the radius vector, or the distance of the earth from the sun, the unit is the average distance or the semi-major axis of the earth's orbit. For that position of the earth's orbit at which the longitude of the sun is $\odot$ the corresponding distance of the earth expressed in this unit is

$$r = 1 + e' \cos(\odot - \pi).$$

In this expression we may for a long time adopt with sufficient accuracy $e' = 0.01676$ and if T denotes a year, we have

$$\pi = 101° \;\; 12.8' + 1.03'(T - 1900).$$

The radius vector r is given for every day in every astronomical ephemeris.

If $\odot'$ indicates the longitude of the direction of the normal at that point of the earth's orbit for which the longitude of the sun is $\odot$, then we have

$$\odot' = \odot + \frac{e'}{\text{arc } 1'} \sin(\odot - \pi) = \odot + 57'.6 \cdot \sin(\odot - \pi),$$

and therefore the longitude of the radiant point in the ecliptic or the apex of the earth's annual motion is $\odot' - 90°$.

Finally the *heliocentric* velocity of the earth at the distance r from the sun is given by the expression $\sqrt{\frac{2}{r} - 1}$.

The quantities λ', β', v', λ, β, v are connected by the three equations

$$\left.\begin{aligned} v \cos\beta \sin(\odot' - \lambda) &= v' \cos\beta' \sin(\odot' - \lambda') - \sqrt{\frac{2}{r} - 1}, \\ v \cos\beta \cos(\odot' - \lambda) &= v' \cos\beta' \cos(\odot' - \lambda'), \\ v \sin\beta &= v' \sin\beta', \end{aligned}\right\} \quad (20)$$

from which λ, β and v can be found.

If we desire only the magnitude of the heliocentric velocity, we obtain that from the equation

$$v^2 = v'^2 + \left(\frac{2}{r} - 1\right) - 2v' \sqrt{\frac{2}{r} - 1} \cdot \cos\beta' \cdot \sin(\odot' - \lambda'), \quad (21)$$

and we obtain the semi-major axis of the respective meteor orbits from equation

$$a = \frac{r}{2 - rv^2}. \quad (22)$$

This orbit, therefore, either an ellipse or hyperbola according as a is either positive or negative, or according as $v^2 \lessgtr \frac{2}{r}$.

The parabola corresponds to $a = \infty$, and hence we obtain the special limiting case $v^2 = \frac{2}{r}$.

Sometimes from the periodical return of an especially rich shower of meteors (such as the Leonids), one deduces a well-known radiant λ', β', and the time of revolution U of a dense swarm of meteors and these can therefore be considered as given or known. In such a case in order to compute the remaining elements of the orbit, we have

$$a = U^{\frac{2}{3}}, \quad (23)$$

and thence also v. Then the three equations (20) give us v', λ and β, from which the elements of the orbits of the stream can be deduced according to the following method:

Let i be the inclination of the heliocentric orbit of the meteor to the ecliptic; τ be the angle of the tangent on this orbit to the radius vector r of the earth's orbit at its node with the meteor orbit; let p be the semi-parameter of the meteor orbit; let e be the excentricity of the meteor orbit; let q be the perihelion distance of the meteor's orbit; let w be the true anomaly for the radius vector r, we then obtain these quantities from the following equations:

$$\left.\begin{aligned} \sin i \sin \tau &= \sin \beta, \\ \cos i \sin \tau &= -\cos \beta \cdot \sin(\odot - \lambda), \\ \cos \tau &= -\cos \beta \cdot \cos(\odot - \lambda), \end{aligned}\right\} \quad (24)$$

$$\left.\begin{aligned} p &= r^2 v^2 \sin^2 \tau, \\ e &= \sqrt{1 - \frac{p}{a}}, \quad q = \frac{p}{1+e} = a(1-e), \\ \cos w &= -\frac{1 - \frac{p}{r}}{e}. \end{aligned}\right\} \quad (25)$$

On account of the determination of the remaining elements, we may refer to the computations of orbits and planets since all necessary data have now been given. The quantities i and τ must always be counted in opposite directions. If we count τ from the prolongation of the radius vector r toward the point $180° + \odot$ toward the sun, but always in the first or second quadrant, then $\sin i$ always has the sign of $\sin \beta$. For the northern radiant, therefore, the corresponding node is always the descending node, hence we have $\Omega = \odot$. Under this assumption (viz.: positive β), the movement is toward either the right or left according as i lies in the first or second quadrant. For radiants in the southern latitudes we have $\Omega = 180 + \odot$ and the motion is either toward the right or left according as i results from these equations in the third or fourth quadrant. In the subsequent presentation of the elements, however, i will be given for the corresponding ascending node with the added words right or left motion, viz.: positive or negative, direct or retrograde. Since for a considerable number of the largest meteors (also so-called detonating meteors and even also those associated with the fall of masses), it has been established by the careful use of observations that the heliocentric velocity v for the above-indicated parabolic limits is considerably exceeded so that a may be negative and e greater than one, hence the heliocentric orbit will be a well-marked hyperbola which on account of its position cannot possibly have originated in the solar system, therefore it must be assumed that such bodies have entered the solar system from the outside cosmic space.

Bodies that describe in space nearly parallel orbits at great distances from each other with identical velocities belong therefore to a sidereal stream of considerable extent, and can intersect the earth's orbit in such different nodal lines that excepting a which depends upon the original cosmic velocity, all other orbital elements of the same type and consequently also the co-ordinates of the apparent radiant can have quite different values.

Under such circumstances a comparison of different cases gives us not *the complex of those elements* that are characteristic of the orbits of planets and comets, but, according to what has already been said, they give exclusively the magnitude and direction of the motion for such large values of the radius vector ρ that relative to these even r may be considered as almost negligibly small. Since such a portion of the orbit is almost the same as the asymptote, we can take $\rho=\infty$ for this distance.

The direction, towards which this asymptote points on the celestial sphere, whose longitude and latitude will be designated by l and b, can be called the *sidereal or cosmic point of departure of* the meteor. The determination of this point for different assumptions of a (*i. e.*, for corresponding v's) for a given radiant point λ', β' is really our most important object in reference to hyperbolic meteors.

If w' is the true anomaly of the meteor orbit for the radius vector $\rho=\infty$ and σ the angle, which the direction of the asymptote drawn from the point (l, b) makes with the radius vector r at the node of the orbit on the earth's orbit in complete analogy as to τ in regard to numeration and definition, then we obtain

$$\cos w' = -\frac{1}{e}, \quad \sigma = w' - w, \tag{26}$$

or if

$$\sqrt{\frac{rv^2}{rv^2-2}} = m, \tag{27}$$

$$\tan\frac{\sigma}{2} = \frac{m \sin\tau}{1+m\cos\tau}, \tag{28}$$

which is more convenient for the inverse determinations, also

$$\cos(2\tau-\sigma) = \frac{2+(rv^2-2)\cos\sigma}{rv^2}, \tag{29}$$

while l and b are then determined from

$$\left.\begin{aligned} \sin(\odot - l)\cos b &= -\sin\sigma\cos i, \\ \cos(\odot - l)\cos b &= -\cos\sigma, \\ \sin b &= \sin\sigma\sin i. \end{aligned}\right\} \tag{30}$$

The velocity of entrance into the solar system ($\rho=\infty$) is given by

$$v_0 = \sqrt{\frac{1}{a}} = \sqrt{v^2 - \frac{2}{r}}. \tag{31}$$

For parabolic orbits we should have $rv^2-2=0$, thus $a=\infty$, accordingly

$$p=2r\sin^2\tau,\quad e=1,\quad w=180^\circ-2\tau,\quad q=\frac{p}{2}=r\sin^2\tau,\quad w'=180^\circ,$$
$$\sigma=2\tau,\qquad v_0=0,\qquad \pi=180^\circ+\odot\pm w. \tag{32}$$

It can sometimes be of great interest to solve the problem in the inverse order, that is to say, to determine the apparent radiant λ', β' for a given day of the year when the sun's longitude is $\odot$ and when, therefore, we assume as given:

(a) The necessary elements of the elliptic meteor orbit, or

(b) The parabolic aphelion through l and b, or finally

(c) The hyperbolic cosmic starting point, which may also be determined by l and b with v_0 or v.

Then according to the previous formulæ a is given for the elliptic orbit by the time of rotation, when it is not otherwise known directly by the system of elements, for the hyperbolic orbit a is given either by the equations (31) or (22).

Further

$$v=\sqrt{\frac{2}{r}-\frac{1}{a}}\,. \tag{33}$$

Since e^2 and i are given among the elliptic elements, we can, therefore, also compute

$$p=a(1-e^2),\quad \sin\tau=\frac{\sqrt{p}}{rv}; \tag{34}$$

and then we can also compute from the equations (24) the position (λ, β) of the true radiant and from equation (20) λ', β', v' for the apparent radiant. The zenith attraction can only be applied for a definite latitude and siderial time.

In hyperbolic orbits a is negative in the equation for v, but in parabolic orbits it is assumed to be infinite.

The system of equations (30) gives i and σ when we know $\odot$, l, and b. Furthermore we obtain τ from equation (29), λ and β from equations (24) and finally, also, λ', β', v'.

Equation (29) gives an associated *pair of radiants* for each initial direction (l, b). Inversely, therefore, it always gives for each $\odot$ two associated values of (l, b) and with *one* position of (l, b) it gives the associated apparent radiants for two far distant points on the apparent celestial sphere. We usually find these two when we reflect that $\cos(2\tau-\sigma)$, even for a specified sign, always gives two values for $2\tau-\sigma$, therefore for a given value of σ there are two values of τ corresponding to the two possible hyperbolas in each plane with a common focus which possess parallel asymptotes on one side. In this case one orbit is direct, the other is retrograde, and their perihelia lie on opposite sides of the radius vector.

Since one of the two perihelion distances is ordinarily very small, the attendant radiant is generally in that portion of the sky covered with sunshine. For the parabolic orbits the true positions of the two associated radiants lie diametrically opposite one another.

The expressions above given for the determination of the orbit in the present condition of the art of observing meteors go far beyond the needs of the accurate computations. They can therefore only be appropriately applied when we are concerned with the further development of definite theoretical views. In the working up of observations we attain our object sooner and without appreciable loss in accuracy when we assume in general that for the earth's orbit we have $e=0$, $r=1$, $\odot'=\odot$, and also that the velocity of the earth is always equal to unity, in short, we take the orbit of the earth as circular.

It is easy to simplify all the previous expressions by means of these substitutions, only we must say that it is not important to seek for the true radiant when we can attain the ordinary elements in the shortest way. We find, in fact,

$$\left.\begin{aligned} v^2&=v'^2+1-2v'\cos\beta'\sin(\odot-\lambda'),\\ \cos\tau&=-\frac{v'}{v}\cos\beta'\cos(\odot-\lambda'),\end{aligned}\right\} \tag{35}$$

$$\left.\begin{aligned} \sin i&=-\tan\beta'\cdot\cot\tau\cdot\sec(\odot-\lambda'),\\ \cos i&=\frac{1+v\cos\tau\tan(\odot-\lambda')}{v\sin\tau},\end{aligned}\right\} \tag{36}$$

and the calculations may be carried further by making the indicated substitutions in the known formulæ. For the determination of the sidereal starting point l, b, we have

$$\left.\begin{aligned} \tan\frac{\sigma}{2}&=\frac{m\sin\tau}{1+m\cos\tau},\quad \text{where } \frac{v}{\sqrt{v^2-2}}=m,\\ \cos(2\tau-\sigma)&=\frac{2+(v^2-2)\cos\sigma}{v^2}.\end{aligned}\right\} \tag{37}$$

whereupon l and b are found from (30). The velocity for $\rho=\infty$ is $v_0=\sqrt{v^2-2}$.

The simplification of the inverse problem to find l and b for the radiants from λ', β' does not here need any further explanation. Computational results from the elements of the orbit from the velocity determined by the observations are almost useless because the basis for this work is too uncertain. The most careful deduction of the velocity is certainly very important in order to at least make known the degree of probability that the corresponding planetary orbit departs to one side or the other from the parabola. The computation of the elements, if we really wish to attempt it, should be carried out with various assumed and appropriate values of the velocities, whereby the general result can be better arranged for comparison with other cases.

III. RESULTS OF OBSERVATIONS AND COMPUTATIONS RELATIVE TO METEORS

1. Average Accuracy of Observations and Computations

A. AT THE END OF THE ORBIT OR POINT OF ARREST

The average error of a given direction (of an azimuth) as the result of 351 observations is found to be ±5.8 degrees.

These determinations were made in 12 per cent of the cases by simultaneous reference to stars, and in about 20 per cent of the cases on the basis of subsequent measurements, in the remaining cases by reference to terrestrial objects in the neighborhood by means of plans and charts.

The average error of any indication or description of the apparent altitude or zenith distance may be taken as ±4.1 degrees from 235 cases.

As a general rule in these cases we have considered only direct references to stars or subsequent measurements. Crude estimates, as is well known, give almost always apparent altitudes that are far too large. When such cases have been used in exceptional cases, we have in general reduced them to $\frac{2}{3}$ or $\frac{3}{5}$ of the given estimates.

The azimuths were not examined so closely since in such cases errors in one direction are less to be feared, which is also easily to be seen by reason of the larger average error of a single observation.

The average error in the determination of the *geographic position* of the terminal point as deduced from 42 cases amounts to ±8.3 kilometers. The very best determinations are uncertain by 3½ or 4 kilometers. The average error of the computed linear altitudes amounted to ±3.4 kilometers.

B. AT THE INITIAL POINT OF THE OBSERVED PATH

The nature of the observations brings it about that a meteor can be first observed by many observers at very different points of its path. These are differences that do not possess any of the characteristics of errors of observation. These characteristics belong only to the transverse departures from the corrected apparent path.

These departures deduced from 217 cases for the initial point average ±4.2. They are deduced for the initial point in a similar way as for the terminal point, but by excluding rough data more frequently than in the latter case.

The apparent relations to the stars when they are determined immediately after the observations resulted in giving the average error of such a relation as ±3.5 degrees for the initial or the terminal point respectively.

C. ESTIMATES OF THE APPARENT INCLINATIONS OF THE OBSERVED PATH

These estimates show from an average of 250 cases a mean error of ±6.5 degrees. Such estimates generally refer to the vertical through the observed terminal point, or some other specific point in the path and were generally obtained by graphic sketches. Radiants that do not lie far above the horizon were generally affected by only a small part of this uncertainty.

D. THE ACCURACY ATTAINED IN THE DETERMINATION OF THE RADIANTS

Of large and generally detonating meteorites, 43 reliable determinations for 537 apparent paths, therefore on the average 12 or 13 observations for each case, gave the average error in the location of these points on the sky at ±3.3 degrees.

The number of the orbital paths in the individual cases was very uneven, exceeding 40 in many cases, but was often only three or four.

At the present time more than 420 radiants of detonating meteors have been found, of which, however, about 30 per cent are identical with others. Much larger is the number of the radiants of shooting-stars listed in the last catalog. Denning[1] compiled from the appropriate literature as well as from his own observations 4,367[2] such radiant points of which, however, probably more than half coincide with others.

When he remarks[3] that on the average, during every night, more than 50 radiants are in action, this is quite correct, but on account of the lesser frequency of individual meteors, many of these radiants cannot be demonstrated every night at the same place and during the same year.

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[1] W. F. Denning, General Catalogue (1899).

[2] Large numbers of these radiants have no proved existence and are probably fictitious. C. P. Olivier.

[3] W. F. Denning, *ibid.*, p. 203.

The rich streams of shooting-stars afford so much observational material that their radiant points can generally be determined more accurately than those of the fire balls, as the following examples may show in which the average errors are shown:

Location of Apparent Radiants

	Right Ascension	Declination	Maximum
Leonids	150.1° (± 0.3°)	+ 23.0° (± 0.2°)	November 14
Perseids	44.0°	+ 56.9°	August 11
Lyrids	271.5° (± 0.7°)	+ 33.4° (± 0.4°)	April 20
Andromedids	23.8° (± 0.9°)	+ 44.0° (± 0.2°)	November 26-28
Quadrantids	230.9° (± 0.7°)	+ 51.3° (± 0.4°)	January 2
Geminids	108.3° (± 0.5°)	+ 33.6° (± 0.4°)	December 10-12
Orionids	89.7° (± 0.5°)	+ 15.6° (± 0.3°)	October 10-16
Orionids	91.5° (± 0.3°)	+ 15.7° (± 0.3°)	October 16-22

Denning believes[1] that the activity of the Perseids should be assumed to extend from July 11 to August 19 by reason of which the radiant point should experience a change from

$$\alpha = 11.5°,\ \delta = 47.7° \text{ to } \alpha = 56.6°,\ \delta = 59.1°.$$

All these streams consist of more or less densely collected particles along the whole extent of their paths as far as yet known, but only the Leonids consist of a specially rich swarm returning to the perihelion in a well-established period of 33¼ years.

2. The Results as to the Altitude of the Luminosity and of the Terminal Points and their Relations to Other of the Factors

In this respect we must distinguish between the small phenomena which we know as shooting-stars and the large meteors known as fire balls which frequently exhibit during their path through the atmosphere a remarkable development of light and often produce great noise and sometimes well-established falls of meteorites.

With regard to the *shooting-stars* of the so-called *Perseids* in August, Weiss,[2] in Vienna, from the discussion of 49 reliable corresponding observations, found on the average for the first luminosity 115 km., for the extinction 88 km.

Independent of this H. A. Newton[3] also found for the *Perseids* from 38 observations the following altitudes, viz.: luminosity 112 km. and extinction 90 km. in excellent agreement with the preceding.

[1] W. F. Denning, Astr. Nachr. 148 (1899), p. 283.

[2] E. Weiss, Wien. Ber., 1868.

[3] H. A. Newton, American Journal of Science and Arts, 2 Series, 40.

For the star shower of the Leonids in November, Newton[1] computed from 78 determinations the average altitudes of luminosity 155 km. and extinction 98 km. According to this the whole path of light for the November Leonids was higher than for the August Perseids which is evidently in connection with the fact that the Leonids entered into the atmosphere with a relative velocity of about 70 km. and the Perseids with only 60 km. Moreover the masses of the November stream seem also to have special chemical characters.[2]

The determination of 159 altitudes of shooting-stars from the fifth to the first magnitude, and of the most varied *radiants*,[3] therefore also including some very slight velocities, gives in general for the luminosity 108.5 km. and for the extinction 86.3 km. which is therefore only a slight variation from the values found for the August Perseids.

For the large meteors, including those with detonations and those with falling meteorites, and from determinations that are especially reliable, but without selection of the greatest phenomena, I found for the luminosity from 121 cases an altitude of 138.6 km.

For the extinction from 213 cases an altitude of 49.7 km.

This collection of data shows the influence of the larger masses, especially because of the comparatively slight altitude of the stopping point and therefore because of the deeper penetration into the atmosphere. This is shown still more plainly by a further classification. For the altitude of the stopping point I found[4] on the average 60 km. for 147 fire balls without detonations; 31 km. for 57 meteors with detonations; 22 km. for 16 falls of meteorites, thus it may well be proper to explain these different types of shooting-stars as due to a gradual increase in mass, since larger masses experience a relatively smaller resistance in the atmosphere and thus can penetrate deeper than the smaller masses.

Still more important are the relations of the altitude of the terminal point to the value of the geocentric velocities that we obtain from the observations. In order to avoid as far as possible any one-sided

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[1] H. A. Newton, *ibid.*

[2] The Leonids among all meteors provide the longest enduring luminous tails in the atmosphere.

[3] Memoirs of the British Astronomical Association, Vols. 9, 12. Part 1 (1900-1903).

[4] G. v. Niessl, "Über die Periheldistanzen und andere Bahnelemente jener Meteoriten, deren Fallerscheinungen mit einiger Sicherheit beobachtet werden konnten," Brünn (1891).

views I have investigated very various material and I submit the most important results in the following tables 1, 2, 3, 4, with the preliminary remark that the groups, under tables 1 and 2, relate principally to small phenomena (star showers), but those under tables 3 and 4 relate principally to fire balls.

TABLE 1 (NOTE 1).

Limiting altitudes	No. of cases	Average observed geocentric velocity	Average terminal altitude
Above 100 km.	23	67.7 km.	106.6 km.
80-100 "	48	51.5 "	88.8 "
60- 80 "	33	35.5 "	73.0 "
30- 60 "	17	30.1 "	46.2 "
below 30 "	2	23.2 "	28.8 "

TABLE 2 (NOTE 2).

Above 100 km.	10	72.3 km.	112.2 km.
80-100 "	11	43.0 "	88.3 "
60- 80 "	13	40.5 "	74.2 "
50- 60 "	6	35.4 "	59.2 "
below 50 "	14	27.4 "	33.9 "

TABLE 3 (NOTE 3).

Above 60 km.	12 (1 deton.)	51.8 km.	86.4 km.
50- 60 "	19 (3 deton.)	55.0 "	54.2 "
30- 50 "	43 (16 deton.)	40.6 "	39.0 "
below 30 "	28 (13 deton.)	37.6 "	24.0 "

[1] The cases under 1 are taken from the above mentioned "Memoirs of the Br. Assoc." (Foot-note 3, p. 25). 78% of them are shooting-stars, 11% meteors from one to four times the magnitude of Venus, 11% fire balls up to the magnitude of the moon without records of detonations.

[2] 2 refers to the older work published by Denning (W. F. Denning, "107 Real paths of Fireballs and Shooting-stars observed in England from 1886 to 1896." Lond. Astr. Soc. Monthly Not. 57, p. 161) wherein 74% are shooting-stars, as above, 6% meteors of the magnitude of Venus or somewhat more, 20% fire balls including *one* which detonated.

[3] 3 is taken from a list of mostly very large meteors which I published in the same number of the Monthly Notices, p. 170. Of the 100 cases given there the velocity could not always be determined; with later additions they gave, however, 102 coherent determinations of the terminal altitude and velocity. This material contains only 8% of shooting-stars of from the first to the fourth magnitude, 27% meteors from one to several times the magnitude of Venus, while 65% are large fire balls comparable in magnitude with the moon or sun, of these 30% detonated and seven were accompanied by a fall of a meteorite.

TABLE 4 (NOTE 1).

Apparent elongation of the radiants		No. of cases	Average altitude of the terminal point
Above 100 km.	9	76.8 km.	116.8 km.
80-100 "	9	72.0 "	89.3 "
60- 80 "	16	49.4 "	72.5 "
50- 60 "	21	49.1 "	58.9 "
30- 50 "	35	42.7 "	39.0 "
below 30 "	21	36.5 "	22.1 "

All four of these collocations show a perfectly definite regular connection between the geocentric velocity deduced from observations and the altitude of the stopping point since they diminish together.

It is natural to conclude that a meteor can penetrate into the atmosphere deeper in proportion as it moves with a low velocity. That this conclusion is correct is also enforced by the following facts:

1. The more rapid Leonids are extinguished at greater altitudes than the slow-moving Perseids as mentioned above.

2. Under the assumption of equal heliocentric velocity, the meteors that meet the earth in its direct course (from the apex) enter the atmosphere with a relative velocity that is about 56 km. greater than that of the meteors that enter the earth from the opposite side (or the anti-apex). If we arrange the meteors according to the distance of the radiant from the apex of the earth, we find the following results:

1. From the material in foot-note 2, page 26.

Between 0 and 40	12	95.6 km.
" 40 " 70	12.	84.5 "
" 70 " 90	12	61.6 "
" 90 " 110	10	59.8 "
" 110 " 180	10	52.1 "

2. From the material in foot-note 3, page 26.

Between 0 and 80	13	54.2 km.
" 80 " 90	9	50.5 "
" 90 " 100	10	44.5 "
" 100 " 110	11	40.2 "
" 110 " 120	7	38.6 "
" 120 " 150	13	38.6 "
" 150 " 180	7	36.4 "

[1] 4 arises from an analysis of 111 cases which I have worked up from material in older literature. Since the notation of magnitude was formerly less determinate, I can only say that these data likewise refer chiefly to large meteors (22% detonating).

Apart from the details that are unimportant in the establishment of this point, both these series show the expected connection between the elongation and the terminal altitude. In the first list the fact that the latter terminal altitudes are in general greater than in the second list is certainly because the meteors in the former list are principally the smaller kind that burn up at great altitudes, whereas mine or the second list relates mostly to the large meteors. In this respect, therefore, the latter is to a certain extent a supplementary continuation of the first. In part, also, the smaller observed velocity of the deep-penetrating meteors must be the result of the diminution of the velocity during the path through the atmosphere. The final stoppage of the meteor is almost instantaneous, still there are certain phenomena that result from observations that relate only to the lowest portion of the path in the deeper layers of the atmosphere that show slighter velocities than the average velocity that results from a consideration of the whole path of the meteor in the same case.[1] But of course the error in the estimation of short intervals of time renders difficult any decision on this point.

COMPARISON WITH THE THEORY OF THE RESISTANCE OF THE ATMOSPHERE

In order to compute the resistance of the air experienced by the meteor in its individual phases, one has attempted to utilize the experiences which have been deduced from experiments with the spherical balls of artillery. The following collection and summary is based upon the formula for resistance given by *Robert*.[2] It assumes a vertical movement of a spherical body weighing 118 grams having a density of 3.5 and a radius of 2 cm. The two assumed velocities with which the ball enters the atmosphere relate to the extreme values of a parabolic orbit, viz.: at the apex and the anti-apex. If for the same density we have another radius of the sphere, viz.: $2r$ cm., and if the inclination of the path toward the horizon be h, then in the column for the velocity the values will remain unchanged if the corresponding atmospheric pressure be multiplied by $r \sin h$.

[1] *Cf.* G. v. Niessl, Wein. Ber., 114 (1905), p. 1511.

[2] Schiaparelli, pp. 23 and 24 after S. Robert, "Del moto dei projettili nei mezzi resistenti." Torino, 1855. (Memorie dell' Academia delle scienze di Torino, II, 9, 16.)

I The entrance velocity 72 km.			II The entrance velocity 16 km.		
Pressure mm.	Altitude km.	Velocity km.	Pressure mm.	Altitude km.	Velocity km.
....	..	72	....	..	16
0.00007	129	70	0.006	94	14
0.00014	125	68	0.016	86	12
0.0005	114	60	0.032	80	10
0.0013	106	48	0.062	75	8
0.0031	99	36	0.128	69	6
0.0082	91	24	0.305	62	4
0.036	80	12	1.1229	51	2
0.082	73	8	4.299	41	1
0.315	62	4	11.619	33	0.5
1.249	51	2	....	..	..
4.318	41	1	....	..	..
11.639	32	0.5	....	..	..

In both these tables the altitude 33 km., at which the planetary velocity is almost completely neutralized, is almost exactly equal to the average altitude of stoppage given for detonating meteors on page 26. But the method of the diminution of the velocity is contrary to all other experiences. Thus, for instance, in the first table the estimated duration for the reduction from 129 km. down to 33 km. velocity should be only 1/18 part of the entrance velocity and for meteors that are first observed in lower regions, for instance between 80 km. and 33 km. which frequently occurs the reduction should indeed amount to only 2/36. Practically for meteors that have been observed only in the lowest part of the path, we obtain almost always much lower velocities, but certainly not to the extent here given.

For an entrance velocity of 16 km. the observed average velocity between 94 and 33 km. in altitude is only $\frac{1}{7}$ of the original, or still too small to observe. Nothing important is changed with respect to these data if we make still other assumptions than those of I and II.

The true geocentric velocity of the Leonids among which there are many particularly bright shooting-stars is given us with some certainty from the known orbital period and amounts to not much less than 72 km. For a small body in this meteoric stream of 2 mm. diameter and 0.12 gram weight, whose orbit intersects the atmosphere at an inclination of 30 degrees to the horizon, we should have to divide by 20 the atmospheric pressures above given under case I, hence the appropriate altitudes will be as follows:

III

Altitude km.	Velocity km.	Altitude km.	Velocity km.
153	70	103	12
147	68	97	8
138	60	86	4
130	48	75	2
123	36	65	1
115	24	57	0.5

For the entire orbit from 153 km. to 57 km., as an average velocity even in this case, we obtain only 4 km. or 1/18 part of the entrance velocity. As before stated, the orbits of the Leonids are supposed to lie between 155 and 98 km. because the particles are entirely dissipated by the very considerable rise in temperature before they can descend any lower. In fact the bodies of this stream, among all the shooting-stars, leave behind them the most enduring tails. It, therefore, appears proper to consider the above given plan as only applicable within similar limits or between 153 and 97 km. Thus we obtain on the average only about 27 km. or $\frac{3}{8}$ of the original velocity whereas from the observations the difference relative to the theoretical average is much smaller.

Direct observations, no matter how fragmentary the data, make it in general probable that the diminution of the velocity in the upper atmospheric mediums is slighter, but in the latter or lower part of the orbit or its lowest part which reaches far down must be greater than they would seem to be according to the previous theoretical views. Many optical phenomena that seem to be connected with the checking of the fire balls also seem to agree with this view.

The dependence of the altitude of the terminal point of the path upon the velocity at entrance demands also some explanation. Under probable assumptions (*Cf.* Schiaparelli, p. 231 ffg.) it is proven that the large but very different velocities of two bodies which enter under otherwise equal conditions into the atmosphere and pass through it in straight line orbits are diminished by the resistance in such a way that at any given altitude they attain almost the identical velocity. In the examples I and II this velocity is attained at the altitude 62 km.

We must not however conclude from this that the terminal altitude is independent of the entrance altitude. For the meteor occurring at the greatest altitude should convert much more kinetic energy into heat and would therefore be much more rapidly consumed.

3. The Masses of the Shooting-Stars

A. Herschel[1] concluded from the comparison of the light power of the shooting-stars at a given distance with that of a given mass of gas, that the meteor of first magnitude on the average weighs very few grams and the smaller meteors weigh only a fraction of a gram.

By similar comparisons with the Drummond light, V. F. Sands,[2] with reference to the Leonids of 1867, found the following estimates:

Apparent brightness	Mass or weight
Jupiter	0.67 grams
Sirius	0.45 "
First Mag. Star	0.06 "
Second "	0.02 "
Third "	0.01 "
Fourth "	0.006 "
Fifth "	0.004 "

Even if such estimates can give only approximate results, still they confirm the assumption that as a substratum for the shooting-star phenomenon only very small masses come into consideration which probably in their original condition could scarcely attain the earth's surface.

According to Buchner[3] the smallest of those aereolites that have been found, of which one can assume that they have descended as individual bodies, is 24 grams. Much smaller particles, which under the protection of preceding larger pieces describe their path through the atmosphere in small aggregates and cause a rain of stones, are in this respect not comparable with the shooting-stars. On the other hand they form, together with the larger pieces, one fire ball.

Experienced observers of shooting-stars frequently expressed themselves that the exterior appearance allows one to infer great original variation in composition.[4] Some points in respect to difference of the velocity might well have been attributed to them. So long as we know nothing more accurate relative to the physical nature of the matter of the shooting-stars, we shall have to consider the difference in the masses between them and the meteorites.

4. The Average and the Unusual Lengths of the Paths

Out of 185 computed paths of shooting-stars from the fifth to the first magnitude as given in the last English statistics, I find on the

[1] A. Herschel, Proc. Brit. Meteor, Soc. II, 19.
[2] F. Sands, Wash. Obs., 1867, pp. 19-30.
[3] Schiaparelli, p. 203.
[4] Weiss, Beiträge, p. 303.

average for the length of the visible path 57 km., on the other hand for 120 large and of these about 30 per cent detonating meteors from my own and other computations I find on the average the length of the path 319 km. In some cases, especially when the radiant point lies in the neighborhood of the horizon, there occur still much longer paths. Such an example is here given.

The meteor of July 7, 1892,[1] was visible when it was 74 km. above the neighborhood of Slobozia in Roumania and could be followed without break until it was 158 km. high about 70 km. WNW. of the mouth of the Tiber above the Tyrrhenian sea. There the observations could no longer be made, not so much because of an explosion, as by reason of the apparently gradual recession. It is not unlikely that at this great altitude the remaining part of this mass actually left the atmosphere. The demonstrated length of the path was 1350 km. This is the first and hitherto also the only case known to me of an undoubted ascending path. Since the point of perigee was undoubtedly at about 74 km., therefore, to the east of Slobozia there must have been a length of path at least as long.

It is worth remarking that in 1892, October 18, in lower Austria and Bohemia, a meteor was observed,[2] especially because of its remarkable long trail which the residuum left behind. So far as the path has been determined with any certainty, this meteor in the course of 1630 km. passed from an altitude of 257 km. above a region 70 km. east of Konigsburg in Prussia, until it was 43 km. high somewhat to the south of the island of Elba. The streak of light or trail, straight and horizontal as if drawn with a ruler, was at least 634 km. long and remained visible for about three minutes, so that its location between the stars could be easily determined.

5. The Heliocentric Velocity

The heliocentric velocity which results from the observed geocentric velocity in most cases far exceeds the limits for a parabolic orbit and leads to the necessary assumption of a decided hyperbolic orbit. It is certainly remarkable that this almost always occurs in the case of those orbits that have the most favorable location for the most accurate determination of the velocity, viz.: for those that are directed from the neighborhood of the anti-apex, as for example in

[1] G. v. Niessl. Wien. Ber., 1893, 102, p. 265.

[2] G. v. Niessl. Verhdl. d. naturf. Vereins in Brüm, 1901, 39, p. 220.

the case of the meteorite of Pultusk for whose path J. G. Galle[1] has shown that the minimum value of the excentricity equals 2.277.

The average of 26 of the best determinations of the paths and mostly large detonating fire balls, gives for the heliocentric velocity 59.05 km., and therefore $a = -\frac{1}{2}$ very nearly. For those few cases of meteors for which sufficient observational material is at hand to enable us to draw any conclusion as to the form of the orbits, the hyperbolic form is beyond all doubt.

For 154 large meteors whose paths are derived from older material or were first computed by myself, there resulted on the average 59.8 km. as the heliocentric velocity.

Schiaparelli,[2] more than 36 years ago, said "It is in fact remarkable that whenever we have been able to investigate with any approximation the velocity with which a meteorite or a group of meteorites have penetrated into the atmosphere, we have always found that the corresponding absolute velocity is *greater than the parabolic would be.*

Therefore, in general, the large meteors are undoubtedly of interstellar origin. As opposed to this conclusion, we find that streams of shooting-stars pursue the same orbits as those of certain well-known comets of well-known periodicity. They are, therefore, interplanetary shooting-stars. Hence we are inclined to consider the large meteors as interstellar, but the smaller shooting-stars as interplanetary. Still we must call attention to the undeniable fact that most of the radiation points of meteors and detonating fire balls as well as the other large meteors, as far as they can be safely determined, *agree with well-established shooting-star radiants.* It is difficult in such cases to ascribe interplanetary orbits to the corresponding small phenomena when the hyperbola described by the large meteors issues from the same radiant points in the cosmic space.

In attempting to solve this apparent contradiction, one might perhaps assume that we have included under the name of shooting-stars different phenomena that are only superficially similar, but whose dynamic basis and cosmic significance are probably not all similar. From the many experiences of the last ten years we may at least draw the conclusion that in the phenomena as a whole there make themselves felt both the limited and minor interplanetary meteors as well as the extended interstellar meteors having particles of the greatest variety as to size, mass, quality, and velocity.

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[1] J. G. Galle. Über die Bahn des am 30. Januar 1868 beobachteten n. bei Pultusk im Königreiche Polen als Steinregen neidergefallenen Meteors. Breslau, 1868.

[2] Schiaparelli. Pp. 207 and 209.

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EXPLORATIONS AND FIELD-WORK OF THE SMITHSONIAN INSTITUTION IN 1916

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EXPLORATIONS AND FIELD-WORK OF THE SMITHSONIAN INSTITUTION IN 1916

Every year the Smithsonian Institution initiates or takes part in numerous expeditions to all parts of the world for the purpose of increasing the knowledge in various branches of science. The present pamphlet deals with explorations and field-work in geology, zoology, botany, archeology and ethnology, and astrophysics, during the year 1916, the various accounts being written largely in the words of the investigators themselves.

Friends of the Institution have generously aided this work, particularly during the past few years, through the contribution of funds for specific purposes. Most of the field-work is carried on directly through the branches of the Institution, including the National Museum, the Bureau of American Ethnology, the Astrophysical Observatory, and the National Zoological Park. Wherever funds are not available for specific explorations every opportunity is taken to send representatives of the Institution with such expeditions in order to add to the natural history and archeological collections. The Bureau of Ethnology conducts extensive field-work among the Indians themselves, detailed accounts of which are published in the reports of the Bureau. The Astrophysical Observatory has continued observations in this country and abroad in connection with its work of studying the sun; and the National Zoological Park has cooperated with similar institutions in securing from other countries animals desired for the collections.

These various activities result in valuable additions to scientific knowledge of unexplored and imperfectly known regions, and bring to the collections of the National Museum important material for exhibition and research. Many opportunities for undertaking important field researches and for participating in various expeditions are lost to the Institution every year through lack of sufficient funds.

GEOLOGICAL EXPLORATIONS IN THE CANADIAN ROCKIES

In continuation of work carried on for several years past in the Canadian Rocky Mountains Dr. Charles D. Walcott, Secretary of the Smithsonian Institution, was engaged during the summer

FIG. 1. (Frontispiece.) Assiniboine, as it rises in a gigantic pyramid 4,800 feet (1,463.4 m.) above the surface of Magog Lake, which is about 7,000 feet (2,134 m.) above sea level. Wedgwood Peak (9,930 feet = 3,027.4 m.) on the right, and on the left Magog Mountain (9,500 feet = 2,896.3 m.) and the great broken eastern ridge that terminates at Wonder Pass, with Naiset (Sunset) Mountain (9,600 feet = 2,926.8 m.) in the distance above the glacier. The north spur of Naiset terminates on the left in the dark Naiset Point (9,000 feet = 2,743.9 m.), which rises as a succession of great cliffs above the shores of the lake. Photograph by Walcott, 1910.

and early fall of 1916 in field investigations on the Continental Divide forming the boundary between Alberta and British Columbia.

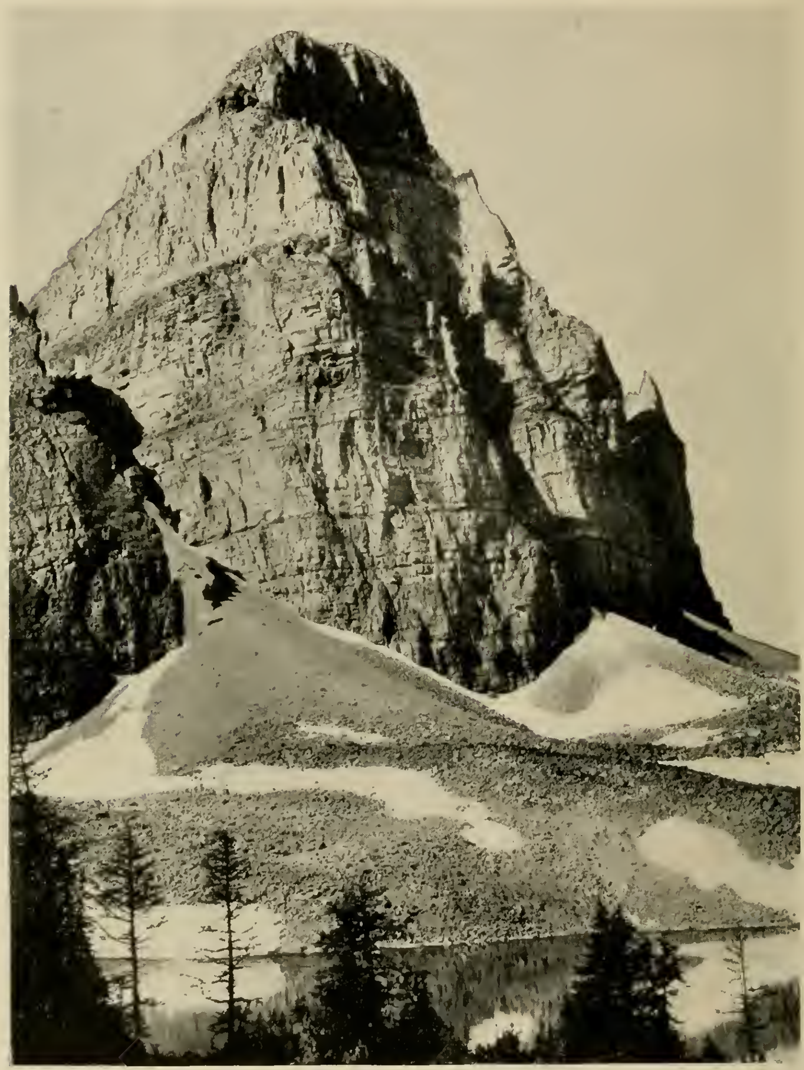

FIG. 2.—Cliffs of massive bedded quartzites at north end of ridge of Wedgwood Peak rising 2,000 feet (609.7 m.) above the small lake in foreground. Note the enormous fans at the base of the cliff, as well as the geological structure of the rock wall above. Photograph by Walcott, 1916.

south of the Canadian Pacific Railway. The very heavy snowfall of the previous winter together with frequent snow and rain squalls

Fig. 3.—Looking southeast toward Wonder Pass; Wonder Mountain rising above pass on left; Naiset Mountain and glacier on right. Many of the trees are fine old specimens of Lyall's larch, found at tree line between 6,500 and 7,500 feet (1,981 and 2,285.9 m.) elevation. Photograph by Walcott, 1916.

Fig. 4.—Mount Assiniboine, the Matterhorn of America, reflected in Sunburst Lake, east of Wedgwood Peak. Around the edges of the melting snow banks anemones, lilies, and other spring flowers bloom in profusion, while on the drier slopes summer flowers carpet the ground. Photograph by Walcott, 1916.

Fig. 5.—The wonderfully eroded front of the Assiniboine massif as seen from the northeast. The line of the great over-thrust fault curves through Wonder Pass on left and, crossing beneath the foreground, passes in front of and beneath great

during the summer, had made the conditions unusually favorable for taking photographs, the air being exceptionally pure and clear

FIG. 6.—A magnificent early morning reflection of Mount Assiniboine in Magog Lake. Note the breeze that has just started at the upper end of the lake as shown by the horizontal streak across the water; also the enormous cones of snow at the base of rock cliffs, where ice and snow avalanches have broken from the face of the glacier above to form a second glacier extending down towards the shore line of the lake. Photograph by Walcott, 1916.

during the field season—conditions, however, very unfavorable for geologic investigations.

FIG. 7.—Mount Assiniboine reflected in Sunburst Lake east of Wedgwood Peak. Note the rapidly forming cloud banner which hides the south point of the summit from view. Photograph by Walcott, 1916.

The sections examined and measured extended from the Mount Assiniboine region southwest of Banff, Alberta, northwest to the

FIG. 8.—Mount Assiniboine with its cloud banner lighted by the midday sun and reflected in Sunburst Lake. Photograph by Walcott, 1916.

Kicking Horse Pass, where the Canadian Pacific Railway has bored a double loop through the mountains on the north and south sides of the Pass.

FIG. 9.—Looking down Corral Creek and across the Bow Valley to Mount Temple and several of the "Ten Peaks" from a point near Ptarmigan Pass, 10 to 12 miles (16.1 to 19.3 km.) distant from the Valley of the Ten Peaks. Photograph by Walcott, 1916.

FIG. 10.—Lake Louise (5,670 feet = 1,728.6 m.), the gem of the Canadian Rockies, lying at the foot of the Victoria Glacier and Mount Victoria, which rises 5,685 feet (1,733 m.) above the lake. Mount Fairview, with Mounts Aberdeen and Lefroy, on the left. The view is from a point on the mountain ridge across the Bow Valley about 7 miles (11.2 km.) northeast from the lake. Photograph by Walcott, 1916.

Fig. 11.—Pinnacle Mountain (10,062 feet = 3,067.6 m.) with Sentinel Pass (8,556 feet = 2,608.5 m.) on the left, near the head of Paradise Valley. A passing snow squall has whitened the slopes and old snow banks below the pass. The pinnacles are eroded from the same kind of rock as that forming the massive cliffs of Mount Assiniboine. Photograph by Walcott, 1916.

Fig. 12.—The cliffs of Mount Hungabee at upper end of Paradise Valley, showing expanse of the Horseshoe Glacier. Frequent avalanches of the fresh fallen snow tumbled down the slopes to the fans above the glacier, as the rising sun loosened their hold on the rock ledges. This illustrates very clearly the formation of this type of glacier. Photograph by Walcott, 1916.

A large number of photographs were secured, including a number of panoramic views made on continuous films eight feet in length, a portion of one of which is reproduced in figure 1, the frontispiece.

FIG. 13.—Paradise River in its fall down the massive quartzite steps of the Giants' Stairway. The rocky walls of Mount Lefroy rise in the background. Photograph by Walcott, 1916.

Fig. 14.—Looking north from the slope of Popes Peak over the beautiful emerald green water of Ross Lake and the dark forest to the steep face of Mount Bosworth on the Continental Divide and above Kicking Horse Pass. Mount Hector in the distance. Photograph by Walcott, 1916.

The season's work was undertaken with two principal objects in view: first, to determine if possible the base line of demarcation between the Lower and Middle Cambrian; and second, to locate the

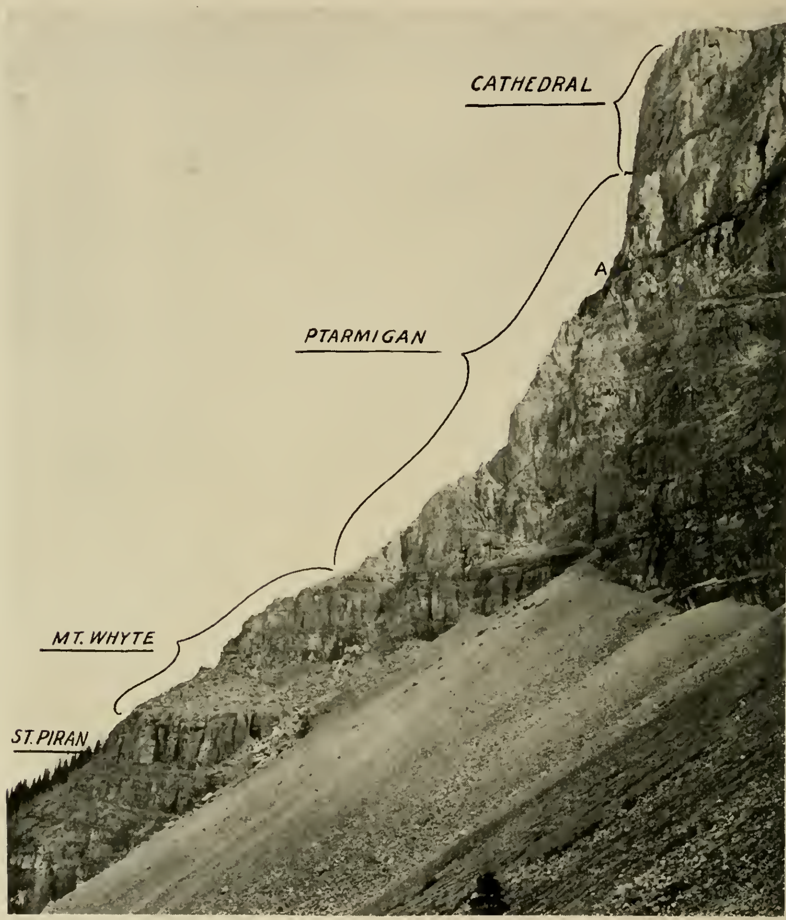

FIG 15.—North profile of ridge above and southeast of Ross Lake, 1 mile (1.6 km.) south of Stephen Station on the Canadian Pacific Railway.

The position of the *Albertella* zone is shown at *A* where the thin band of shale forming the Ross Lake shale member of the Ptarmigan formation may be seen from the Kicking Horse Pass as a dark narrow band.

The relative positions of the Cathedral, Ptarmigan, Mount Whyte, and St. Piran formations are indicated on the plate. Photograph by Walcott, 1916.

exact horizon of a Cambrian subfauna (*Albertella*) that had in its entirety been found only in drift boulders in the Kicking Horse Valley east of Wapta Lake.

FIG. 16.—Panoramic view of Phareo Peak, Scarab Lake, and in the distance Mount Ball. This view well illustrates the cliffs fronting the overthrust fault northwest of Mt. Assiniboine and east of Simpson Pass. Photograph by Walcott, 1916.

FIG. 17.—Alex and Arthur packing up Old Baldy for an early morning start. Photograph by Walcott, 1916.

FIG. 18.—A camp site at last. Where we came down 2,000 feet (609.7 m.) on a blind trail through a wind-fall on "Burnt Timber Hill" in a cold rain. This was one of the reasons why it required three days to reach Assiniboine from Banff. Photograph by Walcott, 1916.

FIG. 19.—Crickett inquiring why the pack train does not start, as she is tired of standing with the heavy pack. Photograph by Walcott, 1916

One of the important incidental results obtained was the discovery at Wonder Pass (fig. 3) of the great overthrust fault by which the basal Cambrian rocks forming the mountains on the west (right) side of the Pass have been thrust eastward over upon the limestones of the Devonian, shown in the slope on the east (left) side of the Pass. The thrust along this fault has carried the rocks forming the main range of the Rockies in this area several miles to the eastward.

FIG. 20.—On the trail to Wonder Pass with a northwest gale to face. The horses always turn their backs to the wind when resting. Photograph by Walcott, 1916.

The fault crosses through Wonder Pass and then curves to the northwest, southeast of Magog Lake, shown in figure 5, to the great cliff forming the northern extension of the Assiniboine massif (fig. 2). During the million or more years that the agencies of erosion had been wearing away the great mass of rocks above the fault, mountain peaks, canyons, and ridges have been carved and polished by frost, snow, and the grinding force of huge glaciers. The glaciers have now retreated to a point near their origin, high up on the mountains, but they have left behind them basins that are filled by beautiful lakes, such as Magog (fig. 5), Sunburst (fig. 4), and Ross (fig. 14).

The line of demarcation between the Lower and Middle Cambrian was found to be high up in the section on the face of the cliffs at Wonder Pass, and throughout the Assiniboine massif.

While camped on Magog Lake below Mount Assiniboine, some marvelous reflections of the peak in the waters of the lake were seen

Fig. 21.—A noonday rest at Wonder Peak, after climbing up the side of Naiset Mountain. A shelter was made of saddle blankets to break the force of the cold wind. Photograph by Walcott, 1916.

in the quiet of the early morning, and by a fortunate combination of a "clear-cut" day and calm at the lake level, the photographs reproduced in figures 6, 7, and 8 were secured. The changes in the "cloud banners," at the peak, which occur very rapidly, are well shown by figures 7 and 8. These views led us to regard the grand pyramid of Mount Assiniboine as the Matterhorn of America.

Northwest of Banff the broad valley of the Bow has been eroded diagonally back through the massive scarf of the overthrust massif and thus exposed to erosion the heart of the great arch that had its crest over the region now occupied by Mount Victoria and other peaks of the Bow Range.

Fig. 22.—Standardizing the size of an old trail gang oven beside the trail. Photograph by Walcott, 1916.

A glance into this wonderland is shown by figures 9 and 10, which are views looking south across the Bow Valley into the heart of the Rockies. The illustration of Pinnacle Peak (fig. 11) tells the story of the tremendous power of erosive agencies, where the colossal quartzites and limestones are shattered and eroded into the most fantastic forms.

West of Pinnacle Peak, at the head of Paradise Valley, Mount

FIG. 23.—Breaking camp and packing up at Mount Assiniboine camp. Photograph by Walcott, 1916.

Hungabee rises in a terraced wall 4,000 feet above the glacier at its foot (fig. 12), while another glimpse of these great cliffs is seen under Mount Lefroy, where the melting snows cascade down as a beautiful brook over the quartzite ledges (fig. 13).

At last, in the cliffs above Ross Lake (fig. 15), the *Albertella* fauna was located in situ, and from the slopes above the lake a panoramic view (fig. 14) was taken of Mount Bosworth, above Kicking Horse Pass on the Continental Divide. Although only 9,083 feet in height, Mount Bosworth exposes in its slopes over 12,000 feet in thickness of bedded rocks that constitute one of the best sections of the Cambrian rocks found in the Canadian Rockies.

FIG. 24.—Waiting for the odds and ends for the last pack at Red Earth Creek camp. The last outfield camp of 1916. Photograph by Walcott, 1916.

Considerable collections of Cambrian fossils were obtained by Secretary and Mrs. Walcott, who accompanied and worked with him throughout the trip, before the storms of late September drove them back to Banff and ended the research for the season.

A few of the incidents of life along the trail are illustrated by figures 17 to 24.

GEOLOGICAL FIELD STUDIES

Dr. George P. Merrill, head curator of geology in the National Museum, devoted several days of the summer vacation period to visiting the gem and feldspar quarries of Auburn, Topsham, and neighboring areas in Maine. While nothing new was secured, he was able to add interesting material to the exhibit illustrating the character and association of the pegmatite dikes, which is now being installed in the Museum.

In May Dr. Edgar T. Wherry was detailed by the Museum to carry on field studies of certain minerals, rocks, and soils in eastern Pennsylvania. Collections of diffusion rings in shale, of glauberite crystal cavities in shale, of the rare iron silicate chloropal, and of certain soils and the associated rocks, were made. These specimens have been added to the Museum collections, and are being investigated. Articles on the glauberite cavities and on one group of soils have been published.

In June certain gem and mica localities in New Jersey and southeastern Pennsylvania were visited by Dr. Wherry, and Dr. W. T. Schaller of the U. S. Geological Survey. In the course of this trip a number of specimens of minerals were obtained for the Museum collections.

HUNTING GRAPTOLITES IN THE APPALACHIAN VALLEY

The great value of the extinct organisms known as graptolites in determining the age of geological formations which contain few and often no other kinds of fossils, has been proved time and again. During the summer of 1916 Dr. R. S. Bassler and Mr. C. E. Resser, both of the division of paleontology, U. S. National Museum, had occasion to test this particular group of fossils in the course of a study of the Cambrian and Ordovician shale formations of western Maryland. Recent excavations along the Western Maryland Railroad, in the great shale belt just west of Williamsport and extending north and south for hundreds of miles, exposed these rocks to such advantage that it was thought possible enough fossils could be found in them to determine their exact geologic age and structure. However, no fossils of any kind were found after much search. It was then decided that the rocks were either barren of organic life or the cleavage produced in the strata by the great forces resulting in their present folded condition destroyed all traces of fossils.

Finally the fold of black shale shown in figure 25 was observed, and at the point marked X, where the cleavage and the bedding planes coincided, abundant graptolite remains were discovered. The species which were collected proved to be of such typical Trenton forms that there could be no doubt of the Middle Ordovician age of this particular shale. Limestones known to be much older outcrop so short a distance to the east of this that a great fault or displacement between the two kinds of rocks is clearly indicated.

With these facts in hand, the fault was traced for a distance of thirty miles north and south, thus again showing that the graptolites proved the key to the geologic structure of the region.

FIG. 25.—Fold in Ordovician shale west of Williamsport, Md. Graptolite fauna found at *X*, where cleavage and bedding planes coincide. Photograph by Bassler.

EXPLORATIONS IN THE OHIO VALLEY FOR FOSSIL ALGAE AND CORAL REEFS

Through the extensive studies of the Secretary for several years past, the collections of the National Museum are rich in limestone-forming pre-Cambrian algæ—a low order of water plants that secrete lime or silica. An instructive series of these fossils has been placed on exhibition, but in order to show the geologic occurrence and evolution of this group of plants it was necessary to supplement the pre-Cambrian forms with specimens of more recent age. Accordingly

Dr. R. S. Bassler, curator of paleontology, spent some weeks in the Ohio valley, particularly in the Blue Grass region of Kentucky, in a search for large exhibition specimens, and in a study of their mode of occurrence. He was successful in procuring a number of showy exhibition specimens as well as numerous study collections.

More difficult, however, was the discovery and quarrying of a fossil coral reef suitable for exhibition in the Museum. Coral reefs are known at several horizons in the Paleozoic rocks of the Ohio

Fig. 26.—Strata outcropping along Chenoweth Creek at Jeffersontown, Ky., and containing a coral reef. See text for lettering. Photograph by Bassler.

valley but they are seldom so exposed that an instructive section can be quarried out without injury to the specimens. A great reef of corals outcrops in the strata along the banks of Chenoweth Creek at Jeffersontown, near Louisville, Kentucky, and this was selected to furnish an exhibit for the Museum. A section of the stratified rocks, 6 feet by 10 feet, outlined in the accompanying photograph (fig. 26), was bodily quarried out of the bank, and these strata with their contained corals were later set up in the exhibition hall of paleontology.

The lowest layer of limestone (A) is composed largely of fossil brachiopod shells. Next above is a layer with scattered corals (B) belonging to a long-tubed species (*Columnaria calicina* Nicholson), probably torn by waves from a nearby coral reef. Overlying this is a limestone stratum (C) largely made of the twiglike stems of stony Bryozoa (Trepostomata).

FIG. 27.—Trenton limestone outcrop near Lexington, Ky., with one stratum containing large heads of coral (X). Photograph by Bassler.

The main reef of corals (D) is chiefly composed of the rounded heads of three species of honey-comb corals, some with radial partitions in the tubes (*Columnaria alveolata* Goldfuss), others without such partitions (*Columnaria vacua* Foerste), and still others with spongy walls (*Calapoecia cribriformis* Nicholson). Large stems of fluted or nodular Hydrozoa (*Beatricea*) are scattered among the honey-comb coral masses.

Horn corals (*Streptelasma rusticum* Billings) are to be seen in both the lower and upper coral beds. The spaces between the limestone layers and also between the heads of coral were filled with clay which contained many other examples of fossil life.

Another coral reef in central Kentucky composed of a single species (*Stromatocerium pustulosum* Safford) was investigated and several massive and complete specimens excavated for exhibition. The smallest of these was several feet in diameter. As shown in the accompanying photograph (fig. 27) these conical coral masses (X) are restricted to a single layer of limestone, on which account they serve excellently in recognizing the bed from place to place. This coral reef occurs in the Trenton limestone and outcrops to advantage around Lexington, Kentucky, although it has been noted at many localities in central Kentucky and central Tennessee.

No expeditions were in the field during the season from the section of vertebrate paleontology. Much valuable material was, however, collected and sent to the Museum by the field parties of the U. S. Geological Survey.

EXAMINATION INTO THE SUBJECT OF SUPPOSEDLY ANCIENT HUMAN REMAINS AT VERO, FLORIDA

On the invitation of Dr. E. H. Sellards, state geologist of Florida, and as his guest, Dr. Hrdlička spent four days in the latter part of October, 1916, at Vero, Florida, where his time was devoted to the study of the site from which certain human bones described by Dr. Sellards were obtained, and to a preliminary examination of the bones themselves.

Laborers were engaged and with their help there was made a clean exposure about 160 feet in length of the geological deposits in close proximity to the localities where the human bones had been discovered. This afforded a comprehensive and enlightening view of the formations involved.

The two human skeletons had been found in the south bank of a recently excavated drainage canal. They occurred, one in fairly close proximity to, and the other within the broad shallow bed of, a small fresh-water stream, now drained by a lateral cut from the canal. The former lay in dark and somewhat indurated sands, the latter for the most part at the base of the muck deposit of the stream bed, and between this and the next older stratum. A few smaller bones which probably belonged to the second skeleton were found at about the same level a short distance from the rest of the remains in an elevation of the lower sandy layer.

The first skeleton lay at a depth of two and a half feet, the second at a depth of two to three and a half feet from the surface. The deposits above the first skeleton consisted partly of somewhat indurated and partly of ordinary sands, overlaid by a layer of marl. The marl when freshly exposed was found to be of the consistency of fresh mortar, but on longer exposure hardened to fairly solid rock. Above skeleton II, there was only muck and irregular sandy patches.

Skeleton No. I is that of a woman probably adult, skeleton No. II that of an adult man of somewhat advanced years. The bones of the former lay close together, those of the latter were dissociated though lying within a moderate-sized ellipse. Broken pottery, bone and stone implements, and stone chips, were found in the same strata, more particularly in the muck layers, with the human bones.

Fig. 28.—The locality of the Vero finds.

Besides the two skeletons, single bones of three additional human bodies—one a child, one a young person and one an adult—were discovered in the vicinity. The human bones were considerably mineralized and in the same strata in which they occurred are found many bones of long extinct animals such as mastodons, tapirs, etc.

Due to the presence of the fossil animal bones in the same strata with the human remains, and to the mineralization of the latter, the opinion was advanced that the human remains were of the same age as the animal bones, which would relegate them to the early part of the Quaternary.

This was not sustained by an anthropological study of the case and of the remains. The human bones show no signs of weathering, gnawing, or trampling, and the two skeletons were represented by so many parts, that the only satisfactory explanation of the conditions can be found in the assumption that the remains are those of intentional burials.

FIG. 29.—The Vero skull (Skeleton No. II), top view. Reconstructed at the U. S. National Museum.

FIG. 30.—The Vero skull (Skeleton No. II), right side.

The pottery and the bone and stone implements are all identical with similar artifacts of the Florida or south-eastern Indians; while the human bones themselves show without exception modern features, with numerous characteristics which permit their identification also as Indian.

The conclusions arrived at are, that the Vero finds represent another of those cases, which are bound to occur from time to time, where the circumstances seem to point to antiquity of the human bones, but where a thorough all-sided inquiry shows that the mass of the evidence is decisively against such an assumption.[1]

Aleš Hrdlička.

TRIP TO FORT MYERS REGION, WEST COAST OF FLORIDA

Following the visit to Vero a trip was made to Fort Myers, Fla., and to several of the outlying keys, where human remains were reported. The particular object of this trip, was to visit a small island off Fort Myers known as the Demorest or Demere Key, on which, according to information obtained from Mr. Sam L. King of Bristol, Tennessee, human bones could be found "imbedded in concretionary materials."

After arrival at Fort Myers a number of gentlemen were met who gave material assistance in locating and reaching the small key, and in making such exploration and collections on the same as were possible within the limited time at our disposal. Those who should be especially mentioned in this connection are Capt. George F. Kinzie, Mr. A. H. Gillingham, and Mr. Richard Eybor.

Demere Key, the surface of which measures about fifteen acres, was originally a low and swampy island, like all the small keys in the vicinity, but a larger part of its surface was in the course of time artificially elevated by the Indians, by means of shells, sand, and soil, for the purposes of habitation and cultivation. Along the middle of this large artificial elevation runs a remarkable platform about 80 feet long, the eastern boundary of which is supported by a still fairly well preserved, well-made wall of conch shells. This structure has been briefly reported by Cushing,[2] and by Mr. Clarence B. Moore,[3] but its origin is in doubt. At a short distance north-east of this elevation there is a low, irregular heap which contains numerous Indian burials. On examining the surface of this heap it was found to

[1] A preliminary symposium on these finds appeared in The Journal of Geology, No. 1, 1917; Dr. Hrdlička's full report will be published by the Bureau of American Ethnology.

[2] Proc. Amer. Philosoph. Soc., Vol. 35, 1896, p. 237.

[3] Antiquities of Florida, West Coast, p. 366.

consist of shells, detritus, sand and vegetable matter, and to be everywhere more or less consolidated to the depth of from six to eighteen inches. The consolidation was such that in many places it was very hard to penetrate the crust with an ordinary mattock. Within this crust, on breaking parts of it off and turning them over, were found numerous human bones, including some more or less defective skulls. Beneath the crust was white sand, which also contained many bones, with a few Indian ornaments and fragments of pottery. The consolidated crust differed in composition. For the larger part it was coquina, of just about such a composition as beach accumulations along the sea; but in other places the solidified part consisted almost entirely of white sand, while in still others it was a dark concretionary mass enclosing shells, sand and vegetable matter, besides the bones. The human bones, though evidently more or less changed, were not yet petrified; and the mound as a whole appears to have no claim to antiquity greater than perhaps a few hundred years; but its surface offers a fine example of what favorable conditions can accomplish in no great space of time in the way of consolidation and inclusion in rock of human remains.

A series of interesting specimens from the mound are now on exhibition in the U. S. National Museum.

ALEŠ HRDLIČKA.

EXPEDITION TO BORNEO AND CELEBES

In the report on explorations during 1915 (Smithsonian Misc. Coll., Vol. 66, No. 3, pp. 41-44), I said that Dr. Abbott had decided to continue the work begun in Celebes by Mr. H. C. Raven, and that Mr. Raven had spent part of the summer of 1915 in Washington assembling his outfit. The return journey began late in October. On January 4, 1916 Mr. Raven arrived at Menado, Celebes. His work from January to the end of August was in the northeastern part of the island. Some idea of the conditions under which it has been carried on is given by the photographs here reproduced, and by the following passages from letters:

MENADO, CELEBES, January 4, 1916.

I arrived here this morning and am very glad to have finished my journey. As yet I have not definitely planned my route, but it will probably be best to start on the extreme end of the peninsula, somewhere in the mountains near Likoepang and work along toward Gorontalo.

LIKOEPANG, CELEBES, March 9, 1916.

I have been collecting here and at a place a few miles southeast of here since January 12th. I am now living in the kampong, but my other camp was in heavy forest more than two miles from any home or clearing. The natives call the former place "Teteamoet" and the forest there is the finest I have seen in

Celebes. Rats were fairly common and I have gotten about seven species. *Sciurus leucomus* is also common as is *Sciurus murinus*, but I have seen no other squirrels. Big game is scarce and I have shot nothing larger than the black monkeys, of which I have a good series (15) and feel quite sure that you will find them to be a different variety than those I formerly collected. The crest seems much longer, the callosities are a different shape and the face narrower. [They are *Cynopithecus* (fig. 34), while those previously obtained were *Magus* (fig. 33).]

FIG. 31.—A mother and her two daughters, natives of Temboan, Celebes. Nearly all of the natives of Minahassa are Christians.

This is not just the bat season, the natives claim, as it has been raining almost steadily and there is no fruit about. I have got five species of bats, among them five specimens of a large-eared *Megaderma* which is new to my collection. In all I have something over five hundred specimens, most of which are mammals; also I have got quite a number of land shells.

I am now about to start for Goenoeng Klabat, as with much trouble I have managed to get fairly dry the specimens on hand.

AYERMADIDI, MINAHASSA, CELEBES, May 9, 1916.

I am sorry to have to say that since Likoepang I have been able to do only a few days' work. Shortly after leaving Likoepang I had a little fever, but thought it was about over. So I hired a native house here and tried to do a little collecting and to get rid of my fever. After a week or so the fever disappeared and I went up on Goenoeng Kalabal and made camp at an altitude of about 5,600 feet. We were in the clouds almost continuously and there was also a great deal of rain. Animal life of all kinds was scarce, though what

FIG. 32.—An old man of Temboan. There are very few natives in Minahassa at the present time who dress in this manner.

little I did get may prove interesting. I saw tracks of two or three Anoa [dwarf buffalo] on the very summit and in the crater; also tracks of a pig, but nothing else large. I changed my traps every night so that I trapped all the way from about 5,000 feet to the summit, but got only a few rats. There are five species, I think, and one or two of them seem to vary somewhat from the ones from Likoepang of the same species. I got ten or eleven species of birds, eight of which are new to my collection, and I think not found in the low lands.

At the end of eight days I felt bad and came down to Ayermadidi. That was on April 12th, and from then on I had more or less fever and finally mumps and high fever. This gradually increased so that I was unable to eat or drink anything for 9 days. As quinine had no effect on the fever I finally had to go to Menado to the military doctor there. He stopped my fever in two days, but then I was nearly "all in," my temperature way below normal and pulse little more than fifty. I came around all right anyhow, so that I

FIG. 33.—"Betchie," my black monkey from Toli Toli, a most affectionate and gentle animal. She remembered me after an absence of ten months.

could walk after four or five days and now am all right but a little weak. The hotel at Menado (or in fact anywhere, where one can get European food) is expensive; here is better (cheaper) than Menado and cooler. The doctor said I should go to Tondano for a couple of months where the climate is very cool, but if I improve as of late I think that in less than a week I can start for Lembeh and do some collecting. Lembeh has no resident population, whereas Tondano has more than 12,000.

FIG. 34.—The black monkey of Likoepang, showing the well-developed crest in comparison with the one from Toli Toli.

FIG. 35.—Many of the natives here use the ground as a floor, with the dooryard always swept surprisingly clean. Temboan, Kalait R., Celebes.

MENADO, CELEBES, August 20, 1916.

I returned to Menado about a week ago from south of Amoerang in the mountains where I had made a camp and stayed for about a month. There I got a great many rats, including one or possibly two species that I had not before seen in Minahassa. Something that you may find interesting is quite a good series of shrews of two species, one grey and one black. I am looking forward to getting more of these now that I know how to catch them. The ones I have were caught by native boys. I have often tried with "Out-o'-sight" traps to catch these, but without success. To catch them the

FIG. 36.—Mount Sapoetan, an active volcano in central Minahassa, Celebes.

natives dig a hole about 4 feet deep and three or four feet in diameter and put corn in the hole as bait.

I have decided that a slight change in our plans will probably save time, so instead of going from here to Makassar I am going from here to Parigi and work southward from there to the Lake of Posso; thence to Palopo. Dr. Abbott has written me about the importance of this central part of Celebes ethnologically, and from what I have heard from officials here it must be very interesting country.

I think if I use Paloe or Parigi as a base and first make a trip north from there I shall have fairly well covered all this northern peninsula. Then I can work southward.

In Minahassa I have been disappointed at not being able to get more bats and more large mammals. A short time ago I got a large squirrel about the size of a Ratufa which I believe is very rare here.

During this expedition Mr. Raven has traveled by land instead of by water. His covered cart is shown in the photograph (fig. 37). At Parigi he intended to secure about six pack horses.

Only one shipment of specimens had been received up to January 8, 1917. It includes three hundred and nineteen mammals and about three hundred birds; also numerous reptiles, mollusks, and insects.

Gerrit S. Miller, Jr.

Fig. 37.—My cart and horses on the road to Tondano. In this way I traveled wherever there were good roads in Minahassa.

EXPLORATION IN CHINA

Owing to a variety of circumstances, the work of Mr. Arthur de C. Sowerby, in China, has been less successful than usual. At the end of 1915 he visited Shanghai and parts of the neighboring country on the lower Yangtze. Field-work during this expedition did not produce any very important results; but the examination of the Heude collection of mammals in the Sikawei Museum has thrown much light on one of the most difficult problems connected with the systematic study of Chinese mammals. Heude assembled a large collection of skulls, chiefly of bears and ungulates, from all parts of China, and from other regions in the east. He made this material the basis of many technical papers. In all of these he applied a standard of specific differentiation so unlike those in use by other zoologists that his work could not be understood. Mr. Sowerby has been able to make good preliminary reviews of Heude's bears, pigs, and goat-antelopes. Papers on these three important groups may be expected to appear in the near future.

In March Mr. Sowerby returned to the Yangtze. This expedition was an almost complete failure. Mr. Sowerby writes (June 10, 1916):

> My recent trip to Che Kiang was brought to a summary close by the outbreak of hostilities in that region. I could not get any transport and very nearly had my retreat cut off. Nothing can be done now till the provinces have come to an agreement as to who shall be president and just how the government is to be run. There is only north Chili left to work in and I hope to go there this autumn. China is in such an unsettled state that if it were not for the war in Europe it would be attracting everybody's attention. Conditions are no better than they were during the revolution of 1911.

No specimens collected during 1916 have yet been received from Mr. Sowerby. Material from the Yangtze and from several localities in northern China is expected soon to arrive.

Gerrit S. Miller, Jr.

EXPLORATIONS IN SANTO DOMINGO

Dr. W. L. Abbott, whose energies for nearly thirty years past have been devoted to explorations in the Old World, made a short visit to Santo Domingo (the scene of his earliest expedition, in 1883), where he spent a few weeks in late summer and fall, 1916, at the eastern end of the island, chiefly in the vicinity of the Bay of Samaná, with trips to several localities in the highlands of the interior, notably at Constanza and El Rio. On this expedition he made a very interesting collection of mammals, birds, reptiles, mollusks, insects, and Indian relics.

In the coast region, Dr. Abbott investigated numerous caves in search of remains of an extinct mammalian fauna. The results of this part of his work have been described by Mr. Miller (Smithsonian Misc. Coll., Vol. 66, No. 12, December 7, 1916). One of the most interesting mammals whose remains were found in these caves is a large rodent, described from a freshly killed specimen in 1836, but not captured since then. Whether it is extinct or not is at present an uncertainty. The skull found by Dr. Abbott is shown in figure 38. At San Lorenzo Bay, on the south side of the Bay of Samaná, there are "many precipitous limestone hills," which, Dr. Abbott writes, are "literally honey-combed with caves. The cave (usually inhabited) near the pier of the abandoned railroad is full of shell-heaps, and contains many Indian carvings, more or less obliterated by smoke and lime deposits." Here he uncovered two hundred or more archeological objects, including terra cotta images, fragments of pottery, stone pestles, carved stone plates and similar material.

After exhausting the caves in the vicinity of Samaná, Dr. Abbott visited the mountains of the interior, where, at El Rio,[1] he made a most surprising discovery in the bird fauna. He writes "I had heard of a very small 'parrot' which lived in flocks in the pines

FIG. 38.—Skull of *Plagiodontia,* a rodent once common in Haiti and Santo Domingo, but now perhaps extinct. It was eaten by the Indians and by the European settlers of the island. (Enlarged.)

on the pine cones. I suspected a crossbill—said to occur here at Jarabacoa, below 2,000 feet, but the pair I shot were at near 5,000 feet." The bird proved to be a veritable crossbill and, what was most extraordinary, a form closely related to the White-winged Crossbill (*Loxia leucoptera*), a species restricted in the breeding season to the Boreal zone of North America (from Alaska to the higher Adirondacks), migrating in winter at rare intervals as far south as North Carolina. Red Crossbills, of the *Loxia curvirostra*

[1] El Rio is "a new settlement formed 16 years ago in the upper valley of the Emenoa, which flows into the Yaqui River (del Norte). Elevation about 4,000 feet. About 20 miles by road from Jarabacoa. There are about 600 to 800 people settled within a few miles of El Rio. No town, only a shop (tienda) and a cock-pit. Beautiful and fairly fertile district," according to Dr. Abbott's descriptive notes.

group, are now known to inhabit the highlands of Mexico and Guatemala and of the Philippines (Luzon), but the presence of a form of White-winged Crossbill within the tropics was wholly unexpected. The new bird, recently described as *Loxia megaplaga,* closely resembles its Boreal relative in color, but possesses a much heavier bill, the mandibles approximating in bulk those of the Red Crossbills, whereas those of the White-winged species are of much feebler build (see fig. 39).

Another problem in distribution is furnished by a new species of *Brachyspiza,* obtained at Constanza, at an elevation of about 4,000 feet. *Brachyspiza* is a genus of non-migratory sparrows, ranging

Fig. 39.—Upper figure, Santo Domingo Crossbill (*Loxia megaplaga*), showing heavy bill. Lower figure, White-winged Crossbill (*Loxia leucoptera*), showing slender bill.

from the mountains of Mexico to Chili, with related species in British Guiana and Curaçao, but hitherto not recorded from any part of the West Indies proper. The discovery of a species of this genus in the mountains of Santo Domingo is noteworthy, particularly as the new bird (*Brachyspiza antillarum*) is more nearly related to the mainland bird (*B. capensis peruviensis*) than to the form from Curaçao (*B. capensis insularis*). A large owl (*Asio noctipetens*) found at Constanza proved to be new, though not distantly related to a species of Cuba and Mexico. The Santo Domingo Barn Owl (*Tyto glaucops*), described many years ago, but still very rare in museums, is represented by three fine specimens, the first received by the National Museum. Five examples of the equally rare Narrowbilled Tody (*Todus angustirostris*) were obtained near Constanza, where it replaces the ordinary Tody (*T. subulatus*) of the lower country. A very rare siskin (*Loximitris dominicensis*), peculiar to the island and hitherto represented in the Museum only by the type of the species, was found at El Rio.

One of the commonest and most conspicuous birds, and one restricted to the island, is the Palm Chat (*Dulus dominicus*), sole member of the family Dulidæ, whose systematic position is in doubt. It is a species of peculiar habits and traits; its manner of nesting, for example, is quite unlike that of any other known American bird. The members of a colony (these birds are gregarious) construct a large mass of sticks and small twigs, within which they build their nests. Dr. Abbott collected skeletons and specimens in alcohol, to serve as a basis for further investigations into the affinities of the family.

The series of birds totalled about two hundred and fifty specimens, of fifty or more species, over thirty of which are peculiar to the island. The indigenous species of this island have long constituted the Museum's chief desiderata among the birds of the West Indies, hence Dr. Abbott's collection has proved of the greatest interest, aside from the special discoveries mentioned above.

CHAS. W. RICHMOND.

DREDGING FOR MARINE INVERTEBRATES OFF THE FLORIDA KEYS

In May 1916, Mr. John B. Henderson, a regent of the Smithsonian Institution, conducted a series of dredgings from his yacht *Eolis* off Key West, Florida. Owing to exceptionally good weather conditions and to the fact that the Gulf Stream had receded much farther off shore than is usual, the party was enabled to carry on most successful operations upon the Pourtales Plateau. This is a strip of rocky bottom off the Florida Keys extending some forty or fifty miles and lying between the depths of 100 to 200 fathoms. It is one of the richest localities in American waters with a fauna peculiarly its own. Owing to the great difficulty of dredging over the rocky floor swept by the maximum current of the Gulf Stream, but little attempt has been made to explore it since the work done there by Pourtales, fifty years ago. The material collected covers all groups of marine invertebrates.

COLLECTING IN WESTERN CUBA

In the last few years, numerous collecting trips to western Cuba have been made by Mr. Henderson, usually accompanied by some member of the museum staff. During the course of these explorations, very large series of land shells have been secured, giving to the Museum by far the largest and most complete collections in the world of that exceedingly rich and interesting mollusk fauna. Practically the entire range of the Organos Mountains, the Sierras of western Cuba, had been explored by representatives of the museum, but there still remained untouched three localities of importance. These were, (1) the extreme eastern prolongation of the Sierra de los Organos, or that region known upon Cuban maps as "Loma de Cuzco" and "Guayajabon." This region furnished the types of several of the first described mollusks of Cuba but has

Fig. 40.—Mr. Henderson's yacht *Eolis* in Florida waters. Photograph by Henderson.

been neglected by all subsequent collectors. (2) The region about "Rangel," one of the most famous of type localities in Cuba, and (3) that section of the Organos Mountains lying between Rangel and the Taco Taco River Gorge and the town of San Diego de los Baños.

In May and June, Mr. Henderson and Dr. Paul Bartsch, curator of marine invertebrates of the Museum, spent a month exploring these three regions. For most of the trips they were accompanied by Dr. Carlos de la Torre and Sr. Rodriquez of the University of Havana. The many localities and stations occupied were thoroughly collected and fine series of mollusks and other organisms were brought home.

Before returning, Mr. Henderson and Dr. Bartsch visited the "Luis Lazo" region in the extreme western part of the Sierra in order to supplement collections hurriedly made there several years ago.

With the completion of the last few items upon the comprehensive program of collecting in western Cuba, the Museum is now in possession of sufficient material for a thorough study of the special fauna of that exceedingly interesting region.

FIG. 41.—Bird Key Reservation, Tortugas, Florida. The large birds on the stakes are Man-o'-war birds; the white-crowned birds nesting in the bushes are Noddy Terns; the birds nesting in the open stretches on the ground are Sooty Terns. Photograph by Bartsch.

VISIT TO THE CERION COLONIES IN FLORIDA

Through the cooperation of the Carnegie Institution and the U. S. National Museum, Dr. Paul Bartsch, curator of marine invertebrates, was enabled to visit the Bahama Cerion colonies which he has planted on the Florida Keys, between Miami and the Tortugas, last May for the purpose of studying the effect of the changed environment upon these organisms. He reports the finding of many adult specimens of the first Florida grown generation, which together with those

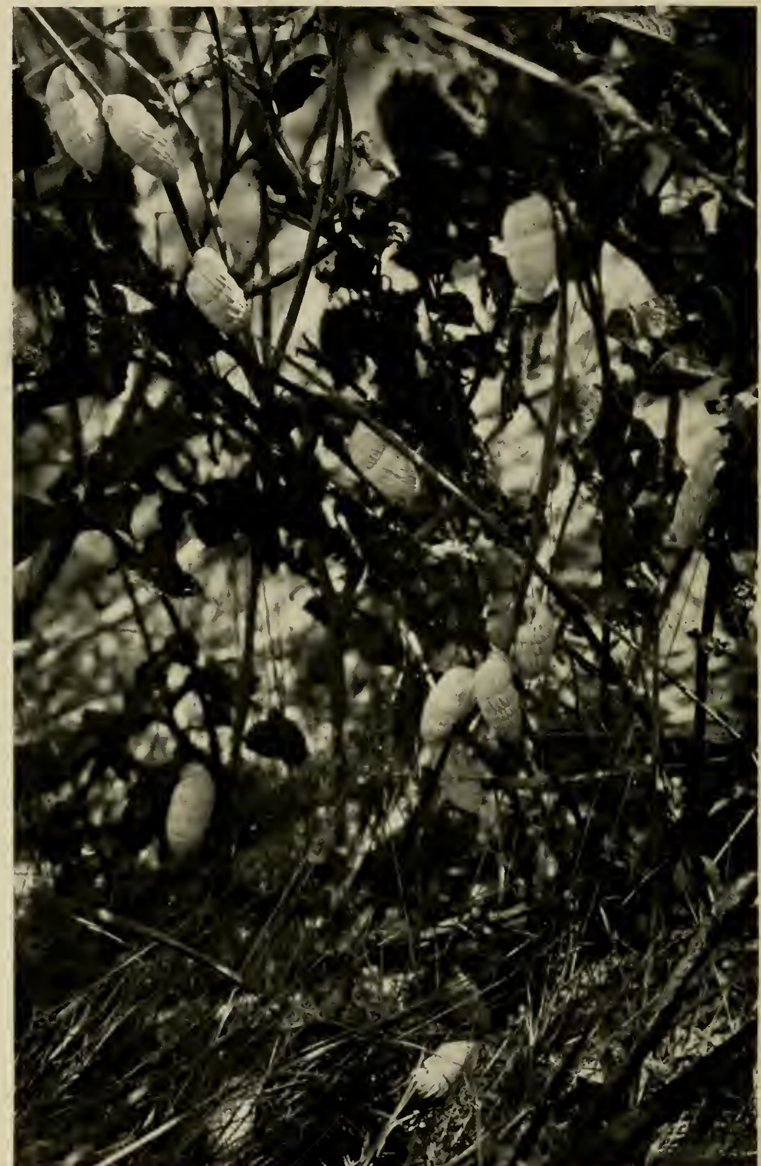

Fig. 42.—Bahama Cerions grown on Loggerhead Key, Tortugas, Florida. Photograph by Bartsch.

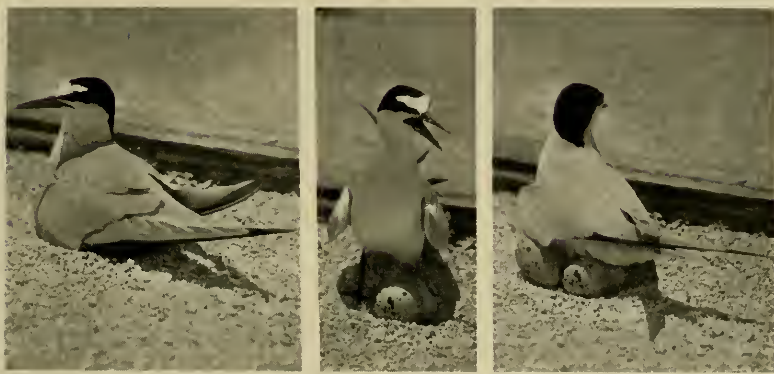

FIG. 43.—Least Terns on Loggerhead Key. Photographs by Bartsch.

FIG. 44.—Noddy Terns on Bird Key. Photograph by Bartsch.

found last year of the same generation, will furnish the basis of a report now in preparation.

No adult specimens of the second generation have as yet been obtained, although many immature individuals of it were observed, which should attain complete development during the year (1917). The results to be shown by this second generation, probably the most interesting one, are eagerly looked forward to.

An unlooked for result was obtained on New Found Harbor Key, where four hybrid specimens between the native *Cerion incanum* and the transplanted Bahama stock were obtained.

FIG. 45.—Mr. Bethel, the Bird Guardian on Bird Key. Photograph by Bartsch.

The Florida tree snails, *Liguus fasciatus,* transplanted from Brickles Hammock near Miami, to the grounds of the Commandant's residence at Key West, and Garden and Loggerhead Keys, Tortugas, have completely disappeared from these places, not even a trace of a shell being found, thus stamping the experiment a failure.

During the Cerion investigations, and while traveling on a slow train between Key West and Miami on June 24, Dr. Bartsch kept records of the birds observed. These are to be shortly published in the Year Book of the Carnegie Institution, as his fourth annual list of the birds observed in southern Florida. Eight species were added this year, which had not been previously noted, bringing the total so far seen to ninety-seven.

STUDY OF THE MARINE INVERTEBRATE FAUNA OF CHESAPEAKE BAY

The hydrographic and biologic study of Chesapeake Bay begun by the U. S. Bureau of Fisheries in 1915 was continued during the past year. On two of the cruises of the steamer *Fish Hawk,* used for these explorations, the U. S. National Museum had a representative aboard with instructions to give particular attention to the invertebrate fauna of the bay.

Mr. J. A. Mirguet was detailed for this work from April 20 to April 26, 1916, during which time dredgings were made at Stations Nos. 8497 to 8536 inclusive. A few of these dredgings were made in Lynnhaven Sound and in the vicinity of Cape Henry. The others were in various parts of the Chesapeake between the mouth and the Patapsco River. But little opportunity was afforded for collecting along shore, the only work of this kind being done during a brief visit to the shores of St. Mary's River and Buckroe Beach.

Mr. William B. Marshall was detailed to the *Fish Hawk* for similar work from July 12 to July 31, 1916. During this cruise, Stations Nos. 8593 to 8622 inclusive were investigated, extending from the mouth of the bay to above the Patuxent River. Near the capes the dredgings yielded rich returns, but the fauna appears to dwindle out to the northward.

On this cruise, many opportunities occurred for collecting along shore and in the inlets and back bays. Lynnhaven Inlet and its shores, the shores of Fisherman's Island and at New Point, Cedar Point, and Solomon's Island were carefully examined. Lynnhaven Inlet yielded some fine material and interesting data. At Cedar Point a fresh-water lake of many acres in extent comes to within a hundred feet of the bay, above which its banks are elevated but a few feet. A small mollusk (*Amnicola*) is abundant in the floating vegetable matter and seems to be the only molluscan life occurring in the lake.

With a small dredge operated from a motor-boat, five or six hauls were made in Mogothy Bay at depths of from 20 to 32 feet. The fauna proved to be very rich, probably owing to the narrow channel and fair current and the clean shores and flats covered with sea-grass. Unfortunately the netting of the dredge was carried away by the weight of a mass of coral. Having no means of making repairs, the party returned to the ship which then moved to another station, leaving the investigation of Mogothy Bay unfinished.

EXPEDITION TO SOUTH AFRICA FOR LIVING ANIMALS

For some years past the National Zoological Park, in common with other similar institutions in the United States, has felt the effect of conditions that operated to hinder more and more the importation of wild animals from abroad and to reduce the supply. While various causes contributed to this, the regulations designed to prevent the introduction of infectious diseases of animals into the United States, have until very recently had most effect. Deer, antelopes, camels, and all other ruminants, also swine, have long been forbidden entry into the United States when coming from the continent of Europe; and for several years past a quarantine has been in effect much of the time against Great Britain because of outbreaks of foot-and-mouth disease there. The same is true of South America; and the restrictions against Africa and Asia are only a little less stringent. With ruminants already almost unobtainable, the outbreak of the European war cut off practically all of the established means of supply for other animals, as the business had been almost wholly in the hands of German dealers.

That this situation was likely to bring serious trouble was soon realized by those having collections of living animals to maintain, and they began to take counsel together. At the suggestion of Dr. W. T. Hornaday, Director of the New York Zoological Park, a conference was held at the Philadelphia Zoological Garden to consider the question of sending a joint expedition, on behalf of the New York, Philadelphia, and National Zoological Parks, to South Africa for animals. From correspondence which Dr. Hornaday submitted at this conference it appeared that some desirable animals were then being offered at a South African port, and that a fairly good representation of the rich fauna of that region would be available if a reliable market were assured. A line of steamships had recently been put in operation between African ports and New York, so that direct shipment could be made. Altogether the conditions seemed reasonably favorable, and it was decided to send a man out to look the ground over, see what could be done in the way of arranging for a supply of animals for the future, and bring back anything desirable that could be secured at the time. As no one of the three institutions could spare a suitable man for this work, they engaged Mr. J. Alden Loring, who had been successful in bringing animals from Europe for the New York Zoological Park, and had also had experience in Africa as a member of the Smithsonian expedition to East Africa.

Mr. Loring sailed from New York July 22, 1916, taking with him hay and grain enough to feed as many antelopes and other herbivora as he was likely to obtain, for one of the conditions necessary to secure their entry into the United States was that no forage from Africa should be brought with the animals. He arrived at Port Elizabeth, South Africa, August 31, and, returning, sailed from Durban November 22.

The opportunities for securing animals to bring back were found to be in some respects less favorable than had been anticipated. Business conditions generally had been disturbed by the war, and animals were no longer being captured and held for sale to the traveling buyers for European dealers, who, it was known, would now be unable to come. Most of the few animals that had been

FIG. 46.—Herd of sable antelope brought in by the hunters. National Zoological Gardens, Pretoria, South Africa.

available were bought and taken away by a private buyer who passed through the region not very long before Mr. Loring arrived. Fortunately the zoological garden at Pretoria was fairly well stocked, and the director was kind enough to deplete the collection somewhat for the benefit of his distant colleagues. Most of the animals which Mr. Loring brought back were obtained there, an interesting collection of mammals and birds being secured. Two nice lots of snakes and tortoises were obtained elsewhere. There was practically no loss during transportation except a koodoo which broke its neck soon after being put in the shipping crate. The voyage from Durban occupied forty-one days, from November 22 to January 2, and on arrival at Boston the animals were immediately transferred by express to the New York Zoological Park, where the ruminants were held in quarantine for fifteen days, under the supervision of an inspector of the United States Bureau of Animal Industry. The mammals obtained include a gemsbuck, a blessbuck, a white-tailed gnu, a nilgai,[1] four springbucks, a pair of duikers, a pair of meerkats, and a few monkeys and rodents. Among the birds are two secretary vultures, a bateleur eagle, a hornbill, francolins of several species, a few touracous and hawks, and a number of smaller birds. The collection has been divided between the three institutions concerned, according to their choice, and in proportion to the share of the expenses that was borne by each. Altogether

FIG. 47.—Yards for antelope, National Zoological Gardens, Pretoria, South Africa.

there were secured 28 mammals, representing 13 species; 60 birds, of 25 species; and 55 snakes and tortoises, of 8 species.

It may be of interest to give a brief abstract of Mr. Loring's notes regarding the zoological gardens which he visited in South Africa, where this feature of municipal life seems to find favor.

Cape Town has a small collection of animals, including lions, antelopes, and various smaller mammals, and some birds. This is on the Cecil Rhodes estate.

Durban, with a population of some 34,000, has a small site and a small collection, with apparently not much popular support.

[1] An Indian antelope, born in the Pretoria Zoological Garden.

Bloemfontein, of about the same size, is developing a very creditable zoological park.

Johannesburg, with a (white) population of more than 250,000, has a zoological garden that is the second in importance. It occupies a large, well-wooded site, and its animals are in good condition.

The garden at Pretoria is the largest and best. The animals are in clean, spacious cages and inclosures, and are in fine condition. The garden is favorably located on a well-watered and wooded site, and is supported in part by the Government. It has long had a high reputation for attractive appearance and interesting exhibits, and

FIG. 48.—Flight cage, National Zoological Gardens, Pretoria, South Africa.

its director, Mr. A. K. Haagner, is well known as a contributor to knowledge of South African animals. He is anxious to establish direct relations with institutions in this country which will secure for Pretoria a supply of American animals and enable him to find place for African animals, of which the Pretoria Garden can arrange to furnish many important and most desirable species.

A. B. BAKER.

BOTANICAL EXPLORATION IN VENEZUELA

Dr. J. N. Rose, associate curator of plants in the National Museum, accompanied by Mrs. Rose, carried on exploration work in Venezuela during October and November, 1916, on behalf of the Carnegie

FIG. 49.—Royal Palms along road north of Caracas, Venezuela. Photograph by Mrs. J. N. Rose.

FIG. 50.—View of harbor at Willemstad, Curaçao, showing the Governor's Palace in the distance and the pontoon bridge which closes the mouth of the harbor to the left. Photograph by Mrs. J. N. Rose.

Fig. 51.—A mountain view between LaGuaira and Caracas, Venezuela. Photograph by Mrs. J. N. Rose.

Fig. 52.—Governor's Palace, Willemstad, Curaçao. Photograph by Mrs. J. N. Rose.

Institution of Washington. Both on his way to and from Venezuela stops were made at Curaçao, where opportunity was given to study the very interesting Cactus flora of this Island. The people of Curaçao make very substantial baskets out of the mangrove, which is so common in all tropical coastal thickets. It is rather surprising that this plant is not more extensively used for this purpose in other countries.

In Venezuela Doctor Rose made extensive collections, especially

FIG. 53.—Market scene at Caracas, Venezuela.
Photograph by Mrs. J. N. Rose.

in the mountains about Caracas and Puerto Cabello. While the purpose of his visit to Venezuela was to study the Cactus flora, he obtained also plants in many other groups, especially the Orchids. Through the cooperation of Mr. Homer Brett he secured for the Museum specimens of "Sabadilla." Very much has been written and said about this plant during the past two years, as it is a source of one of the asphyxiating gases which has been used in the European war. At the present time it is listed as a contraband of war by the British Government.

BOTANICAL EXPLORATIONS IN FLORIDA AND NEW MEXICO

During February and March, 1916, Mr. Paul C. Standley, of the division of plants, National Museum, spent about three weeks in the vicinity of Fort Myers, Lee County, on the west coast of southern Florida. Although the trip was a private undertaking, most of the time was spent in an investigation of the interesting flora of the region.

This part of Florida is remarkable for its uniformly level surface, lying only a few feet above sea level, the soil consisting of almost pure white sand, with scarcely any humus, underlain by beds of marl. Rock exposures are infrequent and are confined chiefly to the banks of the small streams. The two most conspicuous plants are a large pine (*Pinus caribaea*) and the saw palmetto (*Serenoa serrulata*). The former is a large tree, occurring everywhere in uniform, rather sparse stands. The saw palmetto is a palm, forming large dense patches two or three feet high almost throughout the pine woods. On close inspection the palmetto is seen really to be a tree or shrub, whose branching trunk is prostrate upon the surface of the soil and rooted to it. With these two plants are associated many kinds of herbs and low shrubs, some of them with very handsome flowers. Coarse grasses and sedges are very abundant.

The pine woods are interspersed with numerous cypress swamps of varying extent, shallow depressions into which the surface water drains, remaining for most of the year. The vegetation here is quite different from that of the sandy soil. The largest and by far the most abundant tree is the cypress, but it is accompanied by many shrubs and small trees, such as ash, maple, elm, holly, wild fig, custard apple, and numerous others less widely known, which are characteristic of subtropical regions. The wild fig is one of the most interesting plants of these swamps: commonly it is a shrub, but often it is a climber, with a long, slender, whitish, rope-like stem which ascends the cypress trees by means of aerial roots, sometimes to a height of sixty feet or more. The trees of the cypress swamps support a varied and often dense growth of epiphytes or air-plants, chiefly ferns, Spanish moss, bromeliads (*Tillandsia* spp.), and orchids. Some plants which farther north are terrestrial become epiphytes in these swamps. Numerous species of herbaceous plants line the margins of the swamp ponds or "lakes," as they are known locally, which are frequented by flocks of water birds, and by many alligators and other reptiles.

Fort Myers lies only about fifteen miles from the Gulf, and the small streams in the vicinity, as well as the large Caloosahatchee

River, are under the influence of the tides. Their banks are bordered with mangroves and other halophilous trees and shrubs. In many

FIG. 54.—Fort Myers, Fla. An air-plant (*Tillandsia* sp.) growing on a cypress trunk, with Spanish moss (*Dendropogon usneoides*).

FIG. 55.—Fort Myers, Fla. A fern (*Blechnum serrulatum*) growing upon the base of a cypress tree.

localities a conspicuous feature of the vegetation is the cabbage palmetto, a tall, handsome palm with a large tuft of leaves, the "cabbage" of which is used for food.

The town of Marco, about 40 miles farther south on the Gulf, was visited also, for the purpose of collecting plants. Marco is

FIG. 56.—Fort Myers, Fla. Scene in a cypress swamp during the dry season. Numerous epiphytic plants are seen on the tree trunks.

FIG. 57.—Fort Myers, Fla. A saw palmetto (*Serenoa serrulata*). The prostrate trunk, covered by old leaf bases, is seen at the left.

noteworthy because of the large shell mounds of the vicinity, the refuse from the shell-fish used as food by the early Indian inhabitants. The vegetation here is much more tropical than that about Fort Myers and the mounds have a characteristic association of

Fig. 58.—Fort Myers, Fla. A tree in a cypress swamp covered with epiphytic plants, including several species of ferns and bromeliads (*Tillandsia* spp.).

plants. Coconut palms are common along the shores, sometimes forming large groves.

During the three weeks spent in Lee County, about 700 specimens of plants were collected, representing some 500 species. Many of them are plants of rare occurrence, and some represent notable extensions of range, one, at least, being an addition to the known flora of the United States. One of the lichens was determined by Mr. G. K. Merrill as a new species, and some of the parasitic fungi are of unusual interest.

During August and September Mr. Standley was detailed for field-work in New Mexico. He spent four weeks at Ute Park, Colfax County, a locality in the southern extension of the Sangre

Fig. 59.—Ute Park, N. Mex. Showing sandstone hillsides covered with pinyon and cedar.

de Cristo Range of Colorado, and only a few miles south of the Colorado boundary.

Ute Park lies at an altitude of about 7,500 feet upon the Cimarron River, one of the characteristic swift, clear streams of the Rockies. The valley here is rather wide, with gently sloping meadows on one or both sides, although at some places the stream is shut in by cliffs which rise precipitously on both banks. Immediately along the stream and its tributaries are groves of cottonwood, with thickets of alder, aspen, birch, hawthorn, and other shrubs. The stream is inhabited by large numbers of beaver, whose dams are found everywhere. In places fully half of the trees seemed to have been cut down by these animals, to be used as food or in the construction of their dams.

Beyond the stream banks the meadows extend for varying distances. They are characterized by numerous grasses, especially blue grama, and by many showy-flowered herbs which exhibit a wealth of color found only in mountains at high altitudes. Beyond the meadows on one side rise low sandstone mountains covered with cedar and pinyon, and with many characteristic southwestern plants, such as cacti, yuccas, and bear grass. On the other side of the valley rise high mountains of igneous origin, covered with typical Rocky Mountain forests of yellow, white, and foxtail pine, Douglas and other spruces, fir, and aspen. One of the common trees is the cork-bark fir (*Abies arizonica*), a comparatively little known tree, whose

FIG. 60.—Ute Park, N. Mex. Cottonwood tree felled by beavers. The largest trunk felled in this manner was slightly over 2 feet in diameter.

bark, instead of being thick and hard, as in most of the conifers of the region, is soft and thin. After the trees have been dead for some time the bark separates from the wood in great cork-like sheets.

The highest mountain in the vicinity of Ute Park is Baldy Peak, which rises to 12,490 feet. Its top is well above timber line and supports an Arctic-Alpine vegetation.

During the time spent in the region about 5,000 specimens were secured, representing 1,540 collection numbers. Among the flowering plants several genera new to the State were obtained, and many additional species. Special attention was devoted to the cryptogams, and the collection of these is by far the largest ever obtained in the

State. Nearly one hundred rusts were obtained and about 250 collections of fleshy fungi, a group of which scarcely more than a dozen species have been reported from New Mexico. Probably more than 300 species of fungi have been added to the known flora of the State as a result of the expedition.

BOTANICAL EXPLORATIONS IN THE HAWAIIAN ISLANDS

During the summer of 1916, from June to November, Mr. A. S. Hitchcock, systematic agrostologist in the Department of Agriculture and custodian of the section of grasses of the division of plants in the National Museum, traveled in the Hawaiian Islands studying and collecting the flora, especially the grasses. Mr. Hitchcock was assisted by his son, A. E. Hitchcock. The islands visited were Kauai, Oahu, Lanai, Molokai, Maui, and Hawaii, these comprising all the islands of the main group except the two small ones Kahoolawe and Niihau. The islands are all of volcanic origin and the rock is lava except a very little that is coral formation. Kauai, the geologically oldest island, shows the greatest effect of erosion, the deep canyons rivaling in beauty the Grand Canyon of the Colorado. The rainfall on the mountains of the windward side is excessive, that of Waialeale, the highest peak of Kauai, being as much as 600 inches per annum. The lee side of the islands is arid, the rainfall being often reduced to less than 15 inches per annum. The islands to the south are successively younger, Hawaii, the largest, being now in a state of volcanic activity. On this island are the two highest peaks of the group, Mauna Kea, 13,825 feet, and Mauna Loa, 13,675 feet in height. Above 10,000 feet there is scarcely any vegetation upon these peaks, especially upon Mauna Loa which is made up of comparatively recent lava. There is much snow upon the peaks in winter and extensive banks persist throughout the year. The magnitude of the mountain mass is greater than at first appears, because the cones arise from the floor of the ocean 18,000 feet below the surface, thus making the total height over 30,000 feet. The gradual slope from the sea to the summit deceives the eye and the great height is not at first fully realized. Upon Hawaii is the active volcano Kilauea (4,000 feet) with its pit of boiling lava. What is said to be the largest crater in the world (Haleakala) is upon Maui, the second largest island of the group.

The important agricultural industries of the islands are sugar, live stock, and pineapples. The native Hawaiian population is decreasing. It is only in the less accessible parts of the islands that

FIG. 61.—A deeply eroded canyon of the Waimea River, Kauai.

FIG. 62.—A view of Mauna Kea near timber line. The small trees in the middle distance are mamani (*Sophora chrysophylla*). The grass in the foreground is *Koeleria glomerata*. Mauna Loa is seen in the distance. A cloud bank lies between at the left.

FIG. 63.—Near summit of Mauna Kea. Cinder cones in the distance. Snowbank in the foreground about 6 feet high (August).

Fig. 64.—A view in Haleakala crater showing the numerous cinder cones within the main crater.

Fig. 65.—A view in the eastern part of Haleakala crater, looking west, two cinder cones in the center.

the primitive customs still prevail. Here may be found the grass huts of the natives. These huts are made of a frame work of wood filled in with a thatch of grass. The grass used for this purpose is usually pili (*Heteropogon contortus*), an indigenous grass abundant upon the rocky soil of the lowlands.

The cultivated trees and shrubs are of great variety and beauty, and are drawn from all tropical and subtropical lands. The introduced flora is very pronounced in the region of the towns, ranches, and plantations. One must go several miles from Honolulu to find indigenous plants. Of 60 species of grasses found on Oahu about 50 were introduced. One of the introduced trees of great economic

Fig. 66.—View in the garden in Honolulu, formerly owned by Dr. William Hillebrand, author of "Flora of the Hawaiian Islands," showing a tropical tree with brace roots.

importance is the algaroba tree, or kiawe, as the Hawaiians call it (*Prosopis juliflora*). It is found in a belt on the lowlands along the shores of all the islands and occupies the soil almost to the exclusion of other plants. The pods are very nutritious and are eagerly eaten by all kinds of stock. The flowers furnish an excellent quality of honey. The Molokai ranch produces 150 to 200 tons of strained honey per year. The prickly pear cactus (a species going under the name of *Opuntia tuna*) has become extensively naturalized in the dryer portions of all the islands. The ranchmen utilize this for feed when other kinds become scarce, the cattle eating the succulent joints in spite of the thorns. Two introduced shrubs now occupy extensive areas and have become great pests. These are guava (*Psidium guajava*), whose fruit furnishes the delicious guava jelly, and lantana (*Lantana camara*), with clusters of handsome parti-colored flowers. In the moister portions of the islands large areas have been occupied by Hilo grass (*Paspalum conjugatum*) which has little value as a forage plant. The kukui or candlenut tree (*Aleurites moluccana*) with its light, almost silvery, green foliage is now a common and rather striking element in the valleys and gorges.

FIG. 67.—A forest of algaroba trees (*Prosopis juliflora*). The pods are much relished by stock and are an important cattle food. From the flowers are produced an excellent quality of honey which is an important article of export.

The indigenous flora is highly interesting though not abundant in species. Two of the commonest trees are the ohia (*Metrosideros polymorpha*) and the koa (*Acacia koa*). The former, also called ohia lehua and lehua, resembles, in the appearance of the trunk, our white oak, but bears beautiful clusters of scarlet flowers with long-protruding stamens. The koa produces a valuable wood much used in cabinet making, now becoming familiar through its use for making ukuleles. Characteristic of the upper forest belt on the high mountains of Hawaii is the mamani (*Sophora chrysophylla*), a leguminous tree with drooping racemes of yellow flowers and long 4-winged

FIG. 68.—Trees on the windward side of Lanai, showing the effect of the strong trade wind.

FIG. 69.—Grass hut of the Hawaiians. The wooden framework is thatched with pili grass (*Heteropogon contortus*).

pods constricted between the seeds. In the arid regions is found the wiliwili (*Erythrina monosperma*), a deciduous tree with gnarly growth, a very soft light wood, and bright scarlet seeds. Among the peculiar plants of the islands is the silversword (*Argyroxiphium sandwicense*), a strikingly beautiful composite with glistening silvery leaves, which grows only on the slopes of cinder cones in the crater

FIG. 70.—Palms at Hilo. Two royal palms with a slender betel palm between.

of Haleakala and in a few very limited localities on Hawaii. The family Lobeliaceae is represented by about 100 species belonging to 6 genera. The numerous arborescent species are very peculiar and characteristic. Many of them form slender trunks like small palms, crowned with a large cluster of long narrow leaves. The trunks of some species are as much as 30 or 40 feet high and the large bright colored flowers are sometimes remarkably beautiful.

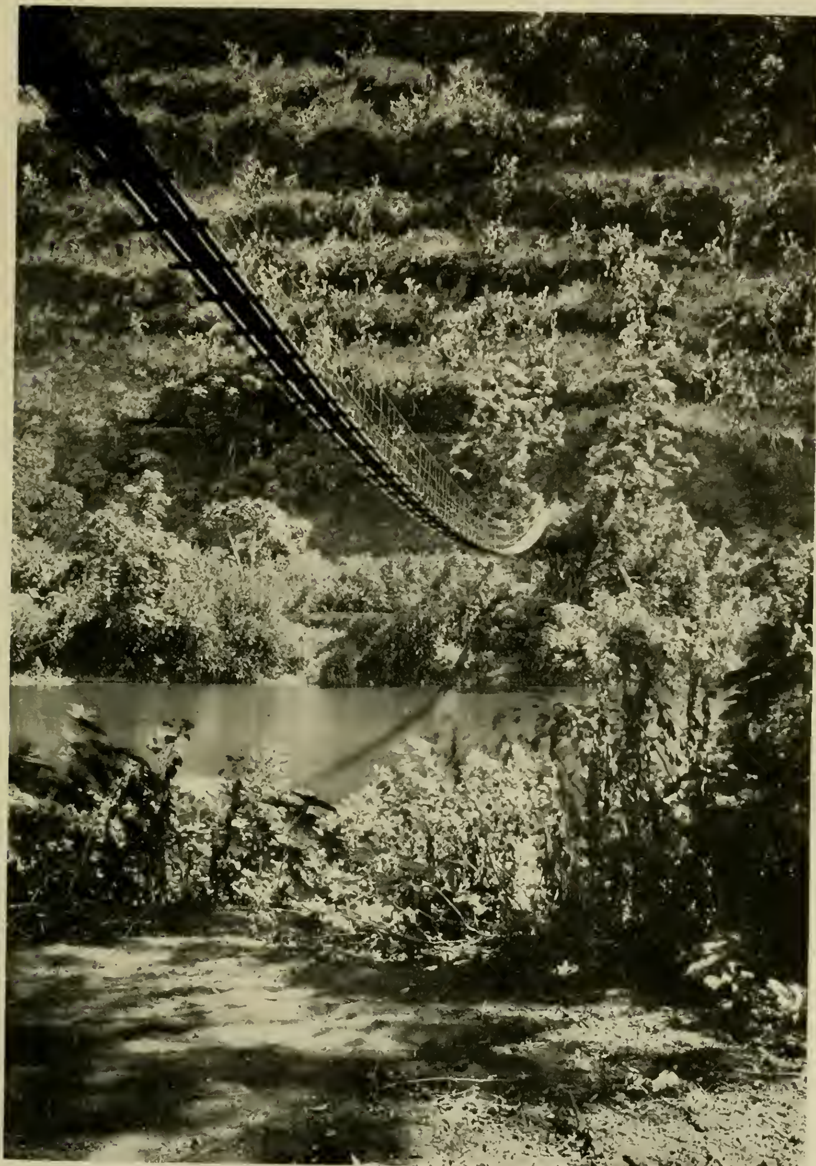

FIG. 71.—A foot bridge across the Waimea River, above Waimea, Kauai. On the opposite cliff are seen numerous plants of prickly pear cactus (the so-called *Opuntia tuna*).

FIG. 72.—Trunk of a large koa tree (*Acacia koa*), on the eastern slope of Mauna Loa, Hawaii. A valuable wood much used in cabinet making, especially for ukuleles.

The indigenous grasses of the Hawaiian Islands are not numerous. The most interesting belong to the genera Panicum and Eragrostis. A tall species of the latter (*E. atropioides*) is the dominant grass upon the plain between Mauna Loa and Mauna Kea. Three peculiar

FIG. 73.—Wiliwili (*Erythrina monosperma*), in an arid gulch on the western part of Molokai. At this season (October) the tree is devoid of leaves. Flowers and pods may be seen at the extremities of the branchlets.

species of Panicum inhabit the open bogs formed on the tops of many of the high mountains in the wet zone such as Mt. Eeka and Mt. Kukui in West Maui, some of the peaks of Molokai and Oahu, and Waialeale in Kauai, that upon the latter covering in all several

FIG. 74.—The silver sword (*Argyroxiphium sandwicense*), growing on cinder slopes in the crater of Haleakala, East Maui, at an altitude of about 9,500 feet.

FIG. 75.—A tree fern (*Cibotium menziesii*) near Puu Waawaa, Hawaii. The undergrowth is a common fern (*Dryopteris fuscoatra*) found in much of the wet forest at an altitude of 3,000 feet.

square miles. These bogs are found near the summits of ridges in the regions of heavy rainfall, are devoid of trees and shrubs, and harbor a peculiar vegetation. Many species form more or less globose tussocks which rise above the general level of the bog. The most interesting of these tussock plants are a sedge

FIG. 76.—A representative of the peculiar arborescent lobelias (*Cyanea* sp.). Forest near Kaholuamano, Kauai.

(*Oreobolus furcatus*) and the three species of Panicum mentioned. The panicums form close masses, the interior consisting of many generations of dead leaves and stems, scarcely decayed, the exterior consisting of short living shoots an inch or two long, with a few contiguous ovate blades and reduced panicles of one to a few spikelets. A showy lobelia (*L. gaudichaudii*) with numerous large

FIG. 77.—Bracket fern (*Elaphoglossum aemulum*) growing on ohia (*Metrosideros polymorpha*). The branching trunk of the latter is common and is probably due to the fact that the early growth was upon some other tree and these roots were thrown down to the ground for support.

cream-colored flowers as much as 3½ inches long, peculiar violets, and a sundew (*Drosera longifolia*) are found in these bogs.

The ferns of the Hawaiian Islands are numerous in species and individuals. They are the dominant feature of all the wet forests. Three species of tree ferns of the genus Cibotium are found and in some places form extensive forests. These produce at the base of the stipe a great ball of brownish-yellow wool called pulu by the natives and used by them for stuffing pillows and mattresses. One species (*C. menziesii*) is shown in figure 75. Contrasted with the tree ferns are numerous small epiphytic forms, some species with fronds only an inch or two long. The ferns and fern allies number about 170 species.

ARCHEOLOGICAL EXPLORATIONS IN GUATEMALA AND HONDURAS

In February, 1916, W. H. Holmes, head curator of anthropology, United States National Museum, had the good fortune to become a member of the Carnegie Institution's archeological expedition to Central America under the direction of Sylvanus G. Morley. Among the ancient cities visited was Antigua, the ancient capital of the Spanish kingdom of Guatemala during the period of its greatest prosperity and power. The splendor of its religious establishments is amply testified by the ruins of upwards of forty great churches now scattered through the modern Indian town which occupies the ancient site. The city was visited by a series of earthquakes during which the splendid structures were shattered or thrown down and it was found impossible to restore them and keep them in repair, and in desperation the capital of the kingdom was removed to a neighboring valley, to the site of the present Guatemala City.

The history of the Spanish capital city and its great buildings proves most instructive to the student who would discover the causes that led to the downfall and destruction of the numerous cities built by the Mayan people in prehistoric times, the ruins of which are now found scattered over Central America.

The present Guatemalan capital is built on the site of one of these ancient cities represented to-day by numerous pyramids, terraces, and quadrangular enclosures as well as by works of sculpture which are scattered over a large area just outside of the limits of the capital city.

An extended visit was made to the ruined city of Quirigua in eastern Guatemala. This city has been the subject of much scientific interest during recent years and its remarkable sculptural and architectural remains have been studied and described by numerous explorers, among whom are Stevens, Maudslay, and Hewett. Much of interest, however, still remains hidden away in the dense tropical forest. The sculptures found here are among the most important known products of aboriginal American genius, the most remarkable example being the "Great Turtle" or Dragon which will be described

Fig. 78.—Temples 20 and 22, Copan, showing the vast magnitude of the substructures. Courtesy of the Peabody Museum.

in detail in an article by Prof. Holmes in the general appendix of the Annual Report of the Smithsonian Institution for 1916.

From the city of Zacapa in Guatemala an excursion was made across ranges of rugged mountains into Honduras where the ancient city of Copan was visited and studied in as much detail as the limited duration of the visit permitted. The vastness of the pyramids, terraces, and courts, the grandeur of the temples and the marvelous

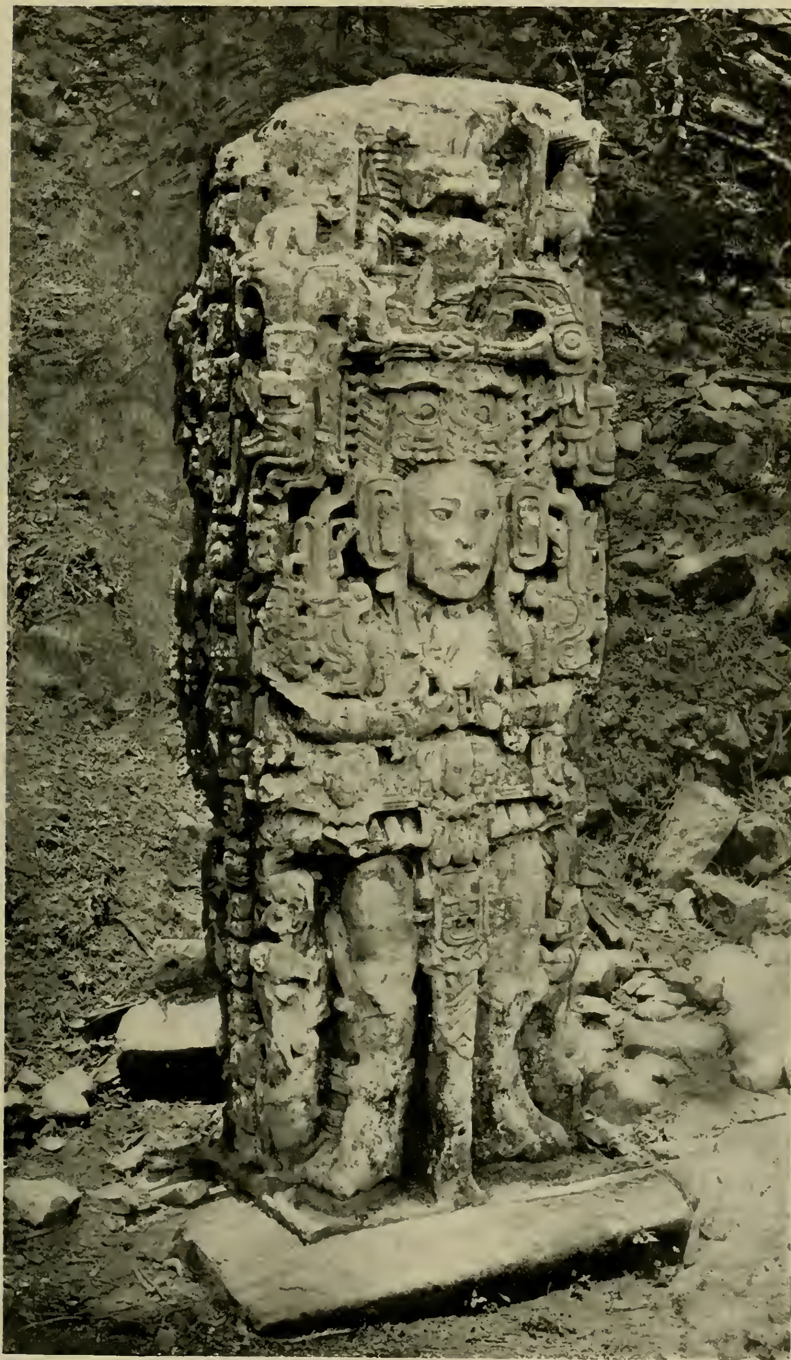

FIG. 79.—A colossal stela at Copan illustrating the remarkably deep and elaborate carving. Courtesy of the Peabody Museum.

sculptures, tell an eloquent story of the civilization and power of the ancient people.

Especial attention was given to the collection of data and drawings to be utilized in preparing panoramic views of the several cities visited, and every effort was made to obtain information regarding the technical methods employed by the ancient sculptors and builders. The quarries from which the stone was obtained were too deeply buried in tropical vegetation to yield up their story without extensive excavation and the methods employed in dressing and carving the stone remain in large part undetermined. Certain chipped and ground stone implements that could have served in dressing the stones used in building were found in numbers, but the story of the carving, especially of the very deep carving of the monuments of Copan, remains unrevealed. Although it is thought that stone tools may have been equal to the task, it is believed by some that without bronze the work could not have been done. There are, however, no traces of the use of bronze by the Central Americans.

PREHISTORIC REMAINS IN NEW MEXICO, COLORADO, AND UTAH

Dr. J. Walter Fewkes, of the Bureau of American Ethnology, spent a little less than five months in the field studying the remains of some of the prehistoric buildings scattered over western New Mexico and Colorado, and eastern Utah. The first month of that time he endeavored to increase our knowledge of the prehistoric migration trail of the Hopi fire people. The months of July, August, and September, were devoted to excavations and intensive studies of a ruined pueblo at Mummy Lake in the Mesa Verde National Park, Colorado. In October Dr. Fewkes investigated certain ancient towers above Hill Canyon, Utah, one of the most northerly localities in which these structures have yet been found.

The inhabitants of the Hopi villages in northeastern Arizona are recognized by ethnologists as a composite people, made up of several clans whose ancestors in some instances spoke different tongues, having drifted into this isolated region of waterless mesas from all directions. The descendants of these clans, some now already absorbed and their language assimilated, others, retaining their original speech and now a people of homogeneous culture, inhabit villages perched on high plateaus. The first colony, or the original settlers, to arrive in this arid country, are said to have been immigrants from the east, or from the region now embraced in Colorado

FIG. 80.—Fire House, a former home of the Hopi Fire Clans.

FIG. 81.—Ruin near Crown Point, New Mexico. Photograph by Fewkes.

and New Mexico, where the peculiar buildings known as pueblos probably originated. These incoming clans of housebuilders forming the nucleus of the Hopi population were augmented, in the seventeenth and eighteenth centuries, by additions from this and other directions.

The arrival in the Hopi country of the first clans occurred in prehistoric times, but legends of that event have been preserved in traditions which may be verified by examination and comparison of archeological data. It is possible by a study of the halting places mentioned in legends to determine the migration trails of these increments and to extend into prehistoric times our knowledge of the history of one of the most instructive groups of North American Indians.

FIG. 82.—Kin-a-a, near Crown Point. Photograph by Fewkes.

The ruin of Sikyatki, situated three miles from Walpi, is generally regarded as one of the oldest of the prehistoric Hopi settlements. All traditions and archeological evidences prove that it was settled before the Coronado expedition in 1540. Legends declare not only that the ancestors of this pueblo came from a region near Jemez, New Mexico, but also recount that before they built Sikyatki their ancestors constructed, on the brink of a canyon 25 miles east of Walpi, a village they called Fire House, the ruins of which (fig. 80), known to Navaho as Beshbito, " Pipe water," are still pointed out in support of this claim. These circumstantial statements can be verified or disproved by archeological observations on the ruin itself or by an examination of pottery found in it.

Doctor Fewkes, who has given much attention to the verification of similar Hopi migration legends by archeological data, took the field in June, having in mind to investigate evidences bearing on the

FIG. 83.—Kin-a-a, near Crown Point. Photograph by Fewkes.

Sikyatki legend. He began work with a visit to Fire House, the locality of which had previously been determined by Mr. Victor Mindeleff who described it in his valuable work on pueblo architec-

Fig. 84.—Far View House, northwest angle before excavation.

Fig. 85.—Far View House, north wall, partially excavated.
Photograph by E. E. Higley.

ture, published by the Bureau of American Ethnology. Doctor Fewkes found the architectural features of this ruin essentially the same as when visited by Mindeleff. The ground-plan of Fire House is exceptional in being circular, while that of Sikyatki appears to be rectangular. On the very threshold of the investigation this radical difference in form seemed to disprove the legend, but it is by no means disastrous to a theory of relationship of the two ruins. On the rim of the East Mesa, above Sikyatki, there stand two conspicuous conical mounds, which legends always associate with the village in the foothills. They are remains of the only circular pueblo

FIG. 86.—Northwest angle of Far View House. Dr. Fewkes in the foreground. Photograph by E. E. Higley.

ruins in the Hopi country, and were probably constructed by relatives of the emigrants from Fire House before they built the larger rectangular village at the foot of the Mesa.

The round form of Fire House has a still more important significance, for it corroborates the Hopi legends that their ancestors came from some place near Jemez, a pueblo situated in or near a zone of round ruins extending from southern Utah to the Zuñi River.

The pottery of Fire House is more instructive than its architecture, for its symbolism is the same as that characteristic of the zone of circular ruins. Its rude character and simple conventionalized figures, as compared with the fine specimens from Sikyatki, add evidence to the theory that characteristic old Hopi pottery is a specialized type distinct from all others in the Southwest.

After having visited Fire House, Doctor Fewkes continued his investigations eastward from this place, still searching for archeological evidence of a possible trail of migration along which people may have left habitations in their travels before they built Fire House. He failed to discover any large pueblo ruins that can be attributed to the Fire clans, although he found many ruins scattered in the extensive interval between the site of Fire House and the next

FIG. 87.—Mummy Lake, Mesa Verde National Park.
Photograph by Mrs. C. R. Miller.

cluster of large ruins, or those of the Chaco canyon. The general character of these ruins does not resemble but is closely related to that of the ancient ruins in the Zuñi valley. A number of representative specimens of pottery collected in these same ruins, especially whole pieces from Black Diamond ranch, were brought to Washington, and were found to resemble those from Kintiel, a ruin situated 25 miles north of Navaho Springs. Kintiel was shown by Cushing to be a Zuñi ruin, and from his knowledge of Zuñi traditions he was able to enumerate the clans that once inhabited it.

After Doctor Fewkes examined, photographed, and roughly surveyed several of the ruins between Fire House and Crown point

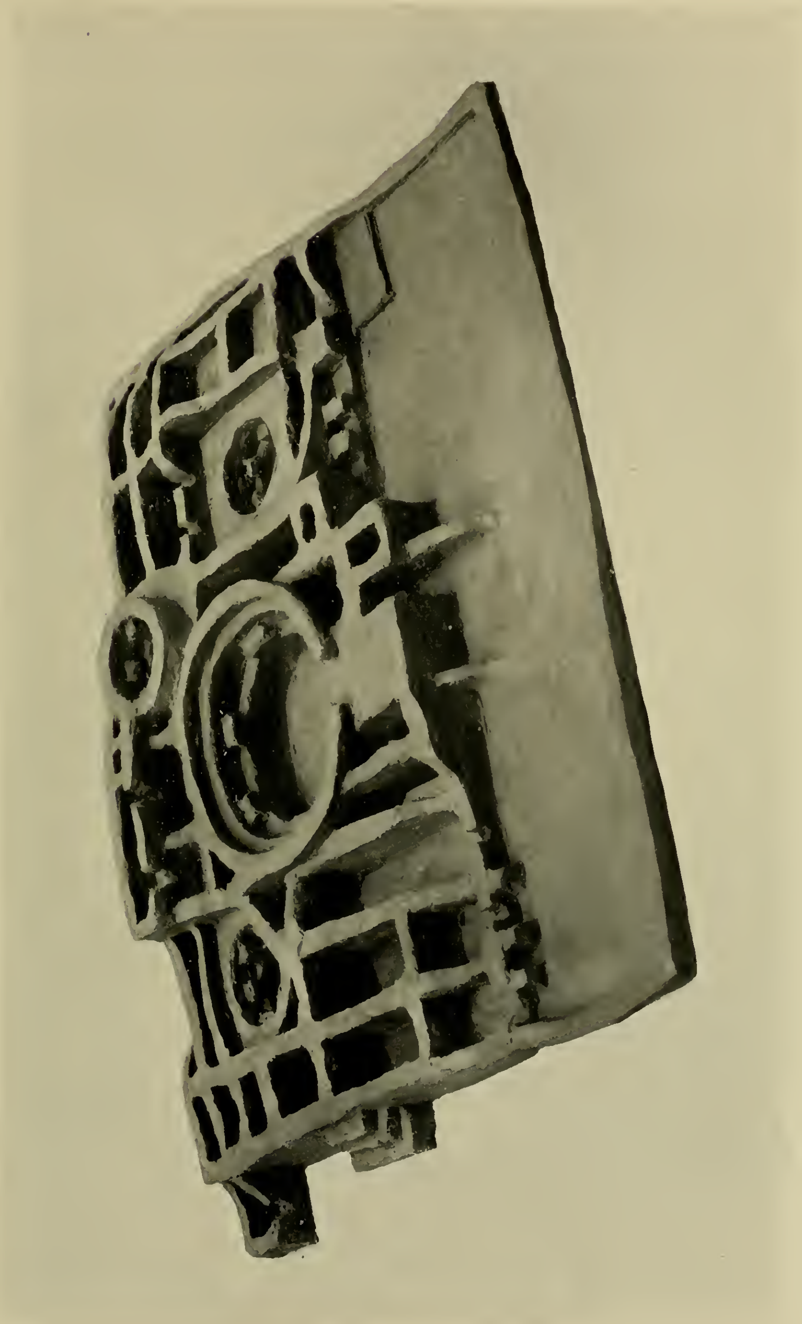

Fig. 88.—Photograph of a model of Far View House, from southwest.

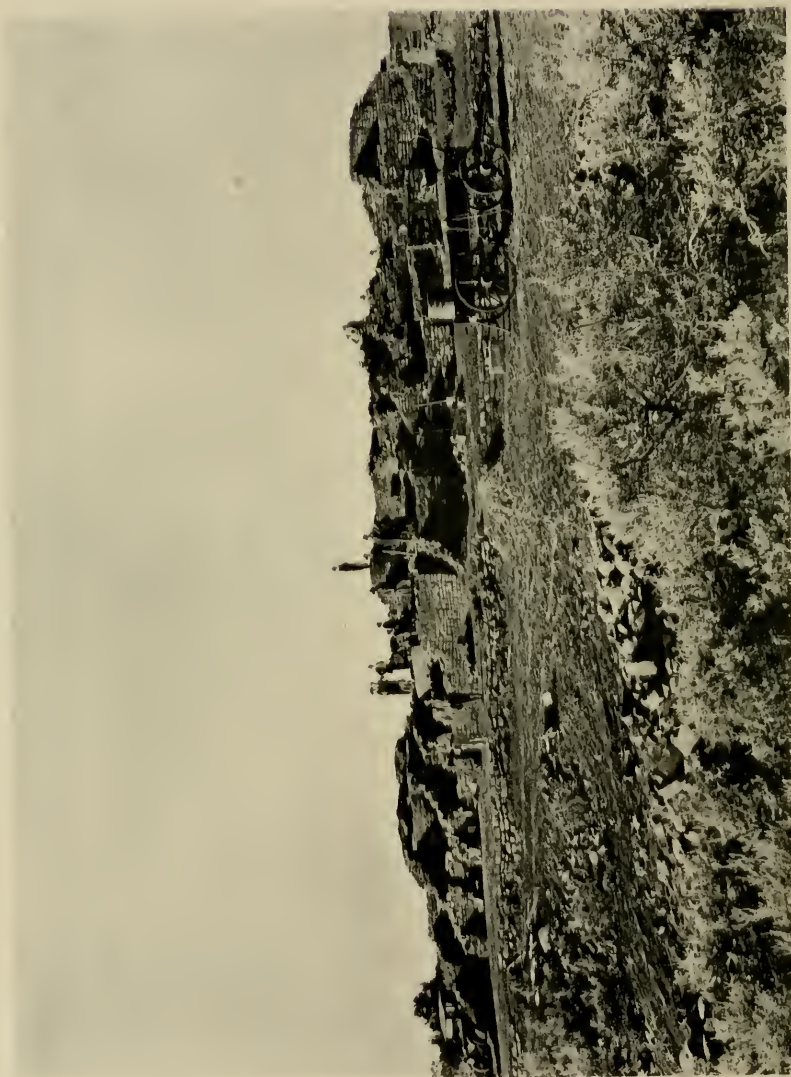

FIG. 89.—Far View House, from the south. Photograph by George L. Beam.

FIG. 90.—Southwest angle of Far View House, Mesa Verde National Park, Colorado. Photograph by W. H. Austin.

FIG. 91.—Tower near Spruce Tree House, Mesa Verde National Park, Colorado. Photograph by Fred Jeep.

(fig. 81), he reached the conclusion, from the resemblance of their pottery to Kintiel, that the majority of them belong to the Zuñi series, or were links, in a cultural chain, connecting the great Chaco ruins with those of the Zuñi valley, thus supporting by archeological evidence, the Zuñi legends that one or more of the Chaco ruins were once inhabited by Zuñi clans. Although not a novel suggestion, it is a significant one, as the fate of the inhabitants of these magnificent buildings is one of the unanswered problems of Southwestern culture-history.

Fig. 92.—Tower in Navaho Canyon, Mesa Verde National Park, Colorado. Photograph by E. E. Higley.

In pursuance of another archeological problem Doctor Fewkes was obliged temporarily to leave his studies of Hopi migration routes unfinished, and on July 20 began the extensive work of excavation and repair of a pueblo ruin in the Mesa Verde National Park, Colorado. This is a continuation of work in which he has been engaged at intervals for the last eight years for the Department of the Interior. The appropriation for work on Mesa Verde was exhausted at the close of September, obliging Doctor Fewkes to abandon the work. A report on this aspect of his summer's field operations has been transmitted to the Secretary of the Smithsonian Institution and will be published in the Smithsonian Report for 1916 under the title, "A Prehistoric Mesa Verde Pueblo and its People."

The plan of the work at the Mesa Verde was to excavate one of the many mounds situated on the top of the plateau for the purpose of discovering the characteristics of the Mesa Verde pueblos, of which formerly nothing was known. One of the most conspicuous

FIG. 93.—Tower in Navaho Canyon, Mesa Verde National Park, Colorado. Photograph by J. Wirsula.

piles of stones (figs. 84, 85, 86), in a cluster of 16 mounds near the reservoir called Mummy Lake (fig. 87), was chosen for this purpose, and in this were uncovered the walls of a rectangular ruin, 113 feet long by 100 feet wide; once 20 feet high on the north side where there were formerly three stories. Led by the distant outlook south of this pueblo, which will serve as a type of many others awaiting investigation, Doctor Fewkes has suggested the name Far View House (fig. 89). His excavations show that it was compactly built, without plazas; it contains about 50 rooms on the ground floor, and four ceremonial chambers, one of which, centrally placed, is 32 feet

FIG. 94. Mushroom Rock Ruin, Hill Canyon, Utah. Redrawn from a sketch made by the author on the spot.

in diameter (fig. 88). These last-mentioned rooms, known as kivas, are structurally identical with those of cliffhouses. They formerly had vaulted roofs, as indicated by pilasters erected around the room for support of the rafters, and a hatchway. Far View House (fig. 88) is not only a type of ruin hitherto unknown on the Mesa Verde, but also is important in comparison with the architectural features of cliffhouses and pueblos throughout a region extending over one hundred miles from the Park in all directions. A considerable collection of objects, as pottery, stone and bone implements, idols and ornaments, illustrating the culture of the inhabitants of Far View

Fig. 95.—Leaning Tower Ruin, Hill Canyon, Utah.
Photograph by T. G. Lemmon.

House, was brought to Washington for future study. The collection is rich in incised designs on stone, spiral forms predominating.

One of the most striking forms of pueblo architecture in the Southwest is known as the tower. These buildings (figs. 91, 92, 93), were first called to the attention of archeologists by Jackson and Holmes over 40 years ago, and are particularly abundant along the McElmo and its tributaries. The tower is not limited to this area, but is intimately associated with another widely distributed well-

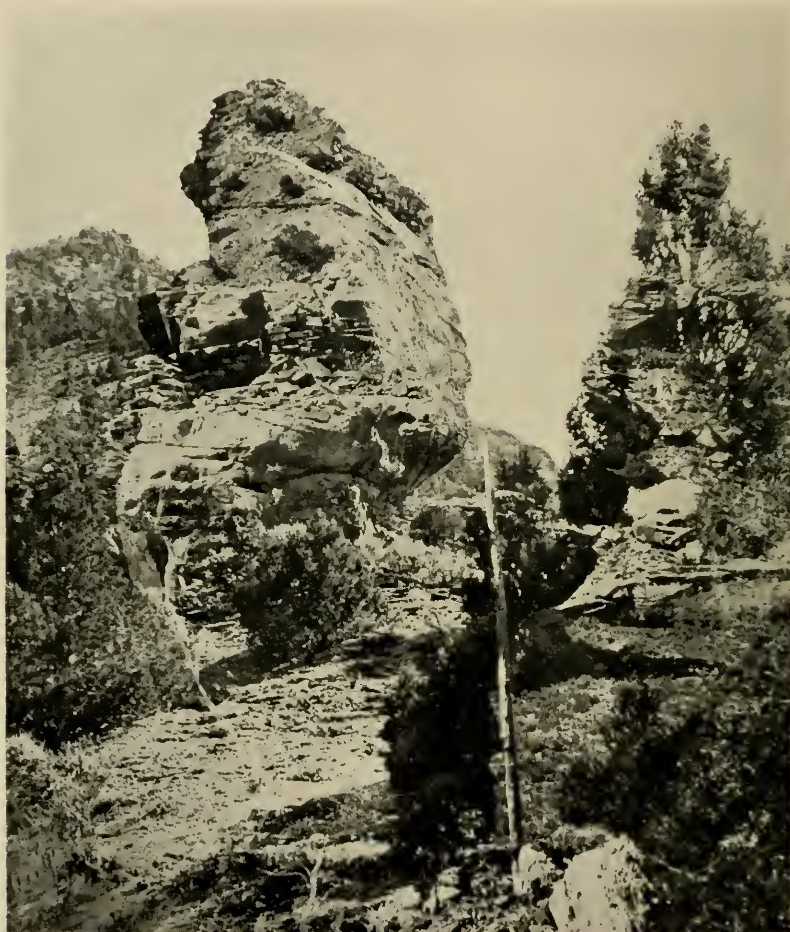

FIG. 96.—Pinnacle Ruin, McElmo Canyon, Colorado.
Photograph by T. G. Lemmon.

defined architectural type known as the circular ruin, which is most abundant in a narrow zone extending north and south, midway between eastern pueblos and the Hopi. There are important variations in the form of towers in different areas, and it is instructive to determine the northern limit of this peculiar prehistoric structure. For this purpose Doctor Fewkes made a trip to Hill Canyon, 40 miles south of Ouray, Utah, having learned from Mr. Kneale, agent of the Ute, of hitherto undescribed ruins of unusual character in that neighborhood.

The ruins in Hill Canyon belong to the true tower type, but they were built at times on top of rocks of mushroom shape, which has led to the designation "Mushroom Rock ruins" (fig. 94), and seems to have placed them in another category. Several of these towers were photographed (figs. 95-97) by Mr. T. G. Lemmon, a volunteer associate, and the writer made sketches of the ground-

FIG. 97.—Eight Mile Ruin, Hill Canyon, Utah. Photograph by T. G. Lemmon.

plans of those he could enter. These observations not only add to our knowledge of the northern limit of the zone in which towers occur, but also introduce to the archeologist several striking forms bearing on important theoretical questions. So far as his observations on these hitherto unknown ruins have gone, Doctor Fewkes regards them as sacred buildings, comparable with the towers along the Yellowjacket, a branch of McElmo Canyon. They have all the appearance of tower kivas, sometimes single, more often in clusters, accompanied with rectangular buildings.

At the close of the work on Far View House, a trip was made from Mancos, Colorado, down the McElmo Canyon, to examine in a comparative way, towers, round, square, or semicircular, in Cannon

Ball and Ruin Canyons. The special object was to compare them with Sun Temple, a mysterious building uncovered last year (1915) on the Mesa Verde. The data obtained, too extensive to be here considered save in a general way, support the view, already published, that the tower is a type of kiva or ceremonial room.

ANTHROPOLOGICAL WORK AMONG THE SIOUX AND CHIPPEWA

Certain critical conditions among the Chippewa tribe and particularly that part of the tribe which occupies the White Earth reservation, have led during the year just past to anthropological work in this tribe, and among the Sioux, which proved not only highly desirable and interesting, but was followed so far as the Chippewa are concerned by certain very practical results.

The Chippewa tribe as a whole is considerably mixed with whites. Most of this mixture is of French origin, but that of more recent times includes different elements of whites now settled or employed in the country.

In behalf of the numerous mixed-bloods on the White Earth reservation, some of whom are well educated and self-supporting, the United States Congress in 1906-1907 enacted laws which made possible individual allotments of the tribal lands and permitted alienation of property. Some of the allotments were covered with valuable timber, while others were desirable on account of the rich soil, the proximity to lakes, or for other reasons. The majority of the Indians were poor, without knowledge of the value of their property or of the ways of white men, and with little or no protection. They became a rapid and easy prey of lumber companies and a multitude of land sharks, as a result of which, within a few years, hundreds of individuals, including full-bloods and minors, were pauperized, and the White Earth affair became one of the most shameful pages in the history of the white man's dealings with the Indian.

These facts are mentioned, however, only because they led to the anthropological study of the tribe. The frauds practised against the White Earth Chippewa became known to the Government, and a serious and prolonged effort was made by the Department of Justice to correct the evil. During the course of the last few years, more than fifteen hundred suits were filed against companies and individuals concerned in the frauds, and many of these could have been settled in justice to the Indian had it not been for the uncertainty respecting the blood status of many of those involved. Efforts were made by the Government authorities, as well as by the opposing interests, to obtain a satisfactory genealogy of each Indian concerned, only to reach the conviction that such data could not be relied on to establish beyond legal doubt the full-bloodedness of any individual.

It was at this point that anthropology was appealed to, and the writer was intrusted with the examination of the White Earth Chippewa who claimed to be or were regarded as full-bloods, with the view of passing on their blood status. There were about 800 such

Fig. 98.—Two Sioux school girls, Standing Rock.

persons, 696 of whom were actually examined and their status determined.

In order to be fully prepared for this important work and to test certain new reactions bearing on the question of full-bloodedness of Indians, a most profitable month was spent among the Sioux along the Missouri, and some time was given also to the outlying parts of the Chippewa territory. This gave on one hand the opportunity to examine a good series of men and women among both tribes for anthropological purposes, while the additional experience gained

Fig. 99.—Chippewa mixed-bloods.

among the Sioux proved invaluable in the final work, so that it was not only possible to detect and separate all mixed-bloods from full-bloods, but to form some estimate of the proportion of white blood wherever mixture existed. Nevertheless, a number also were discovered of those who, so far as physical examination could show, were still genuine full-bloods.

The first report on the work among the Chippewa was published toward the end of the year;[1] while a report on the observations among the Sioux is in preparation.

FIG. 100.—Full-blood Chippewa women.

The study among the Chippewa reached the majority of the full-bloods still existing in that tribe. These full-bloods within a decade or two will have mostly if not entirely died out for with a few exceptions they are all old people. The observations and measurements of these full-blooded Chippewa showed the following main points:

In color, physiognomy, hair, and visible characteristics in general, the full-blood Chippewa were completely of the ordinary Indian type, showing no special features.

In stature they ranged from medium to tall, in body development from medium to stocky, the latter predominating.

[1] Hrdlička, Aleš, "Anthropology of the Chippewa," Holmes Anniversary Volume, Washington, 1916, pp. 198-227.

Fig. 101.—Full-blood Chippewa, Red Lake.

The head is large, predominantly mesocephalic, and of medium height. The face is both long and broad, the supraorbital ridges frequently pronounced, the forehead often more or less sloping, especially among the men, and often low in appearance, particularly among the women.

FIG. 102.—War Chief of the Twin Lake Chippewa.

The nose is of good size, with medium prominence, and differs considerably in shape; in men it is in half the cases more or less aquiline, in women mostly straight, concave, or concavo-convex. The septum is frequently horizontal or nearly so, especially in the females. The average nasal index is mesorhinic, as among the majority of Indians.

Alveolar prognathism in the average is slightly to moderately more marked than in whites; the lips in the majority of cases are of medium dimensions, comparable with those of whites, but occasionally the lower lip or both lips are slightly stouter; the chin and lower jaw are well though not excessively developed; the mouth is rather broad. The ears are large, as among Indians in general.

FIG. 103.—Wife of the War Chief of the Twin Lake Chippewa.

The tribe, though Algonquian in language and supposedly of eastern origin, shows a larger and relatively broader head, as well as a broader face, than most of the Eastern Indians. In these respects it is probably nearer some of the more central and northern Algonquian tribes, and as will be shown in a future report, it also approaches the Sioux fairly closely in some respects, though in the latter the stature is still somewhat higher, the face larger, and the vault of the head lower.

The Sioux were found to be on the average even taller and stronger than the Chippewa. They are also characterized by the large size of the head as well as a large internal cranial capacity, equaling practically that of U. S. whites. But the skull is relatively low, which distinguishes it not only from the Algonquian but also from all the Plains tribes, and especially from the whites.

ALEŠ HRDLIČKA.

PRELIMINARY ARCHEOLOGICAL SURVEY OF LA POINTE ISLAND, WISCONSIN

In August, 1916, on the advice of Dr. Hrdlička, Mr. Philip Ainsworth Means, honorary collaborator in archeology, U. S. National Museum, visited La Pointe Island (now commonly called Madeline) with the intention of conducting archeological investigations on the site of the Ojibwa village on that island. The island is one of the archipelago known as the Apostle Islands, in Lake Superior. The Chippewa have occupied it since 1490. They lived there uninterruptedly until about 1620 when the place was deserted. In 1693 a French fort and an Ojibwa village were built on La Pointe Island and the site was occupied by the tribe with one or two interruptions until the nineteenth century.

There are thus on La Pointe Island two important and dated sites of occupancy by the Ojibwa, and the earlier of these sites with its accompanying cemetery dates from a period when no or but very little mixture with whites existed as yet in the tribe. This makes the site of the greatest importance for both the archeology and the anthropology of the Ojibwa who to-day, although one of the largest existing tribes, are also one of the most mixed. A careful and thorough exploration of this earlier site is one of the most urgent and promising tasks of archeology in this country.

A report on the preliminary survey of La Pointe Island by Mr. Means was published by the Smithsonian Institution.[1]

ARCHEOLOGICAL INVESTIGATIONS IN NEW MEXICO

Dr. Walter Hough, of the National Museum, was detailed to the Bureau of American Ethnology in June to conduct archeological investigations in western central New Mexico. Proceeding to Luna,

[1] Smithsonian Misc. Coll., Vol. 66, No. 14.

Socorro County, Dr. Hough commenced the excavation of a ruin previously located by him, as described in Bulletin 35 of the bureau (p. 59). This site was thought to contain evidence of pit dwellings exclusively, and excavations showed that an area of about 40 acres contained circular, semisubterranean houses (fig. 104) in which no stone was used for construction. Seven of the pits were cleared, and it was ascertained that many more existed beneath the surface, dug in the yellow sandy clay substratum of the region. Burnt sections of roofing clay showed that these houses were roofed with beams, poles, brush, and mud, as in present pueblo construction. The roof was supported by wooden posts, charred remains of which

FIG. 104.—Showing circle of pit. Also showing the environs of the pit village beyond.

were found. Nothing was ascertained respecting the construction of the sides of the dwellings or in regard to the height of the roofs. On the floor of each of the pits uncovered were a rude metate (fig. 105), grinding stones, slabs of stone, and the outline of an otherwise undefined fireplace not quite in the center of the chamber. A bench about a foot high and a few feet in length was cut in the wall of some of the pits, and in one of the pits, against the wall, was a fireplace (fig. 106) with raised sides of clay.

Another type of structures adjoined the pits; these were rectangular, open-air houses with mud roofs, in which mealing and culinary work was carried on. Here were numerous metates, manos, rubbing stones, pottery, etc.; some of the metates were set up on three round stones. Near the pit was a cemetery in which infants were buried,

FIG. 105.—Metate on floor of pit near fireplace.

the burials being associated with burnt clay hearths and much charcoal, and near the bodies were placed small pottery vessels. On the east of the village is a circular depression, 84 feet in diameter, which was found to be a ceremonial assembling place. It was 10 feet deep and has been filled with about 6 feet of fine débris. Large

FIG. 106.—Fireplace in dwelling pit. Jambs of smoother baked clay, bottom a flat stone, hearth of baked clay.

pines grow on the margin and in the depression. Scrapers of flint and bones of deer were also found among the burials. So far as ascertained, the people who used the circular semisubterranean houses had a limited range. Traces of their culture have not been found below an elevation of 7,000 feet in the mountain valley, and it appears probable that their culture was associated with an environment of lakes which once existed in these valleys. It is evident in some cases that the pit dwellings were displaced by houses of stone. In most instances artifacts are different from those of the stone-house builders, and the latter have more points of resemblance to, than of difference from, the ancient inhabitants of Blue River. It is probable that the range of the pit-house people would be found to be more extensive by excavation around the sides of stone houses in other localities, the remains of pit structures being easily obliterated by natural filling. At this time the pit-dweller culture can be affiliated only with uncertainty with that of the ancient Pueblos. At the present stage of the investigation the lack of skeletal material is severely felt, but further work may overcome this difficulty.

ARCHEOLOGICAL RECONNOISSANCE IN WESTERN UTAH

In the last report [1] of the explorations and field-work of the Smithsonian Institution notice was given of the inauguration of an archeologic reconnoissance of western Utah, conducted under the auspices of the Bureau of American Ethnology by Mr. Neil M. Judd of the National Museum. During June, 1916, it was found possible to supplement this first survey, and Mr. Judd was again directed to proceed to Utah, there to engage in limited excavations in continuation of his previous work.

As observed in the report of last year, the mounds at Paragonah, in Iron County, represent but a small portion of the large number which formerly existed at that place; the recent reconnoissance was undertaken primarily for the purpose of gaining definite information regarding the remaining ruins before their final destruction was accomplished by removal of the elevations which concealed them. Limited in time and handicapped by unfavorable local conditions, the expedition was less successful than had been anticipated; the results obtained, however, establish a similarity between the ancient Paragonah habitations and those previously exposed in Beaver and neighboring valleys and tend to show that the builders of the western Utah ruins were more closely related to the house-building peoples of other sections of the Southwest than has been generally suspected.

One of the largest and at the same time one of the least disturbed of the Paragonah mounds was selected as a type for examination. Its dimensions were approximately 100 by 300 feet; its average

[1] Misc. Coll., Vol. 66, No. 3, 1915, pp. 64-71.

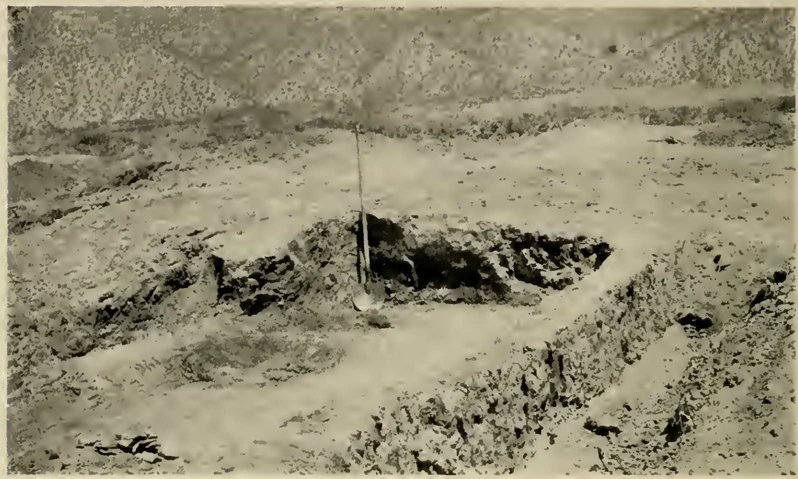

FIG. 107.—One of the ancient Paragonah dwellings. The adobe walls were of the same color as the surrounding soil and frequently were distinguished only by the small roots which followed their sun-dried surfaces.

FIG. 108.—Circular kiva or ceremonial room, Paragonah, Utah. Attempts to brace the thin earthen wall at the left had proved unsuccessful; its final collapse probably hastened the abandonment of the structure. Upon this sloping wall, near the end of the long shadow, is a fireplace which belonged to a temporary shelter, erected subsequently to the destruction of the kiva.

FIG. 109.—Ancient dwellings disclosed during the excavations of 1916. The circular fireplace above the wall in the immediate foreground belonged to a structure which was built upon the floor and which utilized the partially razed walls of a larger house.

FIG. 110.—A long room in the Paragonah mound. These walls had been exposed during previous excavations and were traced only with considerable difficulty.

height was less than 5 feet. Excavations of many years ago had left two great gashes, one at each end of the mound, each partially disclosing a single long room. Including these dwellings, which were reexcavated only with considerable difficulty owing to the hardness of the clay which had accumulated over them, Mr. Judd successfully revealed and measured the walls of 14 rectangular houses, 11 of which were entirely cleared of fallen wall material and other débris. In addition to these habitations less permanent structures were disclosed in various parts of the mound, situated between the ruins of larger houses and even above their razed walls. These temporary structures were built of logs leaned against cross-

FIG. 111.—Interior of an ancient adobe dwelling, showing remains of a wattled partition constructed after completion of the house.

pieces supported by 4 upright posts surrounding a central fireplace and were of the same general character as those discovered in 1915 at Willard and Beaver City. They apparently represent the survival of an earlier type of habitation, preserved in association with the adobe houses as mere shelters wherein were performed most of the domestic activities of the community.

The characteristic ancient dwelling of this region was rectangular in shape; its vertical walls were constructed of superposed masses of plastic clay, forced into position and smoothed by the hands of the workmen. Lacking evidence to the contrary, it is believed that roof openings formed the only means of entrance to these houses, a belief substantiated by the very nature of the dwellings and by the presence of numerous stone disks, in and about the mounds. The roofs were flat and, as in most primitive southwestern habitations, were oftentimes utilized as workrooms.

One of the most interesting discoveries made during the course of the Paragonah excavations was that of a circular room which, with similar remains previously discovered in the Beaver City mounds, tends to establish the use of the kiva, or ceremonial chamber, by the prehistoric house-building peoples of western Utah. The importance of this discovery is quite evident when one recalls that many of the clans composing the modern Pueblo settlements in Arizona and New Mexico constantly point to the north as the general

FIG. 112.—Walls of ancient adobe dwellings exposed at Paragonah, Utah, in 1916.

location of their ancestral homes. It is well known that many of these clans once occupied cliff-villages such as those so widely distributed throughout the upper San Juan drainage, villages in which the circular kiva reached its highest development. Students of southwestern archeology have labored many years with the problem of the origin of the cliff-dweller culture; the round rooms associated with villages of detached adobe houses in western Utah, together with the artifacts recovered from such houses, suggest that a solution of the problem may yet be found in the unknown canyons north and west of the Rio Colorado. It is earnestly hoped that the reconnoissance of western Utah may be concluded in the near future in order that the information resulting therefrom may be used in correlation with archeological data now available from other sections of the Southwest.

Following his studies at Paragonah, Mr. Judd proceeded to Fillmore, Willard County, for the purpose of investigating certain mounds reported from that neighborhood. These and similar elevations near the villages of Meadow, Deseret, and Hinckley, were all superficially identified as of the same type and representing the same degree of culture as those previously described near Beaver City, Paragonah, and other settlements.

STUDY OF INDIAN MUSIC

During the summer of 1916 Miss Frances Densmore continued the study of Indian music, making phonographic records of Indian songs on the reservations. For this purpose she revisited the Uintah and Ouray reservation in northeastern Utah, to complete the study of Ute music commenced in 1914. The work at that time was limited to the Uintah and White River divisions of the tribe, but during the last season it was extended to the Uncompahgre. On comparing the two sets of songs it was found that those recorded by the Uncompahgre differ slightly in structure from those recorded by the Uintah and White River Ute.

The principal subjects of investigation among the Ute were the songs used in the treatment of the sick, the war songs, and those of tribal dances. Among the most valuable songs are those of a certain medicine-man who represented a class that treat the sick without the use of material means and who stated that he received his songs supernaturally and could not transfer them to another. Songs were also recorded by a woman who was actively engaged in treating the sick and who belonged to the class of those who use herb-medicines. Her power was believed to be supernaturally given, its source being an eagle. Songs of this class of "doctors" are usually received in a supernatural manner but may be bought and sold, together with the herbs which, it is believed, would be ineffective without the singing of the songs.

The Bear dance is the most distinctive dance of the Ute, and many songs of this dance were recorded. The Ironline dance and the Double dance are among the more or less unusual dances studied. These dances have long since passed into disuse.

A peculiar war custom of the Ute is that of "washing the wounded." It was said that "when a war party returned with a wounded man they placed him in the center of the circle as they

FIG. 113.—Ute burial ground. Photograph by Miss Densmore.

FIG. 114.—Man weaving net for trapping rabbits.
Photograph by Miss Densmore.

danced. Someone washed his wounds and all the warriors sang. The same songs were used if a man had been killed and his body placed in the center of the circle." Several of these songs were

FIG. 115.—Woman with baskets for gathering berries. Photograph by Miss Densmore.

recorded, together with scout songs and those connected with an attack upon the enemy.

A burial ground in recent use was visited. On the burial places were scattered the bones of horses and dogs slain at the death of their owners (fig. 113). Household utensils had been placed on many graves, and above them hung garments which were evidently tattered by long exposure.

The material culture of the people received attention and specimens have been added to the Ute collection in the National Museum. Notable among these are a set of grinding stones for corn, with specimens of corn, and of bread made by mixing the finely-crushed corn with water and baking it on heated ground, from which coals have been removed. Piñon nuts form a staple article of food among the Ute; some of these parched and still covered with the ashes in which they had been prepared, were added to the collection. Berries were gathered, dried, and prepared in various ways. Figure 115 shows the baskets used for this purpose, it being stated that the berries were placed in the smaller basket when picked, then emptied into the larger basket by passing it over the shoulder. Nets for trapping rabbits were woven from the outer bark of reeds, a specimen of this netting being made by a blind man. The frame used for this purpose and the manner of beginning the net are shown in figure 114.

Analysis of the Ute songs presents many striking contrasts to that of the Sioux and the Chippewa, in which connection it is interesting to note the difference in the environment of these tribes, as well as in their temperament and tribal history. It is not unlikely that all these may have affected the form assumed by the musical expression of these several peoples.

ETHNOLOGICAL RESEARCHES IN OREGON AND WASHINGTON

On July 19, 1916, Dr. Leo J. Frachtenberg left Portland, Oregon, where he spent the preceding winter and spring in the preparation for publication of the Alsea texts and traditions that were collected by him in 1910 and 1913. On that day he proceeded to the Quileute reservation, situated at Lapush, in the northwestern part of Washington, with a view of making an exhaustive study of the ethnology of the Quileute Indians who, with the now extinct Chimakum, form the so-called Chimakuan linguistic family. This work was carried on during August, September, October, November, and December. The most voluminous data were obtained, and the investigation was facilitated by the fact that the Quileute Indians, numbering approximately 300 individuals, live together in a single village and still cling tenaciously to their native language, and to their former customs and traditions. Consequently, Dr. Frachtenberg encountered little difficulty in collecting exhaustive data on the various phases of the ethnology of these Indians, and he succeeded in thoroughly investigating the following phases: Early History

FIG. 116.—View of the Quileute Reservation at Lapush, Washington. Photograph by L. J. Frachtenberg.

FIG. 117.—James Island, former principal village of Quileute Indians at Lapush, Washington. Photograph by L. J. Frachtenberg.

and Distribution, Manufacture (including Basketry, Matting, Weaving and Netting), Houses and Households, Clothing and Personal Adornment, Subsistence (including Hunting, Fishing, Sealing, and Whaling), Travel, Transportation and Trade, Warfare, Games and Pastimes, Social Organization and Festivals, Ceremonials and Societies, Pregnancy, Birth, Childhood, Twins, Puberty, Customs regarding Women, Marriage, Burial Ceremonies, Religion (including Conception of the World, Country of the Souls, Prayers and Observances, Guardian Spirits, Beliefs regarding the Soul, Shamanism, Ethical Concepts and Teachings), Medicine, Surgical Operations, Charms, Current Beliefs, Physical and Mental Traits, Decorative Art, Music and Dancing. This material is contained in 8 volumes numbering approximately 600 manuscript pages. In addition, Dr. Frachtenberg obtained several hundred native drawings and took photographs of some 150 specimens of material culture. He also added considerably to his previous collection of Quileute traditions, by collecting additional 22 native myths and traditions (in Quileute) and 3 narratives in English. These myths and tales comprise 200 pages. Furthermore, Dr. Frachtenberg succeeded in inducing two inhabitants of Clallam County, Washington, to present to the National Museum their valuable collections of Quileute baskets and specimens. These collections contain over 200 baskets, two carved house-posts, and approximately 25 specimens illustrating the material culture and ceremonial life of the Quileute Indians.

The comprehensive study of the ethnology and language of the Quileute Indians, conducted by Dr. Frachtenberg during the calendar years 1915 and 1916, has brought out some very important points, a few of which may be mentioned here in passing. Unlike the other tribes of the Pacific Coast, the Quileute Indians are not a vanishing tribe. On the contrary, these Indians are gradually, though slowly, increasing. Although since 1883 they were subjected to 5 separate epidemics of measles, smallpox, whooping cough, and grippe, their number has increased during that period by more than 10 individuals. The proportion of half-breeds among them is exceedingly small, and they are undoubtedly the most moral and law-abiding tribe of that area. This condition seems to be due to their complete isolation from the other tribes and from the white people, and to their persistence in adhering to the former customs and beliefs. A good proportion of these Indians are members of the Shaker Church, whose chief doctrine is total abstinence from gambling, smoking, and liquor. Up to about 4 years ago the Quileute still hunted whales in the open sea. In former years whale-hunting

FIG. 118.—Types of Quileute canoes. Photograph by George C. Cantwell.

FIG. 119.—Quileute dip-net. Photograph by George C. Cantwell.

constituted one of their principal occupations, in which they were second only to the Makah Indians of Neah Bay. The daring, courage, and skill with which these primitive people hunted, attacked and killed the "Giant of the Sea" in their frail canoes and with their primitive weapons, must have been remarkable. At the present time pelagic hunting is confined to the hunting of the valuable fur-seals which constitute a not unimportant source of income to the Quileute. Last year alone they sold $6,000 worth of furs. The Quileute learned the art of sealing some seventy years ago from the Ozette Indians, who in turn obtained it from the Nootka of Vancouver Island. In the meanwhile, the Ozette and Nootka have abandoned this occupation, partly voluntarily and partly owing to public interference, so that, to-day, the Quileute are the only Indians in the United States proper who are permitted to hunt and kill fur-seals. The Quileute use special canoes for that purpose; these canoes are dug-outs, made of cedar, and are manned by three people. The sealing season lasts from March until July, and the hunters very often go 30 and 40 miles out into the sea. The Quileute derive most of their revenue from the sale of the several species of salmon that are caught in the Quileute river.

A novel feature of American Indian ethnology has been found among these Indians in their former ceremonial life. Like the other tribes of the Northwest area, the Quileute had a number of secret societies, corresponding more or less to the fraternities of the Nootka, Kwakiutl, and Salish tribes, with this remarkable exception: All Quileute secret societies were occupational; that is to say, an individual became a member of a certain order, because he followed the profession of that order. Thus, Dr. Frachtenberg found special orders for Warriors, Hunters, Fishermen, Seal-hunters, Whale-hunters, Rain-makers, etc. The importance of this new phase of primitive social life cannot be overestimated. There can be no doubt that the culture of the Quileute Indians is closely related to the cultures of the Kwakiutl-Nootka and Salish groups. Furthermore, Dr. Frachtenberg is practically convinced that he will be able to produce conclusive evidence in the near future, showing that the languages of the Wakashan, Salish, and Chimakuan families have been derived from one common mother-tongue, which he proposes to call the *Mosan* language, from the numeral *mōs* "Four," which occurs, in one form or another, in all languages that constitute these three groups.

On October 12, Dr. Frachtenberg interrupted his Quileute field-work and proceeded to the Tulalip Reservation, Washington, where for two weeks he assisted Dr. H. K. Haeberlin, of Columbia University, in his ethnological and linguistic researches among the Salish tribes. This trip was made at the suggestion of Prof. Franz Boas and met with the approval of the Bureau of American Ethnology.

FIG. 120.—Twined baskets of the Quileute Indians.
Photograph by George C. Cantwell.

The expenses of the trip were paid by Columbia University. Dr. Frachtenberg resumed his Quileute work on November 6, 1916, but interrupted it again on November 24, when he proceeded to San Francisco, Cal., for the purpose of conferring with Dr. A. L.

Kroeber, of the University of California, and with Mr. John P. Harrington, of the Bureau of American Ethnology, in regard to the relations of the researches of the Bureau of American Ethnology with those of the University of California, especially with respect to the ethnology and linguistics of the Indian tribes of northern and southeastern California and the adjacent regions. This conference took place on December 1 and 2, and a report embodying its results was sent to the Ethnologist-in-Charge of the Bureau of American Ethnology. While in San Francisco, Dr. Frachtenberg attended the meeting of the Pacific branch of the American Association for the Advancement of Science, reading four papers that dealt with the ethnology, mythology, and philology of the Indian tribes of Oregon and Washington. Dr. Frachtenberg returned to Lapush on December 9, resuming his Quileute field-work.

In the latter part of November it became evident that the appropriation granted Dr. Frachtenberg in the beginning of the fiscal year would not be sufficient to enable him to bring the field-work among the Quileute to a successful conclusion. Fortunately, an offer for cooperation was received from Columbia University, through the courtesy of Prof. Franz Boas, whereby Dr. Frachtenberg was enabled to continue his field-work. The Bureau accepted this offer, with the understanding that Dr. Frachtenberg would devote this sum to a comprehensive study of the music of the Quileute Indians, with special reference to the problem of song-variation. Dr. Frachtenberg is, at the present writing, conducting this investigation. He expects to collect about 80 songs, taking down the tune, burden, and translation of each song and obtaining the identical songs at separate times by the same and by distinct individuals. Dr. Frachtenberg expects to complete this work by the latter part of January, 1917, and will then return to Washington.

STUDIES AMONG THE INDIANS OF CALIFORNIA

Mr. John P. Harrington, ethnologist, was engaged during the year in continuing his exhaustive study of the Chumashan Indians of the Santa Barbara region of California. January was spent at Berkeley, Cal., where linguistic and historical manuscripts in possession of the Bancroft library were copied and studied, through the courtesy of the University of California. In the course of the summer this material was thoroughly worked over, transliterated, and corrected with the aid of Indian informants.

At the end of January Mr. Harrington returned to the Southwest Museum, Los Angeles, where he spent the months of February and

March in work on the Ventureño dictionary, which already covers about 8,000 cards and has served as the basis for similar dictionaries which have been started for the other dialects. The entire summer was devoted to an intensive study of the Barbareño, Ineseño, and Purismeño dialects. The supposedly extinct Purismeño is now represented by a vocabulary of several hundred carefully written words and phrases. This work was followed by a month's further study of the Obispeño dialect, beginning September 16. More and better material was obtained than previously. The informant's health being such as not to admit of long or steady hours of work daily, there was opportunity to memorize every word and to digest the material thoroughly as it was presented.

The period from October 14 to November 15 was spent at the Southwest Museum, Los Angeles, in elaborating the notes, and the remainder of the year in field-work on Ventureño, correcting, improving, and adding to the previous notes.

Some of the interesting features of language and culture discovered in Mr. Harrington's studies have been: the use of vowel triplication as a unique grammatical process; a system of relationship terms which extends to the fourth generation (for example, great-great-grandparent, great-great-grandchild, and not merely to the third as with most tribes); the use of sun shrines and their renewal at the coming of the new year; the use of one word for world, year, and God; the use of seaworthy board canoes (fragments of these taken from excavations and now at the Southwest and other museums not hitherto having been recognized as such); the institution of berdaches as undertakers; the erection of tall poles hung with property on the graves of rich persons; the identification of the site of "Pueblo de las Canoas" of early Spanish narratives, and that the Ventureño name for it was Shisholop, meaning "the mud." In connection with this last determination it is interesting to note that the surrounding tribes called Ventura the "mud place" and the Ventureños the "mud people."

WORK AMONG THE OSAGE INDIANS

During the year 1916, Mr. Francis La Flesche, ethnologist, visited the Osage reservation in Oklahoma for the purpose of continuing his researches among the people of that tribe. While changes are continually taking place in the religious institutions of these people, many of the full-bloods still believe in the ancient rites and retain the practices that have grown out of them.

After considerable difficulty Mr. La Flesche prevailed upon Sho^{n}'gemo^{n}i^{n}, one of the oldest members of the tribe, to recite two

FIG. 121.—Sho^{n}'gemo^{n}i^{n}, an Osage No^{n}'ho^{n}zhi^{n}ga.

rituals belonging to his gens, the Tsi′zhu Washtage, namely, the ceremonial naming of a child of the gens, and the initiation of a young man into the mysteries of the war rites. A portrait of Sho^n′gemo^{n}i^n is here given (fig. 121).

The ritual of the ceremonial naming of a child belonging to the Tsi′zhu Washtage gens is the second ritual of this rite that Mr. La Flesche has succeeded in recording since commencing his study of the Osage tribe. The first obtained is the ritual used by the Puma gens, whose gentile function is to conduct the principal parts of the war ceremonies; the second ritual procured is that of the Tsi′zhu Washtage gens whose duty it is to take part in the ceremonies connected with the hunt. This gens is one of the two gentes to which belong the hereditary office of chief, and it is also a peacemaker gens. These two rituals of the child-naming ceremony comprise 107 typewritten pages and will form a chapter in the forthcoming memoir on the Osage tribe. Many of the full-bloods still cling to the idea that a child who has not been ceremonially named has no place in the tribe as a person, and that it is only through the rights acquired at this naming that the child on attaining manhood can command the respect of other members of the tribe. In these child-naming rituals the gentile symbols are clearly set forth.

The second ritual obtained during the year from Sho^n′gemo^{n}i^n, *i. e.*, the initiation of a young man into the mysteries of the war rites, bears the title of No^{n}zhi^{n}zho^n Watho^n, which signifies, "the fasting songs." These relate to the rite of fasting which the chosen leader of a war party takes upon himself in order to excite the compassion of Wako^n′da and thereby enlist the aid of that power in winning success.

The No^n′ho^{n}zhi^{n}ga of the Tsi′zhu Washtage gens always render their version of this ritual with an air of reluctance, the reason being that the office of this gens is to protect life, even that of a caterpillar that happens to stray into the chief's house. During the ceremonial approach to the Sacred House the song and the wi′gie sung and recited have no references to war or to valorous deeds, but to the path of life in which all must strive to travel in peace. In the No^n′zhi^{n}zho^n, or fasting ritual, of the other gentes there is a wi′gie that explains the significance of the rattle used in the ceremony, one that relates strictly to war. But as it has to be included in the fasting rite of the Tsi′zhu Washtage gens, when they recite it they omit the authoritative refrain at the end of each line, *a bi^n da, tsi ga*, ("it has been said, in this house"), for the reason that war was not taught in the Sacred House of the Tsi′zhu Washtage; but as the

No^n'ho^{n}zhi^{n}ga are obliged to use this wi'gie, they changed the words of the refrain to *a bi a*, ("they said," that is, they of the House of the Ho^n'ga). Furthermore, the entire wi'gie is recited in a very low tone so that only the Xóka and the candidate can hear the words.

The task of transcribing the text of the ritual as recorded by the graphophone, and the translating of the wi'gie and the songs is still in progress. At the present time 30 typewritten pages have been completed.

The rigidity with which the Tsi'zhu Washtage gens in its rituals adheres to the peace principle it represents may be regarded as being theoretical rather than an actual restriction of warfare, for the reason that among its members there have been men who have won war-honors and who have even been leaders of war-parties. Sho^n'gemo^{n}i^n himself is an example of this, for he has won more than the number of war-honors required for the ceremonial counting of odo^n'; he has often been chosen to act as Wádo^{n}be, the counter of war-honors, at the war ceremonies.

Sho^n'gemo^{n}i^n recounted in the phonograph for Mr. La Flesche his thirteen war-honors, giving them exactly as he counts them at the war ceremonies. For this service he is usually paid from one hundred to one hundred and twenty-five dollars when he fills the office of Wádo^{n}be. It was as an act of friendship to Mr. La Flesche that he made, for a small sum, the record of his counting of odo^n'.

This record by Sho^n'gemo^{n}i^n has been included in the already completed No^n'zhi^{n}zho^n ceremony as described by Waxthi'zhi of the I^{n}gtho^{n}ga gens. The reason for placing it there is that, according to tribal regulations, Sho^n'gemo^{n}i^n cannot be chosen to act as Wádo^{n}be on his side of the tribal division, but must be called upon from the opposite side to perform this ceremonial act.

In 1863 Sho^n'gemo^{n}i^n took part in a fight in which the Osage warriors destroyed a party of Confederate officers who were on their way to Mexico. In the struggle he struck some of the men, "but," he added, "I do not recount these strokes at the war ceremonies because I am a friend of the white people."

Sho^n'gemo^{n}i^n is one of three surviving old men of the tribe who can count the full thirteen odo^n', or war-honors, at the war ceremonies.

ETHNOLOGY OF THE IROQUOIS

On April 19, 1916, Mr. J. N. B. Hewitt resumed his field studies of the League of the Iroquois, near Brantford, Ontario. His time was devoted chiefly to the collection of native texts, largely in

FIG. 122.—The Black God of Disease and Death: One of three Disease Gods of the Iroquois.

Mohawk, Onondaga, and Cayuga, and as far as practicable interlinear and free translations and expository interpretations in English were also obtained for these texts. This material is being prepared for his projected memoir on the League of the Iroquois or Five Nations. The subject-matter is complex and difficult to understand. It deals with the laws and ordinances, the rituals, the addresses, the chants, the songs, and the traditions of origin, of the League as an institution, which still exists best among the Six Nations of Iroquois in Canada. The very technical and highly figurative diction of the native material is not in most cases understood by the ordinary native speaker, and so it is necessary to test the knowledge of an informant or interpreter before accepting his or her services; even such information must be revised and compared with other sources of information. This is not at all strange, because the native life is being gradually displaced by the culture of European peoples.

These texts embrace a very wide range of subjects—laws, ordinances, decisions as to the meaning or applications of laws, rituals, ceremonies, and constitutional principles—often stated in technical and highly metaphorical terms derived from mythic and legendary sources. The tradition of the parthenogenetic conception and birth of Dekanawida and of his work in establishing the League of the Five Nations diverges into several versions which have adopted striking, though often contradictory, incidents from the legendary and mythic lore of the people. The most noteworthy of these incorporations is the Saga of the Wrath of Hiawatha. So, to obtain a fair understanding of the entire subject it becomes imperatively needful to collect these varying versions, no matter how fragmentary they now may be, for the purpose of providing means for disentangling the probable historical nucleus of the original saga from these variant stories. It must be kept constantly in mind that no small proportion of these ancient laws and ordinances—now largely in abeyance—are recoverable only from the language of the chants and songs and addresses of the Condoling and Installation Council.

Thus the work of recording these native texts dealing with the most highly developed and complexly organized activities of these tribes is most tedious and irksome, and one of some difficulty, because of the highly-wrought diction of these narratives and rituals and because the native annalists of these tribes, whose knowledge of the history and wisdom of their past was unmodified by European culture, are no more, and also because their sons and daughters of to-day have become interested largely in other things, and so they have forgotten, if they ever had learned, the lore and the wisdom

FIG. 123.—Mask of a Corn Goddess of the Iroquois.

of their ancestors. These things do not interest the great majority of persons as they did their ancestors; and as it is absolutely essential that correct lexical and grammatic forms be recorded and expounded it is found a very difficult matter to secure trustworthy informants and interpreters. Inability to translate the meaning of the native vocables into equivalent English words is the greatest bar to the student in the acquirement of a consistent knowledge of the structure of the League and of its constituent institutions. Too pronounced personal views and fanciful preconceptions often render an informant's work useless.

A most important result of Mr. Hewitt's work in the field is the finding of conclusive evidence that the number of federal chiefs of the League of the Iroquois was originally forty-seven, which later by the addition of two recalcitrant Seneca chiefs was raised to forty-nine. The number fifty has appeared in all available written records and printed accounts of the League chiefs. This number has never been questioned hitherto but has been accepted as historical. The supernumerary chiefship, it is learned, was unwittingly added by Thomas Webster, a chief of the New York Onondaga, more than fifty years ago, through a misunderstanding of the meaning of the "Bear-Foot" episode of the ancient time and the significant action of the Federal Council of the League of the Iroquois, with reference to it. This false Websterian interpretation gained credence only after the dissolution of the integrity of the League of the Iroquois following the treaty of 1838 with the United States, which had the effect of permanently dividing the several tribes.

The famous "Six Songs" of the Condoling and Installation Council of the League of the Iroquois were first translated, so far as known, into English for Mr. Horatio Hale ("The Iroquois Book of Rites," 1883) by Chief John "Smoke" Johnson, who is there described as "the only man now living who can tell the meaning of every word of the 'Book of Rites.'" Yet, they were erroneously translated as "Songs of Greeting and Welcome." But on grammatic grounds and from their position in the ritual Mr. Hewitt has decided, tentatively at least, to translate them as "Songs of Parting" or "Songs of Farewell," which are so dramatically sung, therefore, in behalf of the dead chieftain.

The Dekanawida legend rehearsing the story of the founding of the League of the Five Nations, as told by the Mohawk and Onondaga annalists, is largely repudiated by the Cayuga wisemen now living. And there appear to be some grounds for their doctrine. So Mr. Hewitt recorded a Cayuga version of the so-called

Fig. 124.—Small drums for the Onehowih dances of the Iroquois.

Fig. 125.—Figure at top, medicine flute; two bottom figures, knee-rattles of deer hoofs. Iroquois.

Dekanawida legend, in which the great statesman is anonymous. In this interesting version Dekanawida is known throughout the account by the descriptive title, "The Fatherless," or literally, "He

FIG. 126.—Turtle-shell rattle, horn rattle, and gourd rattle of the Iroquois.

Who Is Fatherless." This title was designed probably to emphasize a prophecy that he would be born of a virgin by an immaculate conception. This Cayuga version was dictated by Chief John H.

Gibson of the Cayuga tribe, a son and disciple of his great father, the late Chief John Arthur Gibson of the Seneca tribe. In this account "The Fatherless" is represented as having established among the Cayuga people a form of civil government, the exact type of which he later in life founded among the Five Iroquois tribes, inclusive of the Cayuga. It is stated that the Cayuga statesmen did not realize the suitability of that form of government to the affairs and welfare of all men, and so they had limited its scope and benefits selfishly to their own Cayuga people. And this account relates that because of this bad stewardship on the part of the Cayuga people it became needful for "The Fatherless" to return "from the sky" to the neighbor tribes of the Cayuga for the purpose of establishing among them the League of the Five Nations of the Iroquois, of which he declared all the tribes of men should be co-equal members.

Further, in this account there is an attempt to explain the origin of the obtrusive dualism which appears as the basis of all public institutions of the Iroquois peoples. According to this explanation this dualism arose merely from an alleged agreement between two Cayuga persons who were related the one to the other as "Father And Son," or better, as "Mother And Daughter," to transact public affairs jointly from opposite sides of the Council Fire. It is seen that this explanation seemingly does not account satisfactorily for the occurrence of similar dualisms among other peoples. The most satisfactory explanation of this phenomenon is one proposed by Miss Alice C. Fletcher and Mr. Hewitt, although working independently, a number of years ago, namely, that this dualism is, in brief, a dramatization of the relation of the male and the female principles of nature in the forms of governmental organization.

Mr. Hewitt also recorded in the Onondaga dialect a brief legend describing the three Air- or Wind-Man-beings, or Gods; these Gods are the so-called Hoñdu''i', the patrons of the Wooden-Mask With the Wry-face or "False-face" Society, whose duty is the exorcism of disease and sickness from the community and from the minds and bodies of the people; also a short story of the Medicine Flute; and another on the Husk-Mask Society; and another on the Moccasin Game as Used at the Wake for a Dead Chief; these texts aggregate more than 175 pages of manuscript exclusive of the materials relating to the League.

A number of fine specimens illustrative of Iroquois culture were procured; these objects show a high order of art, and they consist of one wooden mask, colored black (fig. 122); a husk mask for a

Medicine Society (fig. 123); two small drums (fig. 124); a "medicine" flute (fig. 125); a pair of deer-hoof knee-rattles (fig. 125); a horn-rattle, a turtle-shell rattle, and a gourd rattle (fig. 126).

At the close of June, 1916, Mr. Hewitt was still on field duty; up to this time, he had read, revised, studied, and annotated about 8,000 lines of text other than material mentioned in the closing paragraphs of this statement. He also made a number of photographs of Indians.

ETHNOLOGICAL WORK AMONG THE SAUK, FOX, AND PEORIA INDIANS

The first part of June, 1916 found Dr. Truman Michelson among the Sauk and Fox of Iowa. The main work accomplished was the phonetic restoration of a long text, written in the current syllabary, on the origin of the White Buffalo Dance, which is intended as a future bulletin of the Bureau. He secured several sacred packs for the Museum of the American Indian (Heye Foundation), of New York, under the agreement that the Bureau should retain the right to publish the information pertaining to them. In this way more information on these difficult topics was obtained, and more is expected. Other ethnological data, especially sociological, was also acquired. About the middle of August Dr. Michelson proceeded to Oklahoma, where, under the joint auspices of the Bureau of American Ethnology and the Illinois Centennial Commission, he conducted researches among the Peoria. Their ethnology properly speaking has practically vanished, and although their language and folklore still persist, knowledge thereof is confined to a very limited number. The phonetics of the Peoria language, contrary to ordinary belief, is extremely complicated. As surmised from the notes left by the late Dr. Gatschet, Peoria linguistically belongs fundamentally to the Ojibwa group of Central Algonquian languages; yet at the same time it is clear that there has been another and more recent association with the Sauk, Fox, and Kickapoo group. A study of Peoria folklore and mythology also points to this double association, as does the system of consanguinity, which agrees with Sauk, Fox, and Kickapoo, as opposed to Ojibwa, Ottawa, Algonkin, and Potawatomi. It should be noted that Peoria folklore and mythology contain a number of Plains and Plateau elements which thus far have not been recorded among other Central Algonquian tribes. How these elements spread eastward is as yet unknown. A number of strictly aboriginal tales were collected that have not been recorded elsewhere. A large number of European tales have been incorporated, and yet the Peoria Indians are unaware of their origin. While among the Peoria some incidental notes on Shawnee sociology and folklore were obtained by Dr. Michelson. After about four weeks' stay in Oklahoma he returned to Iowa to renew his investigations among the Sauk and Fox at Tama. There the phonetic restoration of a number of texts on minor sacred packs pertaining to the White Buffalo Dance was accomplished, and about 200 pages of the extremely long myth of the Fox culture-hero were also restored. Dr. Michelson witnessed most of the ceremonies that

FIG. 127.—Some of the descendants of the Fox Chief Poweshiek.

were performed when the Potawatomi of Wisconsin presented the Foxes with a new drum of the so-called " Religion Dance."

RESEARCHES BY DR. JOHN R. SWANTON

The only undertaking in the nature of field-work by Dr. John R. Swanton during the year was a visit to Chicago in September to make an examination of the manuscript material in the Ayer collection of Americana in the Newberry Library. This occupied less than a week, but proved rich in results, the most important of which was the discovery of a French memoir containing the best Karankawa vocabulary so far known and the only known vocabulary of Akokisa. A photostat copy of this was secured later, and similar copies of several other original manuscripts or copies of originals: one a second French memoir giving a considerable account of the Choctaw Indians, and censuses, town by town, of both the Choctaw and the Creeks, another an enumeration of the Louisiana Indians, apparently by Bienville, and a third a Spanish census of the Indians in Florida in the early part of the eighteenth century, which includes the town, the name of each Indian, and his approximate age. This library also preserves what appears to be the original manuscript from which the *Mémoires Historiques sur La Louisiane* of Dumont de Montigny was composed. On the basis of the material enumerated it is now possible to classify exactly the little known Akokisa, Washa, and Chaouacha tribes, and to add considerably to our knowledge of the Indians north of the Gulf of Mexico in other particulars.

VISIT TO THE CHEROKEE INDIANS

Owing to impaired health the field-work of Mr. James Mooney in 1916 was confined to a visit of about ten weeks (May 28-August 10) to the old Cherokee country in western North Carolina, during which time he visited the principal Indian settlements and railroad towns and added to his information on the tribal folklore, besides securing several important documents bearing on the participation of the Cherokee in the Confederate service during the Civil War.

SOLAR RADIATION OBSERVATIONS AT MOUNT WILSON

The Smithsonian Astrophysical Observatory has a station at Mount Wilson, California, on ground leased from the Mount Wilson Solar Observatory of the Carnegie Institution. In 1916, as in former years since 1905, observations of the intensity of solar radiation were made there during the months June to October by Messrs. Abbot and Aldrich.

In the course of the research, now continued for more than a decade, the variability of the sun has been definitely proved. Expeditions for checking Mount Wilson results were conducted to Algeria in 1911 and 1912, and simultaneous measurements in California and Algeria confirmed the reality of the suspected variations of the sun. Further confirmation was obtained at Mount Wilson in 1913, and subsequently. For it was found that the distribution of brightness over the solar disk is variable in association with the sun's total radiation. Not only does the sun's radiation fluctuate from day to day, but the average values found in a whole season's work, vary from year to year.

It was primarily to continue and amplify these studies of the solar variability that the observing was done on Mount Wilson in 1916. Both the total radiation of the sun and the distribution of brightness over the solar disk were measured on as large a number of days as possible. Owing to considerable cirrus cloudiness in June and August, a dense haze suggesting the volcanic haze of

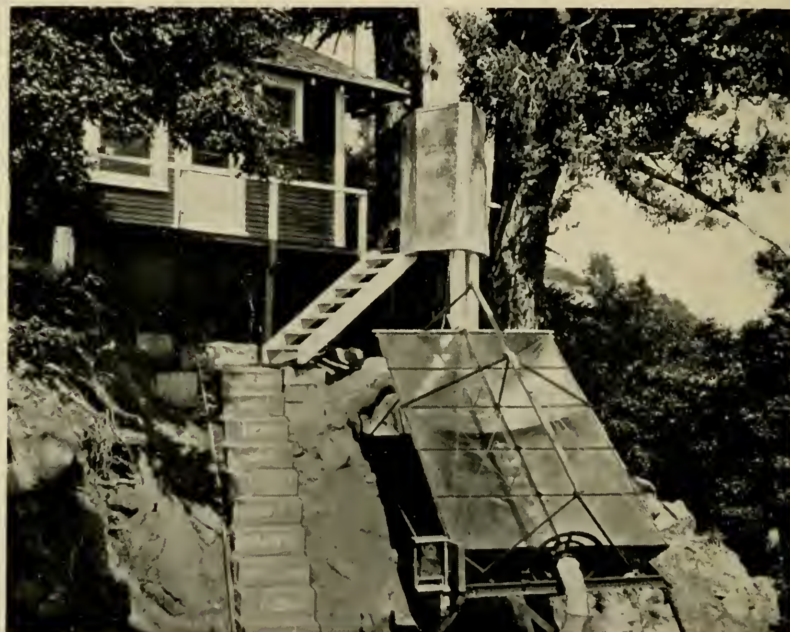

FIG. 128.—Observers' cottage and solar cooker, Mount Wilson, California.

1912 in late July and early August, and to heavy rains in late September and early October, the season proved less favorable than usual, but nearly 100 days of observation were secured. Full reduction of the observations must be awaited before noting the solar changes during the season, but generally high values of solar radiation seemed to prevail, as was expected in view of numerous sunspots. At one time in June nearly 100 spots were seen on the sun's image. Large magnetic disturbances were associated with this spot outbreak, and observations had to be suspended on one day because of them.

As the sun is the ruler of the earth's temperature, and his rays the dependence of all vegetation, solar fluctuations of five, or even sometimes ten per cent, such as have been discovered in these studies must be important. Great need is apparent of checking and completing the Mount Wilson work at other favorable stations. In 1914 Mr. Abbot went to Australia and urged the erection of an observatory for the purpose there, but owing to the outbreak of the war, the Government, though favorably inclined, was unable to take the matter up. Fortunately it has recently become possible for the Smithsonian Institution itself to undertake the support of a station in South America for observing solar radiation, and this is expected to be installed in July, 1917 by Mr. Abbot. It is hoped to make the solar radiation observations every day in the year hereafter either at Mount Wilson or in South America or at both stations.

Further work was done with a solar cooking appliance at Mount Wilson in 1916, but owing to the delay until September of materials ordered for it and expected in April, no satisfactory tests have yet been made. Food was cooked in 1915, including meat, potatoes and other vegetables, and cereals. It is confidently expected to bake bread also when the apparatus is done.

A great drawback to the solar work done hitherto has lain in the tarnishing of the silvered mirror surfaces used to reflect the sun rays onto the bolometer. This is the more serious because it affects rays of different colors differently. Violet and ultra-violet rays are most weakened by the tarnishing of silver. At last a new alloy " stellite " has appeared which does not tarnish, even if exposed for months to sun, rain, snow, and smoke. Two stellite mirrors for the spectro-bolometer were introduced on Mount Wilson in 1916, along with a vacuum bolometer of greatly increased sensitiveness. It is now hoped to determine definitely whether all rays of the sun wax and wane in their intensity proportionally, as the sun varies, or increased solar radiation is preponderatingly associated with special regions of the spectrum.

Comparisons were made in 1916, of the pyrheliometers used daily in Mount Wilson work with the standard waterflow pyrheliometer. The results showed that no detectable change of the sensitiveness of the secondary pyrheliometers has occurred. We may be confident that the entire series of observations at Mount Wilson, from 1905 to 1916, is expressed on a constant scale of radiation to within one per cent. Numerous and varied measurements show also that this constant scale is the true standard scale of measurement whose unit is the calorie. About thirty standardized silver disk pyrheliometers have been sent out by the Smithsonian Institution at cost, so that this same scale of measurement is now available in many countries, including Canada, United States, Mexico, Peru, Brazil, Argentina, Philippines, Java, Teneriffe, Spain, Italy, France, England, Germany, and Switzerland.

A new instrument, the "pyranometer," adopted for measuring the brightness either of the sun alone, the sun and sky, the sky alone, or the nocturnal radiation of a blackened surface to the whole sky, has been perfected and was much used at Mount Wilson in 1916. This instrument is suitable for measuring the intensity of light where plants grow, whether in full sunlight or deep shade. Its results agree accurately with the standard scale of radiation mentioned above.

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On the Occurrence of Benthodesmus Atlanticus Goode and Bean on the Coast of British Columbia

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ON THE OCCURRENCE OF *BENTHODESMUS ATLANTICUS* GOODE AND BEAN ON THE COAST OF BRITISH COLUMBIA

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A specimen of *Benthodesmus*, 41½ inches long, was obtained May 30, 1916, from a fish dealer in Victoria, B. C., having been caught by fishermen off Bentinck Island, which lies near Race Rocks, about ten miles by water from Victoria. The specimen is the property of the Provincial Museum of Victoria, and has been submitted to us for identification by Mr. F. Kermode, the Director of the Museum.

Description: Greatest width of body 2⅔ in height at vent. Length of caudal peduncle half greatest height of body. Least height of tail ⅓ bony interorbital width. Greatest width of head ⅙ its length. Greatest height of head 3¾ in its length. Width of interorbital area (bony) ¼ height of head. Length of snout 2¼ in head. Tip of maxillary not reaching the orbit, the length of maxillary equaling the postorbital part of head. Length of lower jaw 1⅞ times greatest height of body. Flexible part of mandibular tip short in the preserved specimen, about ¼ diameter of orbit. Eye postmedian, 5⅓ in head, 2⅓ in length of snout.

Sides of maxillary with 9 or 10 triangular teeth, which decrease from middle of sides of jaw both forwards and backwards. Two pairs of narrow compressed fangs in the anterior part of the upper jaw, the anterior pair immediately behind the tip, the posterior pair separated by a considerable interspace, but located in front of the series of compressed lateral teeth already described. In advance of the most anterior of the compressed lateral teeth, a series of 6 or 7 short slender conical teeth continued forwards to the anterior pair of fangs and passing outside the posterior pair of fangs. Side of mandible with 14 or 15 compressed triangular teeth in a single series, decreasing in length forwards, and inclined slightly towards the front of the jaw. In advance of these, on each side of the symphysis, are two pairs of short retrorsely directed teeth, the anterior pair much shorter than the posterior pair. Other bones of the mouth toothless.

First gill-arch with 4 or 5 to 7 or 8 slender short distant rakers, the longest about 2 mm. in length. Each rises from a plate which bears short spines, and between each pair of these plates, on the outer surface of the arch, are interposed two similar smaller plates, which do not bear rakers. The rakers are borne only on the posterior third of the horizontal limb of the arch, but the spinous plates are continued farther forwards, and become merged along the anterior part of the arch in a narrow spinous strip. The other arches are similar to the first, but contain fewer free rakers. The upper pharyngeals are well toothed and work against the spinous plates on the horizontal limbs of the arches.

First dorsal ray slightly in advance of the middle of the operculum, the front of the orbit midway between the first ray and the tip of the snout. There are 142 rays in all, the posterior the longest. The rays rise from the anterior ends of a series of interneural bones, which form a sharp ridge along the dorsal profile.

The vent is beneath the 46th dorsal ray, its distance from the tip of the snout $3\frac{1}{7}$ times the length of the head. Distance from vent to postanal scute $\frac{5}{6}$ diameter of orbit. Immediately behind the scute begins a series of 88 interhæmals, which form a continuous sharp ridge along the lower profile. The anterior ones bear no rays, but these gradually appear posteriorly, about 40 of the posterior plates bearing evident free rays, which increase in length posteriorly.

The pectorals contain 12 rays, the lower distinctly the longest, equaling the postorbital length of the head. Ventrals mutilated, their base posterior to that of pectoral by $\frac{2}{5}$ diameter of orbit. Caudal deeply forked, its longest ray equaling the diameter of the orbit.

Color silvery, becoming posteriorly steel gray, and finally black. Lips black, as are also the inside of the mouth and the gill-cavity, including the gill-arches. Peritoneum also black.

One specimen, $41\frac{1}{2}$ inches long, the property of the Provincial Museum of British Columbia.

Benthodesmus elongatus (Clarke) from New Zealand differs notably from this species in the much more elongate form, the depth scarcely exceeding one-fortieth of the length. The third species of the genus, *B. tenuis* (Guenther) from Japanese waters, has much shorter vertical fins, the dorsal having but 126 rays and the anal but 71 rays. The specimen in hand differs in only minor respects from the description of *B. atlanticus* given by Goode and Bean. The width of the body is slightly greater, $2\frac{2}{3}$ in its height; the snout slightly longer, its length $2\frac{1}{4}$ in the head; the mandibular tip shorter, $\frac{1}{4}$ the orbit; the eye smaller, $2\frac{1}{3}$ in the snout. And there are four long teeth in the upper jaw, instead of three. The species has been known hitherto from a single specimen.