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Bulletin of the Geological Society of China

Vol. XV *No. 3*

NOTES ON THE MAOKOU LIMESTONE IN SOUTHERN KWANGSI*

BY C. LI (李捷) AND W. Y. CHANG (張文佑)

National Research Institute of Geology, Academia Sinica

The name Maokou Limestone was established in 1927 by Mr. S. S. Yoh to represent a limestone found in the Maokouho (茅口河) Gorge, Kueichow. It carries a rich foraminifera fauna which consists of the following species:

Neoschwagerina craticulifera (Schwager)
Neoschwagerina globosa Yabe
Neoschwagerina parva Deprat
Doliolina schellwieni Deprat
Doliolina lepeda (Schwager)
Sumatrina annæ Volz
Verbeekina verbeeki Geinitz

The equivalent formations occur also in the provinces of Yunnan, Hunan, Szechuan and Hupeh; but especially well developed in southern Kwangsi.

At Hoshan (合山), about 20 miles northwest from the city of Ts'ienchianghsien (遷江縣), S. Kwangsi, the authors have found the best outcrop of the Maokou Limestone which may roughly be divided into five parts: Fusulinidæ limestone, coal seam, *Lyttonia* cherty limestone, black well bedded siliceous rock, and black well bedded cherty limestone. Its total thickness is over 400 m.

The Fusulinidæ Limestone consists of three parts. The lower part is dark-gray in color and contains small black cherty nodules along bedding planes. The middle part is mostly of light-gray color and more pure. The upper part gradually becomes impure, swine and black in

* Received for publication in June 1936.

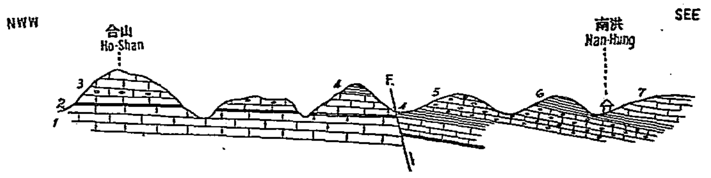

Fig. 1. 1-5 Maokou Limestone: 1. Fusulinidæ Limestone, 150 m±, 2. Coal Seam with pyrite-bearing Sandy Shale at base, 1-4 m±, 3, *Lyttonia* Cherty Limestone, 150 m±, 4. Black, Well Bedded Siliceous Rock, 50 m±, 5. Black, Well Bedded Cherty Limestone, 65 m±. 6. Lungtan Series, Black Siliceous *Gastrioceras* Shale, 60 m±. 7. Lower Triassic Thin Bedded Limestone, 300 m.

color. This limestone is very rich in foraminifera. Brachiopods and corals may also be found. The fusulinidæ has been determined by Mr. S. Chen; the list is as follows:

Pseudofusulina sp.
Pseudofusulina deprati Ozawa
Pseudofusulina douvillei Colani
Pseudofusulina sp.
Neoschwagerina sp.
Neoschwagerina craticulifera Schwager
Neoschwagerina simplex Ozawa
Neoschwagerina douvillei Ozawa
Doliolina lepida Schwager
Verbeekina verbeeki Geinitz
Yaberina sp.
Sumatrina sp.
Colania? sp.
Eoverbeekina?

The base of this limestone is not exposed in the surveyed area and its exposed thickness is about 150 m.

The Coal Seam is made up of semi-anthracite coal about half a meter thick and underlain by a bed of gray sandy shale with pyrite grains. This shale lies disconformably upon the Fusulinidæ Limestone, it is hard and compact, with great resistibility to weathering, often with a notable color of red brown; and then it may be a good indication of coal. The total thickness is 1-4 m.

Upon the Coal Seam there comes the *Lyttonia* Cherty Limestone. It may be divided into three parts by their petrographical character and their faunal elements. The lower part contains thick-bedded limestone with small cherty nodules. Among the brachiopods, *Lyttonia* and *Productus* are easily seen. The middle is chiefly of thin-bedded limestone, impure, rich in cherty nodules and sheets of irregular shape between bedding planes. This part is full of small brachiopods and an *Orthoceras*-like sponge, *Amblysiphonella asiatica* Yü frequently occurs. The upper part of this limestone becomes massive and thick bedded with large cherty nodules along bedding. *Waagenophyllum* and *Wentzelella* are frequently found. The thickness of this limestone is about 150 m.

The black, well bedded, siliceous rock disconformably lies on the *Lyttonia* beds. The lower part is largely composed of black thick-bedded siliceous rocks, very rare in light color but often red colored in bedding planes due to iron coating. Foraminifera are very poorly preserved. The upper part includes thin-bedded siliceous rocks inter-bedded with clayey sandstone and sandy shale. In the beds of sandstone and shale *Walchia*, Brachiopods, *Gastrioceras*, Cephalopods and Trilobites are easily found. This bed is less resisting to weathering and forms smooth low hills. The outcrop is mostly covered by soils. The thickness is about 50 m.

The black, well bedded, cherty limestone is continuously deposited on the black, well bedded, siliceous rocks and is about 65 m. in thickness. It is essentially composed of black well bedded and thin-bedded impure limestone with irregular cherty bands along bedding planes. Foraminifera appear abundantly but not well preserved. Corals, sponges and brachiopods are very abundant in this limestone. Among the corals *Waagenophyllum* is easily recognized.

Upon the Maokou Limestone there unconformably lies the black, siliceous, *Gastrioceras* shale that is in turn overlain unconformably by Lower Triassic thin-bedded limestone. The *Gastrioceras* beds also contains plants fossils, equivalent to the Lungtan Series near Nanking and belongs to the Upper Permain age.

Near the City of Ts'ienchianghsien, the Maokou Limestone is underlain by the Chihsia Limestone rich in Corals *(Tetrapora, Polythecalis* and *Michelinia)*; *Doliolina Claudai* occurs also in the lower part. Under the Chihsia Limestone lies the Chuanshan Limestone in which *Schwagerina princeps* is the dominant fossil.

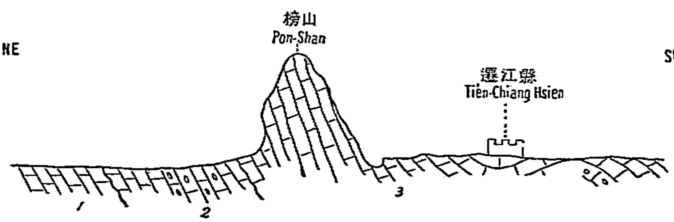

Fig. 2. 1. Chuanshan Limestone — gray and thick bedded with *Schwagerina princeps, Triticites parvulus, Quasifusulina longissima.* 2. Chihsia Limestone — dark gray and well bedded, rich in chert with *Michelinia, Tetrapora, Polythecalis, Doliolina Claudai.* 3. Maokou Limestone — light gray, thick bedded to massive, sometimes with chert, containing *Verbeekina verbeeki, Pseudofusulina deprati, Neoschwagerina douvillei, Pseudodoliolina* sp., *Pseudodoliolina Ozawai, Neoschwagerina megaspherica, Waagenophyllum, Wentzelella.*

The karst landscape in the area drained by the Left River or Tsoho (左河) and Ningming River (寧明河) is largely formed by the Maokou Limestone, only a small portion of the karst formed by the Huanglung Limestone, Chuanshan Limestone and Lower Triassic Limestone. Evidently the Maokou Limestone in this area is also well developed. The upper part of this limestone is, however, largely eroded away, the remaining portion is still about 200 m. to 300 m. in thickness. It lies disconformably and directly on the Chuanshan Limestone, where the Chihsia Limestone is not found between them.

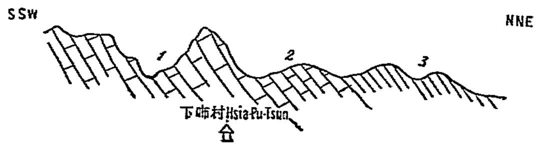

Fig. 3. 1. Chuanshan Limestone—Dark-gray thick-bedded limestone with *Qusifusulina longissima, Pseudofusulina prica* and Simple corals. 2. Maokou Limestone—gray and light-gray with *Neoschwagerina.* 3. Purple shale, Middle Triassic.

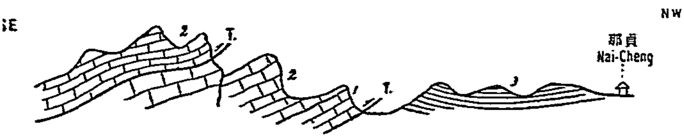

Fig. 4. 1. Chuanshan Limestone—gray thick-bedded with *Pseudofusulina kraffli* Staff. 2. Maokou Limestone—whitish gray, massive, with *Neoschwagerina simplex, Neoschwagerina douvillei, Pseudofusulina* sp. 3. Cretaceous red sandstone and tuff sandstone. T. thrust.

The Maokou Limestone in this area is largely composed of light colored limestone of thin-bedded to massive character. The lower thin-bedded part is interbedded with cherty bands. The middle part is thick-bedded to massive, rich in fusulinidæ; it is widespread forming karst landscape of extensive scale.

The fusulinidæ found in this part of Maokou Limestone and determined by Mr. S. Chen are as follows:

Cancellina schellwieni Deprat
Verbeekina verbeeki Geinitz
Pseudofusulina sp.
Neoschwagerina simplex Ozawa
Neoschwagerina douvillei Ozawa
Neoschwagerina craticulifera Schwager

Neoschwagerina sp.
Neoschwagerina minoensis? Deprat
Pseudofusulina douvillei Colani
Verbeekina sp. nov.
Doliolina lepida Schwager
Parafusulina japonic? Cumbel
Pseudodoliolina ozawai Yabe and Hauzawa
Sumatrina annæ Volz
Sumatrina sp. nov.
Sumatrina annæ var. *stricta* Deprat.

On the top of this part there occurs a bed of red shale, hard and compact, rich in iron (hematite) probably equivalent to the pyrite-bearing shale, under the coal seam of Hoshan, Ts'ienchianghsien. Pyrite after a long time of weathering changed to hematite and the coal seam was eroded away, not present in this area. This red iron shale follows closely the Maokou Limestone. Having seen the pebbles and débris beside the foot-path, we may conclude that the Maokou Limestone is not far away.

Unconformably above the red iron shale frequently lies the Triassic Limestone. This Limestone is more siliceous than the Maokou Limestone and contains *Schwagerina*-like concretions showing no septa.

Only near the city of Pinghsinghsien (凴祥縣) the upper part of the Maokou Limestone may be observed. It is essentially a black impure thin-bedded limestone interbedded with cherty bands. *Lyttonia*. Foraminifera, and *Orthoceras*-like sponge are very abundant. Upon this formation unconformably lies the *Gastrioceras* Shale, which carries *Gastrioceras*, *Oldhamina?*, and plant fossils. Among the plants fossils Dr. H. C. Sze recognizes the following species:

Walchia sp.
Tæniopteris cf. *multinervis* Weiss
Pecopteris sp.

The *Gastrioceras* was examined by Mr. C. C. Tien who considered it as belonging to a new horizon between *Orthoceras* and *Gastrioceras* Beds and equivalent to the Upper Permain of Timor and India.

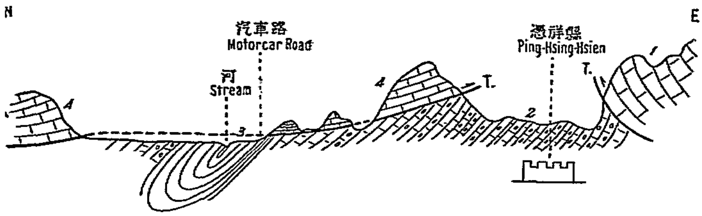

Fig. 5. 1-2 Maokou Limestone. 1. Fusulinidæ Limestone — gray thick-bedded with *Neoschwagerina*. 2. *Lyttonia* Cherty Limestone — Black impure thin-bedded interbedded with cherty bands, containing *Lyttonia*, Foraminifera, *Orthocreras*-like sponge, etc. 3. Upper Permain *Gastrioceras* Shale, with *Gastrioceras*, plants, *Oldhamina* etc. 4. Lower Triassic Limestone — shale with pelecypods at base, thin-bedded limestone in middle, and thick-bedded siliceous limestone on top.

The Maokou Limestone in Southern Kwangsi, so far as we know, is better developed than any other known places in Southern China. It is disconformably underlain by the Lower Permain Limestone (Chihsia Limestone) and unconformably overlain by the Upper Permain (Lungtan Series). And then from the superposition, we may consider the age of the Maokou Limestone to be Middle Permain.

CONFIRMATORY EVIDENCE OF PLEISTOCENE GLACIATION FROM THE HUANGSHAN, SOUTHERN ANHUI*

BY

J. S. LEE (李四光)

(Academia Sinica)

A body of facts gathered a few years ago from the Lower Yangtze Valley compelled the writer to draw the conclusion that glaciation occurred in parts of this region some time during the Pleistocene period. So radically this explanation differs from the "orthodox" view that "scientific scepticism" has tended to do all what it can to keep such a disturbing interpretation in the background. A few geologists however may have been anxiously waiting for further evidence. For their consideration I venture to offer the present case. In this short note I shall endeavour to call attention to a number of crucial points which have a fundamental bearing on the problem, leaving the detailed consideration to a later occasion.

According to the 'New Atlas of China' (Ting, Wong and Tseng) the position of the Huangshan is located at about long. 118° 8′ E. and lat. 30° 10′ N. Barometric readings by different observers vary considerably as regards its altitude. The figures recorded by Dr. Lishouhua appear to represent the happy mean. According to this observer the Lienhuafeng which is the highest peak, reaches a height of 1,820 m. above sea level. If we take Tienmenkan and Sihaimen as representing the minimum height of the top of the mountain, then we may say that the altitude of the Huangshan minus the few peaks varies between 1,500 and 1,660 m. These figures are of course only provisional.

The whole mountain is almost entirely composed of a course-grained granite with large phenocrysts of feldspar, irregularly shaped quartz, some hornblende and a little black mica. Fine-grained granite of similar

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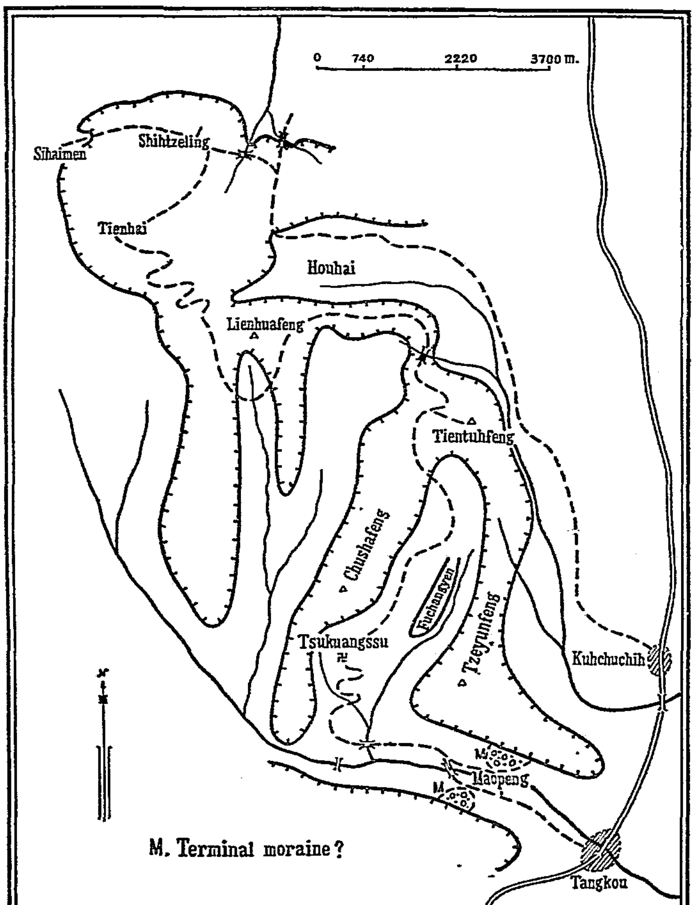
* Received for publication in June 1936.



A sketch showing the general plan of sculpturing of the Huangshan.

composition occasionally occurs. Whether it represents a marginal facies or a later intrusion into the main body of the porphyritic granite is yet unknown. Usually the Huangshan granite is traversed by vertical or nearly vertical master joints. As a consequence, huge prisms of rock are liable to be detached at a time from the mountain by natural agencies of destruction leaving fantastic peaks looming high and carvernous precipices forming the walls of the cañons which rapidly head their way into the mountain from all sides. In these circumstances it may be easily understood that the processes of destruction of former geomorphological features have been rigorously at work. Few would therefore suspect the existence of any trace of ice-action in such an area, if it had ever taken place.

It is by mere chance that certain glacial features have been preserved. The most striking of these were found in the U-shaped valley above Tsukuangssu. This U-valley is walled on both sides by massive granite with the Chushafeng standing on the west and Fuhchangyen on the east, and carries a meagre stream which has not yet eroded the valley to the extent as to destroy its U shape. It hangs to the depression of Tsukuangssu lying in front of it. Close examination of the rocky walls on both sides of the valley shows that the even and smooth surface of the walls is not entirely due to the peeling off of huge slabs of granite along its master joints, but is at least partly due to a process of abrasion traceable to a disappeared glacier or glaciers.

The evidence of glacial erosion is particularly clear at a point less than a mile above Tsukuangssu where the ice-abraded and striated surface is well preserved in the lower part of the eastern wall of the U-valley already referred to (about 960 m. in altitude), and is readily visible from the foot-path along which visitors usually climb the mountain. Fairly deep and broad markings of variable length are arranged parallel to each other on an abraded surface of the granite. They are not strictly horizontal, but are slightly inclined towards the lower part of the valley. The latter fact indicates the direction of flow of the ice. In this particular part of the granite the rock is fortunately free from joints, cleavages or any other kind of structural habit that might possibly give rise to pseudo-glacial striation. At any rate, the nature of the striæ and the form of the abraded surface on which they are developed are so characteristic of glacial origin that such possibilities hardly need to be considered.

The effect of ice-abrasion becomes even more manifest when we come to consider the projected part of the rock-surface which forms the upper rim of the abraded area, and stands out in strong relief. The lower edge of this overhanging feature has been obviously ground up by some forcible mechanical agency that operated against the rock-surface below it. That this salient feature runs parallel to the striæ is also a fact of some significance. If we compare the nature of the rock-surface below this line of demarcation and that above it, it will be at once realized that the glacier which effected this abrasion and wrought out the markings maintained its upper limit for some time at the level of the lower edge of projection. Above this level the wall of the valley is generally less smooth, though still fairly even as a whole. In the higher part of the rocky wall obliterated horizontal striæ are in places recognizable with difficulty. They are however so faint that it would be rush to regard them as of glacial origin.

A few markings of a similar kind, but less distinct, were found on a rock-surface at Tienhai, one of the areas of mild relief developed on the top of the northern part of the mountain. This together with the cirque-like depressions in the neighbourhood of Shihtzeling apparently formed vast snow-fields in glacial time. The local topographical features together with the direction of the few striæ suggest that fairly large glaciers were sent from these places down to the northern side of the mountain. Overflow of ice-tongues found their way however to the south-east as indicated by the gaps on the south-eastern side of the cirque-like areas.

No less important is the evidence offered by a striated boulder found in one of the side-valleys leading to Houhai behind Tientuhfeng. The rock of which the boulder is composed is a relatively fine-grained granite. It was found among a number of subangular boulders of the ordinary coarse variety of the Huangshan granite, and was half buried in a reddish sandy clay. None of the other boulders however shows any scratches, though they generally have one or two faces polished.

The boulder under consideration has not yet lost its angularity. Two opposite faces are polished and scratched. One of these faces is more strongly worn off than the other as shown by its slightly convex shape. Three sets of striæ are noticeable on each of the polished faces. In each case one set runs nearly parallel to the long axis of the boulder, another almost perpendicular to it, and the third oblique to it. The oblique sets on the two faces do not agree in direction. On the slightly convex face the first set of striæ agrees in direction with the long axis of the boulder. They are barely visible in the apical and basal parts of the triangular surface under suitable incident light. The other two are distinct enough as to show that they are true scratches. The other face is not only striated, but indented, a phenomenon often noted among glacial boulders. These facts point to the conclusion that the boulder in question achieved a steady movement against some gritty but fairly even surface being all the time firmly held by some agency which at the same time applied a considerable pressure. Nothing but a glacier, perhaps of a fairly large size, would answer these requirements.

Moraine-like material is often met with in the foot-hills and valleys on the southern side of the Huangshan, though by no means as extensive as on the northern side. Sometimes it is covered by the red clay, but more often by rock debris and gravels. From the village of Kuhchuchih to that of Tangkou beds of whitish or reddish tough clay, exceedingly fine in quality, are now and then intercalated with the boulder clay being overlain by a rudely stratified, detritus material, In places the tough clay is apparently free of pebbles, and is finely laminated with the laminæ alternately whitish and reddish in colour and finer and coarser in texture. Most of the coarse grains consist of angular particles of quartz, but a few are of fragments of feldspar. The thickness of each individual lamina varies from a fraction of a millimetre to a little over two millimetres. These varved clays were apparently deposited in a local lake which received its water from the glaciers under varying seasonal conditions. In some cases a number of successive laminæ are distinctly deeper in colour than those succeeding. Such deep coloured bands appear in regular intervals suggesting the effect of minor climatic cycles during the time of their deposition.

The puzzling problem that calls for attention arises from the fact that these varves and their associated boulder clay obviously cannot be produced by the small and probably decaying glaciers such as the one which marked the rock-surface above Tsukuangssu. If they had originated from glaciation, the glaciers must be of large size, and came down to an altitude of no more than 300 m. above sea level. The provisional explanation is that glaciation occurred in several stages, the oldest of which has left no geomorphological record because of the erosion which had subsequently taken place. Some light may be shed upon this problem through comparative studies in other areas.

Explanation of Plate I

PLATE I.

Upper figure: A U-shaped valley developed above Tsukuangssu on the southern side of the Huangshan being slightly eroded at the bottom by a small stream. Left side: Chushafeng; right side: Fuchangyen.

Lower figure: Lower end of the same valley showing its overhanging position as viewed from Tsukuangssu.

(趙太侔先生攝影)

Explanation of

Plate II

PLATE II.

Figure 1. A portion of the ice-abraded surface preserved in the lower part of the left wall of the U-valley shown in Plate I with parallel, coarse striæ slightly inclined down-stream.

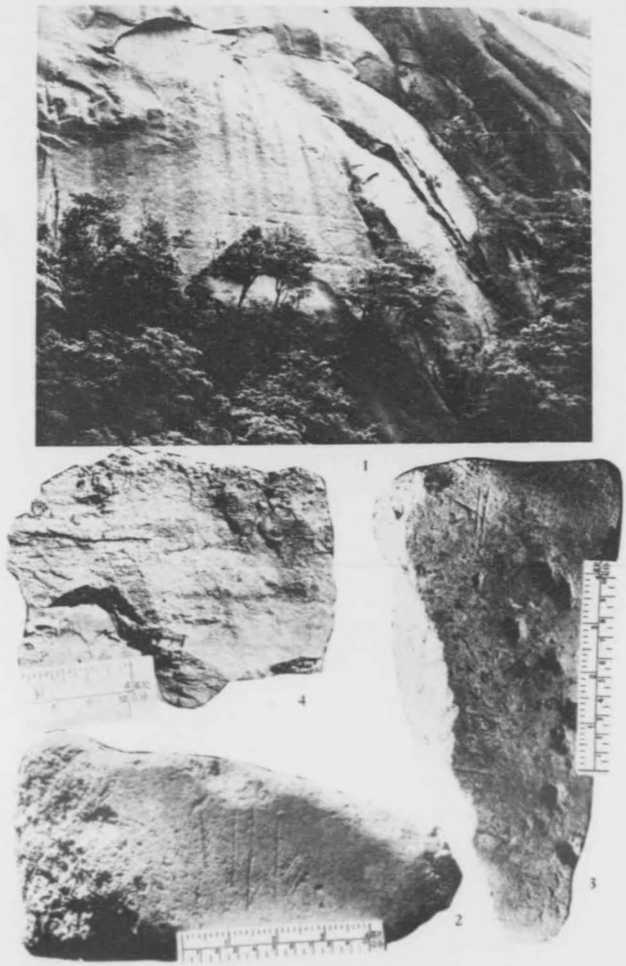
(趙太侔先生攝影)

Figure 2. A polished and scratched boulder found in a valley to the north-east of Tientuhfeng. Note the three sets of striæ, the earliest of which is almost unrecognizable in this photograph, and also the strong weathering suffered by a part of the granite boulder since the process of polishing and scratching took place.

Figure 3. The back-face of the same boulder as shown in fig. 2 with several sets of striæ and indentation.

Figure 4. A specimen of the varves intercalated with the boulder clay exposed at Tangkou (See also Pl. III. lower figure).

(以上三圖孟憲民先生攝影)


1
4
3
2

Explanation of Plate III

PLATE III.

Upper figure: Partial view of Tienhai looking towards Lienhuafeng from the east. The gap below Lienhuafeng on the left side of the picture has been largely produced by a stream which has attacked this cirque-like depression from the south-eastern side. Glacial striæ are preserved in one place on the hummocky surface of the granite. They show the movement of the ice directed to the west or west by north.

Lower figure: A section at Tangkou showing varves (white) intercalated with moraine-like material being overlain by a thick deposit of stratified rock-debris and gravels. The latter are probably of fluvio-glacial origin.

（趙太侔先生攝影）

ON A NEW CHASMATOSAURUS FROM SINKIANG*[1]

BY

C. C. YOUNG (楊鍾健)

(National Geological Survey of China)

All the triassic reptiles so far described from Sinkiang were Dicynodontia. It is therefore of special interest to describe from the same formation a completely different, carnivorous type belonging to the Sub-order Pelycosimia of the Thecodontia. The specimen was discovered by Prof. P. L. Yuan in the same Fuyuan area as the Dicynodont forms, but its exact horizon still remains uncertain. The colour of the bone, however, and the degree of fossilization, are the same as in the *Lystrosaurus murrayi* described before[2]. The preparation of the fossil was also made in the Cenozoic Research Laboratory under my care.

Sub-order PELYCOSIMIA v. Huene

GENUS CHASMATOSAURUS Haughton

Chasmatosaurus yuani Young (sp. nov.)

Material: The anterior portion of a skull and its lower jaws with a considerable number of teeth still more or less in natural position were prepared from the same block, but found in very disturbed condition, including a set of vertebræ, a great number of ribs, a whole series of slender rib-like bones, the distal end of a humerus, two ulnæ, one radius, two ilia, two tibiæ, two fibulæ and many isolated hand and foot bones. With exception of the humerus, an ulna and some hand bones (characterized chiefly by a considerably smaller size, see below) all these pieces belong surely to a single individual.

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* Received for publication in March 1936.

1 The author is deeply indebted to Prof. F. Broili in Munich and Dr. C. L. Camp in California for their kind criticisms.

2 Yuan, P. L. and Young, C. C. On the Occurrence of Lystrosaurus in Sinkiang. Bull. Geol. Soc. China, Vol. XIII, No. 4, 1934.

The bones, almost black in colour and strongly mineralized, were embedded in a red, unusually hard sandy clayish matrix. With exception of the skull on which the two maxillæ are somewhat compressed laterally, they are not disformed. The good preservation of these pieces, contrasting with the fact that a large part of the cranium and several parts of the skeleton are missing, seem to indicate that either a portion of the fossil has been left unexcavated in the field, or is still kept unpacked in the boxes brought from Sinkiang by Prof. Yuan.

As it was in the case of the Dicynodontia, the preparation of this material proved to be a difficult task, although the matrix was not so hard as in the previous case. The bones were scattered in a most irregular manner and it required a long time to connect all those pieces. There still are a number of fragments, mostly broken pieces of vertebræ and ribs, left unconnected.

Description. Essentially the form is characterized by a remarkable downward bending of the tip of the muzzle, and also by the laterally compressed and finely serrated teeth of both upper and lower jaws which show the utmost similarity to *Chasmastosaurus van hœpeni* Haughton, a Pelycosimian recently described by Broili and Schröder[1].

SKULL

Anterior (pre-frontal) part only preserved. Premaxillæ, maxillæ nasalia complete. Prefrontalia, frontalia, palatine and pterygoid represented only by their anterior portion. The specimen is somewhat disformed, and the maxillæ laterally compressed. The outlines of the bones generally are difficult to locate either due to obliteration of the sutures, or due to breakage of the specimen.

The most characteristic feature observable on the specimen is a downward bending of the premaxillæ in exactly the same way as in

1 Broili, F. and Schröder, J. 1934. Über *Chasmatosaurus van hœpeni* Haughton. Sitzungsberichte der Bayerischen Akademie der Wissenschaften. Math. u. Natur. Abt.

Chasmatosaurus van hœpeni. This incurved part of the muzzle is even a little longer than in the S. African species. Posterior boundary of the premaxillary with the maxillary marked by a faint suture just above the ninth tooth, counting backwards. Nasal opening large and set more posteriorly. The upper part of the nasal opening is broken, this fact indicating a curvature of the nasalia.

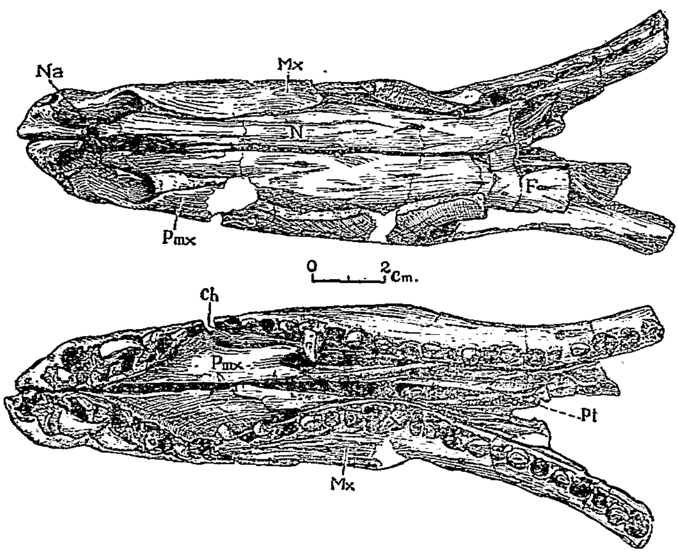

Fig. 1. *Chasmatosaurus yuani* Young (sp. nov.). Skull fragment in top and palatinal aspect. Ch. Choana, F. Frontal, Mx. Maxilla, N. Nasal, Na. Nasal opening, Pmx. Premaxilla, Pt. Pterygoid.

On account of the lateral compression of the fossil, and of the broken condition of the posterior part of the muzzle, the exact shape of the maxillæ can not be ascertained. But judging by the reconstruction of *Chasmatosaurus van hœpeni* illustrated by Broili and Schröder (1934, p. 227, fig. 1), the broken part visible on our specimen above the upper jaw represents the anterior boundary of the preorbital foramen. The nasal bones are complete, but their posterior boundary with the frontalia is missing.

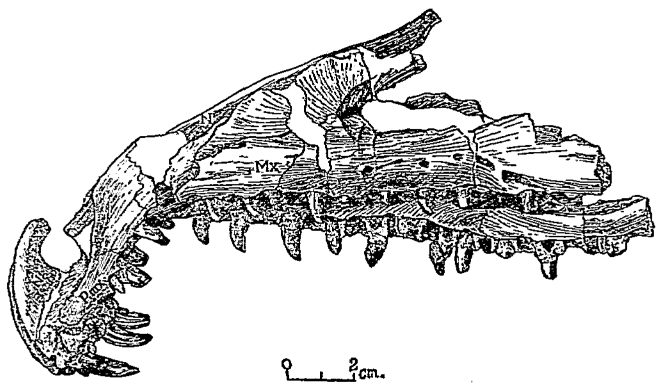

Fig. 2. *Chasmatosaurus yuani* Young (sp. nov.). Skull fragment in left side view.

On the whole, it seems that the muzzle was slender and did not expand so strongly in its posterior part as in the African form. This character is mostly noticeable in the premaxillary region which is free from lateral crushing.

Observed in palatal view, the skull is characterized by the posterior location of the choana, which begins only *behind* the bent part of the muzzle, (in *Chasmatosaurus van hœpeni* the anterior part of the choana extends on the bent portion of the premaxilla). Due to the crushing of the specimen, the exact shape of the choana and of the vomer is not recognisable. Pterygoid bones preserved but incomplete. Palatal bones either concealed, or destructed by the compression of the maxillary area.

In size, the Sinkiang form is much smaller (by about two fifth) than the Karroo species, at least as far as the breadth of the muzzle is concerned. It was also apparently a long and slender muzzled type.

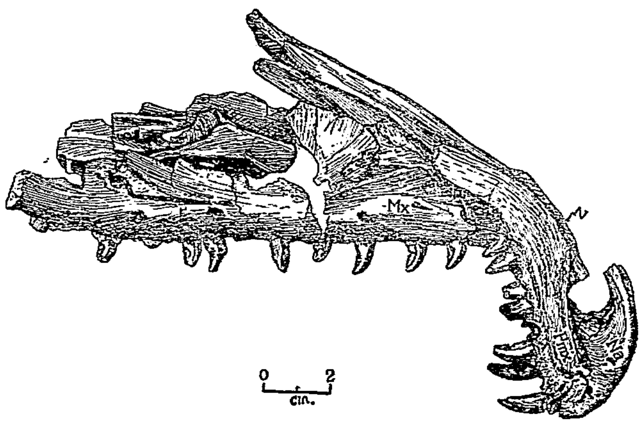

Fig. 3. *Chasmatosaurus yuani* Young (sp. nov.). Skull in right side view.

Lower Jaw

Both lower jaws are preserved but mostly broken behind the dentale.

In proportion to the skull, the mandibula looks rather massive, slightly convex externally and flat internally. 8-9 foramina for the nerves are clearly expressed on the external side. Along the anterior inner side, a shallow groove extends backward and disappears below the toothrow. Suture between the dentale and the spleniale obliterated. Symphysial area roughly granulated labially and lingually. On the whole, the lower jaw of our form seems to be more massive than that of *Chasmatosaurus van hœpeni.* Its depth increases also much more rapildy backward (cf. measurements, below). With much smaller upper jaw and muzzle, the Sinkiang *Chasmatosaurus* nearly reaches the same size as the Karroo species with its lower jaw.

Dentition

a) *Upper teeth.* In our specimen the teeth are preserved or indicated on both upper and lower jaws. But since the maxillæ are broken on both sides posteriorly, the total number of the upper teeth is uncertain. There are 32 teeth alveoli visible on the right side and 30 on the left side. Half of the teeth only are still embedded in the bone. I agree fully with the idea of Broili and Schröder, that the loss

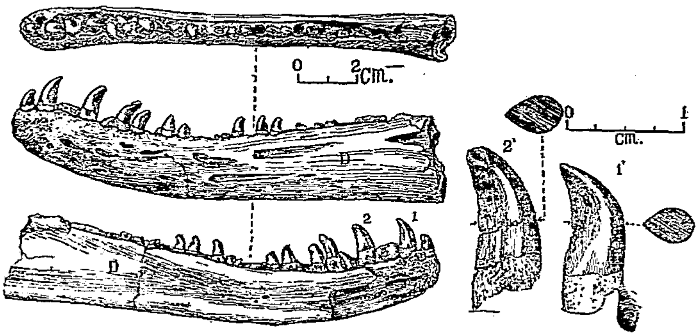

Fig. 4. *Chasmatosaurus yuani* Young (sp. nov.). Left lower jaw in upper outer and inner views. D. Dentary. 1 and 2. Two teeth enlarged on the right side of the figure.

of the others occurred largely postmortem. All these teeth are sub-equal in size, but a differentiation is already weakly indicated on them: the 8 premaxillary teeth are stronger than those set on the maxillæ. Most probably, the total number of the teeth was approximately 35 on each side, similar to the Karroo species.

b) *Lower teeth.* On the lower jaw, the complete toothrow is preserved on both sides, only a few of the teeth are missing and indicated by a hole in the dental bone, 24 teeth on each side, that is the same number approximately as in *Chasmatosaurus van hœpeni*[1]. With the exception of the first tooth which is small, the two or three teeth following the first one are considerably larger. Then the size reduces

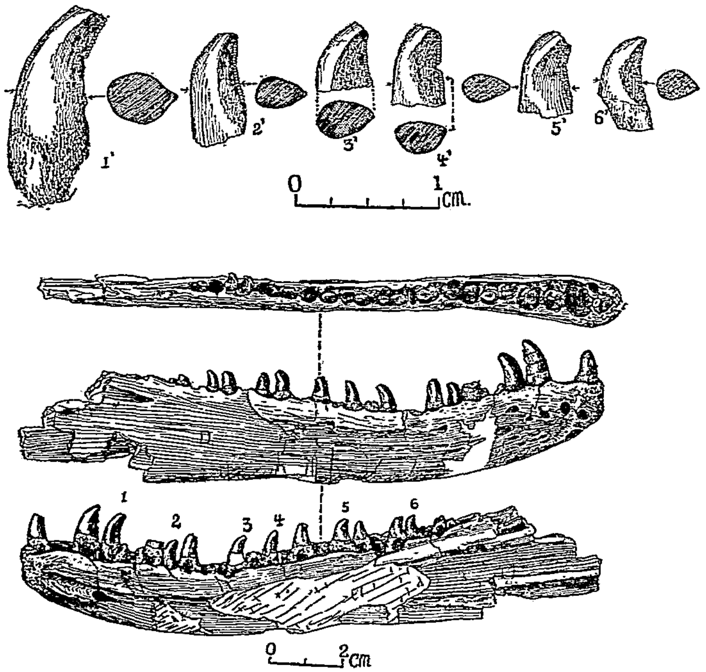

Fig. 5. *Chasmatosaurus yuani* Young (sp. nov.). Right lower jaw in upper, outer and inner views. 1,2,3,4,...6. Some teeth shown on a larger scale on the upper part of the figure.

1 In figure 1 of *Chasmatosaurus van hœpeni* given by Prof. Broili, there are 22 teeth for a left lower jaw. In figure 8, 24 teeth for a right lower jaw.

gradually posteriorly, the last few teeth being the smallest. This character is not clearly expressed on the figures given of *Chasmatosaurus van hœpeni.*

c) *Structure of the teeth.* By their detailed structure the teeth of our specimen agree with the description given by Broili and Schröeder for *Chasmatosaurus van hœpeni.* Anterior serration mostly well indicated, but replaced gradually in other cases by a smooth edge, and finally by a smooth surface. A fusion between the root of tooth and the bone of the jaws was also observed in some cases, this fact indicating that the teeth of our form were acrodont as in the African form.

Size of both upper and lower teeth about the same as in *Chasmatosaurus van hœpeni.*

d) *Pterygoid teeth.* Beside the teeth set on the præmaxilla, maxilla and dentale a large number of smaller teeth is observable on the pterygoid, mostly indicated by small cusps only. These pterygoid teeth seem to be more anterior in their position than in *Chasmatosaurus van hœpeni.*

Dimensions:	Dimensions of *Ch. yuani*	Same dimensions of *Ch. van hœpeni* using fig. 1 and 8 of Broili and Schröder.
Length of the skull from the tip to the posterior margin of 32nd. tooth....	............185 mm	...................231 mm
Length of the premaxillæ along the teeth 1-8 (the bent part of the muzzle)..	............53 mm	...................69 mm
Breadth of the muzzle (across the 3rd. tooth)	............30 mm	...................49.5 mm
Breadth of the skull between the premaxillæ and maxillæ	.............40 mm	...................61.5 mm
Length of the lower jaw from the tip to the posterior margin of the last tooth	Left 126 mm; Right 119 mm	Left ...153 mm; Right 168 mm
Depth of the jaw between 3rd. and 4th. tooth	Left 21.4 mm; Right 20 mm	Left ...21 mm; Right 21 mm
Depth of the jaw behind the last tooth	Left 27.5 mm; Right 28 mm	Left ...27 mm; Right 31 mm

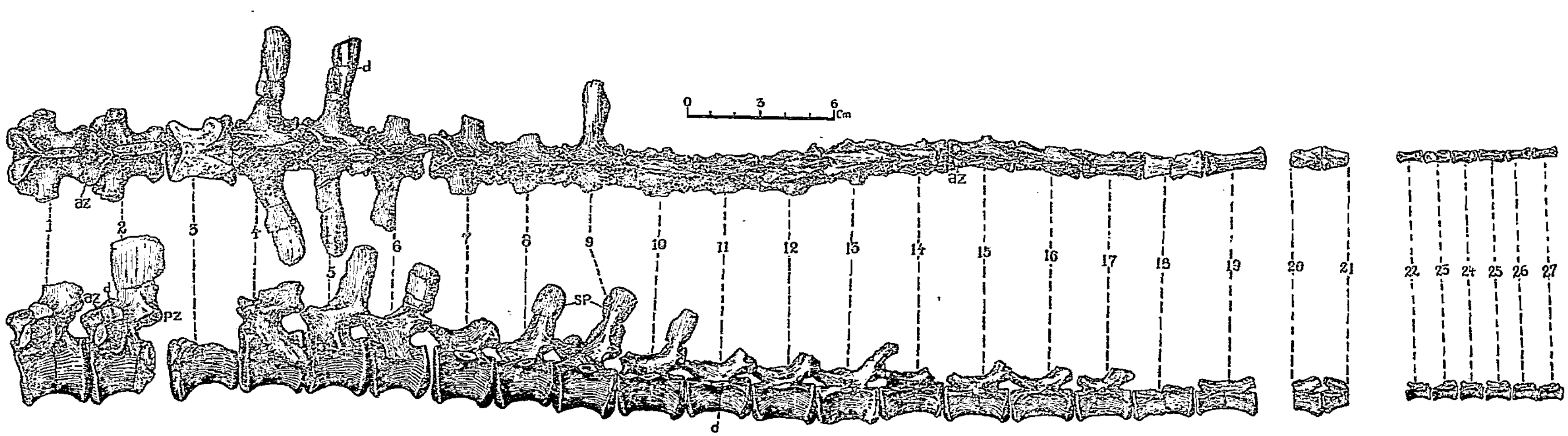

Fig. 6. *Chasmatosaurus yuani* Young (sp. nov.). The preserved vertebræ in dorsal and lateral views. Az. Prezygapophysis, D. Diapophysis, Pz. Postzygrapophysis, sp. Spinal dorsalis.

POSTCRANIAL SKELETONS

The postcranial bones are only incompletely represented. With the exception of four vertebræ, a humerus, a doubtful ulna, and a few associated fragments of carpal and digital bones most of which are considerably smaller in size, they fit well together in size and shape and evidently belong to the same individual.

Vertebræ. 31 vertebræ are preserved. With exception of the four vertebæ (see below), these certainly belong to *Chasmatosaurus.* But nearly all of them were found isolated, so that their real connection is not sure. According to the size and to the general structure, we have sorted them as shown in text-figure 6 numbered from 1-27. Nos. 1-10 may best be regard as pre-, and nos. 11-27 as post-sacral vertebræ. All of them are typically amphicelous in structure, but not deeply excavated. In most cases, the dorsal spina and the diaphysis were broken. In many of them the various facets can be recognized.

Ribs and rib-like bones. Besides the vertebræ, our material includes a large number of complete and fragmentary slender bones. Many of them are clearly ribs usually well indicated, and some times less differentiated "head". In the best preserved pieces, the curvature of the rib is still well preserved. The cross-section of the rib is flattened in the upper portion of the bone as result of the presence of an anterior and a posterior grooves. Further on it becomes oval or round. In some specimens, the distal part is flattened again.

More of a puzzle is another large series of "rib-likes" elongated bones, thin, round in cross-section, curiously undulated or contorted, showing no trace of head, but only a weak excavation on both ends. Average thickness, 6 mm. Average length, 140 mm. On a piece of rock, three or four of these peculiar bones were found associated in close parallel position, 3-4 mm. apart from each other. They might well be interpreted as representing some ossified elements of the animal.

Slightly similar but probably quite different from these "ventral ribs?" are two elongated bones (one of them complete, see fig. 8), slightly contorted also, but at a lesser degree and characterized by a definite shape: One end thicker than the other. By their general

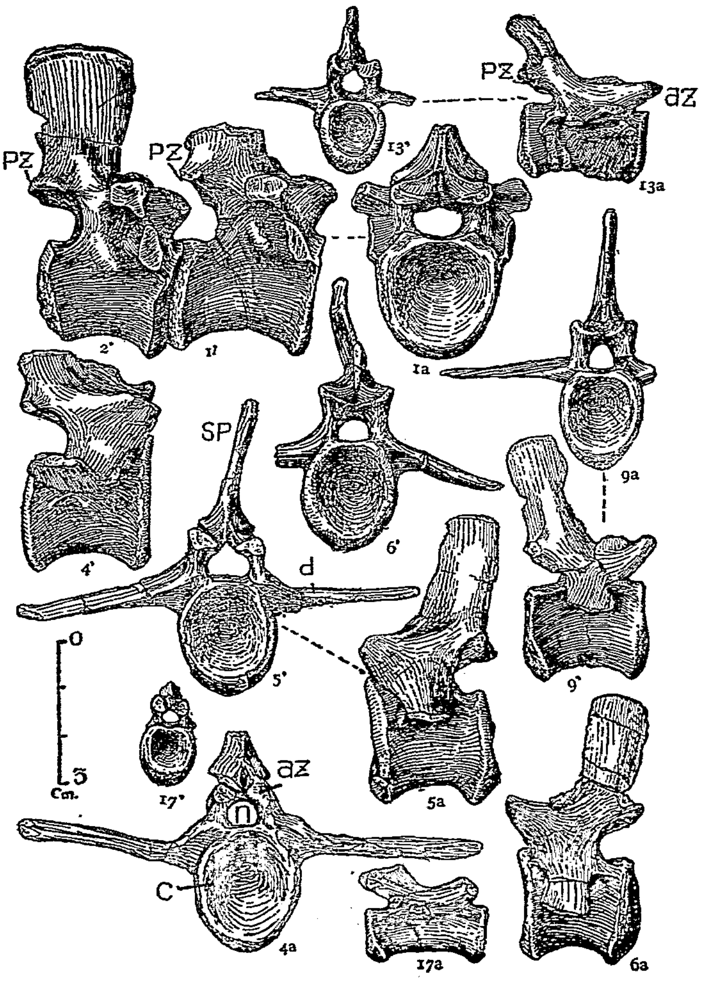

Fig. 7. *Chasmatosaurus yuani* Young (sp. nov.). Some vertebræ shown in lateral and anterior views. C. Centrum, n. Nerve canal. Other abbreviations see fig. 6. The numbers followed by an apostrophe"'" correspond to those of Figure 6.

outline, these bones resemble the "cornua branchialia" as figured and described by Broili and Schröder for *Chasmatosaurus van hœpeni*. Since however our specimens were not found in association with the skull (the posterior part of the skull is unknown) this interpretation is not certain.

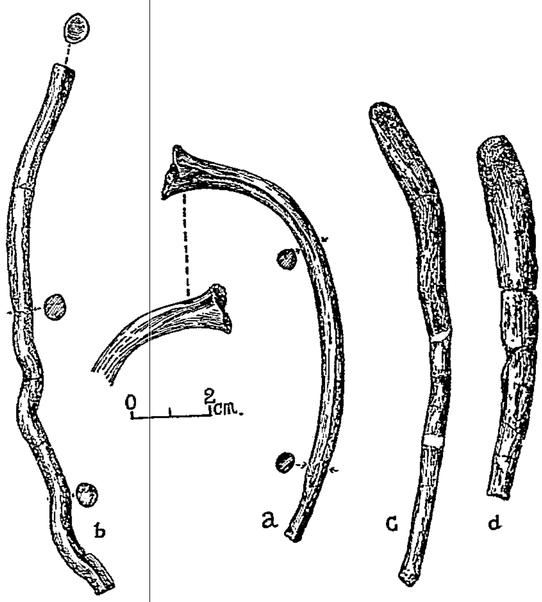

Fig. 8. *Chasmatosaurus yuani* Young (sp. nov.). a. Rib, b. Problematical ventral rib, c. and d. ?Cornua branchialia.

Radius and ulna. No trace of the presence of Pectoral girdle and humerus. The radius and ulna are represented for the right side only. But are complete, and sub-equal in length. General appearance rather stout. The *radius* has a very well rounded proximal end. From there the bone thins out gradually up to a point corresponding to two thirds of the total length of the bone; and then it expands considerably up to the distal end. Distal portion of the bone weakly excavated ventrally, and distal end of epiphysis is rounded triangular in distal view. In the middle part of the diaphysis a distinct postero-lateral ridge is observed. Proximal end of *ulna* massive, but with weakly developed olecranon area. The proximal end of the bone is semi-circular. Distally the ventral face

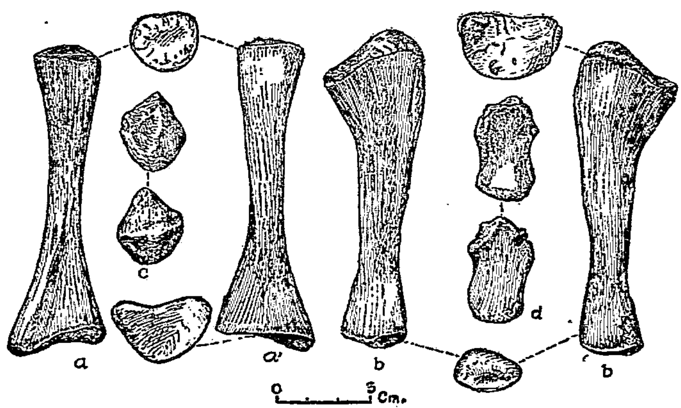

Fig. 9. *Chasmatosaurus yuani* Young (sp. nov.). a. and a'. Right radius in outside and inside views, b. and b'. Right ulna in outside and inside views. Their proximal and distal ends are shown, c. Left radial, d. Left ulnare.

becomes nearly flat, but is not strongly excavated. The middle part of the bone is compressed. The shaft reaches its minimum thickness very close to the distal end. The expansion of the distal end is very weak, with ovally elongated distal end.

Radial and ulnare. Both completely preserved. They are illustrated, from the left side in text-figure 9 c and d. The *radial* is a rounded rectangular bone of irregular thickness. The articular facet with radius, central and distal carpalia are recognizable but without sharp boundaries. The *ulnare* is an elongated flat bone, with a proximal end considerably thickened. Articular facet with the intermedium very distinct.

Many of the round or square bones in our possession represent probably the intermedium, the central or other carpalia. But, in the absence of clear connections observed *in situ,* and on account of lack of material for comparison, we shall refrain from giving them a definite name.

Ilium. From the pelvic girdle, only the two ilia are preserved. They show a marked opposition between the base and the wing. The bone is extremely massive in its lower part and thins out gradually and develops posteriorly a peculiarly shaped expansion. External depression for articulation with the femur rather strong. Connection with pubis and ischium indicated by rough sutures. Above the cotyloid depression, the antero-superior border of the bone is marked by a prominent ridge developing a distinct protuberance above the middle of the depression. Further on this ridge forms the antero-superior border of the acetabulum. Then, behind the acetabulum, it vanishes into the fan-like thin elongated expansion mentioned above. On the whole the bone shows an internal convexity. Its surface on both sides is marked by a somewhat radiated structure. No trace of attachment with the sacrum can be observed.

Tibia and fibula. These bones are completely represented for both sides on our specimens. Both of them are rather elongated. On the *tibia* which is a strongly built bone, the proximal end is massive and triangular in cross-section with a small embayment on the external side. Distal end is well rounded. The *fibula* on the contrary is slender, weakly and symmetrically expanded on both ends. Shaft gently curved in a peculiarly S-shaped way.

Astragalus. Fig. 11, c. Among the tarsalia the most recognisable bone is a right astragalus, of a rather elongated shape. The

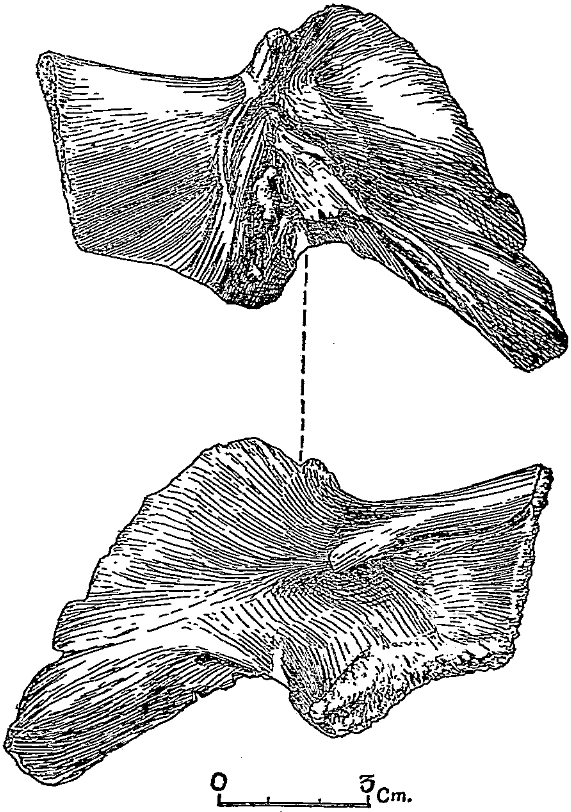

Fig. 10. *Chasmatosaurus yuani* Young (sp. nov.). Right ilium, inner and outer views.

proximal end narrow and elongated; distal portion expanded. The dorsal side is flat while in the ventral side the bone thins out and slopes down remarkably to the anterior border.

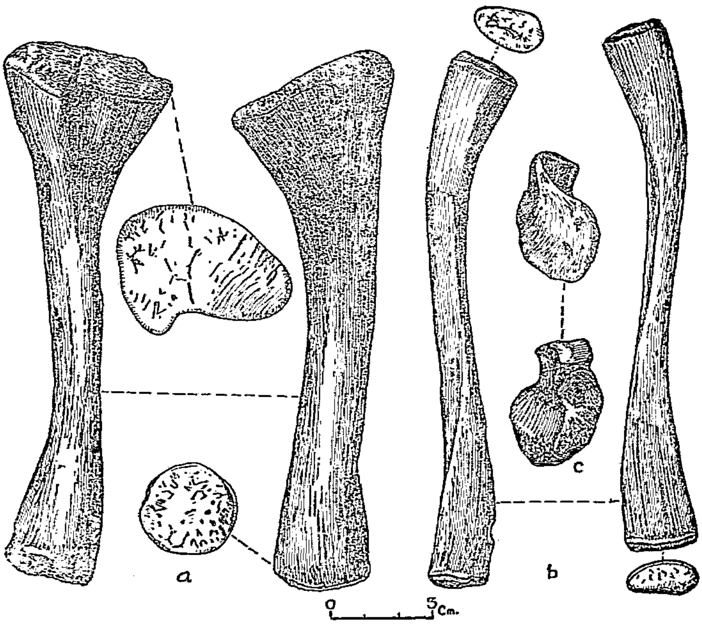

Fig. 11. *Chasmatosaurus yuani* Young (sp. nov.). a. Left tibia in two views, b. Left fibula, and c. Right astragalus.

Other tarsalia possibly represented in our collection; but not determinable immediately.

Hand and foot bones. In text-figure 12 we have tentatively arranged a series of metapodial bones, found isolated in the matrix.

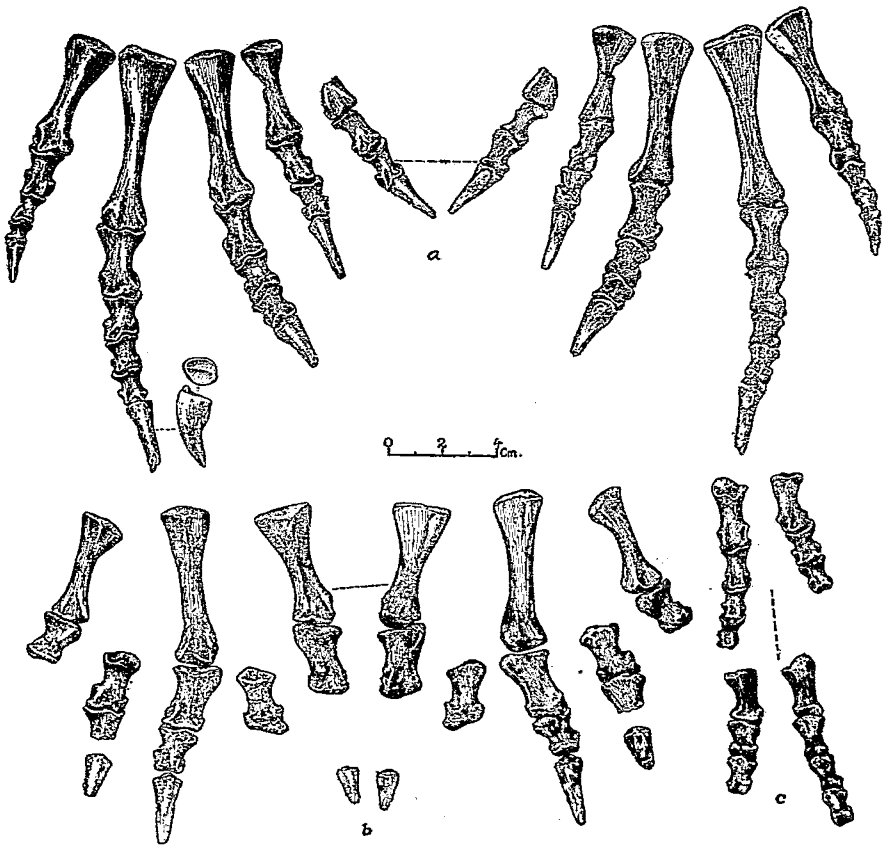

Fig. 12. *Chasmatosaurus yuani* Young (sp. nov.). Hand and foot bones. Explanation see text.

Groups *a* and *b* have about the same size and are larger than group *c*, so that *a* and *b* represent possibly the feet and *c* the hand. The ungual phalanx is characteristic, being compressed laterally with a general curved tip, a clear indication of a carnivorous reptile.

OS INCERTÆ SEDIS

Beside the above described bones there are some pieces which on account of their poor preservation and disconcerting shape we cannot determine with certainty. These specimens are illustrated in text-figure 13.

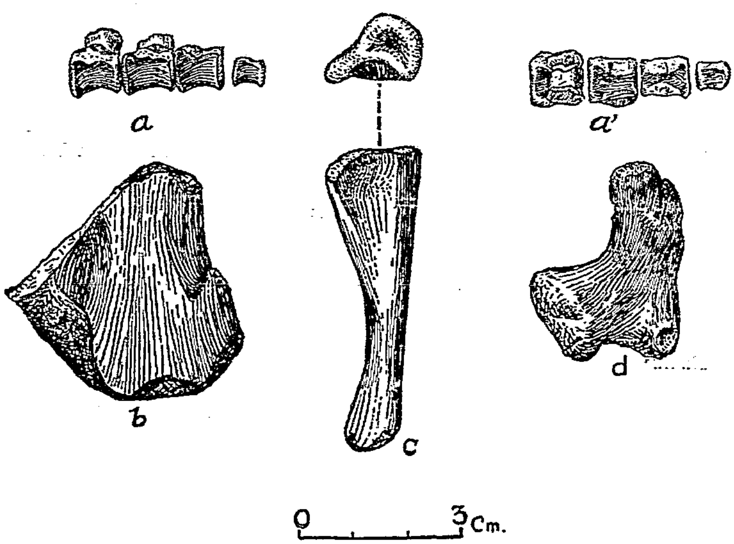

Fig. 13. Os incertæ sedis. a Vertebræ in lateral view and a′ in top view. b. Distal end of a humerus, c. ?Ulna, d. ?Calcaneum.

Spec. A There are 4 vertebræ which do not fit with the others described above. They are too small for being presacral- and too short for postsacral vertebræ. The centrum is moderately amphicelous, two of them have the prezygapophysis (eventually postgyapoprysis) preserved. Length of the largest one, 9 mm. Anterior breadth, 9.5 mm.

Spec. B. A broken distal end of a humerus. It belongs probably to *Lystrosaurus*.

Spec. C. An ulna, which belongs either to a young individual, or which indicates the presence of a second form. Proximal end characterized by a thinly compressed protuberance. (Distal end a little damaged.) Size is much smaller than in the ulna described above.

Spec. D. It is a L-shaped flat bone with weakly convex middle portion. According to Dr. C. L. Camp, it may represent the first metacarpal of a crocodilian-like animal, probably *Chasmatosaurus*, but the slenderly constructed ulna and radius would seem to exclude its attribution to this latter form. A definite determination of this bone requires further evidences.

DIMENSIONS:

Vertebræ

Length of the first and second vertebræ..........58 mm
Breadth of the anterior centrum of the first vertebra ....25.5 mm

Radius

Length ....93 mm
Proximal breadth..21 mm
Distal breadth..31 mm
Medial breadth (minimum)..............................10.5 mm

Ulna

Length ....102 mm
Proximal breadth..32 mm
Distal breadth..22 mm
Minimum breadth near the lower end...............13 mm

Radial		
	Length	22 mm
	Breadth	19 mm
Ulnare		
	Length	32 mm
	Breadth	22 mm
Ilium		
	Maximum length of the left ilium from the anterior tip to the posterior tip of the wing-like expansion	121 mm
	Length of the lower part (across the acetabulum)	66 mm
	Minimum breadth above the acetabulum	41 mm
Tibia		
	Length	152 mm
	Maximum proximal breadth	47 mm
	Maximum distal breadth	38 mm
	Minimum medial breadth	14 mm
Fibula		
	Length of the right one	155 mm
	Proximal breadth	21 mm
	Distal breadth	20.5 mm
	Minimum medial breadth (lateral)	9 mm
Astragalus		
	Length	34 mm
	Proximal breadth	13.2 mm
	Distal breadth	22 mm
Foot bones		
	Length of the fourth digit from the proximal end of metatarsus to the tip of the distal phalanges	158 mm

Summary and Determination

As already made clear in the description, the present form is characterized by a downward bending of the muzzle, by laterally compressed and serrated teeth, and by phalanges of a carnivorous type. The first two characters (including the number of the teeth) are exactly those of *Chasmatosaurus van hœpeni* as recently fully described by Broili and Schröder. A further comparison between these two forms is made difficult by the fact that the posterior part of the skull is missing in our specimen, and the limb bones mostly unknown in the African fossil. Yet the reference of both to the some genus is practically certain.

Specifically, several differences are clear. The Chinese form shows at least the following differential characters: 1. Size much smaller (about one fourth), 2. Muzzle more slender, 3. Choana set more posteriorly, 4. Lower jaw comparatively more massive with heavier symphysis, 5. Differentiation of the teeth more advanced. The Sinkiang form represents therefore, a new species which I name *Chasmatosaurus yuani* Young (sp. nov.), in honor of P. L. Yuan, the discoverer of a Theromorpha fauna in Sinkiang.

Chasmatosaurus van hœpeni has been found in the *Lystrosaurus* zone (Lower Trias) from the Karroo formation. Together with *Proterosuchus fergusi* Broom (perhaps a synonym, according to Broom, of *Chasmatosaurus*) it represents the carnivorous type of the zone. Parallelizing exactly these conditions, *Chasmatosaurus yuani* has been collected (judging by its field number and its mineralization) in the same horizon as *Lystrosaurus* (*Lystrosaurus hedini* Young). Both therefore swam together and had the same biological struggle for existence as supposed by Broom[1]. The presence of a *Chasmatosaurus* in the *Lystrosaurus* beds of Sinkiang reinforces strongly and strangely the stratigraphical and palæobiological affinities already noted by others and the present writer between Central Asia and South Africa in the Triassic times.

1 Broom, R. 1932. The Mammal-like Reptiles of South Africa. London. Witherby. p. 253.

We may add that the limb bones of *Chasmatosaurus yuani* show a decided analogy with those of *Varanosaurus*, a Pelycosauria.

Concerning the systematic position of *Chasmatosaurus* discussed by Broili and Schröder (loc. cit., p. 257) they agree with Haughton, Broom and Huene, in regarding the *Chasmatosaurus* as a form closely related with *Erythrosuchus*. According to Haughton and those other authors, both belong to the sub-order Pelycosimia.

Explanation of

Plate I

PLATE I.

Fig. 1. *Chasmatosaurus yuani* Young (sp. nov). Skull in left side aspect. ibid. Pl. II and Pl. III, Fig. 1. Nat. size.

Fig. 2. *Chasmatosaurus yuani* Young. Left lower jaw in external view. ibid. Plate IV, Figs. 1 and 1a. Nat. size.

1
2

Explanation of Plate II

PLATE II.

Figs. 1 and 2. *Chasmatosaurus yuani* Young (sp. nov.). Skull in top and palatinal views. ibid. Plate I, Fig. 1 and Plate III, Fig. 1. Nat. size.

1

2

Explanation of

Plate III

PLATE III.

Fig. 1. *Chasmatosaurus yuani* Young (sp. nov.). Skull in right side view. ibid. Plate I, Fig. 1 and Plate III. Nat. size.

Fig. 2. *Chasmatosaurus yuani* Young. Right lower jaw in external view. ibid. Plate IV, Figs. 2 and 2a.


1
2

Explanation of

Plate IV

PLATE IV.

Fig. 1 and 1a. *Chasmatosaurus yuani* Young (sp. nov.). Left lower jaw, in inner and top views. ibid. Plate I, Fig. 2. Nat. size.

Fig. 2 and 2a. *Chasmatosaurus yuani* Young. Right lower jaw, in top and inner views. ibid. Plate III, Fig. 2. Nat. size.


1
1a
2
2a

NOTES ON SOME REMAINS OF FOSSIL MAMMALS FROM CHINA AND MONGOLIA*

BY

BIRGER BOHLIN

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1. CHALICOTHERIOIDE REMAINS FROM THE CHINESE HIPPARION FAUNA

Chalicotherioidea gen. & sp. indet.

Locality: Province Shansi, Loc. 77. Age: Lower Pliocene.

The only find in the collection on Uppsala is a well preserved astragalus in which the upper part of the trochlea on the outer side is missing. The locality lies in Central Shansi in an area in which the sediments are of fluviatile or lacustrine origin (Licent & Trassaert 1935). The matrix attached to the bone is a friable red sandstone and already Schlosser (1903) noted this difference from the true *Hipparion* clay and stated that the finds indicated a forest fauna. In a paper 1935 I have followed Schlosser and tried to hold that there is a sharp limit between this fauna and the fauna of the *Hipparion* clay proper. In their paper 1935, which reached me when my monograph already was printed, Licent & Trassaert announced finds of *Chilotherium* from Central Shansi (det. Teilhard de Chardin; the only find in the Uppsala Museum from this region is as far as I can see a calcaneum which Ringström has determined as *Chilotherium* sp. [compare Ringström 1928 p. 14 where Loc. 71 is found in the list of new localities for *Chilotherium*] but which shows greater resemblance to a calcaneum of *Diceratherium*). When arranging the collections here I have came upon a fragment of a metatarsus of a *Samotherium* sp. from the Yüshehsien basin and it is thus evident that also this genus occurs, although it might have been rare. This introduction I have thought necessary in

* Received for publication in May 1936.

order to give a true idea of the fauna to which the indetermined species here described belongs.

A P_2 of a *Chalicotherioide* from the *Hipparion* fauna (evidently from the *Hipparion* clay of Shansi) was described by Schlosser 1903 (p. 76) as *Chalicotherium* sp. Several other finds are made in China and Mongolia but these are either younger or older than the *Hipparion* fauna.

DESCRIPTION

The trochlea of the astragalus in the Uppsala collection is low, somewhat oblique and has a broadly rounded inner condyle. The outer condyle is damaged but it must have had about the height indicated in the drawings. Its lower part extends below the outer end of the navicular facet. Distally there is a small outer facet for the calcaneum (C_1; clearly visible also from behind) and a large facet for the articulation with the naviculare. A cuboid facet seems to be absent (see below). From behind one sees in addition to the calcaneal (C_1) facet mentioned above: at the inner side of this a small facet also for the calcaneum (C_2), separated from C_1 by a groove and from the navicular facet, with which it forms a right angle, by an edge. Above these facets there is a broad and deep cavity representing the ectal facet for the calcaneum. The sustentacular facet is complicated, trilobated with an upper and an lateral lobe folded together so that their surfaces form an angle of about 120° and a lower lobe the surface of which is divergent from both the former but is more in accordance with the upper than with the lateral lobe. The lower medial end almost reaches the lower border of the back side of the bone. Finally there is a facet about at the middle of the lower border. This facet is separated from the navicular facet by a sharp edge (the angle between the facets is about 90°). This might be a facet for the cuboid but its surface is not smooth except in a small area medially, the rest is rough with several nutrition holes and the whole facet is more likely a portion of the back side which remains as a facet like rest between the adjoining true facets.

Maximal length (medially).....................................74 mm
Maximal breadth...115 mm
Height of the medial portion ....69 mm

From my figures it is at once evident that the Chinese astragalus is quite different from the one of *Moropus cooki*, the only species of which I have material for comparison. The astragalus of *Moropus* is higher, the groove of the trochlea is deeper, the medial condylus is narrower. The sustentacular facet is simple and flat, instead the lower outer facet for the calcaneum is complicated and divided by a groove in an upper and a smaller lower surface which enclose a very obtuse angle. Further this facet is less distinct from the large concave ectal facet for the calcaneum. A small facet (C_2) corresponding to C_2 in the Chinese astragalus is present but more widely separated from the outer lower facet C_1. The navicular facet is flatter and its outline les anguler than in the Chinese specimen.

Forms like *Eomoropus* and *Grangeria* do not need to be taken into consideration, their astragalus being much higher than even in *Moropus* and also in other respects quite different (OSBORN 1913, fig. 4; COLBERT 1934, fig. 6).

The astragalus of *Ancylotherium (Chalicotherium) pentelicum* (ABEL 1920, fig. 10) is higher and reminds, although it is decidedly lower than the one of *Moropus*, rather much of this, having a more deeply grooved trochlea with a more compressed lateral condylus. Of other differences I may mention the shape of the navicular facet, which in *A. pentelicum* is someway rectangular with a lateral border parallel with the medial border, while in the Chinese specimen the facet runs out in a point laterally. The cuboid facet is evidently missing also in *A. pentelicum* (at least has the facet marked "cub" in Abel's figure nothing to do with the cuboid but is the same facet for the calcaneum as C_1 in my figures; compare Colbert 1935, who places *A. pentelicum* in his tribe *Schizotheriini* in which the cuboid facet is missing).

The astragalus of *Macrotherium magnum* (HOLLAND & PETERSON 1914, fig. 98:3 & 5) shows a certain resemblance in the structure of the trochlea, this is however lower and the lateral condylus has a much flatter profile. The navicular facet is of a somewhat similar shape as in the Chinese specimen, but it has along its posterior border an elongated facet for the cuboid (I suppose that the darker shaded part in fig. 98:5 is the facet mentioned in the text on the same page although there is no indication of this in the figure; the great extension of the facet medially seems to me to be strange).

In *Metaschizotherium fraasi* the astragalus seems to have about the same height, the medial trochlea is however much more compressed and the neck is evidently lower.

In *Schizotherium turgaicum* the astragalus has a certain resemblance to the one in *Moropus* ("its trochlea is relatively deep, as in primitive Eocene perissodactyls", COLBERT 1935 p. 6). On p. 12 Colbert places the species of Borissiak in the genus *Macrotherium*, which is evidently a lapse (compare p. 6: "a close scrutiny of the figures of *S. turgaicum* leads to the conclusion that this form is not a *Macrotherium*. . . . ").

In its general habitus the astragalus from Shansi resembles *Macrotherium*, but it has some features in common with *Ancylotherium pentelicum* from Pikermi, above all the absence of a cuboid facet (the absence of the facet in the Chinese specimen can however be questioned, see above). The differences from all the astragali which I have had a chance to study either in original or in figures seem to allow the conclusion, that the specimen in the Uppsala museum cannot belong to either of the genera *Macrotherium*, *Moropus*, *Schizotherium*, *Metaschizotherium* or *Ancylotherium*. It may belong to the same genus (or species) as the tooth described by Schlosser or to a species ancestral to the Nihowan *Chalicotherioidea*. We must also have in mind a form *Macrotherium brevirostris*, described by Colbert 1934 from the Tungur formation, the fauna of which has great similarity with the *Hipparion* fauna. I therefore prefer not to give a new name, but I figure the specimen as completely as possible to enable future workers to draw definite conclusions, when more material is available.

I will take this occasion to express my doubts regarding one of Abel's conclusions on the biology of the *Chalicotheriodidea*. Abel seems to be of the opinion that the reduction of the centra of the neck vertebræ and the strong development of the zygapophyses is an adaption to a thrusting function of the neck ("Wie die Reduktion der Wirbelkörper und die enorme Verstärkung der Zygapophysialregion beweist, muss der Hals als Sturmbock benutzt worden sein, wenn das Tier nach den unterirdischen Knollen und Zwiebeln suchte", p. 60). In *Ovibos* for instance, where the neck has to stand the pressure when the animal is butting, the centra are very well developped. I have the impression that the great development of the upper parts of the vertebræ is instead connected with a great development of the upper muscles of the neck, which enable the animal to pull roots and other eatables, which it has uncovered with the aid of its large claws, out of the ground. The strange position of the end surfaces of the centra seems to me to fit well in with such a use of the neck. The wedge shape of the head was quite convenient if the animal wanted to reach the bottom of its pits, which undoubtedly were narrowing downwards.

LITERATURE

Abel, O. Studien über die Lebensweise von *Chalicotherium*. Acta zoologica I. Stockholm 1920.

Bohlin, B. Cavicornier der *Hipparion*-Fauna Nordchinas. Palæontologia sinica, Ser. C, Vol. IX: 4. Peiping 1935.

Borissiak, A. The Remains of Chalicotherioidea from the Oligocene deposits of Turgai. Ann. Soc. Pal. Russ. III. Leningrad 1918.

Colbert, E. H. Chalicotheres from Mongolia and China in the American Museum. Bull. Amer. Mus. Nat. Hist. Vol. LXVII, Art. VIII. New York 1934.

—"— Distributional and phylogenetic studies on Indian fossil mammals III. A Classification of the Chalicotheroidea. Amer. Mus. Nov. No. 798. New York 1935.

Holland, W. J. & Peterson, O. A. The Osteology of the Chalicotheroidea. Mem. Carnegie Mus. III No. 2. Pittsburgh 1914.

Koenigswald, G. H. R. von. *Metaschizotherium fraasi* n. g., n. sp., ein neuer Chalicotheriide aus dem Obermiozän von Steinheim a. Albuch. Palæontographica, Suppl. Bd. VIII, Teil VIII.

Licent, E. & Traessart, M. The Pliocene lacustrine series in Central Shansi. Bull. Geol. Soc. China, Vol. XIV, No. 2. Peiping 1935.

Osborn, H. F. *Eomoropus*, an American Eocene Chalicothere. Bull. Amer. Mus. Nat. Hist, XXXII. New York 1913.

Ringström, T. Über quartäre und jungtertiäre Rhinocerotiden aus China und der Mongolei. Palæontologia sinica, Ser. C, Vol. IV: 3. Peiping 1927.

Schlosser, M. Die fossilen Säugethiere Chinas nebst einer Odontographie der recenten Antilopen. Abh. d. K. Bayer. Akad. d. Wissensch., II. Cl. Bd. XXII, Abth. I München 1930.

2. ?HYÆNARCTOS SP. FROM OLAN CHOREA (MONGOLIA).

Among the very fragmentary remains from Olan chorea are two tooth fragments of a large Carnivore which were put together with tooth fragments of Mastodon and evidently regarded by Schlosser in his paper "Tertiary Vertebrates from Mongolia (Palæontologia sinica, Ser. C, Vol. 1:2) as fragments of milk teeth of this genus: "Among these scarce fragments, however, two must be mentioned specially, for they have very thin enamel and cannot belong therefore to true molars, but only to milk-molars, probably to the second, the D_3" (l.c. p. 93). It is difficult to understand how Schlosser could make this mistake, but as there are no other fragments which apply to this description, and the genus *Hyænarctos* or a related genus to which the fragments must be referred is not mentioned by Schlosser, it is probable that he, after having made a hurried first sorting of the material, paid very little attention to the quite uninteresting fragments of *Mastodon* teeth.

M^2. This tooth is represented by the posterior part with the metacone, half of the hypocone and a comparatively small talon. The enamel shows a fine wrinkling in places where this structure is not deleted by wear. The breadth of the posterior part of the tooth has been about 26 mm. The tooth is much bigger than the M^2 of *Indarctos lagrelii* and has evidently had a less extended talon (fig. 7 & 8). The animal must have had about the same size as *?Hyænarctos* sp. (ZDANSKY, Jungtertiäre Carnivoren Chinas, Palæontologia sinica, Ser. C., Vol. II: 1, Pl. III, fig. 5) and the tooth fragment fits rather well in the outline of the poorly preserved M^2 of the skull of this species. I therefore refer the fragment to the same genus as this skull, rather than to *Indarctos*. There is however an *Indarctos* larger than *I. lagrelii, I. sinensis* (ZDANSKY, l.c. Pl. V)$_2$ of which the upper dentition is unknown.

Left M_1 (fig. 10 a & b). The fragment represents the posterior outer part of the tooth as is evident from a comparison with the M_1 of *Indarctos sinensis*. It is much more worn than the tooth figured by Zdansky but agrees well in all details which are still preserved and the marked wear facet to the left in fig. 10 cannot be anything else than the contact facet with M_2. The enamel is wrinkled in the same way as in the M^2 described above.

The fragments evidently do not belong to the same individual. The colouring of the specimens is different (M^2: enamel olive brown, dentine brown; M_1: enamel orange to yellow, root cream coloured) and the M^2 is much less worn than the M_1.

It cannot be proved of course that these fragments belong even to the same genus, but I do not hesitate to refer also the M_1 to some big *Ursidæ*. The conformity in size, the fact that both fragments come from the same locality and the Ursid character of both are the things which connect them. It is however clear that, except the small *Ursus* sp. described by Schlosser, the Olan chorea fauna comprises also a large representative of the same family.

Explanation of

Plate I

PLATE I.

Fig. 1. *Chalicotherioidea* gen. & sp. indet. Right astragalus. Front view.

Fig. 2. Idem. Inferior view.

Fig. 3. Idem. Medial view.

Fig. 4. *Moropus cooki.* Astragalus. Posterior view. Agate, Sioux county, Nebraska, U.S.A.

Fig. 5. Idem figs. 1-3. Posterior view.

Fig. 6. *Moropus cooki.* Astragalus. Medial view.
Figs. 1-6. 1/2 nat. size. C_1 and C_2 see text. ?cub=possibly cuboid facet.

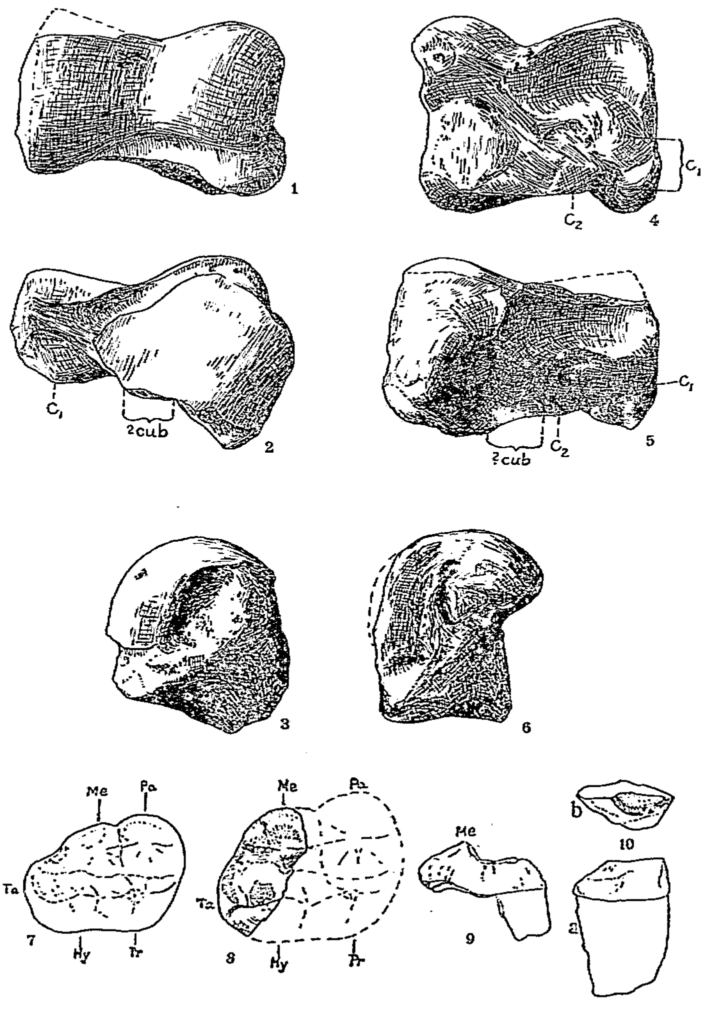
Fig. 7. *Indarctos lagrelii.* Right M^2. Drawn after the original to Zdansky, l.c. Pl. IV, figs. 1 & 2.

Fig. 8. *?Hyænarctos* sp. Fragment of right M^2. Outline of the tooth schematic.

Fig. 9. Idem fig. 8. Posterior view.

Fig. 10. *?Hyænarctos* sp. Fragment of left M_1. a Exterior view; b from above.

Figs. 7-10 nat. size. Hy=Hypocone, Me=Metacone, Pa=Paracone, Pr=Protocone, Ta=Talon. Dotted areas in figs. 8 & 10=wear facets.


1
C₁
C₂
4
C₁
?cub
2
C₁
?cub
C₂
5
3
6
Me
Pa
Ta
7
Hy
Tr
Me
Pa
Ta
8
Hy
Pr
Me
9
b
10
a

SOME QUATERNARY GASTROPODS FROM EASTERN SZECHWAN*

By

TENG-CHIEN YEN** (閻敦建)

The molluscan fauna of Szechwan Province had been worked out by several distinguished authorities during the past few decades. In recent years, Dr. Haas of Senckenberg Museum reported on some collections made in Kwantung, Szechwan, and Hupei Provinces by Dr. K. Krejci-Graf of Sun-yat-sen University, Canton, and Dr. Pilsbry also published a paper on some collection made in western Szechwan by the Dolan West China Expedition of 1931.

The present collection consisting of a small number of land gastropods was obtained from one locality near the hot spring of Pahsien (巴縣), eastern Szechwan. These specimens appear to be in subfossil state. Through the courtesy of Dr. C. C. Young and Père Teilhard de Chardin, of the National Geological Survey, the author was able to undertake the study of these gastropods which are mostly forms already known and represented in living state either in the same province or in adjacent regions. Sincere thanks are due to Drs. Young and Teilhard for putting the material at the author's disposal.

Family ZONITIDÆ

Xestina chrysoraphe krejcii Haas 1933

Pl. I, Figs. 1, 1a, b, c.

1933 *Xestina chrysoraphe krejcii*, Haas, Senckenbergiana, Band 15, Nr. 5/6. p. 319, abb. 8.

Shell orbicularly depressed in outline, rather large in size, subconically spired, and reducedly convex below. The apical part injured,

* Received for publication in April 1936.

** Work carried on by the aid of a grant from the research fund of the National Research Institute of Geology, Academia Sinica, Nanking, China.

with the last three whorls preserved. The exposed surface of the preserved whorls is rather flatly convex, embracing to the ambital region, and last one increasing rapidly in width. The first half of the first preserved whorl, probably the third whorl of the entirely well preserved shell, bears strong growth lines become very distinct and pronounced, and appear to be in spiral series, but on the basal surface of the last whorl, these granulose marks are not observed, and only some prominent growth-lines are visible. The body-whorl is obtusely angulated at the ambital region, and the angulation is rather obsolete near the aperture. Suture well incised and marked by the ambital angulation of the whorls of the spire, which is partly exposed on the larger whorls. The aperture is obliquely transversal ovate in outline, the outer lip appears to be thin and simple at its superior margin, and the inner lip is also very thin. The columella is short and slightly reflected, and the umbilicus is small but well exposed, and about 1/15 the diameter of the shell.

Measurements of the single specimen:
Altitude of Shell..19.0 mm
Width of Shell..33.0 mm
Height of Aperture (oblique).............................14.0 mm
Width of Aperture...18.6 mm
Diameter of Umbilicus.....................................2.5 mm
Locality: Pahsien (near the hot spring), Eastern Szechwan.

The single specimen here recorded agrees well with Dr. Haas' subspecies, a living form described from the western Szechwan. Our specimen is not good in preservation, the apical part being especially injured. The granulose sculpture is, however, distinct, and the last three whorls are well preserved.

Macrochlamys sp.

The shell is poorly preserved as only the body whorl has been preserved. It is impossible to identify it satisfactorily with any species of this genus. The preserved body whorl shows that the shell is rather thin in substance, delicate, and small in size. The body whorl is somewhat convex and inflated below. The umbilicus is very small but exposed, and the columellar margin is not preserved. The diameter of the shell is about 5.3 mm., the height of the body whorl is 2.8 mm., and the diameter of umbilicus is about 0.5 mm.

Locality: same as the preceding species.

Family CEPOLIDÆ

Aegista accrescens (Heude (1882)

Pl. I, Figs. 2, 2a, 2b.

1882 *Helix accrescens,* Heude, Mem. Conc. Hist. Nat. Emp. Chinois, p. 31, pl. XV, fig. 2.

1884 *Helix (Aegista) accrescens,* Mœllendorff, Jahr. Deut. Malak. Gesel., Vol. XI, p. 355.

Shell orbicularly discoidal, rather thin, widely umbilicated, the umbilicus is 2/5 the diameter of the shell. Spire depressed, body-whorl narrowly inflated. The whorls are 6 and 1/2 in number, embracing to the ambital region, increasing rather gradually in width, and somewhat descending at the aperture. The exposed surfaces are scarcely convex, obtusely angular at the ambital region. The suture is well incised and somewhat canaliculatic.

Measurements of the single specimen:

Altitude of Shell..6.5 mm

Width of Shell...14.0 mm

Diameter of Umbilicus.......................................5.5 mm

Locality: same as the preceding species.

The single specimen is not well preserved, part of the whorls of the spire being injured. The general characters are, however, identical with the species. The measurements of the present specimen are nearly the same as that given by Heude, except that the spire is in average slightly lower, and the umbilicus somewhat wider than that of the typical form of Heude. Moreover, the size of the present form is just one half that of *"Helix" vermis* Reeve, a form described from the Yangtze Valley, e. g. Wuchang.

Cathaica constaniae vestita Pilsbry 1934

Pl. I, Figs. 3, 3a, b, c.

1934 *Cathaica constaniæ vestita*, Pilsbrw, Proc. Acad. Nat, Sc. Philadelphia, Vol. LXXXVI, p. 15, pl. 3, figs. 5-7.

Shell moderately sized, widely umbilicated, the umbilicus is about 1/4 the diameter of the shell. The spire is rather low but elevated, and the body-whorl is angulated at the ambital region, and very convex at the base. The whorls are 4 and 3/4 in number, and the first 2 from the protoconch. The protoconchial whorls are rather roundly convex, gradually increasing in size, and clearly marked off from the conch by an elevated, lip-like growth line. The exposed surface is in rather worn condition, and the granulose appearance near the end part of the stage is obscure. The conchial whorls are less convex, more rapidly increasing in width, and abruptly marking with growth lines on the exposed surfaces. The growth lines gradually become coarser and granulose on the final part of the penult and the whole body-whorl. Suture well marked, and impressed by convex whorl-surfaces. The aperture is subovate in outline, slightly descending. The outer lip is thin and simple, inner lip attenuated, and the columella is rather straight, short probably due to injury.

Measurements of the single specimen:

Altitude of Shell	11.2 mm
Width of Shell	19.0 mm
Height of Aperture	9.4 mm
Width of Aperture	9.0 mm
Diameter of Umbilicus	4.2 mm

Locality: same as the preceding species.

This subspecies was originally described from the locality somewhat further westward from the present site. This specimen agrees well in general contour of the shell as well as its characteristic sculpture on the exposed surface, except that there is one volution less in the present form while the spire is higher and the umbilicus wider.

This specimen appears to be slightly injured at its apertural region, as its peristome shows no tendency of expansion, and its columellar margin is non-reflected.

Coccoglypta pinchoniana (Heude 1886)

1886 *Helix pinchoniana,* Heude, Journ. de Conchyl., Vol. LXI, p. 213.

1890 *Helix pinchoniana,* Heude, Mem. Conc. Hist. Nat. Emp. Chinois, p. 135, pl. XXXV, fig. 33, 33a.

Shell in the present collection is not in good condition, only its spire preserved, while the body-whorl is entirely broken off. The whorls of the spire are, however, well preserved, 5 in number, and the first 1 and 1/2 probably constitute the protoconch. The exposed surfaces of the first 1 and 1/2 whorls are very convex, appearing to be rather smooth, and those of the subsequent whorls are scarcely convex, bearing costulate growth lines and spiral striæ on early whorls, and these lines are in granulose condition and the spiral striæ also more distinct beginning from the final third of the fourth whorl. The granulose appearance is less prominent on the base of the present specimen or the usually embraced surface of the penult whorl of a perfect shell. The whorls are normally embracing to the ambitus, and angulated at the ambital region. The umbilicus is rather wide although the opening of the present specimen is filled up by sand particles.

Measurements of the single specimen in mm:

Altitude of Shell...16.0
Width of Shell...26.0
Height of Aperture...11.0
Width of Aperture..11.5
Diameter of Umbilicus...8.0

Locality: same as the preceding species.

The above mentioned measurements are proportionally smaller than those given by Heude for the species, as these are made on an imperfect specimen with its body-whorl injured. I have compared our shell very carefully with the typical form of this species, and find that they are essentially identical.

This species was originally described by Heude from "Tchen-tou-fou" which is not far from the site of our specimen.

Family VALLONIDÆ

Vallonia pulchellula (Heude 1882)

1882 *Helix pulchellula,* Heude, Mem. Conc. Hist. Nat. Emp. Chinois, p. 20, pl. XIII, fig. 17.

1882 *Helix (Vallonia) pulchellula,* Hilber, Sitzb. der lais akad. der Wissensch., p. 346, Taf. III, figs. 11, 12.

1898 *Helix (Vallonia) pulchellula,* Hilber in Wissensch. Ergeb. der Reise Grafen Bela Szechenyi in Ostasien 1877-1880, Band II, p. 600, Taf. II, figs. 15, 16.

The shell is minutely sized, somewhat orbicularly depressed. The whorls are 3 in number, increasing in width gradually at first, and rapidly in the last two whorls. The apex is large and prominent. The exposed surface of the whorls bears distinct growth lines, and these lines are finely costulated on the body whorl. The aperture is subcircular in outline, somewhat descending at the aperture, and the umbilicus is widely exposed, attaining about 1/3 the diameter of the shell.

Measurements of the singie specimen in mm.

Altitude of Shell	1.4
Width of Shell	3.0
Height of Aperture	0.7
Width of Aperture	0.7
Diameter of Umbiliculs	1.0

Locality: same as the preceding species.

This species was originally described from Shanghai and "Ning-kuo-fou" of Anhwei Province by Heude and his comtemporaries (Hilber, Mœllendorff, etc.) recorded it from Szechwan and Kansu Provinces. It seems to be rather widely distributed along the Yangtze Valley as I have had it from various places of this region.

Family ENIDÆ

Ena fuchsiana (Heude 1882)

1882 *Buliminus fuchsiana*, Heude, Mem. Conc. Hist. Nat. Emp. Chinois, p. 53, pl. XX, fig. 21.

1884 *Buliminus fuchsiana*, Mœllendorff, Jahr. Deut. Malak. Gesel. Vol. XI, p. 172.

The shell is turreted and oblong in outline, ramit rather attenuated at apical part. The whorls are 7 in number, the early ones are very convex, the latter ones less convex, increasing in width rather gradually in the first three, and very rapidly in the last four. The exposed surfaces bear distinct lines of growth. Suture is well impressed by the convex whorl-surfaces. The aperture is rather elongated in outline, somewhat oblique and descending. The outer lip is thin and reflected, with its upper part inclined, the inner lip is very attenuated, and the columella is short, slightly oblique and very reflected.

Measurements of the single specimen in mm.

Altitude of Shell..17.0

Width of Shell..6.3

Height of Aperture..5.5

Width of Aperture..4.5

Locality: same as the preceding species.

The single specimen here recorded agrees well with the figures of the species given in Heude's work, but Heude's specimens show a great deal of variation and some of them even rather swollen in the middle part of the shell.

This species was originally recorded by Gredler (Jahr. Deut. Malak. Gesel., VIII, 1881, p. 20.) as *Buliminus rufistrigatus* Benson, and being separated as a distinct species with description and illustration by Heude. The original locality is in "Hou-nan" (Hunan), and it is said to be rather common in that province.

Ena cf. *clausiliæformis* (Mœllendorff 1902)

A single specimen with the upper part of its shell preserved. This preserved part shows its close resemblance to this species, as its early whorls are rather convex, gradually increasing in width, and become very gradually inflated. The apical part is not preserved but is probably rather papillary.

Ena sp.

Only the last 3 and 1/2 whorls are preserved in this case, and it is impossible to identify it satisfactorily. Its whorl-surface is rather flatly convex with distinct oblique growth lines present on it. On the last whorl, which is probably the actual penult whorl, there is an angulation on the ambital region.

Family CYCLOPHORIDÆ

Cyclophorus punctatus (Grat. 1841)

1847 *Cyclophorus punctatus*, Pfeiffer, Zeit. fur Malak. p. 107.

1852 *Cyclophorus punctatus*, Reeve, Conch. Icon. Cyclophorus, pl. XII, fig. 51.

1881 *Cyclophorus punctatus*, Gredler, Jahr. Deut. Malak. Gesel., Vol. VII, p. 129.

1882 *Cyclophorus punctatus*, Mœllendorff, Ibidem, Vol. VIII, p. 268.

1933 *Cyclophorus punctatus*, Haas, Senckenbergiana, Band 15, Nr. 5/6, pages 318, 320, 321.

Two imperfect specimens are included in this collection, one with the whorls of the spire preserved, and another with 2/3 of the body whorl preserved. The two fragments give features identical with the species, except that the spire is somewhat higher. The characters like the marked angulation at the ambitus, the characteristic way of banding present above and below the ambital angulation, and its rather narrow umbilicus are all well shown on these fragments.

These specimens are evidently very close to *Cyclophorus fargesianus* Heude (l. c. p. 89, pl. XXII, fig. 2, 1885), a form described from

Tchen-keou of Szechwan, but the specific distinction of Heude's species needs further consideration.

This species was originally described from South China in a living state, and recently Haas recorded it from several localities in western Szechwan as well as from Ichang in Hupei, and the present site where these fragments were obtained is just about mid-way between the two.

Cyclophorus youngi Yen (sp. nov.)

Pl. I, Figs. 4, 4a, b.

Shell trochoid in outline, rather high-spired, and widely umbilicated. The umbilicus is nearly 1/5 the diameter of the shell. Only the last three whorls preserved, early ones injured (probably 2 or 3 in number). The exteranl surface is not well retained except some fragmentary parts near the sutural region, which show the surface bearing well developed strong growth lines, yellowish brown in coloration. The preserved whorls are roundly convex, rapidly increasing in size, especially the body whorl. The first fourth of the last whorl is very obtusely angulated at the ambital region, and the last three-fourth roundly convex. The aperture is descending, and subcircular in outline. The peristome is continuous, appearing to be thickened and reflected.

Measurements of the Holotype in mm.

Altitude of Shell	24.0
Width of Shell	29.0
Height of Aperture	15.6
Width of Aperture	15.2
Diameter of Umbilicus	6.0

Locality: Pahsien (near the hot spring), Szechwan.

This species is closely related to the preceding one and also to *Cyclophorus exaltatus* (Pfeiffer, Proc. Zool. Soc., London, p. 300, 1854), another form described from South China. It differs however from both of them, by its more elevated spire, and much wider umbilicus and rather roundly convex ambital region of the body whorl, as shown distinctly on the preserved part of the shell.

Whether or not this species will be found in living state, is a matter for further observation, as the molluskan fauna of the present locality and its vicinal regions are not yet thoroughly explored.

I take pleasure in naming this species after Dr. C. C. Young of the National Geological Survey of China, for his courtsey in submitting his collection of these upper Pleistocene gastropods to me for study.

SUMMARY

In summarizing the foregoing pages, the following points may be noted as of particular interest:

1. All the species comprised in this small collection are terrestrial forms, and they appear to be identical with the recent gastropods of the province.

2. These forms, except Cyclophorus youngi, a new species here described, are all represented in living state, and were originally described either from the same province or from its neighbouring districts.

3. Some of the species are rather widely distributed in east, central and south China.

4. The geological age of these gastropods, judging from its close resemblance to the recent forms, seems not to be earlier than the Middle Quaternary or the Pleistocene Epoch, or it may even belong to the base of the Upper Quaternary. Any further suggestion in regard to this question can only be made by examining additional collections around the locality where this collection was made.

Explanation of

Plate I

PLATE I

Fig. 1-1b. *Xestina chrysoraphe krejcii* Haas, Natural Size.

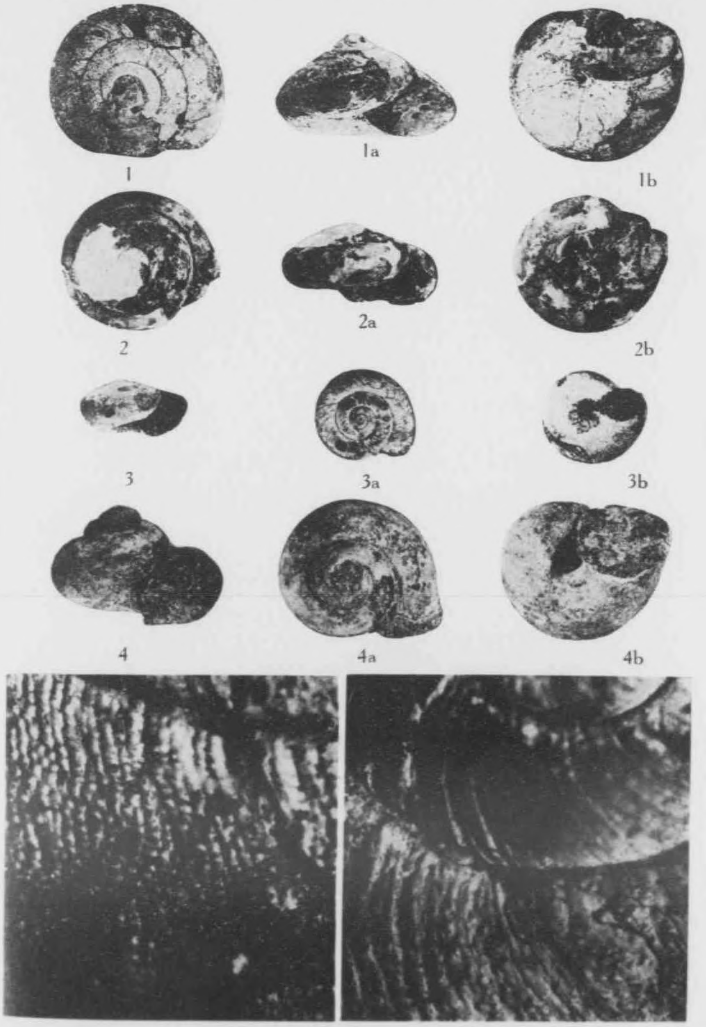
Fig. 1c. The Epidermal Sculpture of the Same Species × 9.

Fig. 2-2b. *Aegista accrescens* (Heude), × 2.

Fig. 3-3b. *Cathaica constaniæ vestita* Pilsbry, Natural Size.

Fig. 3c. The Epidermal Asperities of the Same Species × 9.

Fig. 4-4b. *Cyclophorus youngi* Yen (sp. nov.), Holotype, Natural Size.


1
1a
1b
2
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2b
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3a
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4
4a
4b
1c
3c

ZUR KENNTNISS DER GATTUNGEN *BORNHARDTINA* SCHULZ UND *STRINGOCEPHALUS* DEFR.

VON

T. H. TING Z. ZT. MARBURG

1. EINLEITUNG

Auf einer zusammen mit Herrn Professor Wedekind im März 1936 ausgeführten Exkursion in die Eifel haben wir bei Niederehe und Ahütte im oberen Korallenkalk der Hillesheimer Mulde zahlreiche Exemplare glatter Unciten aufgefunden. Es fanden sich neben ganzen Exemplaren auch Naturpräparaten besonders der Dorsalklappe in so ausgezeichneter Erhaltung, dass der Bau der Gattung *Bornhardtina,* d.i. der typische Repräsentant der glatten Unciten, nunmehr einwandfrei dargestellt werden kann. Da mir Herr Professor Wedekind gleichzeitig die Bearbeitung der noch unbearbeiteten, geradezu mustergültig erhaltenen Naturpräparate von *Stringocephalus* aus der Rohrer Mulde zur Verfügung stellte, war es mir möglich, die zwischen diesen beiden Gattungen bestehenden Beziehungen festzustellen.

Der obere Korallenkalk, den Eugen Schulz als erster ausgeschieden aber ganz mangelhaft definiert hat, bildet in der Hillesheimer Mulde überall ein Plateau oberhalb der Steilkante mit *Newberria amygdalina* (=Caiquaschicht alter Bezeichnung). Es gelang uns die Gattung *Bornhardtina* immer in der gleichen Lage über der Steilkante mit *Newberria amygdalina* auch an anderen Fundpunkten festzustellen. Bei der grossen stratigraphischen Bedeutung der Bornhardtinen und ihrer auffallenden Aehnlichkeit mit *Stringocephalus,* mit dem sie immer wieder verwechselt wurden, ist eine genauere Darstellung nötig.

2. DER BAU DER GATTUNG BORNHARDTINA

Die Gattung *Bornhardtina* hat Eugen Schulz[1] 1913 aufgestellt und

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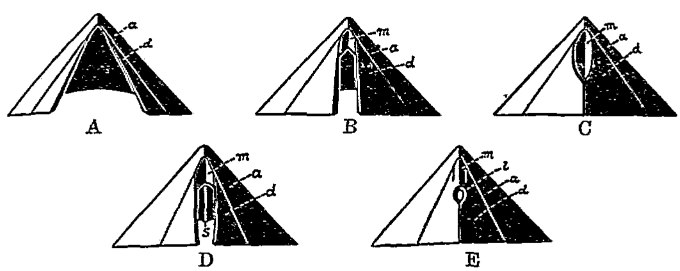
1 Eugen Schulz: Ueber einige Leitfossilien der Stringocephalenschiten der Eifel. (Taf. 7-8, S. 363-37). (Die Verhandlungen des Naturhistorischen Vereins der presussischen Rheinlande und Westfalens 70. Jahrgang 1913).

bei dieser Gelegenheit darauf hingewiesen, dass sie der Gattung *Stringocephalus* ausserordentlich ähnlich sein kann, sich aber von dieser durch das Fehlen des ventralen und dorsalen Medianseptums immer einwandfrei unterscheiden lässt. Die Angaben von Eugen Schulz über den inneren Bau sind durchaus unzureichend.

Das Gehäuse von *Bornhardtina* kann die Grösse eines ausgewachsenen *Stringocephalus* erreichen, sodass die Bornhardtinen mit zu den Riesen unter den Brachiopoden gehören. Das Gehäuse bikonvex, der Umriss bald kreisförming, dreieckig oder ± langoval (Tafel I, Figur 1-4, Tafel II, Figur 1-4). Häufig hat es einen asymmetrischen Umriss. Die Schalenoberfläche ist glatt, und zeigt feine oder seltener wulstartige Anwachstreifung. Die wulstige Anwachstreifung entspricht der von *Leptæna* (Tafel I, Figur 4a-4b). Nur bei bester Erhaltung ist eine feine Radialstreifung der Schalen zu erkennen (Tafel I, Figur 1a, 5a).

Die Ventralschale besitzt einen spitzen ± lang=gestreckten schnabelartigen Wirbel, der fast gerade oder auch stärker eingekrümmt ist und häufig seitlich verbogen sein kann. Das Delthyrium ist gross und dreieckig, die Area dagegen schmal, viel schmaler als bei Stringocephalus. Bei Jugendexemplaren ist das Delthyrium noch offen (Tafel I, Figur 6). Im Verlauf des Wachstums wird es durch zwei Deltidialplatten fortschreitend geschlossen, die von den Seitenrändern der schmalen Area aus gegen die Mitte wachsen (Tafel I, Figur 6). Dabei wird das Delthyrium immer kleiner und vorübergehend zu einem in der Hinterecke des Delthyriums gelegenen Foramen reduziert (Tafel I, Figur 3 und Tafel II, Figur 2c). Bei noch grösseren Exemplaren wird auch das Foramen durch eine konkave Mittelplatte geschlossen (Tafel I, Figur 1c, 3a).

Es ist eine häufige Erscheinung bei den Bornhardtinen, dass die Vorderränder der beiden Deltidialplatten wulstartig in radialer Richtung gefaltet sind. Bei der Gruppe der *Bornhardtina uncitoides* ist die Faltung der Deltidialplatten besonders ausgeprägt (Tafel I, Figur 1c, 3a). Die beiden Platten liegen ausserdem in einer Ebene. Bei der Gruppe der *Bornhardtina triangularis* fehlt die Faltung und ausserdem sind die beiden Deltidialplatten nach innen zueinander konkav gestellt (Tafel II, Figur 2c, 3a). Bei *Stringocephalus* bilden sich an den beiden Seitenkanten des Delthyriums ebenfalls zwei Deltidialplatten, die in der Jugend durch eine Längsspalte getrennt sind. Mit fortschreitendem Wachstum wird die hintere Hälfte des *Delthyriums* durch die etwas eingesenkte und von den beiden Deltidialplatten kantig abgegrenzte Mittelplatte geschlossen (Textfigur 1,E). Während bei *Bornhardtina* der vordere Abschnitt der Längsspalte sich durch Zusammenwachsen der Deltidialplatten schliesst, bleibt er bei *Stringocephalus* offen.



Textfigur 1. Geometrische Figur zeigen die Entwicklungen Deltidialplatten und Mittelplatte bei *Bornhardtina* und *Stringocephalus*.
A - C Bornhardtina, D - E Stringocephalus.
(a - area, d - Deltidialplatte, m - Mittelplatte s - Medianseptum, l - Stielloch.)

Die Mittelplatte (=Pseudodeltidium) von *Bornhardtina* ist deshalb interessant, da sie bei jungen Exemplaren noch ganz fehlt (Tafel I, Figur 6). Im Verlaufe des Wachstums entwickelt sie sich in dem zwischen den Deltidialplatten gelegenen Stielschlitz in der Richtung vom Wirbel nach dem Schlossrand als ein konkaves fischschwanzartiges Plattenstück (Tafel I, Figur 7), während die Deltidialplatten zur gleichen Zeit im vorderen Abschnitte des Längsschnittes von den beiden Seitenkanten nach der Mitte zu wachsen beginnen. Dieses Wachsen der beiden Deltidialplatten ist manchmal vollkommen und führt dann dazu, dass sie in der Mitte miteinander unter Bildung einer Naht zusammenwachsen (Tafel I, Figur 1c).

Bei *Stringocephalus* entwickelt sich die Mittelplatte in den jüngeren Stadien ebenfalls, was Wedekind[1] bereits 1917 abgebildet hat. Bet einem grossen Exemplar von Rohr habe ich beobachtet, dass die Mittelplatte mit den Deltididalplatten verschmolzen ist. Trotzdem ist sie in der oberen Schlitzecke noch angedeutet. Von Bedeutung ist es, dass der Deltidialapparat in der Jugend bei *Stringocephalus* dieselben Stadien durchläuft wie bei *Bornhardtina*.

Bei *Bornhardtina* sitzen zwei Schlosszähne jederseits am Schlossrande unterhalb der Area. Sie sind langgestreckt und durch eine Längsfurche geteilt, die dem Rande der Area parallel läuft. Von diesen beiden greift nur der obere in die Zahngrube, der untere unter die Teile der Schlossplatte, welche die Zahngruben nach vorn begrenzen.

Ein Längsschliff (Tafel III, Figur 4) zeigt, dass auch die Seiten der Ventralschale—nicht aber die Mitte!—innen durch ein nach hinten dicker werdendes Kalkpolster verstärkt sind. Dadurch wird der ganze innere, seitliche Hohlraum der Wirbelpartie ausgefüllt. Von diesem Kalkpolster gehen auch die, wie der Schliff zeigt, sehr hohen Zähne aus. Ein Medianseptum fehlt. Dieses innere ventrale Kalkpolster ist auch bei *Stringocephalus*, aber nur mit einer inneren, dünnen Kalklage vertreten. Es wird nur unter der Area und den Deltidialplatten dicker.

Die Dorsalklappe ist mit ihrer Wirbelpartie in das Lumen der Ventralklappe hineingekrümmt (Tafel III, Figur 1a-1b). Der gebogene Schalenrand wird auf jeder Seite von der Schlossplatte durch die nach vorn tiefer werdenden länglichen Zahngruben getrennt. Die bei *Stringocephalus* deutlich entwickelte innere Area ist bei *Bornhardtina* sehr schmal (Tafel III, Figur 5-6). Die Schlossplatte selbst besteht aus zwei nach innen konvex gebogenen Platten, die polsterartig dem Schalenboden aufsitzen und im Jugendstadium durch eine Medianfurche getrennt werden (Tafel III, Figur 6). Bei *Stringocephalus* stehen sie ± senkrecht zum Schalenboden (Tafel III, Figur 7-8). Mit fortschreitendem Wach-

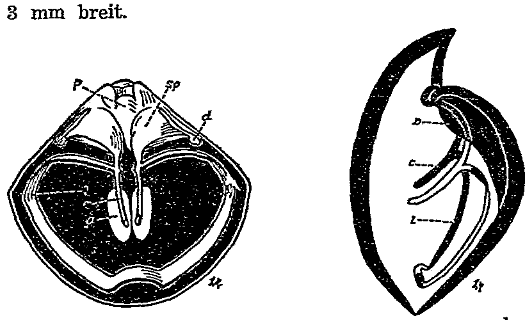
1 R. Wedekind: Ueber *Stringocephalus burtini* und verwandte Formen. (Die Nachrichten von der K. Gesellschaft der Wissenschaften zu Göttingen. Mathematisch-physikalische Klasse. (1917).

stum entwickelt sich am Hinterende dieser Furche eine polsterartige, zunächst kurze Verdickung, die sich nach vorn weiter ausbreitet und die ganze hintere Hälfte der Medianfurche ausfüllen kann (Tafel III, Figur 5). Aus dieser polsterartigen Verdickung entwickelt sich der Schlossfortsatz von *Stringocephalus* (Tafel III, Figur 7-8).

Die inneren und vorderen Winkel der beiden Hälften der Schlossplatte sind in Spitzen ausgezogen, an denen die Schleife ansetzt. Ein Medianseptum fehlt entweder ganz oder ist lediglich durch einen schwachen und platten Medianwulst angedeutet (Tafel III, Figur 5-6). Ein Längsschliff durch die Dorsalklappe zeigt, dass die Aussenschale durch ein hinten dickes, nach vorn dünner werdendes inneres Kalkpolster verdickt ist. Dieses reicht über die Mitte der Schale nach vorn nicht hinaus. Manchmal greift es hinten über den Schalenrand hinweg auf die Aussenseite des Wirbels und verdickt auch die Wirbelspitze von aussen. Ein Längsschnitt durch ein derartiges Exemplar, (Tafel III, Figur 1a-1b), zeigt das deutlich. Auch Naturpräparate zeigen diese Eigentümlichkeit deutlich. Das innere Kalkpolster ist der Träger des ganzen Schlossapparates. Die Adduktoren sind in der Mitte des Bodens der Dorsalklappe als langsovale Eindrücke (Tafel II, Fig. 5) zu erkennen.

3. Der Armapparat

Der Armapparat konnte durch Präparation teilweise freigelegt und weiterhin durch Schliffe ergänzt werden. Der Armapparat besteht aus den beiden Cruræ, die weit nach vorn reichen und hier hakenförmig eingekrümmt sind (Tafel III, Figur 2 und 1a-1b). In unmittelbarer Nahe der Schlossplatte entspringen die Primärlamellen von den Cruræ. In den Schliffen (Tafel III, Figur 3 und 1b) sind die Abzweigungsstellen der Schleife von den Cruræ deutlich erkennbar. Aus jeder Crura entspringen also Seitenäste, die sich zu der Schleife entwickeln. Die Schleife bildet einen Bogen, der dem Vorderrand der Schlossplatte und dann direkt den Seiten und dem Stirnrand der Dorsalschale folgt. In ihrer Biegung folgt die Schleife genau den Verbiegungen des dorsalen Schalenrandes, ist aber in der Mitte des Stirnrandes ± stark nach der Ventralseite brückenartig ausgebogen. Die Schleife ist fein längs und nicht radial gestreift. Bei einem Exemplar von 4,5 cm Länge ist die Schleife 3 mm breit.



a b

Textfig. 2, *Bornhardtina triangularis* Wdkd. (nat. Grösse)
2a, ergänzte innere Ansicht der Dorsalschale
2b. ergänzte Profil-Ansicht
p - polsterartige Verdickung, sp. - Schlossplatten
d - Zahngruben, a - Adduktor, c - Crura
l - Schleife, D - Verdickung der Schale

4. Die Gruppen und Arten von Bornhardtina.

I. *Gruppe der Bornhardtina uncitoides*

Deltidium gefaltet, flach, Wirbel lang. Schale glatt oder fein konzentrisch gestreift, seltener mit radialer Streifung. Schalenumriss auffallend unsymmetrisch.

a. Mit kurzen Furchen auf den Deltidialplatten.

1. Der schnabelartige Wirbel ist hakenartig über die Schalenrandebene hinweggekrümmt.

   B. uncitoides Schulz. (Taf. I, Fig. 1a-c)

2. Der schnabelartige Wirbel ist ventralwärts zurückgebogen.

   B. ahüttensis Ting. (Taf. I, Fig. 2a-b).

b. Mit langen Furchen auf den Deltidialplatten. Wirbel fast gerade.

B. sulcata Ting. (Taf. I, Fig. 3a-b)

II. *Gruppe der Bornhardtina triangularis.*

Deltidium glatt und konkav. Wirbel meist kurz. Schale glatt, fein konzentrisch gestreift oder quergerunzelt, mit feinen Längsstreifen. Gehäuseumriss nur schwach unsymmetrisch.

a. Gehäuse gross, Schale glatt oder feingestreift. Umriss abgerundet dreieckig.
B. triangularis Wedekind[1] (Taf. II, Fig. 1a-b)

b. Aehnlich der Vorigen aber Umriss langoval.
B. ovalis Wedekind (Taf. II, Fig. 3a-b).

c. Aehnlich der Vorigen aber doppelt so lang als breit.
B. lævis McCoy (Taf. II, Fig. 4a-b).

d. Gehäuse klein. Schale stark (wie *Leptæna*) quergerunzelt. Schalenumriss dreieckig.
B. rugosa Ting (Taf. I, Fig. 4a-b, 5a-b)

5. Die Beziehungen von Stringocephalus Defr. und Bornhardtina Schulz.

Die Gattung *Bornhardtina* kann in ihrem Habitus der Gattung *Stringocephalus* so gleichen, dass jene von dieser nur durch eine genauere Untersuchung zu unterscheiden ist. Erst die kleine Abhandlung von Eug. Schulz (1913) zeigte, dass die rheinischen Bornhardtinen durchweg unerkannt als *Stringocephalus* bezeichnet waren. Grundsätzlich ist *Bornhardtina* von *Stringocephalus* durch das Fehlen des dorsalen und ventralen Medianseptums und des stielartigen Schlossfortsatzes unterschieden. Das sind Merkmale, die auch im Steinkern überaus deutlich sind und eine einwandfreie Untersuchung ermöglichen.

1 R. Wedekind: "Kritische Bemerkungen zur Gliederung des Eifler Mitteldevons" (Zeitschr. d. deutsch. geol. Gesellschaft, Band 86, Jahrgang 1934, Heft I).

Demgegenüber bestehen ohne Zweifel zwischen den beiden Gattungen Beziehungen, die zu der Anschauung zwingen, dass *Bornhardtina* der direckte Vorfahr von *Stringocephalus* ist, zumal *Bornhardtina* unmittelbar vor *Stringocephalus* auftritt.

Es ist schon die Aehnlichkeit in der Gehäuseform, die besonders auffällt. Während aber die Gehäuseform von *Stringocephalus* immer regelmässig und symmetrisch ist, erscheint die von *Bornhardtina* meist ± unsymmetrisch, was besonders an dem langgestreckten schnabelartigen Wirbel hervortritt, der bei *Stringocephalus* kürzer und regelmässig hakenförming eingekümmt ist.

Der Schlossrand, der bei *Stringocephalus* breit und fast gerade ist, ist bei *Bornhardtina* schmal und stark gebogen. Die Deltidialplatten sind bei *Bornhardtina* wulstartig gefaltet, bei *Stringocephalus* aber plan. Die Area ist bei *Stringocephalus* noch relativ breit, während sie bei *Bornhardtina* sehr schmal ist oder sogar ganz fehlt. Infolgedessen müssen bei dem Uebergang von *Bornhardtina* in *Stringocephalus* die noch vorhandenen Reste der Area wieder eine stärkere Ausdehnng erfahren haben. Auffallend ist die Uebereinstimmung, die zwischen den beiden Gattungen im Bauplan der dorsalen Schlossplatte besteht. Während die beiden brückenartig gebogenen Hälften der Schlossplatte bei *Bornhardtina* dem Schalenboden polsterartig aufliegen, sind sie bei *Stringocephalus* senkrecht zum Schalenboden gestellt, also aufgerichtet. Ein Schlossfortsatz fehlt bei den kleineren Individuen' von *Bornhardtina* noch ganz, bei grösseren und ausgewachsenen Exemplaren erscheint er lediglich als ein flaches Kalkpolster—nicht stielartige Verdickung—unmittelbar vor der Wirbelspitze. Bei *Stringocephalus* dagegen wächst diese polsterartige Verdickung zu einem vertikal stehenden, langen stielartigen Schlossfortsatz aus, dessen gespaltene, distale Enden das ventrale Medianseptum umfassen. Die medianen Teile der beiden Schlossplattenhälften legen sich seitlich an den Schlossfortsatz an, ohne aber vollkommen mit diesem an den Schlossfortsatz an, ohne aber vollkommen mit diesem zu verschmelzen. Der Schlossfortsatz selbst zeigt auf seiner Unterseite eine knopfartige Erhebung. Die Abbildung (Tafel III, Figur 8) lässt auch noch bei

Stringocephalus die Artikulation der Schlosszähne und der Zahngruben erkennen.

Das dorsale Medianseptum, das den meisten *Bornhardtinen* noch fehlt, ist bei einigen Formen dieser Gattung bereits als eine schwache, wulstartige Verdickung angedeutet.

6. Das zeitliche Vorkommen von Bornhardtina und Stringocephalus

Mit dem Nachweis, dass die Gattung *Bornhardtina* nach ihrer Form und ihrem inneren Bau die engsten Beziehungen zu *Stringocephalus* hat, stimmt auch das zeitliche Auftreten der beiden Gattungen überein. In den Schichten[1] mit *Newberria amygdalina* (Caiquaschichten älterer Bezeichnung) fehlen noch beide Gattungen. In dem diese Schichten überlagernden oberen Korallenkalk (=untere Cosmophyllenstufe, Zone des *Stenophyllum intermedium* und des *Cosmophyllum geigeri*) sind die Bornhardtinen häufig, während *Stringocephalus* noch fehlt. Erst in den darüber folgenden oberen Cosmophyllenschichten (Zone des *Stenophyllum implicatum* und des *Cosmophyllum dachsbergeri*) stellen sich die ersten Stringocephalen ein. In den bekannten Mühlenbergmergeln von Gerolstein herrschen Stringocephalen von besonderem Aussehen vor, während Bornhardtinen znrücktreten, doch nicht ganz fehlen. Die langovale *Bornhardtina lævis* ist wiederum für die höheren Teile des mittleren Mitteldevons charakteristisch (Tafel II, Figur 4a-4b).

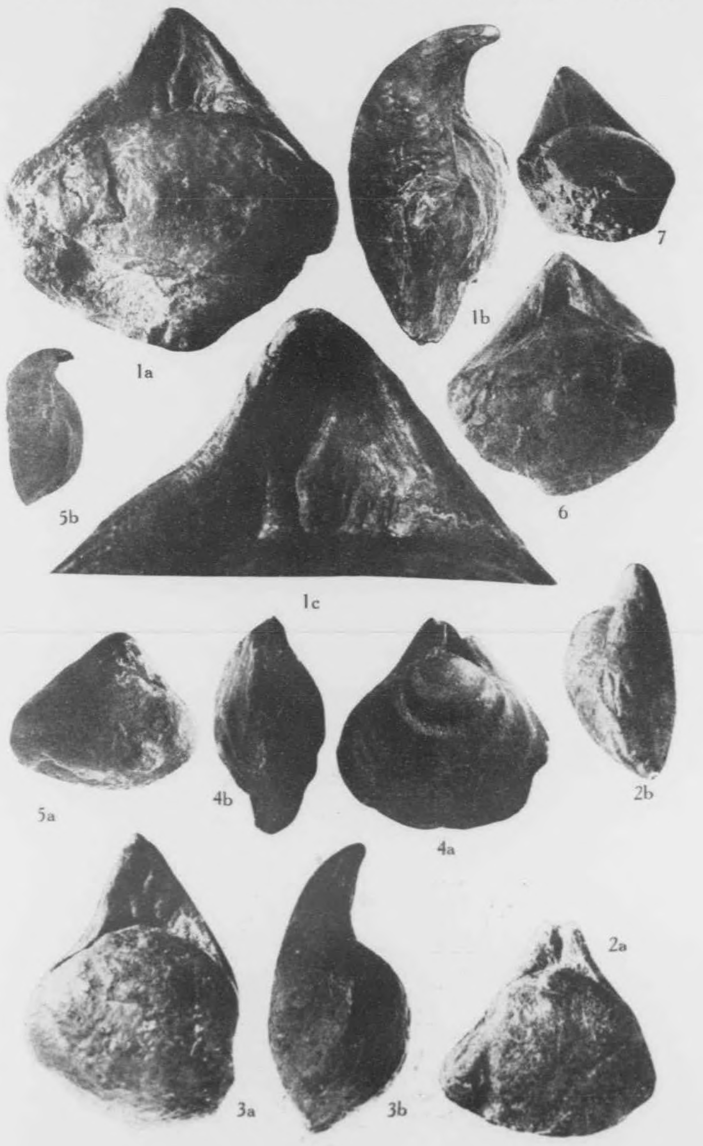
Bornhardtina uncitoides, B. sulcata, B. adhüttensis, B. triangularis, B. ovalis und *B. rugosa* geben dem oberen Korallenkalk im Gelände ein so charakteristisches Gepräge, dass dieser Horizont im Gelände nicht zu verkennen ist. Meine mit Herrn Professor Wedekind im Gelände ausgeführten Untersuchungen haben gezeigt, dass diese Bornhardtinen nicht nur in der Gerolsteiner und Hillesheimer sondern auch in der Dallendorfer Mulde allgemein verbreitet und immer an den oberen Korallenkalk gebunden sind.

1 R. Wedekind: Das Mitteldevon der Eifel, Teil II (Schriften ges. Beförd. ges. Naturw., Marburg 1925).

Tafel I

TAFEL I

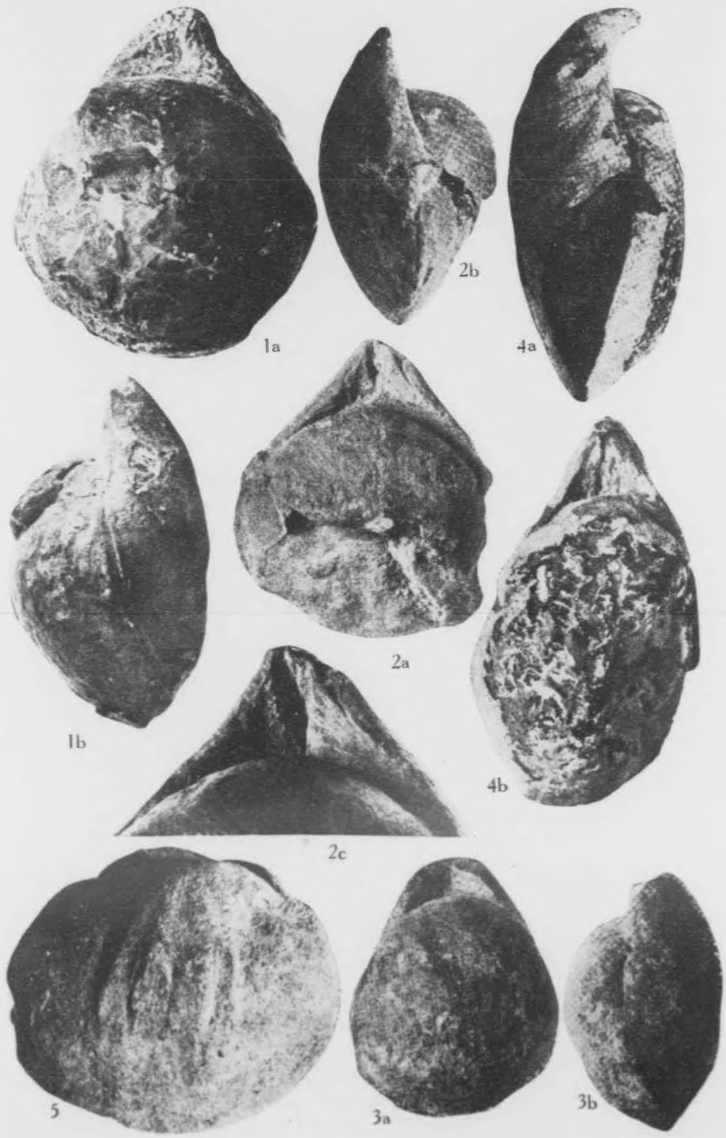
Fig. 1a-c	*Bornhardtina uncitoides* Schulz 1a, Dorsale Ansicht (1:1) 1b, Seitenansicht (1:1) 1c, Area und Deltidium (2:1) Fundpunkt: Niederehe.
Fig. 2a-b	*Bornhardtina ahüttensis* Ting (n. sp.) 2a, Dorsale Ansicht (1:1) 2b, Seitenansicht (1:1) Fundpunkt: Ahütte.
Fig. 3a-b	*Bornhardtina sulcata* Ting (n. sp.) 3a, Dorsale Ansicht (1:1) 3b, Seitenansicht (1:1) Fundpunkt: Niederehe.
Fig. 4-5	*Bornhardtina rugosa* Ting (n. sp.) 4a, 5a, Dorsale Ansicht (1:1) 4b, 5b, Seitenansicht (1:1) Fundpunkt: Niederehe.
Fig. 6	Junges Exemplar von *Bornhardtina* sp., bei dem das Delthyrium fast ganz offen ist (2:1) Fundpunkt: Ahütte.
Fig. 7	Junges Exemplar von *Bornhardtina sulcata* Ting. Es zeigt die Deltidialplatten, die Mittelplatte und das Stielloch (1:1) Fundpunkt: Ahütte.


1a
1b
7
6
5b
1c
5a
4b
4a
2b
3a
3b
2a

Tafel II

TAFEL II

Fig. 1-2	*Bornhardtina triangularis* Wdkd. 1a-b, Dorsal- und Seitenansicht (1:1) Fundpunkt: Niederehe. 2a-b, Dorsal- und Seitenansicht (1:1) Fundpunkt: Ahütte. 2c, Area mit Deltium (2:1) Fundpunkt: Ahütte.
Fig. 3a-b	*Bornhardtina ovalis* Wdkd. Dorsal- und Seitenansicht. Glattes und konkaves Deltidium (1:1) Fundpunkt: Pelm.
Fig. 4a-b	*Bornhardtina lævis* McCoy. Dorsal- und Seitenansicht (1:1) Fundpunkt: Paffrath.
Fig. 5	*Bornhardtina* sp. Ansicht der Dorsalklappe eines Steinkerns von Gerolstein mit den deutlichen Eindrücken der Adductores und der Gefässe (1:1).


1a
2b
4a
1b
2a
4b
2c
5
3a
3b

Tafel III

TAFEL III

Fig. 1a-b *Bornhardtina triangularis* Wdkd.
1a Längsschliff durch die Mitte des Wirbels.
Die Crura liegt in der Verdickung und reicht bis in die Mitte des Gehäuses *senkrecht und frei hinab*. Die Schleifenschnitte sind am Stirnrand erkennbar. (1.5:1)
Fundpunkt: Niederehe.
1b Längsschliff in der Nähe des Wirbels.
Die Abzweigungsstelle der Schleife von der Crura liegt etwas vor der Schlossplatte (1.5:1)
Fundpunkt: Niederehe.

Fig. 2 *Bornhardtina sulcata* Ting.
Der Schliff geht parallel dem Schalenrand. Die Cruræ und die Schleifenschnitte sind deutlich zu erkennen. (1.5:1)
Fundpunkt: Niederehe.

Fig. 3 *Bornhardtina uncitoides* Schulz.
Querschliff durch die Abzweigungsstelle der beiden Cruræ und Schleife. Die Schleife ist beiderseits in der Nähe der Schalenränder nochmals geschnitten. (1.5:1)
Fundpunkt: Niederehe.

Fig. 4 *Bornhardtina triangularis* Wdkd.
Längsschliff durch die seitlichen Teile der Schalen. Ein Schlosszahn der Ventralklappe greift in das Innere der Dorsalklappe. Die Schleifenschnitte sind neben dem inneren Stirnrand vorhanden. (1.5:1)
Fundpunkt: Niederehe.

Fig. 5 Dorsappe einer *Bornhardtina*.
In der Furche der Schlossplatte tritt eine polsterartige kurze Verdickung hervor, aus der der Schlossfortsatz bei *Stringocephalus* sich entwickelt. (1:1)
Fundpunkt: Niederehe.

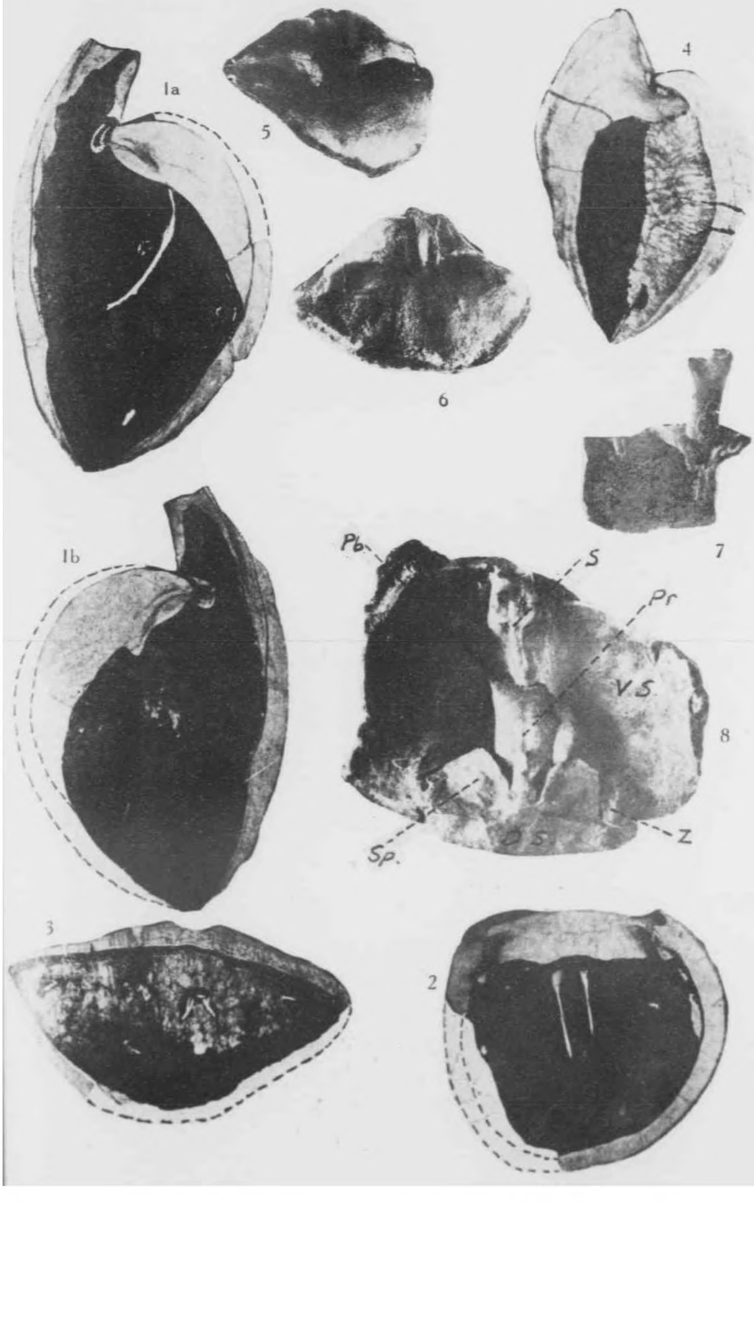

1a
5
4
6
7
1b
Pb
S
Pr
V.S.
8
Sp.
D.S.
Z
3
2

Fig. 6 Dorsalklappe von *Bornhardtina* sp.
In der Mitte ist der schwache Medianwulst angedeutet, d.i. der Ausgangspunkt des Medianseptums von *Stringocephalus*. (1:1)
Fundpunkt: Niederehe.

Fig. 7 *Stringocephalus burtini.*
Schlossfortsatz mit blattartigen Enden und Medianseptum. (1:1)
Fundpunkt: Rohr.

Fig. 8 Innerer Bau von *Stringocephalus burtini.* (:)
V.S. — Ventralklappe
D.S. — Dorsalklappe
S. — Dorsales Medianseptum
Z. — Zahn
Sp. — Schlossplatte
Pr. — Schlossfortsatz
Pb. — Blattartige Enden.
Fundpunkt: Rohr.

MINERALIZATION AT HUANTZETUNG, KIANGNINGHSIEN, KIANGSU

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INTRODUCTION

Towards the end of last November, the writers accompanied by a party of several students took trip to Huantzetung (罐子洞) as one of the field excursions forming a part of an elementary course on economic geology offered at the Department of Geology, National Central University. Huantzetung is located at the southernmost part of Kiangninghsien and almost at the Anhui border. In spite of its proximity to Nanking, being only 65 Km. away, it is not at all of easy access. The quickest way of approach is to go by bus to Linchiao (令橋) station at a distance of 33.10 Km. from Chunghua Gate (中華門), Nanking, and shortly beyond Molinkuan(秣陵關), and from Linchiao by foot for 12 Km. until Hêngchichiaocheng (横溪橋鎮) is reached where one better stays overnight as further on no lodging accomodation can be acquired. Then by meandering along narrow paths between rice fields for an additional distance of 9 Km. the next morning, one arrives at Huantzetung where is located a copper mine. According to verbal narration by its present promoter, the proprietor of a certain antique shop in Nanking. the mine had its history dated back in the Ming Dynasty and had a glorious record then. When exploitation was most active, there were employed no less than ten thousand workers, the ore extracted being smelted at the mine and the metal used for coinage. About thirty years ago, a certain business man at Hêngchichiaocheng undertook to rework the mine, but with unpromising results. He suspended the work after short duration and subsequently turned the property over to the present owner. Work was renewed last spring with less than thirty men who, however, quickly dwindled in number as prospects were not any better.

* Received for publication in June 1936.

At present, less than ten men remain and all with lean subsistence. It is claimed that considerable sum has already been spent within less than a year with not a single ton of ore shipped away. Mining is all in open-pits and no indication of any underground extraction is noticed. Judging from the magnitude of these open-cuts, the reported grandeur of its past appears to be a grotesque distortion. As the ore appears at present, the iron content far surpasses that of copper, but as an iron ore, the grade is too low to warrant extraction. However the mineralization observed herein is replete with scientific interest in spite of its economic insignificance. The writers although spending only half a day at the mine, have nevertheless made sufficient observations of the field relationships and have further brought back for detailed laboratory studies abundant material on the basis of which, they are able to arrive at certain conclusions regarding the genesis of the ore and to reconstruct in general the natural history of the deposit. They are deeply indebted to Mr. C. C. Chiang (蔣志超) for valuable assistance in the preparation of most of the illustrations which appear in the paper.

GEOLOGY

The hill reaching a height of 245 m. on which Huantzetung as well the mine are located is one of the many rather maturely dissected hills found near Nanking. Geologic conditions in the vicinity of Huantzetung are relatively simple. In ascending order one observes the following rocks (Plate I).

1. *Conglomerate.* This is found as a medium-textured rock with limestone making up most of the somewhat subangular pebbles averaging four or five cm. in diameter but may reach more than ten cm. Quartzite forms a subordinate pebbly constituent but in general coarser. The coexistence of limestone and quartzite pebbles seems unusal but the phenomenon is singularly present here. The cement is mostly coarse sand, tinged deep red or brownish-yellow by iron oxide and subordinately chert, limestone and calcite fragments. Above and below the conglomerate are found coarse sandstone layers, reddish and occasionally yellowish in colour. At Huantzetung, thin red coloured shale partings are found in

the quartzitic conglomerate. The thickness of the above rocks is approximately eighty meters. A characteristic feature of this conglomerate is that it shows many ellipsoidal or oval cavities, practically all filled by later mineralization with few however remaining still open (Fig. 2 & 5).

2. *Calcareous Shale.* This is all bluish-gray in colour having a fine-grained texture. It is richly calcareous and somewhat profusely mineralized as it shows contamination by a good number of minerals. On the eastern slope of Hsishan (西山), north of Huantzetung, there is found an intercalated limestone layer about 5 cm. thick, which at Huantzetung proper yields no good outcrops. This shale series is about thirty meters thick.

3. *Shale-quartzite Series.* Above the calcareous shale are found in succession 1, Yellowish-green shale, 2, Grayish and occasionally purplish shale with intercalated quartzite layers, 3, Light-grayish quartzite with shale gradually diminishing. Between the quartzite and shale, one finds occasionally thin conglomerate beds. This series has a thickness of about 250 m.

The three series described above reach a total thickness of 260 m. On account of insufficiency in time, no fossil was found except that few dark-coloured spots were observed on the yellowish-green shale suspected to be plant fossils but their poor preservation prevents any identification. By comparison, however, with the stratigraphic series in the neighbouring regions, the rocks at Huantzetung could be placed above the buff sandstone of the Chungshan formation (鍾山層). Its lower reddish sandstone is probably equivalent to the variegated sandstone and shale of the latter formation. Previous workers assigned this variegated sandstone and shale to the Cretaceous period. North of Huantzetung one finds overlying its rocks, effusive sheets of considerable extent which have been considered Cretaceous. Therefore the sedimentary series of Huantzetung cannot be later than this period; they are most probably middle or lower Cretaceous. A still further indication is found by comparison with its neighbouring region, namely Tangtu in Anhuei province. The

Tsaishih formation (采石層) at Tangtu seems to run continuously to Huantzetung. But Prof. Hsieh's description[1] of the said formation does not fit in with the rocks exposed at Huantzetung. It seems to apply, however, to the geologic conditions at Hêngshan (橫山), east of Huantzetung. Huantzetung occupies probably the top of the Tsaishih formation, not exposed at Tsaishih. Since the latter formation has been placed at the lower part of the Chungshan, namely, equivalent to the Huangmaching shale and Tzuhsiatung quartzite, the belief that Huantzetung represents the topmost part of the Chungshan is further strengthened.

Monzonite porphyry intrusion. On the south-western slope of the hill, there is exposed an intrusive body, pale yellowish-green in colour and distinctly porphyritic in texture. Megascopic examination reveals phenocrysts of predominent feldspar and slender prismatic hornblende in a groundmass too fine to be determined. Microscopically phenocrystic orthoclase and acidic plagioclase — mostly oligoclase but some albite and andesine as well — showing Carlsbad and Albite twinning are present. They are somewhat sericitized but deeply kaolinized. Hornblende in prisms and rhombic cross-sections is observed to have suffered sericitization, chloritization as well as epidotization. Apatite and titanite are present as accessories with specularite plates as contamination. The groundmass is a fine aggregate of feldspar with little intermixed quartz. In the field one would provisionally identify this rock as diorite porphyrite but as the orthoclase and plagioclase feldspars are present in about equal amount, it is more precisely named monzonite porphyry. By comparison with other intrusions found in the neighbourhood, a post-Cretaceous age is assigned to this body which is undoubtedly the parent magma for the contact metamorphic change and the subsequent hydrothermal mineralization in this locality.

The Deposit

The deposit is in the form of veins in the quartzitic conglomerate

1 Hsieh and others: Geology of the Iron Deposits in Lower Yangtze Region, Mem. Geol. Surv. China, Series A, No. 13, 1935.

or along the contact between the conglomerate and the intrusive mass. The chief ore mineral is massive hematite and specularite with subordinate intermixed pyrite and chalcopyrite. Oxidized iron and copper compounds add some value to the very lean primary ore. The most abundant gangue material is calcite, garnet and quartz. The deposit has been worked in a series of open-cuts, reaching 13 in number. Pits number 1-6 group together to form an outline having a striking linear extension (Plate II, Fig. 1). They form a zone heading N56°E and averaging 12 m. wide with an inclined distance of little less than 100 m. Assuming a probable downward extension of twenty meters and taking one quarter of the bulk as extremely low grade copper ore, one arrives at about 20,000 metric tons as reserve for this zone. And as the other scattered pits together could not exceed this amount, the total estimated reserve would be less than 50,000 tons of poor ore. The existing conditions do not warrant venturing beyond this rough approximation. The country rock is almost without exception a quartzitic conglomerate but with thin shale and sandstone partings well exposed in pit No. 1. Two striking structural features attract the attention of every observer. One is the ellipsoidal shape of much of the ore or gangue material in the conglomerate and the other is the splitting vein as is shown in pit No. 10 (Plate II, Fig. 2). The genetic significance of these features will be duly interpreted. No major geologic structure is present if one were to ignore some minor post mineralization faults and slickensides so clearly shown in some exposures. Primary mineralization has evidently been in two stages followed by oxidation and little supergene action.

MINERALOGY

Notwithstanding the fact that the ore here is low-grade, the assemblage of minerals and their genesis are worthy of the keen interest of a mineralogist or economic geologist. An individual description of these minerals in general order of formation follows.

Garnet: This mineral occurs abundantly and in two distinct habits, the massive and the crystalline, with the former earlier in age and in very close association with coarsely crystalline calcite which it strongly corrodes and from which it undoubtedly has derived some of its calcium content. Calcite remnants sometimes peculiarly orbicular in shape still remain; once a while they assume a plano-convex outline indicating a rupture of the originally more rounded forms (Fig. 1). The crystalline variety occurs in calcite or more frequently in cavities in quartzitic conglomerate which are as a rule ellipsoidal in shape. The crystals sometimes show in addition trapezohedrons, which are occasionally quite prominent. These crystals sometimes show an extension along one axis

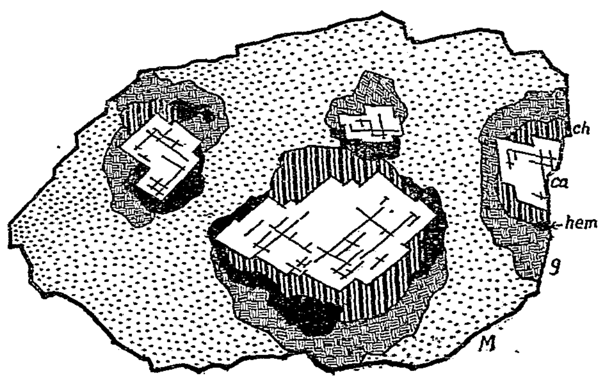


Fig. 1. Incomplete ring structure of the different pyrometasomatic products. Open-cut No. 2. Natual size. Ca, Coarsely crystalline calcite with impregnated pyrite and specularite. Ch. Chlorite and fine-grained calcite mixture. Hem. Hematite-specularite mixture. g. Massive brown andradite. M. Massive garnet and fine calcite mixture with impregnated hematite.

simulating tetragonal symmetry measuring 1.3 cm long, i.e. becoming a distorted crystal. In the same cavities are found specularite, pyrite and quartz which are as a rule of later formation. Specific gravity determination gives an average value of 3.7515 for most of the crystals, showing that they are mostly andradite. But the other common varieties of garnet namely grossularite, brown and often with resious luster, and almandite, nearly black, are present in some amount. These cavities often measuring 3 × 3 cm. in size represent undoubtedly spaces occupied originally by limestone pebbles in the conglomerate entirely removed by metasomatic action leaving part of the calcium content for the succeeding garnet. Resting on these high temperature garnet crystals are later crystals of quartz (Fig. 2). One observes close to these cavities the existence of another type of open spaces, namely the long and winding, drusy openings in which only quartz crystals appear with garnet entirely absent showing the limited range of the latter and the more persistent nature of the former. Microscopically, the garnet, whether massive or crystalline shows strong shattering with quartz and calcite appearing along its periphery or filling fractures in it. It shows alteration to fibrous hornblende and in turn to massive epidote. Specularite plates, chlorite veinlets and secondary iron oxide extensively replace it (Plate III, Figs. 1,2,3). The crystalline variety shows as a rule optic anomaly under + nicols and exhibits beautiful symmetrical zoning (Plate III, Fig. 4). The alteration to hornblende and chlorite is sometimes of a centrifugal type *i.e.* commencing from the center and advancing towards the periphery. The mineral, while pyrometasomatic in the beginning stage of formation especially that of the massive variety, the later facies, namely the crystalline development in cavity, has, at least, in part advanced to the hydrothermal stage, the temperature remaining still high *i. e.* at intense hypothermal conditions.

Apatite: Occurring in very small quantity, this mineral is found only microscopically. It appears in tiny prisms or grains entirely enclosed in crystalline and granular quartz and is clearly of very early formation.

Rutile: This is also of microscopic occurrence only. It appears in needly and hair-like inclusions in crystalline quartz with the acicular individuals sometimes lying parallel to the crystal faces of quartz and occasionally forming reticulated structure (Plate IV, Fig. 2). Some probably occur in altered biotite but too indistinct to be accurately determined.

Quartz: Persistent and abundant, this mineral occurs generally as colourless and once in while smoky masses and crystals. In cavities of whatsoever origin, well formed crystals appear with ± rhombohedrons

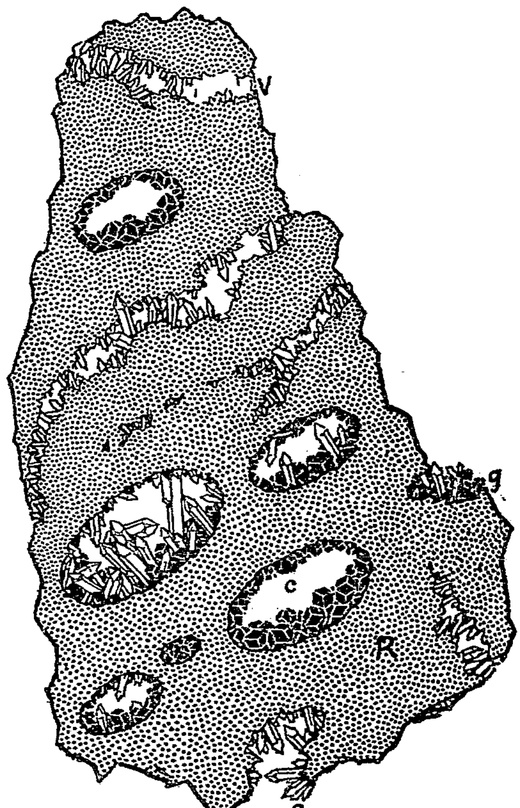


Fig. 2. Mineralized limestone conglomerate. Open-cut No. 2. 3/4 Natural Size. C. Oval or ellipsoidal cavity now partly mineralized. g. Dodecahedral and trapezohedral garnet crystals partly overlain by Q. Colourless quartz crystals. R. Rock. V. Later irregular vugs with only drusy quartz.

and well-developed prisms averaging 1-2 cm. but may reach 4 cm. in length (Figs. 3,4). These crystals line cavities in quartzite and calcite or in massive garnet in association with specularite and crystalline garnet, but may be found in late dolomite with which it forms alternate bends.

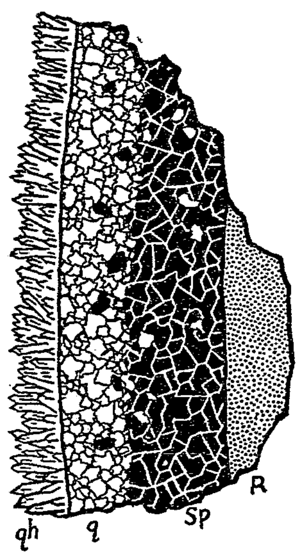


Fig. 3. Crustification of vein material. Open-cut No. 8. Natural size. R. Slightly chloritized and epidotized rock. Sp. Platy specularite with little granular quartz. q. Granular quartz with some specularite. qh. Comby quartz with little secondary chlorite and some incrusted hematite.

Microscopically it is found as well developed crystals in garnet and calcite but much of it is interstitial between garnet or traversing it in the form of veinlets. Its earliest appearance is distinctly earlier than that of specularite the plates of which coat it. It is also present as mosaic of fine grains in carbonatized rock as a result of silicification.

Shreds and foils of chlorite are found as inclusions in it while veinlets of calcite cut it freely. It may be also sagenitic with the rutile needles showing sometimes incomplete reticulated structure. A ferruginous variety also occurs as free crystals surrounding calcite or in cavities in it, entering its rhombohedral cleavages or appearing along the contact between chlorite and calcite. This is evidently of much later formation. Hence commencing from the garnet-quartz intergrowth and terminating towards this ferrugineous variety and the banded quartz with dolomite, this mineral has a long range of formation and wide stability field.

Biotite: Of microscopic amount, this appears as six-sided plates or lath-shaped crystal outlines but now extensively altered to chlorite. Another frequent alteration is to actinolite, columnar or shreddy in shape in which some remnant biotite can still be perceived.

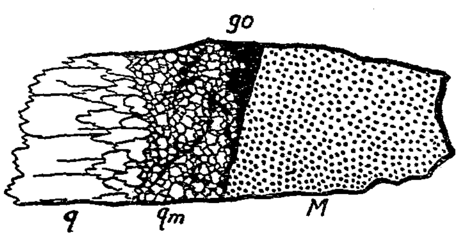


Fig. 4. Vein material. Open-cut No. 10. Natural size. M, Calcitic-garnetiferous rock with impregnated specularite. qm, Mixture of granular, colourless and smoky quartz. q. White to colourless crystalline comby quartz. go, Goethite veinlet between M and qm and interstitial in qm.

Hornblende: This is observed in thin sections extensively replacing garnet. Originally chiefly green and subordinately brown, it has faded in colour changing to greenish-yellow. It shows a strong tendency to fibrous development with the fibres occasionally characteristically radial in form. It is in turn abundantly altered to chlorite which far surpasses it in quantity. Hence it forms a transition stage between garnet and chlorite.

Diopside: This is present as inclusions in calcite and together with chlorite imparting to it a greenish colour characteristic of a portion of calcite here. In thin sections few grains are found occasionally in association with bands of specularite in calcite.

Actinolite: Occurring as greenish-yellow prismatic aggregates somewhat radiating in form, this mineral is found either in parallel position with plates of specularite or as winding veinlets in or enclosed by it. In thin sections it appears as columnar to shred-like aggregates somewhat lath-shaped with occasional biotite remnants which it has altered resulting in the development of numerous fibers (Plate IV, Fig. 1). These enclosed fibers have a characteristic cloudy appearance suggesting a further development of asbestus from the actinolite prisms with probably later leaching further intensifying the cloudiness. The actinolite is found also to alter to chlorite.

Specularite: This mineral, occurring rather abundantly, is of two general habits; namely 1, coarse, fresh plates (Plate IV, Fig. 4) impregnating massive garnet or filling ellipsoidal cavities in quartzitic conglomerate (Fig. 5) with sometimes garnet in the midst and 2, aggregates of fine scales or specks tinged red on account of incipient alteration to earthy hematite. These two varieties may correspond in part to the pyrometasomatic and hydrothermal actions respectively representing at least products of two distinct and successive stages. The plates are found coating quartz crystals or as veinlets in garnet and pyrite (Plate V, Fig. 2) and often interstitial between them. The platy aggregates with intermixed calcite are found sometimes as angular and subangular fragments $3 \times 1\frac{1}{2}$ cm in size in quartzitic rock and show slickensided surfaces indicating brecciation after formation. Cavities in this mineral are lined with pyrite. It, however, is present as veinlets in massive pyrite and may show a streak of quartz in the middle separating it into narrow lines giving a railroad-tract structure. It is also observed as crustified bands lying against altered chloritized and epidotized rock on one side and covered by a layer of quartz on the other. It is found in thin sections to have formed partly after the development of fibrous hornblende and chlorite. The finely scaly variety is found intimately intermixed with calcitic and dolomitic material and is of distinctly later formation.

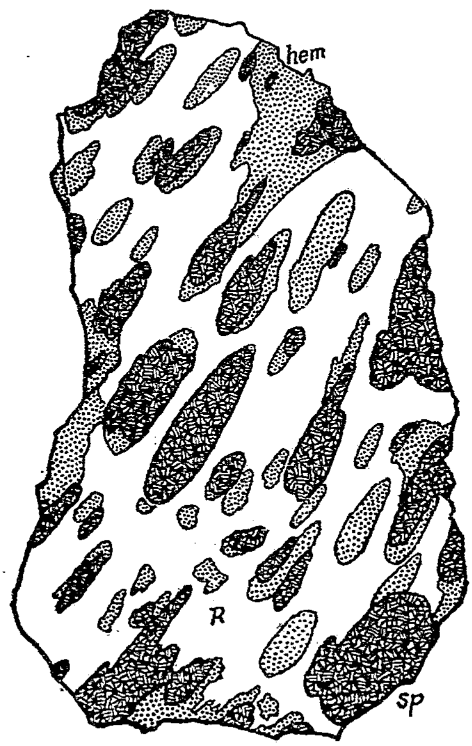


Fig. 5. Mineralized limestone conglomerate. Open-cut No. I. Natural size. Sp. Platy specularite and Hem. earthy hematite with intermixed calcite filling the parallelly arranged ellipsoidal cavities. R. Fine quartzitic cement.

Pyrite: This is the earliest sulphide formed appearing in simple octahedrons or pyritohedrons or in both forms approaching sometimes 1 cm. in diameter (Plate IV, Fig. 3). These crystals are embedded in a quartzitic or a carbonatized rock, either in the quartzitic cement bordering the somewhat replaced pebbles or filling their oval cavities in association with specularite (Plate V, Fig. 1) and calcite. Polished sections show the mineral mostly as massive crystalline aggregate somewhat shattered and cemented by a dark green silicate. It is also embedded in calcite and is usually fresh except somewhat replaced by specularite and corroded by calcite. However it is also found as veinlets in specularite. Some crystals have been altered to limonite preserving their pyritohedral and octahedral forms. This mineral is chiefly hydrothermal with a very limited amount pyrometasomatic.

Bornite: Found only microscopically, this is in close association with chalcopyrite which corrodes it in the form of veinlets. A lattice structure is occasionally shown with chalcopyrite forming parallel reticulating streaks in a field of bornite (Plate VI, Fig. 3). It is replaced by chalcocite and covellite.

Chalcopyrite: Found only sparingly admixed with pyrite in hand specimens, this is present chiefly in polished sections although in limited amount. It is embedded in quartzitic gangue or impregnating or replacing pyrite, and is in frequent association with specularite with which it is contemporaneous but with much shorter range. Seen also as triangular fragments in quartzite, it represents a shattering product with free crystal faces sometimes still preserved.

Chalcocite: This is observed only microscopically in and bordering pyrite (Plate V, Fig. 4, Plate VI, Fig. 1) and to some extent specularite and also along pyrite-specularite contact. Its contact with pyrite is sometimes sharp showing mutual type of boundary indicating a contemporaneous deposition and also its hypogene origin. This is confirmed by the fact that there is no evidence of exidation in the immediate neighbourhood. While partly contemporaneous, it is found also to corrode to some extent the terminating edges of pyrite, showing therefore that it is slightly later in age (Plate V, Fig. 3). When found near bornite-chalcopyrite intergrowth, it shows tendency to replace the former leaving the latter unaffected. While ordinally bluish-white in colour it is sometimes differentially blue indicating the presence of covellite in solid solution; such covellite may sometimes be seen as mechanically mixed tiny grains. Remnant grains of chalcocite are found in calcitic-hematitic gangue with which it forms a pseudo-eutectic structure.

Covellite: Present in still smaller amount, this mineral is found in few polished sections to associate with chalcopyrite in quartzitic gangue. With chalcocite, it replaces pyrite and bornite (Plate VI, Fig. 2) and with the latter mineral it shows preference in association.

Epidote: This is found invariably as an alteration product in thin sections. The principal original mineral is garnet but biotite and to some extent hornblende also alter to it. Very sparingly it is found in hand specimens as a coating on calcitic material or entering its rhombohedral cleavages. A little primary epidote is however present in recrystallized quartz in calcite. It is crystalline in contrast to the massive hydrothermal alteration product.

Chlorite: This occurs abundantly as greenish inclusions in coarsely crystalline calcite and microscopically as alteration product of principally garnet but also of biotite and actinolite. It surrounds the borders of calcite and enters specularite as veinlets.

Sericite: Besides its occurrence as hydrothermal alteration product in monzonite, it is found as light-green fibrous aggregate replacing garnet and calcite and is associated once in a while with malachite.

Calcite: Of widespread occurrence, this mineral is found in two general habits, namely, the early coarsely crystalline variety in association with garnet and specularite and the late fine aggregates or interstitial grains as well as veinlets and drusy, scalenohedral crystals. The coarse crystalline calcite is often surrounded and corroded by massive garnet which in turn may be enclosed in the former as minute imperfect crystalline grains. It encloses chlorite shreds and octahedral pyrite crystals also often filling cavities in quartzite. Specularite plates often penetrate far into it. Under + nicols, it shows characteristic twin lamellæ and wavy extinction due perhaps to mechanical causes. This coarsely crystalline calcite is either white, containing few garnet crystals or specularite plates, or green due to chloritic and diopsidic inclusions. The late form is found in the coarser variety as veinlets, or often replacing garnet and quartz. It is often fine-grained due to the processes of carbonatization of an originally silicified cementing material or even to some late secondary action as it is seen to traverse earthy hematite in the form of veinlets. As vein material it sometimes shows crustified banding with quartz, goethite etc. Fractures in it are sometimes filled by dolomite. Of special interest is the ring structure, although sometimes incomplete shown with the associated minerals. The sequence relationships are determined as follows (Fig. I): (1) Coarse calcite core with little impregnated pyrite and specularite. (2) Chlorite and fine-grained calcitic matter forming a distinct band. (3) Ring of mixture of specularite and hematite. (4) Massive andradite. The above are evidently all of high temperature deposition followed by (5) alteration of specularite to earthy hematite, (6) development of malachite perhaps from the little copper contained in the nearby pyrite.

Dolomite: Often mixed with calcite, this mineral shows two varieties: one is the white coarsely crystalline, impregnating quartzite, originated in the same fashion as the early coarse calcite and the other is brown with shining luster appearing along quartzite-calcite contact or between ellipsoidal specularite and its neighbouring cement. Vugs in it are often lined with crystals of siderite which elsewhere may rest in turn on dolomitic material.

Siderite: This is present as light brown, small, crystals sometimes with the rhombohedral faces curved to form saddle-shaped subindividuals. It replaces specularite along its borders. Central portions of its narrow veins with still unfilled cavities are lined with calcite (Fig. 6). This is evidently a late hydrothermal product.

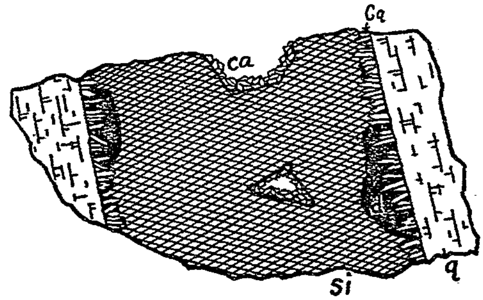


Fig. 6. Symmetrically banded vein. Natural size. q, Colourless, granular quartz with fine interstitial calcite. Cq, Layer of comby quartz at its sides. d, Dolomite, light brown. Si, Siderite, sometimes saddle-shaped sub-individuals. Ca, Vuggy, pink calcite crystals.

Malachite: This is sparingly found as coatings on calcitic material and microscopically in association with sericite. It is usually a mere stain on the green chloritic material or on chalcopyrite. Its rarity is a partial indication of the low copper content in the ore.

Goethite: This hydrous, secondary product is seen as brownish fibres with excellent radiating structure between crustified bands of garnet and mixture of granular calcite. Microscopically intergrown with it, there seem to be many slender prisms of quartz arranged in parallel position (Plate VI, Fig. 4). Descending solutions containing iron seemed to have precipitated goethite which was perhaps originally specularite, leaving quartz unaffected. It is also found as prismatic crystals in cavities in quartzite. Actinolite is seen microscopically to have altered to this mineral.

Hematite and Limonite: These are secondary oxidation products coating garnet, specularite and practically all the silicates containing iron. They are seen to fill oval cavities in quartzite with residual specularite and pyrite in the center. They generally fill fractures in early sulphides and silicates, or surround them and are present abundantly in cavities as a massive, earthy material typical of gossans.

Limonite is seen as perfect pseudomorphs after octahedral crystals of pyrite.

Pyrolusite and Wad: These are found as a black, earthy material in the form of surface coatings on the already oxidized material. In cavities they are especially abundant imparting a general superficial black colour to garnet as well as the other minerals.

Kaolin: Although mostly a hydrothermal alteration product of the monzonitic rock and of an original fibrous material in the vein, this has been found in part also by surface decomposition adding to the bleached appearance and crumbly nature of part of the material collected from the mine.

All the minerals described above are summarized in the following table showing their association as well as genesis.

GENESIS

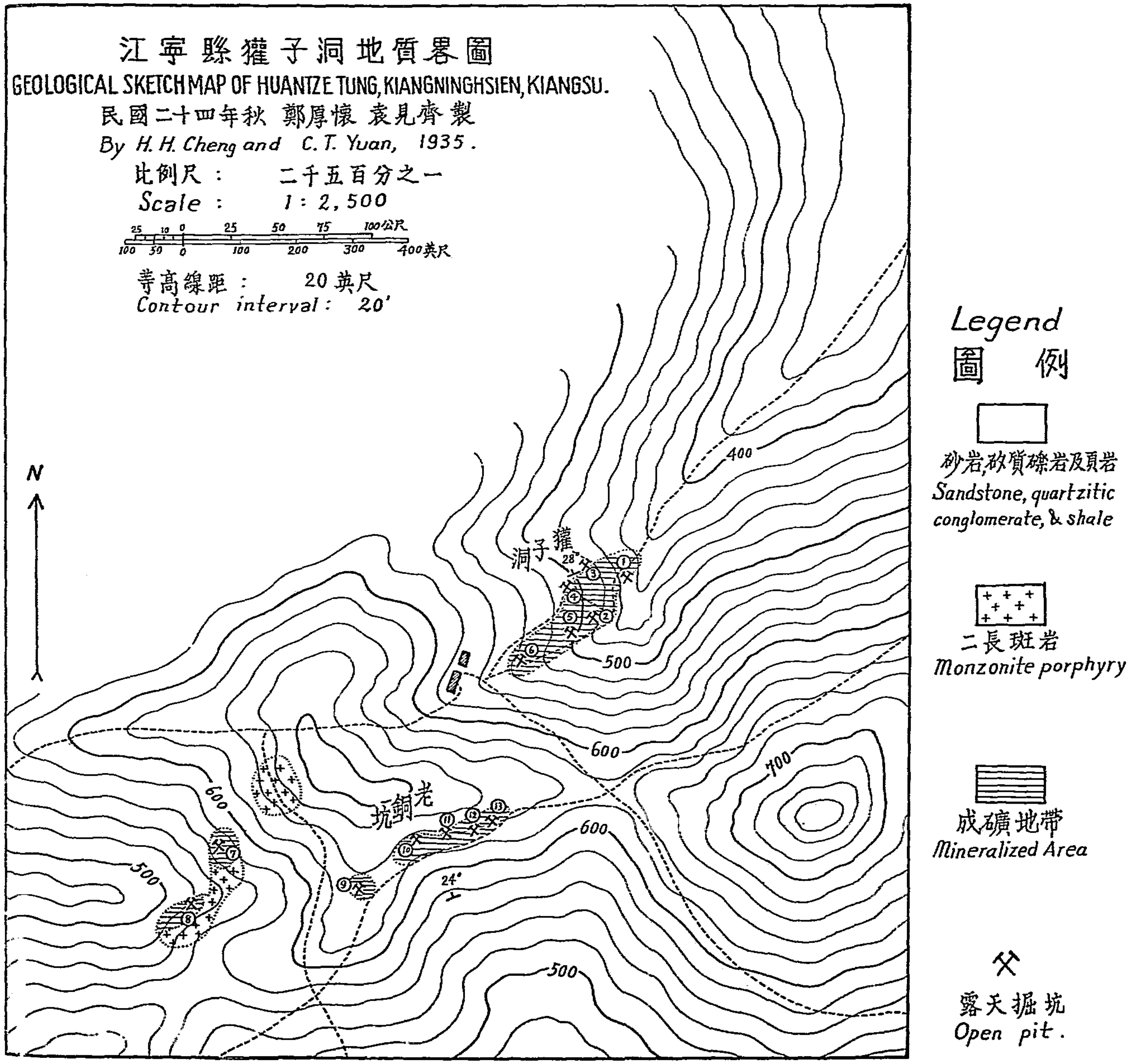
The Huantzetung deposit of whatsoever origin has undoubtedly the monzonite porphyry as its parent magma. But this intrusive body in its ascent through the sedimentary-metamorphic series of rocks was not efficacious on account of the general unfavourable chemical nature of the country rocks to effect much mineralization except little specularite and few silicates, the production of which in this initial stage was quite limited in amount. The mere exceptional case is the mineral garnet, the abundant silicate found, a considerable portion of which was formed by the contact-metamorphic action. An explanation lies in the almost complete replacement of the limestone pebbles found originally in the quartzitic conglomerate which elsewhere still remain but in the mineralized belt here completely removed. Were these pebbles made of some other more resistant material, the pyrometasomatic garnet would certainly not have been of such abundant occurrence. Hydrothermal solutions carrying much iron and some copper then arose producing much of the specularite, almost all of the primary sulphides, most of the high temperature silicate gangue minerals and effecting further hydrothermal alteration of the silicates formed by the early contact-metasomatic action. Proof of this hydrothermal mineralization lies in the tabular form shown by the linear extension of the open-cuts, in the

Paragenesis Table of the Minerals of Huantzetung

Mineral	Pyro-Metasomatic	Hydrothermal		Oxidation
		Intense	Late	
Garnet	—	—		
Apatite	?	—		
Rutile		—		
Quartz	—	—	—	
Biotite	—			
Hornblende	—			
Diopside	—	—		
Actinolite	—	—		
Specularite	—	—		
Pyrite	—	—		
Bornite		—		
Chalocpyrite		—		
Chalcocite		—		—
Covellite				—
Epidote	—	—		
Chlorite		—		
Sericite		—		
Calcite	—	—	—	—
Dolomite	—		—	
Siderite			—	
Malachite				—
Goethite				—
Hematite				—
Limonite				—
Pyrolusite				—
Wad				—
Kaolin		—	—	—

abundance of open cavities, in the nature of alterations as revealed by microscopic examination and in the repeated appearance of crustification. Finally oxidation ensued with the development of the well known carbonates and oxides and a little supergene copper sulphide.

Correlation of the minerals with their source reveals the following interesting facts. Contact metamorphic action is restricted to open cuts No. 2, 7 and 10. For 7 and 10, the phenomenon is natural as they are closest to the monzonite exposures. The closer the material is to the igneous rock the more metamorphic effect it shows as is true with the minerals from open cut No. 7 exhibiting in general a characteristic interlocking, closely-knitted texture well-known of material from pyrometasomatic zones. In open cut 2, however, no visible igneous rock is present, yet the minerals such as garnet, specularite, and chlorite exhibit textural relationships similarly characteristic of contact-metamorphic effect. It is assumed therefore that an igneous body underlies it in rather shallow-seated condition. This hypothetical igneous body represents perhaps a local protuberance of a still greater mass which shows a similar bulging in open-cut No. 7. An equally interesting fact is that the sulphides are restricted to open-cuts No. 1, 2 and 6. In 2 where there are evidences of contact-metamorphic action, the sulphides may have been partly formed by the intrusive action, but in 1 and 6 where there is no sign of pyrometasomatism and where the sulphides occur most abundantly, the responsible process is evidently hydrothermal action. Hence it is concluded that ore deposition as well as the general mineralization in Huantzetung is subordinately pyrometasomatic and predominently hydrothermal.


江寧縣獾子洞地質畧圖
GEOLOGICAL SKETCH MAP OF HUANTZE TUNG, KIANGNINGHSIEN, KIANGSU.
民國二十四年秋 鄭厚懷 袁見齊 製
By H. H. Cheng and C. T. Yuan, 1935.
比例尺: 二千五百分之一
Scale: 1:2,500
等高線距: 20英尺
Contour interval: 20'
N
獾子洞
老銅坑
400
500
600
700
Legend
圖例
砂岩,矽質礫岩及頁岩
Sandstone, quartzitic conglomerate, & shale
二長斑岩
Monzonite porphyry
成礦地帶
Mineralized Area
露天掘坑
Open pit.

Explanation of Plate II

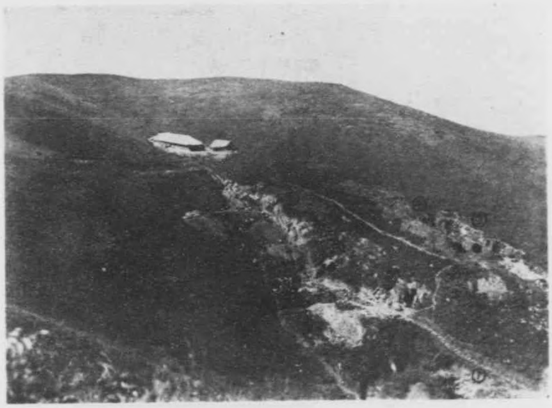
PLATE II

1.

General view of the principal workings showing the linear extension of the open-cuts No. 1-6.

2.

A splitting vein (dark) in metamophosed *conglomerate*, open-cut No. 10.



1

2

Explanation of Plate III

Photomicrographs of thin sections.

PLATE III

1.

Shattering of garnet (g) and subsequent replacement by specularite (sp), chlorite (ch) and calcite (ca) along its fractures and borders. Open-cut No. 7. × 36.

2.

Replacement of garnet (g) along fractured surfaces by hornblende (hb) and eventual alteration to fibrous radial chlorite. Interstitial calcite (ca) is also shown. ×35.

3.

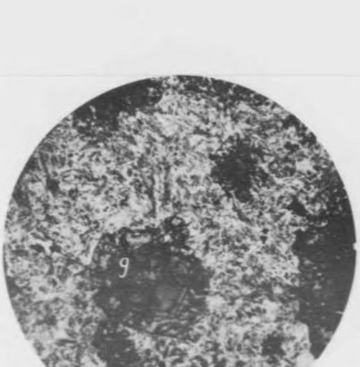
Garnet (g) remnants in chloritized actinolite and intermixed specularite. × 15.

4.

Beautiful symmetrical zoning in garnet crystal. Open-cut No. 7. ×125.

1

2



3

4

Explanation of
Plate IV

Photomicrographs of thin and polished sections.

PLATE IV

1.

Chloritized actinolite (ch) replacing biotite (dark) and calcite (ca). Limonite (lim) rimming chlorite. Open-cut No. 2. ×36.

2.

Sagenitic quartz showing acicular rutile inclusions. g. garnet, ch. chlorite. Open-cut. No. 7. ×34.5

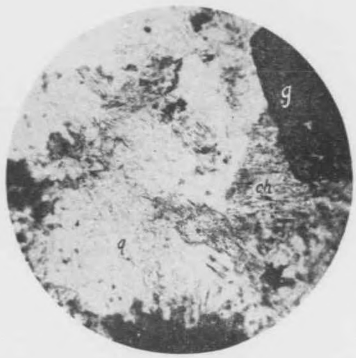
3.

Mineralization of a portion of ellipsoidal cavity in quartzite. Pyrite (py) in well-developed polygonal outlines embedded in calcite. Hem. earthy hematite. Open-cut. No. 1. × 11.

4.

Specularite plates in quartz gangue. ×40.

1



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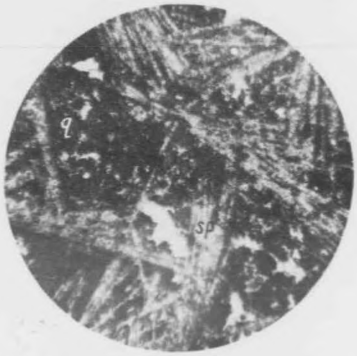


4

Explanation of Plate V

Microphotographs of polished sections.

PLATE V

1.

Peripheral replacement of shattered pyrite (py) by massive hematite (hem). Q quartz. Open-cut No. 2. ×100.

2.

Pyrite (py) replaced by quartz (q) and specularite (sp), the latter appearing occasionally along the pyrite-quartz contact. Open-cut No. 2. ×91.

3.

Mutual type of boundary between pyrite (py) and chalcocite (cc), indicating contemporaneous deposition. But corner of pyrite somewhat corroded by chalcocite, the former hence little earlier. Open-cut No. 2. ×40.

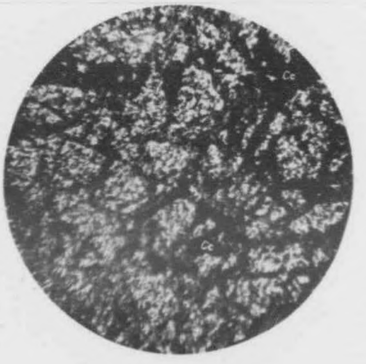
4.

Shattering of pyrite (py) and subsequent replacement by hypogene chalcocite (cc). Open-cut No. 6. ×112.

1

2

3



4

Explanation of Plate VI

Microphotographs of polished sections and thin sections.

PLATE VI

1.

Same as Plate V, Fig. 4. More advanced stage of replacement. ×145.

2.

Pyrite (py) remnants in bornite (bn) which is in turn replaced by supergene chalcocite (cc) and covellite (cv). Open-cut No. 6. ×500.

3.

Lattice structure of chalcopyrite (cp) and bornite (bn), and replacement by covellite (cv). ×1090.

4.

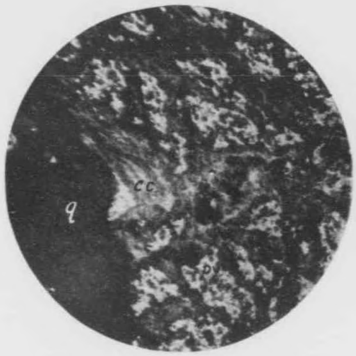
Crustified Banding.

g. Garnet impregnated by specularite and cemented and traversed by late calcite.

Qca. Silicification of calcite. Granular aggregate of quartz and calcite (q).

go. Veinlets of slender prismatic crystals of goethite (go).

ca. Transverse late calcite veinlet (ca). × 15.



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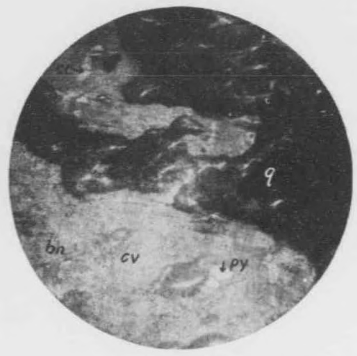

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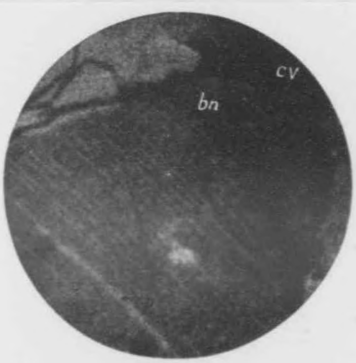

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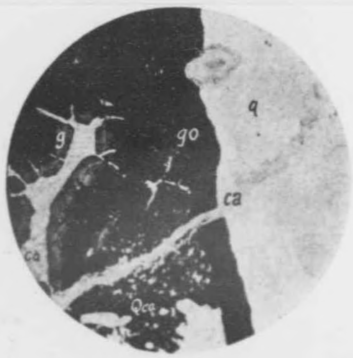

4

ORE DEPOSITS OF CHINCHUANTANG, CHENHSIEN, HUNAN*

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(National Geological Survey of China)

I. INTRODUCTION

The ore deposits of Chinchuantang were known to geologists since the publication of the report by Mr. H. C. Wang[1] and others in the year of 1930. In this region a great number of different ores including zinc, lead, arsenic, sulphur, manganese, tungsten and bismuth have been mined by several companies such as Paosiang Co. in Chinchuantang proper, Chiyuan and Fukang Co. in Chaishan, Tachern Co. in Shihchuyuan and Tafu Co. in Shuihuli. The area of the mineralized region is about 3,400,000 sq. m. In the winter of 1931 while investigating the pyrite reserve in S. Hunan, Mr. H. S. Wang and the writer went to Chinchuantang to see these deposits. With Mr. H. C. Wang's report and geological map at our disposal, we had more time to study the genesis of the ore deposits, particularly on the relationships of the tungsten ore in Shuihuli with greisenization that have not hitherto been emphasized by the previous workers.

The writer wishes to acknowledge Prof. C. Y. Hsieh, Prof. H. H. Cheng and Mr. H. J. Chu for their direction and encouragement in preparing this report. To Mr. H. S. Wang he is deeply indebted for his guidance during the field work.

II. GENERAL GEOLOGY

The geology of Chinchuantung and its neighbouring regions is rather simple; it is composed of granite with some pegmatitic or quartz veins intruding through a limestone formation. The latter partly shows the roof-pendent structure enclosed in the granite.

* Received for publication, November 1935.

1 H. C. Wang, Y. T. Hsu & H. C. Hsin:—Report on the mineral deposits of Chinchuantang, Chenhsien, Bull. Geol. Sury. Hunan, No. 10.

The limestone may be reasonably correlated with the so-called Shihtentze limestone of Lower Carboniferous age near the Chenhsien city. It is dark gray in color and contains usually cherty nodules. In most cases, it is metamorphosed into marble and disturbed by the igneous intrusion, so that fossils are not found.

The granite shows in general a more or less porphyritic texture consisting mainly of orthoclase, plagioclase, hornblende, actinolite and biotite, their relative proportion varies from place to place. Orthoclase is the most abundant mineral among them and shows a tabular form ranging from 1 to 24 mm in width. It is often intergrown with quartz forming the typical micrographic (or eutectoid) texture which is clearly shown in the thin sections. Plagioclase determined to be an oligoclase occurs in small quantity and exhibits occasionally zonal structure. Both orthoclase and plagioclase are partly converted to sericite and kaolin and sometimes the plagioclase may also be changed to epidote. The color of the granite varies in different localities due chiefly to the content of orthoclase. It is reddish in Chaishan, pinkish red to white in Chinchuantang proper (including Tachiling), reddish white in Shuihuli, and greenish white in Shihchuyuan, in the last case the color is evidently resulted from the absence or rarity of the orthoclase. Quartz is present in euhedral grains and occasionally in corroded crystals varying from half a milimeter to 8 mm in diameter. It is vitreous and colorless differing from that found in pegmatitic veins which is of milky white appearance. Hornblende and actinolite are sparingly distributed in the granite, with the former comparatively more abundant than the latter. Biotite shows brownish black crystals with good basal cleavages. In Shihchuyuan, it is preponderant over the hornblende and actinolite and in others they are in reverse proportion. All these dark minerals in granite are mostly altered to chlorite. Muscovite in irregular flakes and patches is very rarely present in the granite but common in the pegmatitic or quartz veins. Occasionally, there are some bluish black crystals of tourmaline cutting through the quartz and feldspar crystals in granite; they evidently come from the last emanation of the magmatic solution. Magnetite, pyrite, apatite and zircon occur sparingly as the accessory constituents of the granite.

The pegmatitic or quartz veins are found in or adjacent to the granite. They are more abundant in Shuihuli and occur subordinately in Chaishan and Chinchuantang proper. They are irregularly intersected and are composed almost entirely of quartz with minor amount of associated minerals.

Although the granite is found here to have intruded into the Carboniferous limestone only, but when comparing the granite intrusion in other parts of Hunan, it is evident that the age of intrusion should be extended up to early Cretaceous or still later; the intrusion probably took place during or after the Yenshanian movement of Dr. W. H. Wong.

III. Distribution of the Ore Deposits

The ore deposits in this region are in various forms of chimneys, pockets, veins, etc. All of them are commonly found near the contact zone between granite and limestone, less frequently they are found also in the granite or in the limestone. An individual description of different parts of the deposits is given as follows:

(1) Tachiling:—This region is situated about 22 km SE of Chenhsien city. The ore body occurs in limestone showing chimney structure with an average diameter of 12 m. and an approximate vertical extension of about 220 m. An interesting feature is that the deposit shows a vertical variation of mineral constituents in such a way that galena and sphalerite are characteristic of upper zone, while pyrrhotite, pyrite and arsenopyrite become more and more abundant in depth. The primary ore minerals are arsenopyrite, pyrite, pyrrhotite, sphalerite, tetrahedrite, chalcopyrite and galena. At the lowest part of the ore body, there is a garnet zone containing garnet, epidote, feldspar, quartz, calcite with scattered pyrite, arsenopyrite and pyrrhotite grains.

In the east of the Paosiang Co., there is the Mn-deposit of Wuleichihku; the ore occurs in laminated form and is composed of psilomelane, pyrolusite and wad. The origin of this deposit is not certain; most probably it is of residual origin, being formed from weathering and decomposition of a preexisting manganese sulphide to be described in detail in the following paragraphs. Further east of the Mn-deposit, a small and thin wolframite-quartz vein was also found, but it is of no economic value.

(2) Chaishan:—Chaishan is situated about one and half km. S of the Chinchuantang proper. It is essentially a pyrite deposit with minor amount of arsenopyrite, sphalerite and galena. The ore body assumes the shape of a vertical chimney with the same width and extention as that of Tachiling deposit, but here the ore is almost exclusively confined to the limestone portion. The pyrite body is generally penetrated by purple fluorite veinlets.

Near the top of Chaishan, a deposit of pyrite and bissmuthinite with gangues of calcite, quartz, and fluorite was found. This mine was abandoned at the time of our visit, so detailed description can not be given.

On the SE or along the lower slope of Chaishan for about half a kilometer in distance, there is a thin pegmatitic vein composed of quartz, topaz, epidote, sericite, fluorite and pyrite in small amount.

(3) Shihchuyuan:—This deposit is located about 2 to 2.5 km east of Chinchuantang proper. It occurs as pocket and veins in the limestone and consists mainly of pyrite and subordinately of arsenopyrite both being associated with gangues of calcite and quartz.

(4) Shuihuli:—Shuihuli is about one and half km N W of Chinchuantang proper and is about 20 km away from the city of Chenhsien. The deposit is characterized by rather considerable amount of wolframite and cassiterite occurring in a number of quartz veins and greisen rocks. The wolframite and cassiterite veins are rather regular in shape being more or less parallel to each other and extend in a direction of N 30° E dipping 60° toward NW. Among the different veins, there are two principal ones each measuring about half a meter in thickness and 95 m in length.

The walls immediate to these two principal quartz veins are highly altered by the process of greisenization. The altered rocks are composed mainly of topaz, muscovite, tourmaline, and garnet, and subordinately of chlorite, fluorite, sericite, calcite, epidote and spinel. All of these minerals occur in massive form or in a series of zonal arrangement. The greisen carries a minor amount of ore minerals, such as cassiterite, arsenopyrite, pyrrhotite, pyrite, sphalerite, tetrahedrite, chalcopyrite, bornite, stannite, galena, and also wolframite.

Besides these two principal veins, there are a great number of smaller ones intersecting irregularly and carrying as a rule a little amount of wolframite and cassiterite. Although such veins are small and narrow but on account of their greater number, they are still of considerable economic importance.

(5) Manaoshan:—This is located about one km W of Shuihuli and 3 km NW of Chinchuantang proper. It is chiefly a manganese-iron deposit containing magnetite, pyrrhotite, arsenopyrite, alabandite in the lower part, and the oxidized products of the above minerals, such as psilomelane, pyrolusite, limonite, and wad in the upper. Unfortunately we are not able to make personal inspection of the underground working for the shaft was full of water during our visit.

IV. Mineralogy

A. Ore Minerals

1. Magnetite:—Magnetite with arsenopyrite and pyrrhotite occurs as irregular grains at the bottom of the Tachiling mine; near the limestone side of the greisen in Shuihuli; and with alabandite in Manaoshan. It is obviously the earliest mineral in these deposits. Hematite and limonite veinlets are occasionally seen to cut through the grains.

2. Arsenopyrite:—Arsenopyrite occurs hypidiomorphically as related to the magnetite, but idiomorphically to the pyrite and pyrrhotite. It is also present in Shuihuli as euhedral grains associatied with pyrite and pyrrhotite in the veins and in the greisen. The size of grains varies from 2-15 mm across.

3. Pyrite:—At Shuihuli pyrite occurs generally in fine euhedral crystals in the greisen near the limestone portion. At Tachiling and Shihchuyuan, it forms large mass at the lower part of the ore bodies and is more or less replaced by sphalerite and galena. At Chaishan, it is the most important ore mineral and is generally cut by fluorite veinlets.

4. Cassiterite:—This mineral is almost entirely restricted to the Shuihuli quartz veins and their greisen. The large crystals are found in association with quartz and wolframite in the quartz veins; while the fine aggregate of cassiterite usually forms crusts surrounding the grossularite in the greisen and at the same time is enclosed or penetrated by the fluorite.

5. Wolframite:—Wolframite is dark brown to black in color and occurs in long prismatic form, being found both in the quartz vein and in the greisen rock itself at Shuihuli. The crystals of wolframite are found to penetrate through both quartz and arsenopyrite grains indicating therefore a definitely later age of deposition. Wherever the wolframite occurs in the greisen, it is usually accompanied by fluorite, sericite, and a little or no quartz. Part of it has been changed to limonite and tungstite on the weathered surfaces of the specimens.

6. Pyrrhotite:—Pyrrhotite is found at both Tachiling and Shuihuli to replace pyrite, magnetite and arsenopyrite; sometimes it is irregularly disseminated in the andradite grains. At Manaoshan some fine grains of pyrrhotite are enclosed in the alabandite in such a way as to resemble somewhat the phenomenon of 'unmixing'.

7. Sphalerite and Smithsonite:—Sphalerite is rather abundant in Tachiling and rare in other localities. It is usually associated with pyrite, pyrrhotite and galena. Generally it inlcudes small dots and rods of chalcopyrite forming a grating texture. In the greisen of Shuihuli, smithsonite in stalactitic forms is found to coat the sphalerite and quartz crystals.

8. Tetrahedrite:—Tetrahedrite occurs in small amount but is rather common in Tachiling and Shihchuyuan. It is gray in color and

under the microscope it is evidently earlier than bornite and later than sphalerite.

9. Stannite:—Few grains of it with steel-gray color are recognized in intergrowth with sphalerite, cassiterite, and arsenopyrite in Shuihuli greisen rock. It is probable that the latter three minerals have been replaced by stannite.

10. Bornite:—Bornite in Shuihuli shows the mutual intergrowth with tetrahedrite and chalcopyrite and they are probably to be regarded as of contemporaneous deposition.

11. Chalcopyrite:—Chalcopyrite occurs together with pyrite in small amount in the deposits of Tachiling and Shuihuli and usually forms fine to medium disseminated grains in the chimney of Tachiling and the greisen rock of Shuihuli. It replaces arsenopyrite, pyrite and tetrahedrite. Small grains or rods of chalcopyrite are sometime intergrown in sphalerite forming thus a typical unmixing texture.

12. Galena and anglesite:—Galena is the chief ore mineral in the Tachiling deposits, but rarely in other localities. It occurs more abundantly in the upper part of the ore body and gradually decreases in amount with depth. On its weathered surfaces some anglesite may be recognized.

13. Bismuthinite:—It is found near the top of Chaishan being adjacent to the granite; it appears to replace pyrite, quartz, fluorite, and calcite.

14. Alabandite:—At Manaoshan there are found some manganese minerals, one of which with gray color and green internal reflection is identified to be alabandite. Chemical analysis has confirmed the presence of manganese and sulphur. It includes more or less along its crystallographic direction many fine rods and spots of pyrrhotite.

15. Psilomelane and pyrolusite:—Psilomelane occurs as stalactitic masses with concentric layers at Manaoshan and Wuleichihku. It is commonly associated with pyrolusite, the latter occurs in reniform shape forming alternating layers with psilomelane. These are evidently oxidation products of the primary manganese minerals.

B. GANGUE MINERALS

1. Spinel:—Spinel of a dark green variety occurs side by side with fluorite and garnet grains in Shuihuli. Occasionally it is penetrated by the topaz grains and enclosed by sericite shreds.

2. Garnet:—Two varieties of garnet have been determined in the greisen of Shuihuli and the lowest part of Tachiling ore body. One being found both at Shuihuli and Tachiling, is a flesh red or deep red colored andradite, and the other only seen in Shuihuli is a grossularite with brownish-yellow color. The former is intimately associated with fluorite and pyrrhotite and the latter with cassiterite, fluorite, and sericite. Alteration of andradite to chlorite has been noticed in the greisen of Shuihuli.

3. Quartz:—Quartz is the commonest gangue mineral in the deposits. It occurs in two forms, massive and granular. The massive quartz usually showing a milky white appearance is found only in the vein of Shuihuli. The granular transparent quartz occurs more commonly in all of the other deposits. Its range of deposition seems to be quite long, being started from the end of the deposition of garnet till the end of wolframite, for quartz at one place is seen to be replaced by most oxides and sulphides while at others it replaces them. In Chaishan it seems to be contemporaneous with calcite and definitely prior to the purple fluorite.

4. Topaz:—It is only found in the quartz veins of Shuihuli and SE of Chaishan. It shows fine aggregate with individual crystals frequently penetrated by streaks and patches of sericite and tourmaline. Most probably it is formed by reaction between orthoclase and a predominantly fluorine-bearing solutions during the process of greisenization, as shown by the following chemical equation:

$$\underset{\text{(orthoclase)}}{2KAlSi_3O_8} + 2F = \underset{\text{(Topaz)}}{[Al(O_1F_2)]AlSiO_4} + K_2O + 5SiO_2$$

5. Muscovite:—This mineral is present chiefly in the quartz vein and rarely in the greisen rock. It is in large white plate with greenish tint and elastic foliation.

6. Tourmaline:—Tourmaline occurs more abundantly in the veins and the greisen of Shuihuli and rarely in the granite of Chinchuantang proper. At Shuihuli, there are two varieties of tourmaline; one is the black variety restricted to the limestone side in occasional association with grossularite and green fluorite and the other is a green one confined to the aggregate of topaz, quartz, muscovite and fluorite. The black one frequently forms parallel veinlets while the green one as isolated crystals of radiated aggregates. In Chinchuantang proper there are many small stringers of bluish black tourmaline embedded in the quartz crystals of the granite.

7. Epidote:—It occurs in brownish green, fine-grained aggregates in the fluorite veinlets or in association with garnet, calcite, sericite and fluorite masses near the quartz veins of Shuihuli and Chaishan. At Tachiling, it is closely associated with garnet, sericite, calcite and quartz in the lower wall of the ore body.

8. Fluorite:—The color of fluorite varies from purple to green. The green fluorite occurs throughout the greisen as isolated crystals or rarely in veinlets with cassiterite, wolframite, arsenopyrite and chalcopyrite. It replaces both quartz and topaz, therefore its development is definitely later than the process of greisenization. It is also found in the lower part of the Tachiling ore body accompanying pyrite and galena. The purple fluorite on the other hand is found only at Chaishan, being intimately associated with pyrite, quartz, calcite and tourmaline. Besides fine disseminations, the fluorite may also occur in connecting veinlets of lenticular form in limestone.

9. Sericite:—This mineral is seen in the greisen of Shuihuli megascopically and is cotton-white in color forming zonal arrangement parallel with black tourmaline bands. Under the microscope, a number of minute flakes or scales of sericite firmly aggregated together and sometimes cut by the fluorite veinlets are found.

10. Chlorite:—It has been previously mentioned that considerable amount of ferromagnesian silicates, as biotite and hornblende in granite and garnet in greisen, were mostly altered to chlorite. In Chaishan, some veinlets of penninite are also seen in association with pyrite, quartz, and fluorite crystals.

11. Kaolin:—Kaolin occurs as fine, amorphous aggregate upon the weathered surface of the country rock and igneous body.

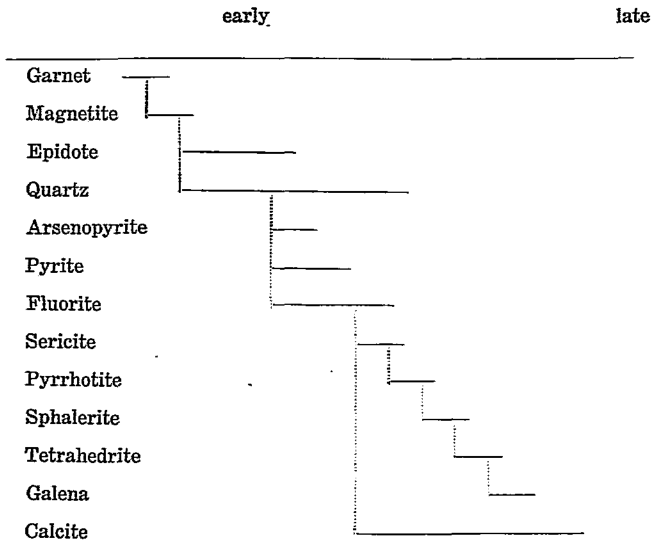
12. Calcite:—It is limited to the limestone side of both the greisen and the ore bodies. Calcite in the ore body sometimes includes pyrite grains.

13. Apatite:—It is present in minute slender crystals sparingly distributed throughout the country rocks and the greisen.

V. Genesis and Paragenesis

Although the different ore deposits herein described were formed under almost identical genetic conditions and belonging evidently to the same metallogenetic type, they differ however, slightly in their mineral compositions as well as paragenetic relationships; accordingly they may be described separately as follows:

1. Tachiling:—From the presence of high-temperature minerals, such as magnetite, arsenopyrite, pyrrhotite, garnet, biotite, epidote, and fluorite, it is concluded that the Tachiling chimney-like deposit in limestone may belong to the hypothermal type. Though tourmaline is probably absent in this deposit but a small amount of it has been found in the granite near ore body. The tungsten-quartz vein at the Wuleichihku north of Tachiling may be considered as a pneumatolytic deposit. The pargenetic sequence of the different minerals in the Tachiling deposit is shown in the following table:



2. Chaishan deposits:—This deposit is characterized by the presence of arsenopyrite, bismuthinite, fluorite and large amount of pyrite and belongs therefore to hypothermal type. The paragenetic sequence may be determined as follows: Garnet, quartz, calcite, pyrite, arsenopyrite, bismuthinite, fluorite, sphalerite, chalcopyrite, and galena.

3. Shihchuyuan deposits:—The Shihchuyuan deposit characterized by the presence of arsenopyrite, pyrite, sphalerite, chalcopyrite, tetrahedrite and galena with gangues of calcite and little quartz is evidently of hypotherml to mesothermal origin. The order of crystallization is: Garnet, quartz, arsenopyrite, calcite, pyrite, sphalerite, chalcopyrite, tetrahedrite, and galena.

4. Manaoshan deposit:—This deposit contains abundant magnetite, arsenopyrite, pyrite, pyrrhotite, alabandite and galena. The only associated gangue is quartz. It may be said to be a deposit of hypothermal to mesothermal in origin. Pyrolusite, psilomelane, and wad are the oxidized and enriched products of the Mn-bearing minerals.

5. Shuihuli deposits:—The minerals introduced into the greisen made their way by replacement along the minute fractures in almost parallel direction. In the greisen and the ore body the minerals are: pyrite, fluorite, cassiterite, andradite, sericite, tourmaline, topaz, spinel, chalcopyrite, arsenopyrite, pyrrhatite, stannite, sphalerite, galena, prismatic wolframite or columnar wolframite and quartz. The two kinds of garnet are separated from each other by black tourmaline and sericite bands in the greisen, and are characterized by two different types of mineral assemblage. The minerals commonly associated with grossularite are cassiterite, fluorite, sericite and pyrite; those with andradite are chlorite, epidote, fluorite, and pyrrhotite. While topaz, spinal, chalcopyrite, arsenopyrite, sphalerite, stannite, galena and wolframite are minerals not found in association with garnet in our collected suite of specimens. Judging from their mode of occurrence and their associated minerals the wolframite-cassiterite ore bodies may be taken as pneumatolytic to hypothermal in origin and obviously related to the mother granite. When the granitic magma came in contact with the limestone, the contact silicates and oxides as spinel, garnet, epidote, and rarely magnetite were first formed in succession. Fractures and cracks due to marginal cooling stresses of the magma were developed along contact zone; an ascent of a residual solution or siliceous ichor of the granitic magma ensued them with a number of mineralizers as boron, chlorine, fluorine and possibly water, acting on the wall rock and transforming it to greisen, and then ore minerals as pyrite, arsenopyrite, and wolframite, pyrrhotite, sphalerite, stannite, tetrahedrite, bornite, chalcopyrite, and galena, were deposited in succession. These minerals appeared in normal sequence following the lowering of the temperature-gradient with some of them showing however partial overlapping crystallization. As to the gangue, the minerals, spinel, garnet and epidote, named in their orders of formation

had an early appearance as previously mentioned. They were followed by topaz, muscovite, sericite and tourmaline which were developed, presumably before the interior of the granite was fully crystallized. Fluorite of irregular patches, streaks and wavy veinlets might have been introduced at the time of injection of the quartz veins by solutions carrying an appreciable amount of tin and tungsten. The paragenetic sequence of all those minerals in these deposits may be summarized in the following table (see p. 404).

6. The other deposits:—The Mihuli and Huayuanli Pb-Zn deposits in limestone are located W of Paosiang Co.; the former one containing arsenopyrite, pyrite, sphalerite and galena with gangues of quartz, calcite and fluorite; and the latter containing pyrite, sphalerite, and galena with small amount of pyrrhotite. According to their mineral composition and mode of occurrence, they appear to belong to the mesothemal type.

Conclusively, the deposits in this region have probably been formed during one general period of mineralization and have had a common relation with the mother granite. The difference in the character of the ores is probably due to difference in the physical conditions under which they were formed and possibly also due to slight difference in stage of formation during the general period of the ore deposition.

The events that led to the mineralization were recognized to have assumed the following general order:

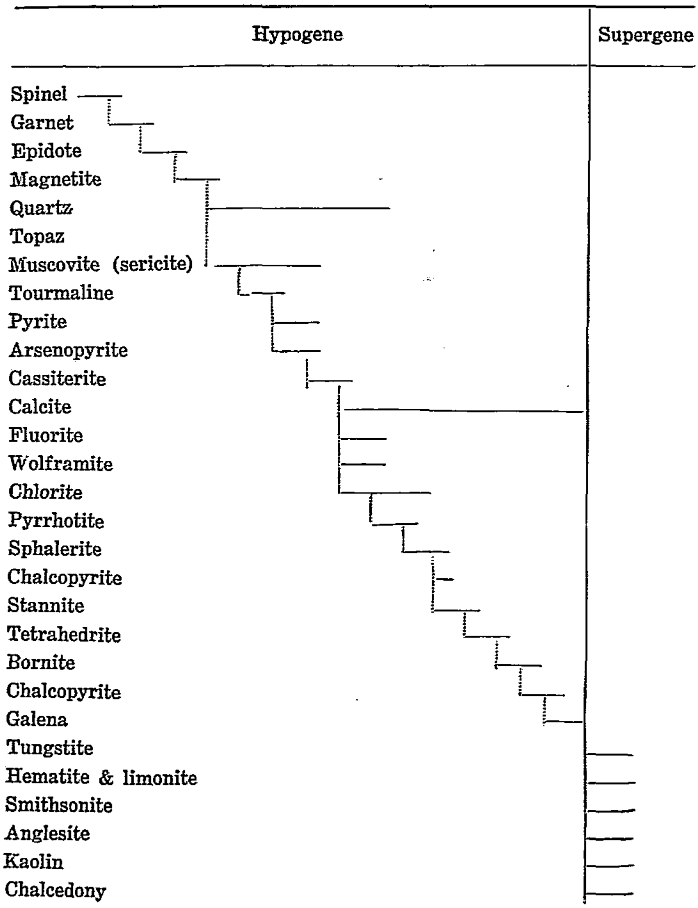
(1) The intrusion of the granitic magma and the accompanying fracturing and fissuring of both the granite body and the adjacent sediments.

(2) The passage, along the fissures or cracks, of solutions of deep-seated origin that resulted in the formation of greisens and other alterations of the wall rocks.

(3) Deposition of pneumatolytic ore minerals succeeded by

(4) Hydrothermal mineralization. Highly heated solution deposited the iron sulphides as in Tachiling. When the temperature and possibly the pressure were reduced, lead-zinc ores were deposited.

(5) Finally the ores were oxidized and partly enriched by surface waters.


Hypogene
Supergene
Spinel
Garnet
Epidote
Magnetite
Quartz
Topaz
Muscovite (sericite)
Tourmaline
Pyrite
Arsenopyrite
Cassiterite
Calcite
Fluorite
Wolframite
Chlorite
Pyrrhotite
Sphalerite
Chalcopyrite
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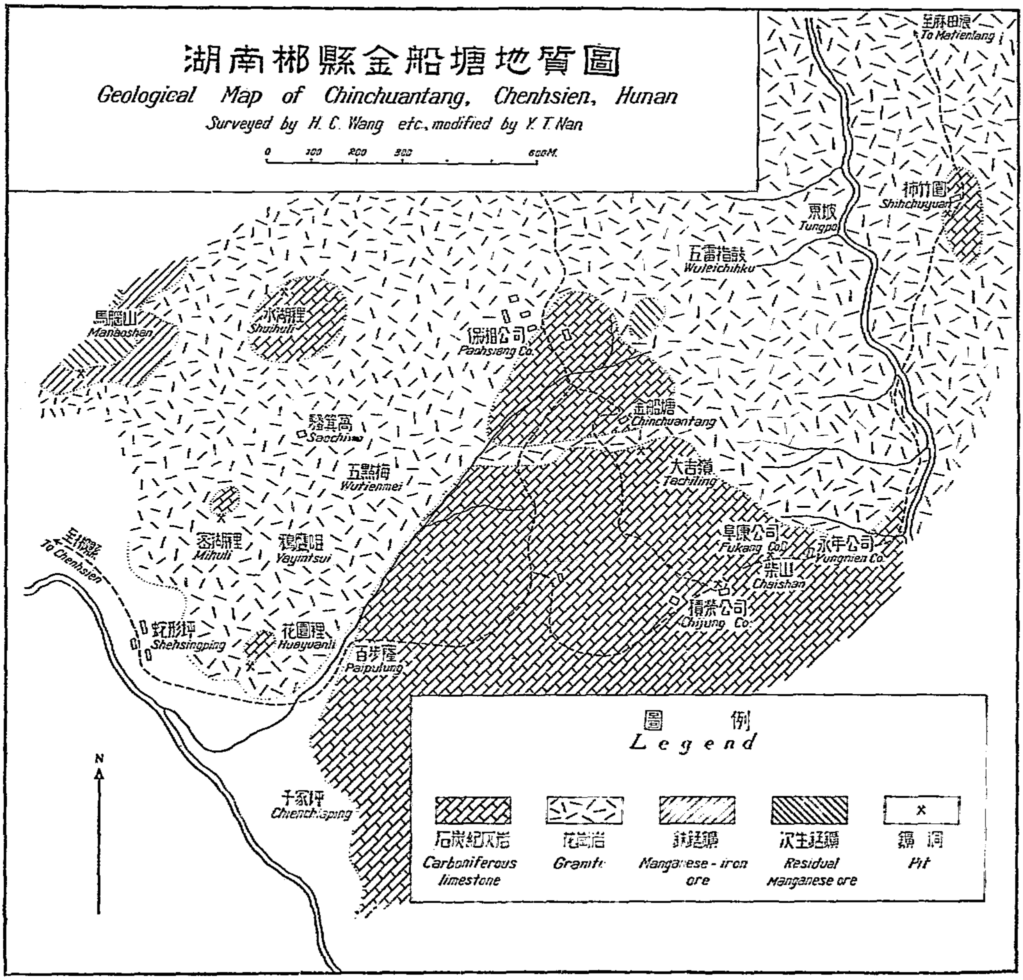
Bornite
Chalcopyrite
Galena
Tungstite
Hematite & limonite
Smithsonite
Anglesite
Kaolin
Chalcedony


湖南郴縣金船塘地質圖
Geological Map of Chinchuantang, Chenhsien, Hunan
Surveyed by H. C. Wang etc., modified by Y. T. Nan
0 100 200 300 600M.
圖例
Legend
石炭紀灰岩
Carboniferous limestone
花崗岩
Granite
鐵錳鑛
Manganese - iron ore
次生錳鑛
Residual Manganese ore
鑛洞
Pit
N
To Chenhsien
To Matientang
Manaoshan
Shuihuli
Paohsiang Co.
Saochi
Wutienmei
Mihuli
Yaymtsui
Shehsingping
Hueyuanli
Paipulung
Chenchiaping
Chinchuantang
Tachiling
Fukang Co.
Yungnien Co.
Chaishan
Chijung Co.
Wuleichihku
Tungpo
Shihchuyuan

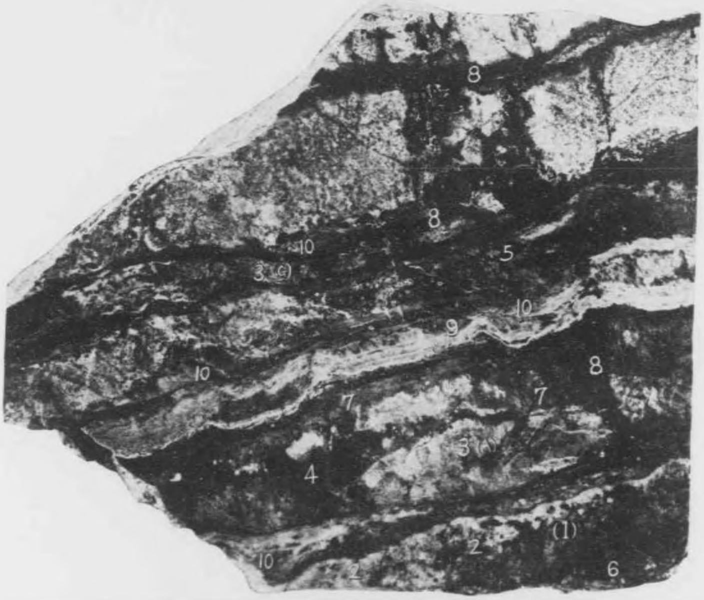
Explanation of

Plate II

PLATE II

Fig. 1 A Greisen rock aside the wolframite-cassiterite vein consists of spinel (1), topaz (2), garnet (3), epidote (4), and disseminated ore minerals of pyrite (5), arsenopyrite (6) and pyrrhotite (7), cut through by tourmaline (8), sericite (9), and fluorite (10) veinlets. The upper part is the limestone side. Polished section × $\frac{3}{4}$. Shuihuli.

Fig. 2 Wolframite (1)-quartz (2) vein in contact with topaz greisen (3) which contains topaz, muscovite and some arsenopyrite grains (natural size). Shuihuli.



1

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Explanation of

Plate III

PLATE III

Fig. 1. Greisen showing banded structure contains tourmaline, sericite, fluorite, epidote, quartz and some ore minerals (black). Thin section, × 10. Shuihuli.

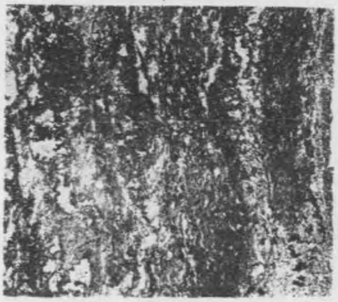
Fig. 2. Green tourmaline embedded in the topaz-greisen rock. Thin section, × 15. Shuihuli.

Fig. 3. Arsenopyrite crystals (opaque) in the greisen of topaz and muscovite. Thin section, × 10. Shuihuli.

Fig. 4. Spinel (dark) replaced and brashed by garnet and fluorite. Thin section, × 10. Shuihuli.

Fig. 5. Greisen rock with topaz (high relief), quartz and fragments of hornblende. Thin section, × 10. Shuihuli.

Fig. 6. Alabandite with pyrrhotite inclusion replaces magnetite. Polished section, × 45. Manaoshan.



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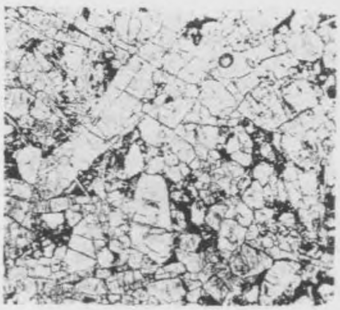

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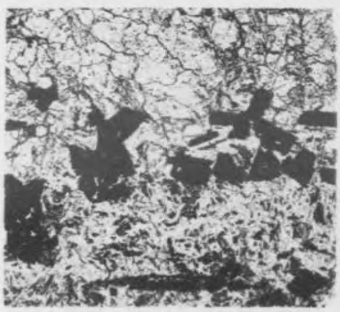

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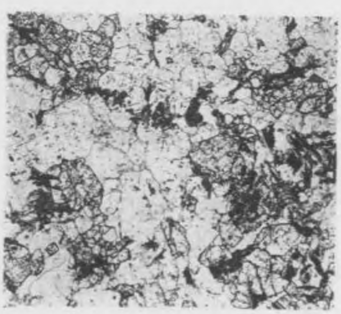

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Explanation of

Plate IV

PLATE IV

Fig. 1 Bismuthinite replacing pyrite. Polished section, × 45. Chaishan.

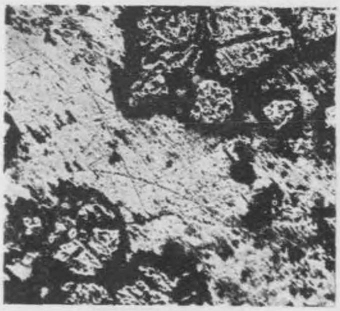
Fig. 2 Arsenopyrite with little pyrrhotite replaced by quartz gangue. Polished section, × 45. Tachiling or Chingchuangtang proper.

Fig. 3 Stannite (gray) replacing arsenopyrite (white). Polished section, × 90. Tachiling.

Fig. 4 Crystals of pyrite enclosed by sphalerite which contains chalcopyrite dots. Polished section, × 45. Tachiling.

Fig. 5 Tetrahedrite (light gray) and bornite (gray) replaced by chalcopyrite (white). The former two are in contemporaneous relation. Polished section. × 300. Tachiling.

Fig. 6 Galena with triangular pits replacing pyrite and sphalerite (Unmixing). Polished section, × 45. Tachiling.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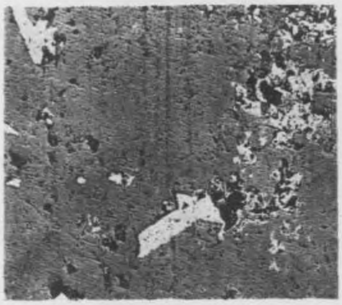
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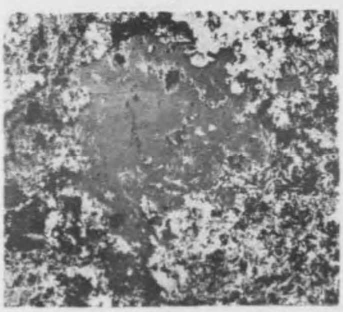
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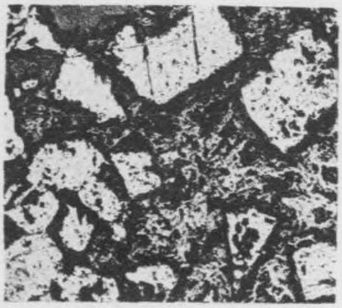
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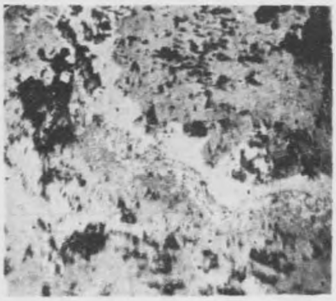
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ENCLAVES DES ROCHES CRISTALLINES DU NORD-OUEST DU PLATEAU CENTRAL FRANCAIS*

PAR YANG KIEH (楊傑)

The National Geological Survey of China

Le granite du massif de Guéret contient fréquement des enclaves, mais dans les autres roches ignées, on rencontre aussi des masses étrangères, quoique en quantité moindre. Ces enclaves sont toujours de teinte plus foncée que les roches englobantes et elles ont presque toutes des contours bien définis. Il s'agit donc d'enclaves enallogènes; elles ne présentent pas en effet les mêmes compositions monéralogiques que les roches encaissantes. Je vais décrire d'abord les enclaves des granites et ensuite celles des granulites, des diorites, etc.

I. ENCLAVES DES GRANITES A BIOTITE

Ces enclaves présentent en général, la composition minéralogique d'une diorite quartzique, cependant quelques échantillons montrent des particularités méritant d'être signalées. Ils ont des analogies aves la grano-diorite, la syénite, la diorite et le gabbro.

a) *Enclave grano-dioritique.* Dans le granite de La Souterraine, j'ai observé certaines agglomérations micacées à grain fin, dont la dimension atteint parfois un mètre de diamètre. Les caractères microscopiques de cette enclave sont les suivants:

L'oligoclase acide et la biotite, avec quelques grandes sections, se montrent soit en amandes macroscopiques, soit en grains plus ou moins arrondis *(Pl. I, fig. 2). Les plages menues xénomorphes d'orthose, d'ailleurs très peu abondantes, sont localisées dans les intervalles des autres minéraux. Les paillettes de séricite se trouvent généralement à l'intérieur du plagioclase; la muscovite est assez rare.

* Received for publication in January, 1935.

b) *Enclaves quartzo-dioritiques.* Ce groupe englobe un grand nombre d'enclaves de granite du Massif de Guéret. Bien que les compositions minéralogiques des ces agglomérations aient une grande analogie, leurs textures sont assez variées.

Au sommet de Maupuy (cote 685), j'ai rencontré des masses noirâtres, compactes, à la surface des quelles se détachent des lamelles de biotite. Celles-ci se groupent en trainées orientées. De ce fait, la roche envisagée a un aspect légérement zonê. Le microscope démontre que cette structure dérive des actions dynamiques. Les cristaux de quartz, d'andésine à environ 38% d'an., et de biotite sont souvent brisés, orientês et moulés par de petits grains de ces mêmes minéraux. Il faut remarquer que les paillettes micacées, les plus fines, sont de la biotite qui n'a subi aucune altération, ni aucun écrasement. Cette biotite serait de nêoformation.

Ce type d'enclave contenue dans le granite de Maupuy se trouve aussi dans celui de La Souterraine où la roche considérée ne montre aucune trace d'actions mécaniques (Pl. I, fig. 3).

Une autre enclave de Maupuy (même localité) à grain fin présente une certaine ressemblance avec l'enclave grano-dioritique de la Souterraine, sauf qu'elle ne contient pas d'orthose.

A La Chapelle-Taillefer (carrière du Nord-Ouest), le granite banal contient des amas surmicacés et grenus. En plaque mince, on observe quelques particularités. Le fond est composé principalement de sections, allongées de plagioclase et de biotite: dans leurs intervalles, se trouvent, outre de petites plages et des grains, quelques cristaux plus grands et presque arrondis de quartz.

L'enclave de granite du Village de Gachard (SE de Fontanieres) a une texture granitique, où les plages xénomorphes des quartz moulent les cristaux d'andésine et de biotite chloritisée. Celle de St. Dizier (tranchée de route, 1300 m. environ au SE.) présent une texture micropegmatitique (Pl. I, fig. 5). Dans certaines plages de plagioclase très séricitisées se trouvent des grains de quartz qui s'éteignent tous à la fois entre nicols croisés. Dans le granite de l'Est d'Aubusson, les enclaves très micacées forment des lentilles aplaties qui dépassent souvent plusieurs centimètres de diamètre. Elles paraissent un peu schisteuses et contiennent abondamment de labiotite; les cristaux d'andésine sont accompagnés de cordiérite.

Enfin dans toutes ces enclaves de granite, on observe un grand nombre de prismes ténus d'apatite.

c) *Enclaves syénitiques et monzonitiques.* J'ai rencontré quelques enclaves très intéressantes dans le massif granitique de Huriel (Allier) et dans son prolongement au village des Trillers (vallée du Cher). Ces amas foncés sont très hétérogènes, les uns présentent une composition minéralogique de syénite ou de monzonite, les autres, de diorite ou de gabbro; les enclaves syénitiques et monzonitiques seront d'abord en question.

Dans le granite légerement schisteux et plus ou moins écrasé de la tranchée du chemin de fer, 1000 m. environ au SSW des Trillers (cote 255), se trouvent de petites bandes brunes compactes. Au microcope, on voit que la roche de ces dernieres est composée de microcline dont certains cristaux les plus grands ont 4 ou 5 m.m. de diamètre. Ce feldspath contient abondamment des grains d'albite et des paillettes de biotite. Ces éléments menus dessinent sur les grandes sections de ce microcline une texture micropœcilithique, cependant, certains petits cristaux d'albite sont orientés dans un sens unique, la texture est bien microperthitique (Pl. I, fig. 4). Dans la plus grande partie, par l'abondance extrème des éléments fins, on n'apercoit pas nettement ces textures, il y a simplement un agrégat de petits débris. Mais si l'on tourne le platine de microscope, une grande plage quelconque de microcline pleinement incrustée d'albite et de biotite, montre l'éclairement uniforme.

A Huriel, les petites enclaves noirâtres ont toujours une dimension modeste, leur diamètre ne dépasse guère quelques centimètres. Elles présentent une structure très fine et montrent en plaque mince les caractères suivants: un mosaïque de petits cristaux de microcline accompagné d'un peu d'albite; les paillettes de biotite moulent les intervalles de ces feldspaths. Parfois la proportion du plagioclase devient très grande, l'enclave envisagée paraît nettement monzonitique.

Parmi les éléments accessoires de ces enclaves de granites des Trillers et de Huriel, je signale l'apatite, la magnétite, le zircon, et l'amphibole (à Huriel).

d) *Enclave dioritique.* Les enclaves noires du granite de Huriel présentent le plus souvent des caractères de diorite. Leur aspect extérieur est identique à celui des enclaves syénitiques décrites dans le précédent paragraphe. Les différences consistent en l'absence complète de microcline et en ce que le plagioclase devient plus calcique; on y observe de l'oligoclase (Pl. I, fig. 6). Quelquefois le feldspath triclinique est représenté par l'andésine. En outre, il y a des agrégats de séricite qui provient de la transformation d'un mineral primaire (Cordiérite?).

e) *Enclave gabbroïque.* C'est encore dans le granite de Huriel que J'ai observé une autre curieuse enclave présentant la composition minéralogiqe de gabbro. Elle se trouve dans la carrière située au pied de la croupe de Fareille et a été décrite dans un précédent memoire[1].

II. Enclaves de Granites A Muscovite

Les granulites contiennent généralement très peu d'enclaves. Toutefois certains amas micacés observés dans ces roches méritent d'être signalés.

a) Tranchée de route, SE. du Chateau de Clavière, dans le massif de Crozant, j'ai observé quelques enclaves plus biotitiques que la granulite englobante. Elles sont grenues et présentent un aspect granitique. Le microscope démontre que ces enclaves possèdent une composition de diorite quartzique. Les éléments constituants sont les suivants: le quartz, l'oligoclase, la biotite, la muscovite, l'apatite, etc.

b) Dans le granite à deux micas et légérement porphyroïde de St. Benoit-du-Sault, les petits nodules micacés à grain fin sont constituées principalement par de la biotite. Le quartz et l'oligoclase paraissent peu abondants.

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1 Yang Kieh: *Mém. Soc. géol. Fr.*, Nlle. Scrie, T, VIII, Fasc. 3 et 4,1932, p. 37, Pl. XXIV, fig. 1.

c) A Arnac-la-Poste, dans la zone de contact de la granulite et du gneiss, par exemple, au SSE du hameau de Margot et aux moulin des Bordes, se trouve une roche qui présente des caractères intermédiaires entre ceux de deux premières. Elle renferme en abondance de petites lentilles aplaties de mica noir, dont le diamètre a à la moyenne 3 ou 4 centimètres. Les cristaux de biotite sont généralement orientés, de sorte que cette enclave est schisteuse. Une section mince faite perpendiculairement à leur stratification montre que le fond est constitué par des trainées de cette biotite (accompagné d'un peu de muscovite), qui s'intercallent avec des zones de chlorite et de sillimanite. Les prismes ténus de cette dernière sont sectionnés en petits fragments rectangulaires, et apparaissent sur le fond de chlorite. C'est pourquoi l'on observe à la surface des lentilles micacées en question, quelques feuillets blancs. Enfin, il y a encore quelques cristaux de quartz, d'oligoclase, d'apatite, transformée partiellement en une matière amorphe, et de zircon, inclu dans la biotite, avec de belles auréoles polychroïques, etc.

d) Le granite à muscovite, à gros éléments du bois de Chabanne (S. de Dun-le-Palleteau) renferme de grands amas schisteux aplatis de biotite de plusieurs décimètres de diamètre, qui sont interstratifiés dans les pseudo-couches de la roche laminée. Au microscope, on voit que les groupements de grains de quartz sont moulés par des trainées de biotite accompagnes de muscovite. Il y a encore, de la tourmaline qui est transformée partiellement en fibrolite et en séricite. Le mica noir paraît plus ou moins transformée en un mica blanc.

III. Enclaves de Grano-Diorites et de Diorites, a Amphibole.

Dans ces roches amphiboliques se trouvent aussi quelques enclaves foncées et à grain fin, qui présentent généralement la composition minéralogique de la diorite, mais leur structure paraît parfois un peu schisteuse.

La diorite quartzique et occasionnellement orthosique de Beaumont (SE. de Huriel) contient des amas vert noirâtre à contour bien défini. Ils se composent de cristaux menus d'oligoclase, de hornblende verte et de biotite. On observe encore de petits groupements d'amphibole en plages plus grandes (Pl. I, fig. 1).

Dans la grano-diorite porphyroïde légerement zonée de Bonneil (Hte.-Vienne), les minces bandes amphibolique présentent presque la même composition minéralogique que la roche encaissante et ont subi des actions dynamiques.

A Combrand, NE. du Bourg d'Hem, les diorite très amphiboliques renferment fréquemment des zones schisteuses qui sont composées de hornblende, de biotite, de plagioclase, etc.

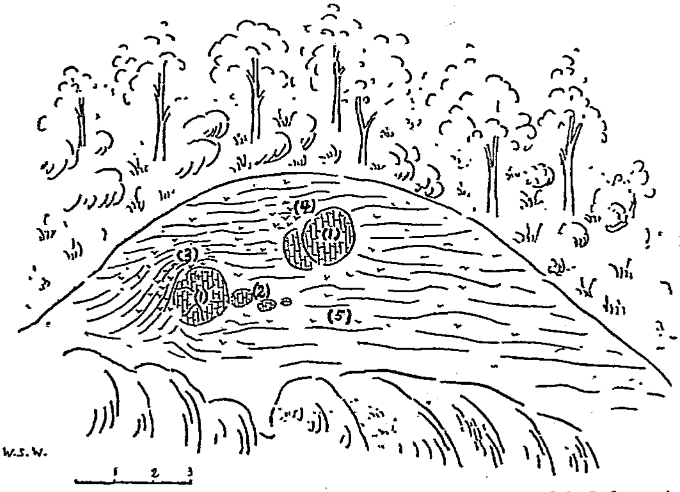


Figure 1. Profil de la petite carrière creuée dans la tranchée de la route du Pont Noir qui mène à Baraize, à l'Ouest de l'écluse du moulin de Gargilesse. Les grands blocs d'amphibolite (1) sont englobés dans les gneiss légèrement granitoïdes (5), en couches diaclasées. Quelques blocs (2) les plus petits, se composent du cipolin. Certains bancs de gneiss (3) paraissent très pegmatitisés et la roche se rapprochent de la diorite quartzique; dans l'endroit (4), elle contient beaucoup de grenat entourés de chlorite.

Les grandes enclaves contenues dans la diorite ou le gabbro de Chatelus-Malvaleix montrent une structure finement grenue. Leur composition minéralogique est analogue à celle des roches encaissantes.

IV. Enclaves de Gneiss

Les très grands blocs amphiboliques contenus dans les gneiss de la zone du Pont Noir (Gargilesse) que j'ai déjà mentionnés dans mon précédent mémoire[1] offrent quelque interêt pétrographique. L'endroit où l'on observe facilement ces enclaves se trouve à quelques centaines de mètres au SW. du Pont précité, suivant la route qui conduit à Baraize. La figure ci-jointe présente le profil d'une carrière creusée dans la tranchée, et montre que les blocs noir amphiboliques tranchent nettement sur la masse gneissique diaclasée.

Ces enclaves sont très compactes et à grain fin. En plaque mince, on voit que le fond est constitué par de petits cristaux d'une hornblende brun verdâtre et d'un plagioclase très séricitisé. Dans certains blocs où la métamorphose de ce dernier minéral n'est pas très avancée, il semble que ce soit du labrador ou de la bytownite. Quelquefois les plus grandes des plages d'amphibole sont aussi transformées en un agrégat de séricite, de kélyphite, de calcite, etc. Parmi les minéraux accessoires, le quartz se trouve dans certains blocs, les grains de magnétite se montrent en abondance et ceux d'apatite et de zircon paraissent plus rares.

Resume

Au Nord-Ouest du Plateau Central francais on rencontre fréquemment, dans les granites à biotite, des enclaves qui sont beaucoup moins abondantes dans les autres roches éruptives. Ces enclaves présentent presque toujours des caractères différents de ceux de roches encaissants. Elles paraissent généralement très foncées et à grain fin, leur composition minéralogique semble plus basique. Il y a en effet, en quantité de la biotite ou de la hornblende.

1 Yang Kieh: *Loc. cit.* p. 27, Pl. III, fig. 4.

On peut lithologiquement conclure que les enclaves des granites, ressemblent à la diorite quartzique, sauf celles de granite de Huriel et des Trillers qui se rapprochent de la syénite, de la diorite et du gabbro. Les enclaves des granulites ont un aspect très micacé et plus ou moins schisteux, celles des grano-diorites, des diorites quartziques et des diorites présentent des analogies avec la diorite ou l'amphibolite. Les grands blocs contenus dans les gneiss du Pont Noir possédent la même apparence, de ces denières.

Explication de
Planche I

PLANCHE I

(Microphotographie des enclaves de roches cristallines du Nord-Ouest de Plateau Central francais; en lumière polarisée et au grossissement 15.)

Figure 1. *Enclave dioritique de la diorite quartzique de Beaumont* (SE. de Huriel). On observe sur le fond de petits éléments d'oligoclase, de biotite et de hornblende. Les cristaux, les plus grands, de ce dernier minéral forment çà et là quelques amas (h).

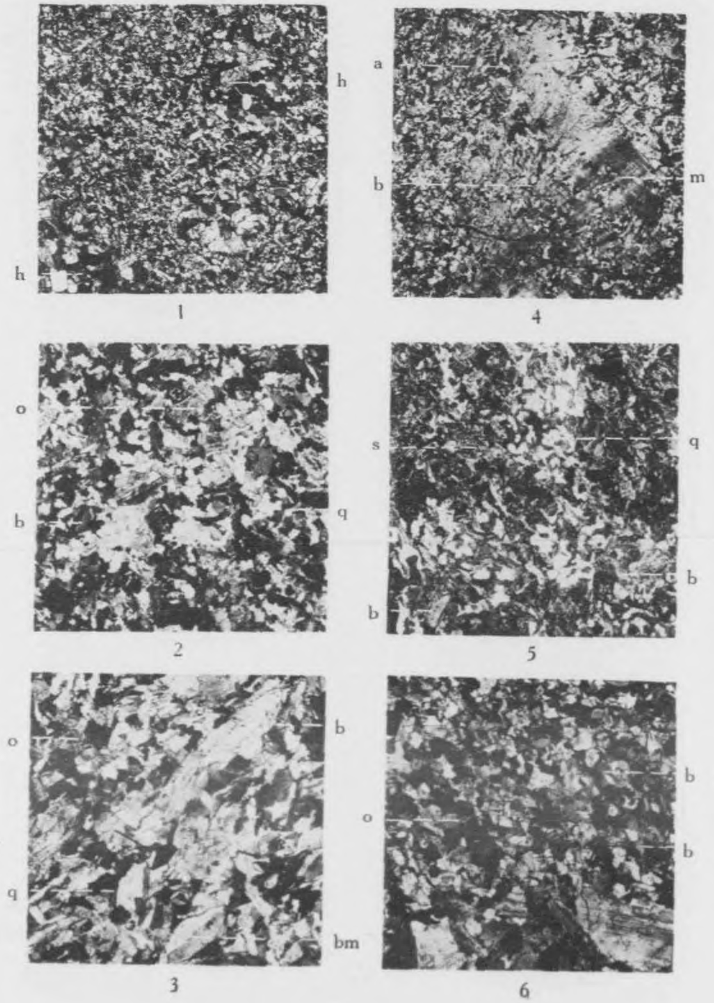
Figure 2. *Enclave grano-dioritique du granite de La Souterraine.* La masse de cette enclave est constituée par de petits prismes de plagioclase (o), et de biotite (b). Sur laquelle se détachent des grains plus ou moins arrondis de quartz (q).

Figure 3. *Enclave quartzo-dioritique du granite de La Souterraine.* Parmi les petites plages de plagioclase (o) et de mica noir (b), se distinquent quelques grandes lamelles de biotite (b) qui sont parfois maclées (bm).

Figure 4. *Enclave syénitique du granite des Trillers* (N. de Montluçon). La grande plage de microcline (m) est entierement incrustée de cristaux menue d'albite (a) et de biotite (b).

Figure 5. *Enclave quartzo-dioritique à texture micropegmatitique du granite de St.-Dizier.* Les grains de quartz (q) qui desinent une texture hiéroglyphique, sont moulés par un feutrage sériciteux (s), dérivant de l'altération du plagioclase. On y observe encore quelques lamelles de biotite non chloritisée (b).

Figure 6. *Enclave dioritique du granite de Huriel.* La masee générale de cette enclave se compose de petits cristaux d'oligoclase (o) et de biotite (b); quelques grandes plages plagioclasiques qui se trouvent en bas de la figure, appartiennent au granite encaissant.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NEW REMAINS OF *POSTSCHIZOTHERIUM* FROM S.E. SHANSI

By P. Teilhard de Chardin & E. Licent

(Musée Hoangho-Paiho, Tientsin)

Postschizotherium chardini nov. gen., nov. sp., is the name created in 1932 by Dr. von Koenigswald[1] for the curious animal described in 1930 by Teilhard and Piveteau[2] as Chalicotherid nov. gen. ind. on two isolated teeth (upper molar and premolar) collected by F. Licent in the Villafranchian (=Sanmenian) beds of Nihowan.

Since that time nothing more had been found leading to a better understanding of *Postschizotherium*, when recently, amongst an important fossil material sent to FF. Licent and Trassaert from the Yushê basin (S.E. Shansi)[3] two important pieces were discovered clearly referable to this puzzling form.

We think advisable to give immediately a preliminary description of those specimens.

Material

1) The damaged anterior part of a skull broken in front of P^4. Series P^4-M^3 well preserved on both sides of the palate, which is not crushed. The antero-external part of the maxillaries is also preserved, and the general shape of the muzzle recognisable.

2) The anterior part (two branches) of a mandible broken behind P_4. Symphyse complete, and teeth preserved on both sides.

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1 Von Koenigswald, G.H.R. *Metaschizotherium fraasi* n.g.n.sp, ein neuer Chalicotheriide aus dem Obermiocän von Steinheim. Palæontographica, Suppl.-Band VIII, teil VIII, 1932, p. 21.

2 Teilhard de Chardin, P. & Piveteau, J. Les Mammifères fossiles de Nihowan (Chine). Annales de Paléontologie, t. XIX, 1930, p. 23.

3 Licent, E. & Trassaert, M. The Pliocene lacustrine series in Central Shansi. Bull. Geol. Soc. China, Vol. XIV, 1935, pp. 211-220.

These two pieces, embedded in the same matrix (a soft rusty sandstone) belong evidently to the same individual. The skull was apparently complete when dug out by the local fossil-hunters.

Description

1. *Upper jaw and muzzle* (Fig. 1). Palate short and very narrow in comparison with the size of the teeth. Anterior margin of the posterior notch not extending further forward than the second lobe of M^3. Maxillary deep and short. Ante-orbital foramen large, single, set 31 mm. above P^4. 10 mm. above this foramen, the margin of the nasal fossa is clearly marked (over a length of 30 mm.), this fact suggesting that the nasal bones were reduced and the premaxillary area short and steep. Palatal foramina set in the re-entrant between M^1 and P^4.

2. *Upper teeth.* On the whole, the upper molars are remarkable by their large triturating area and by the depth of their labial side (the lingual side being decidely brachyodont). This peculiar hypsodonty results into a strong curvature (external convexity) of the crown. Cement just so thick as in a Horse. Premolars much and abruptly smaller than the molars. Although M^3 is scarcely erupted, the anterior teeth (P^4 and M^1) are much worn, as if the molars had a tendency to erupt and to work in succession.

P^3 smaller than P^4 (judging by traces of alveoli).

P^4 small, and yet distinctly molarised. In the outline, the tendency to form two lobes is only indicated by a faint re-entrant on the outer and the inner walls of the crown. But on both anterior and posterior sides of the median pit two ridges parallelize clearly the paralophe and the metalophe of the molars, a rounded anterior cusp holding the place of the protocone.

M^1 much worn, and longitudinally reduced by wear. Built essentially as M^2, but smaller, and probably shorter.

M^2 moderately worn. Paracone and metacone crescentic, with anterior and median columns (parastyle and mesostyle) very strong. A

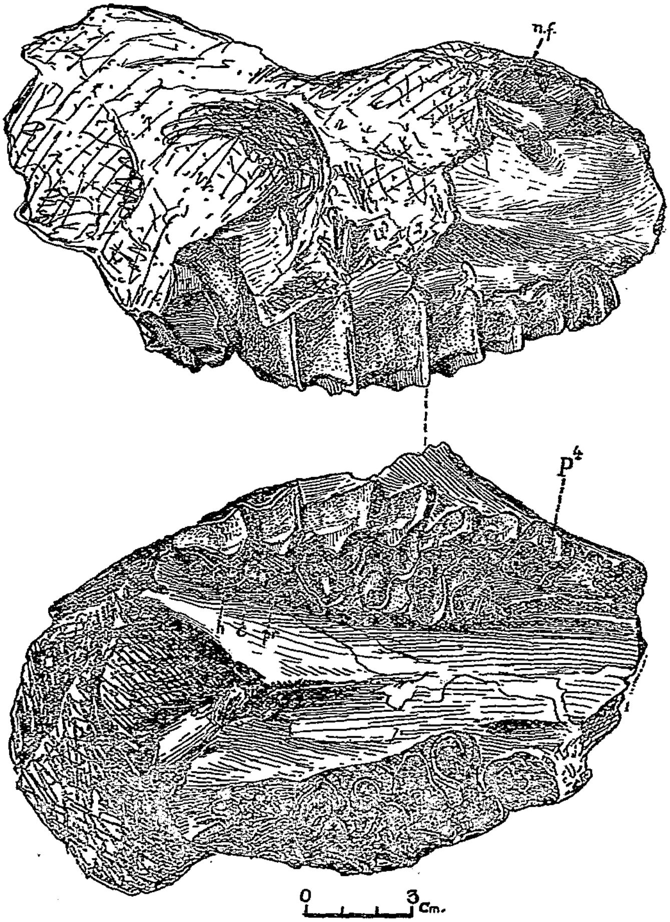

Fig. 1 *Postschizotherium chardini* v. K. Palate, from the right side, and from below. *n. f.*, nasal fossa. P^4, fourth premolar. *pr*, protocone. *h*, hypocone. *c*, accessory cusp. Reduced approximately to 2/3.

ridge (paralophe) connects the paracone with the well rounded protocone; and another ridge (metalophe) the metacone with the convex, but less rounded, hypocone. A deep fossa, open lingually, runs between the two lophes; and another one, circular and closed, occurs between the metalophe and the posterior cingulum. These two fossae are largely filled with cement, but still with a narrow central open pit.

M^3 scarcely erupted, and essentially built as M^2, but with crown more compressed, posterior lobe somewhat reduced, mesostyle much less projecting. Between the unworn conical protocone and hypocone, an accessory cusp *c*, coated with cement, has no clear equivalent on M^1 and M^2. In spite of this apparent reduction of its upper face, the crown observed labially expands antero-posteriorly and curls transversally in a most extraordinary way.

DIMENSIONS

	Shansi specimen				*Nihowan specimen*	
	P^4	M^1	M^2	M^3	P^4	M^3
External length	15	28	37	29	21	44 mm.
Breadth	16,5	32	28,5	22	20	31
External breadth at the base	?	?	?	47		34
External height of the crown (in straight line)	19	?	?	55		54

Length M^1-M^3, 87; P^4-M^3, 100.

3. *Lower jaw* (Fig. 2.) Symphysial area strong, deep and narrow. The two branches are completely fused, and the symphyse extends backward so far as the anterior part of P_3. A strong external muscular fossa runs externally below the premolars and the canine; and another one expands internally just behind the incisive border.

4. *Lower teeth.* Premolars four in number, closely set, extremely reduced. The crown, much worn, is of a clear Chalicotherid type

(rather elongated trigonid, and a talonid). *Internal* cingulum continuous, sharply indicated. Coat of cement distinct,

Canine rounded, very small, separated by a short diastema (10 mm), both from P_1 and from the following incisor.

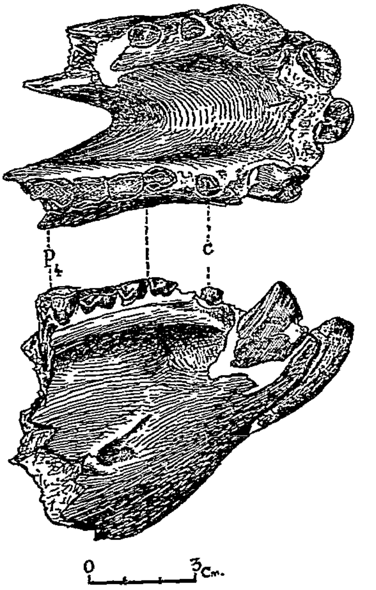

Fig. 2. *Postschizotherium chardini* v. K. Anterior part of the mandible, from above and from the right side. *c*, canine. P_4, fourth premolar. Reduced approximately to 2/3.

Incisors large, two in number, separated by a short diastema (10 mm.). The anterior one is approximately built as is a Horse, and is completely coated with enamel. The posterior one (tip broken) apparently caniniform, has a curiously irregular cross section along the inner side, and the enamel seems to be restricted to the external side of the crown.

DIMENSIONS

Maximum depth of the jaw (below P_4) .... 65 mm.
Length between the posterior side of P_4 and the anterior side
of the anterior incisor 92
Internal length of the symphyse, in straight line 71
Transversal distance between the two canines (external side).....48
Transversal distance between the two posterior incisors
(external side) 55
Length and breadth of P_4, 13,5/9; of P_3, 9/8; of P_2, 9/7; of P_1, 8,5/6.
Length P_1-P_4, 41.
Length and breadth of the canine, 6/5.
Length and breadth of the caniniform incisor, 18/12.
Length and breadth of the anterior incisor, 15/10.

COMPARISONS

In spite of a somewhat smaller size, there is no doubt that the above described specimens belong to the same genus (and to the same species) as *Postschizotherium chardini* from Nihowan, and that they improve greatly the knowledge we had of this strange animal.

On the whole, the probability increases that *Postschizotherium* represents really an aberrant type of Chalicotherid. To this assumption point well the shortness of the muzzle and the shape of the lower premolars. Yet, by the hypsodonty of the molars, the extreme reduction of the premolars and of the canine, the thick cementation of the back-teeth, the transformation of the incisors, the form is still more specialized than we thought, and along a line strangely converging to the Notungulata of South America: the curvature of the upper molars reminds of a Toxodont, and the anterior lower jaw is built as in *Thoatherium*.

It is unfortunate that no limb bones referable to *Postschizotherium* have been found so far,—and also that in the here described material the lower jaw is broken in such a way (just before the molar series) that we can not decide whether the lower molar from Choukoutien Locality 12 belongs really to this genus[1].

From a biological point of view, it remains uneasy to explain the peculiar shape of the upper molars in which the external hypsodonty of the crown (paracone and metacone) is countereffected by the brachyodonty of the inner half (protocone and hypocone) (cf. Teilhard and Piveteau, loc. cit., p. 23, fig. 9). In fact, as shown by the Shansi specimen, the teeth, in spite of their extremely elongated outer wall, did not wear deeper than the height of the protocone.

Horizon and Locality

Pliocene lacustrine beds of the Yushê basin, S. E. Shansi (King Yang Ping Tsunn),—most probably in the *Equus* beds (Villafranchian =Sanmenian).

1 Teilhard de Chardin, P. and Pei, W. C., New discoveries in Choukoutien. Bull. Geol. Soc. China, Vol. XIII, 1933-34, p. 376, fig. 5.

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