University of the State of New York

BULLETIN

OF THE

New York State Museum

VOL. 3 No. 11

APRIL 1893

SALT AND GYPSUM INDUSTRIES OF NEW YORK

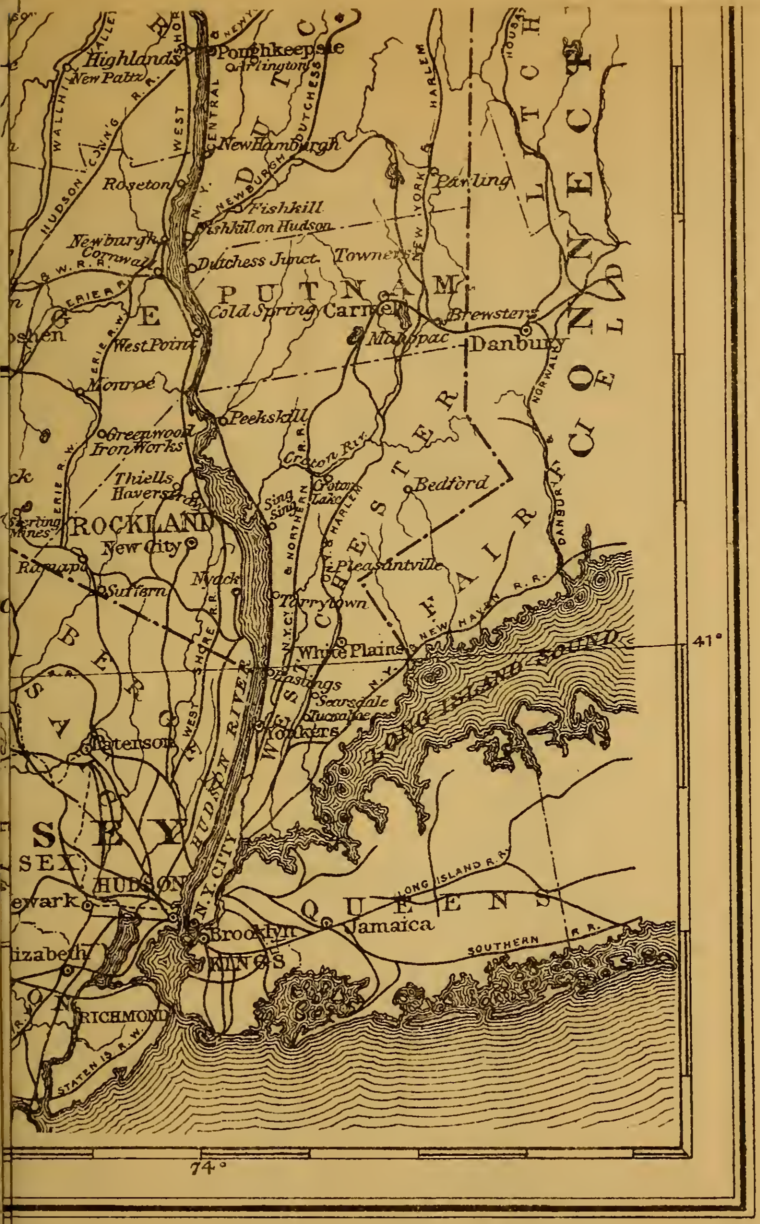
BY

FREDERICK J. H. MERRILL, PH. D (COLUMBIA)

ASSISTANT STATE GEOLOGIST

ALBANY
UNIVERSITY OF THE STATE OF NEW YORK
1893

Price 40 cents



Poughkeepsie
Arlington
Highlands
New Paltz
WALLKILL VALLEY
WEST SHORE R. R.
N. Y. CENTRAL
DUTCHESS
HARLEM
NEW YORK & HARLEM
HOUSATONIC
NEW YORK
New Hamburgh
NEWBURGH
Pawling
Roseton
HUDSON C. & N. G.
Fishkill
Fishkill on Hudson
Newburgh
Cornwall
Dutchess Junct.
Towners
N. Y. W. & B.
ERIE R. R.
ERIE R. W.
PUTNAM
Cold Spring
Carmel
Brewsters
Goshen
West Point
Mahopac
Danbury
Monroe
NORWALK
Peekskill
Greenwood Iron Works
Croton Riv.
Croton Lake
Thiells
Haverstraw
Bedford
Sing Sing
N. Y. C. & NORTHERN
N. Y. C. & HARLEM
Sterling Mines
ROCKLAND
New City
DANBURY &
Ramapo
Pleasantville
Suffern
Nyack
Tarrytown
WEST SHORE R. R.
N. Y. NEW HAVEN R. R.
White Plains
41°
Hastings
Scarsdale
Tuckahoe
Paterson
Yonkers
HUDSON RIVER
N. Y. CITY
LONG ISLAND SOUND
WESTCHESTER
FAIRFIELD
CONNECTICUT
BERGEN
SEX
HUDSON
Newark
LONG ISLAND R. R.
QUEENS
Brooklyn
Jamaica
Elizabeth
KINGS
SOUTHERN R. R.
RICHMOND
STATEN IS. R. W.
74°

MAP OF NEW YORK

SHOWING LOCATION OF SALT WELLS

1893.

BY FREDERICK J. H. MERRILL,
ASSISTANT STATE GEOLOGIST

Vermeule & Bien
Civil & Mining Engineers

University of the State of New York

BULLETIN

OF THE

New York State Museum

VOL. 3 No. 11

APRIL 1893

SALT AND GYPSUM INDUSTRIES OF NEW YORK

BY

FREDERICK J. H. MERRILL, Ph. D. (Columbia)
ASSISTANT STATE GEOLOGIST

ALBANY
UNIVERSITY OF THE STATE OF NEW YORK
1893

N. Y. State
Museum

Bulletin

11
1893

Salt
and
Gypsum
Industries
of
N. Y.

507.73
M

U. S.
National
Museum

Morocco Chocolate brown

TABLE OF CONTENTS

PREFACE

The following bulletin on the salt and gypsum industries of New York State is published in accordance with the law of 1892 relating to the appropriation for the geological map. As its preparation has been somewhat hurried in order to ensure its appearance during the legislative session of 1893, it has not attained that fulness of detail, and perfection of literary finish which was originally hoped for by the author. He trusts, however, to be able to remedy any errors or omissions in a subsequent edition which may be prepared more at leisure. The purpose of this bulletin is not merely to publish such new information as can be gathered, but to give in concise form what has previously been made public. Therefore, in order to make the report as reliable as possible, the most authentic sources of information have been drawn upon. In this connection grateful acknowledgments are made to Prof. I. P. Bishop for well records and statistical information and for several photographic views of salt works. Dr F. E. Englehardt has supplied the author with data of varied character and a detailed article illustrated by drawings, on the manufacture of salt in the State of New York. To Prof. James Hall, State Geologist, the writer is indebted for valuable information and advice.

In the field the author's personal observations have been supplemented by those of Messrs William C. Clarke, E. M., and R. D. White, C. E., who, in the course of their duties in collecting material for the World's Columbian Exposition, have obtained measurements of the altitudes of the salt wells and have accurately located them on the map. The chapter on gypsum is based on the field notes of Mr Clarke.

The writer has also consulted the following works:

Johnston's Encyclopædia, Article Salt, by Chas. A. Goessman; Elemente der Geologie, H. Credner, 6te Auflage; Chemische Technologie, R. von Wagner, 11te Auflage; Geology of the 3rd Dist. of N. Y. State, L. Vanuxem; Geology of the 4th Dist. of N. Y., James Hall.

Prof. I. P. Bishop's article on salt in New York State published in the report of the State Geologist for 1884, has been freely quoted and also the articles of Dr F. E. Englehardt in the Annual Reports of the Superintendent of the Onondaga Salt Reservation.

The brief historic sketch of the discovery of the Onondaga brines by the Jesuit missionaries has been translated from the original *Relations*, and, for the early history of salt manufacture, Clarke's Onondaga has been consulted.

For information collected by the writer and his assistants the former desires to express his thanks to the salt companies and their representatives and to the proprietors of the gypsum quarries, and it is hoped that they will take sufficient interest in the work to notify him of any errors in this bulletin and to supply him with any new information they may possess.

FREDERICK J. H. MERRILL.

SALT

ITS DISTRIBUTION AND ORIGIN

Common salt or chloride of sodium in a chemically pure condition consists of chlorine 60.41% and sodium 39.59%. It occurs in great abundance on the earth both in a solid state as halite or rock-salt and in solution in sea water and brine. As rock-salt it occurs in very large masses. It is found interstratified with clay, shale and gypsum in large beds of great extent and its distribution is almost world wide. It occurs in New York, Pennsylvania, Maryland, Virginia, West Virginia, Kentucky, Tennessee, Louisiana, Texas, Ohio, Michigan, Kansas, Utah, Nevada and California, in Canada at Goderich and in South America at the foot of the Peruvian and Bolivian Andes. In Europe it is abundant in the tertiary formations north and south of the Carpathians, and in the Spanish province of Catalonia. In the Triassic formation, important beds of salt occur in England at Cheshire and in Germany in Wurtemburg, Prussia, Saxony and at many other points. It is also found in the Punjaub, in Algeria and in Abyssinia.

The following table of distribution is taken with some modifications from Credner.*

Geological formation	Locality
Recent	Kirghiz steppes; Arabia; South America; shores of Dead Sea and *Great Salt Lake.*
Tertiary	Cardona in Catalonia, Spain; Wieliczka and Bochnia in Galicia; Siebenbürgen; Asia Minor and Armenia; Rimini in Italy; *Petit Anse, Louisiana.*

---

* Elemente der Geologie 6th Auflage p. 40

Geographical formation		Locality
Cretaceous		Westphalia brines, Algiers.
Jura		Rodenburg on the Deister, Bex in Canton of Waadt, Switzerland.
Trias	Keuper	Lorraine; Hall, Tyrol; Hallein and Berchtesgaden (near Salzburg).
	Muschelkalk	Wurtemburg; in Thuringia, Ernsthall, Stottenrheim.
	Buntersandstein	Hanover, Schoeningen near Brunswick, Salzderhelden, Cheshire, England, *Kansas* and *Texas*.
Permian		Gera, Artern (Thuringia) Stassfurt, Halle, Sperenberg; Segeberg (Holstein); Kirghiz steppes on the river Ileck.
Carboniferous		*Kanawha and New river, West Virginia;* Durham, and Bristol, England.
Devonian		*Winchell, Michigan.*
Upper Silurian		*New York, West Virginia, Saginaw, Michigan,* Goderich, Canada.

The secondary occurrence of crystallized salt must be distinguished from its primary occurrence in beds. Atmospheric waters penetrating into the earth's crust dissolve salt and bring it back to the surface. In this manner salt springs and salt lakes are formed, from which, by evaporation, salt is produced again, and in this connection may be mentioned the occurrence of salt as an efflorescence on the ground in the Kirghiz steppes and in one of the dried up bays of the Caspian sea. Among the well known salt lakes are the Great Salt Lake in Utah, the Dead Sea, that of Eisleben and the Elton Lake near the Volga.

Whatever be the occurrence of salt springs or natural brines it can not be doubted that their contents of salt are derived from the leaching of salt in the solid state. Wherever salt springs abound there is a probability of rock-salt being present in the underlying strata. In addition to the instances mentioned, salt is found dissolved in sea water, and in the polar regions it is found in a granular state on the surface of the ice.

COMPOSITION OF SEA WATER

Sea water from different parts of the world contains approximately the same substances, as shown by the following analyses*

---

* Wagner; Chemische Technologie, 11th Auflage p. 227.

	Caspian Sea	Black Sea	Baltic Sea	North Sea Average	Mediterranean Sea	Atlantic Ocean Average	Dead Sea Average
Salts in solution	.63	1.77	1.77	3.31	3.37	3.63	22.30
Water	99.37	98.23	98.23	96.69	96.63	96.37	77.70
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
The solid matter contains							
Sodium Chloride	58.25	79.39	84.70	78.04	77.03	77.07	36.55
Potassium Chloride	1.27	1.07	---------	2.09	2.48	3.89	4.57
Calcium Chloride	---------	---------	---------	.20	---------	---------	11.38
Magnesium Chloride	10.	7.38	9.73	8.81	8.76	7.86	45.20
Sodium and Magnesium Bromide	---------	.03	---------	.28	.49	1 30	.85
Calcium Sulphate	7.78	.60	.13	3.82	2.76	4.63	.45
Magnesium Sulphate	19.68	8.32	4.96	6.58	8.34	5.29	---------
Calcium & Magnesium Carbonate	3.02	3.21	.48	.18	.10	---------	---------
Nitrogenous & Bituminous matter	---------	---------	---------	---------	---------	---------	1.
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

The variation in the quantity of these is dependent upon local conditions ; upon the character of the sea bottom, upon the dilution of the sea with fresh water near the mouths of large rivers and in the polar regions on the presence of masses of ice ; or upon its concentration in land locked bays. The specific gravity of sea water from the open ocean varies between 1.0269 and 1.0289 at a temperature of 17° C. That of the water of the Red Sea is much greater and is about 1.0306.

DEPOSITION OF SALT BEDS

The theory of the formation of deposits of salt is ably discussed by H. Credner, whom I have freely translated and in part quoted in the following paragraphs.

The beds of rock-salt which occur in the earth's crust have been produced by direct separation from sea water or from the water of inland seas in which chloride of sodium was the principal substance held in solution. In quiet bodies of salt water the stronger brine formed at the surface by evaporation sinks to the bottom and accumulates there, so that a concentration of the salt takes place from the surface toward the bottom.

In open seas full of currents such a concentration cannot occur for, on the one hand, in consequence of the currents, there is a constant mingling of the stronger and weaker solutions of salt, and, on the other, the rivers replace the evaporated water, but in inland seas, especially those into which but little river water flows, the conditions are the same as in a glass vessel, since in them a saturated solution of salt sinks to the bottom, from which rock-salt crystallizes out and by continual accumulation a layer of salt is formed.

In periods of abundant rainfall when the tributary streams are muddy, beds of saliferous clay are deposited upon the layers of rock-salt. If the mud is calcareous a deposit of carbonate of lime is formed.

On the other hand, in periods of drought when more water evaporates than is contributed by streams, deposits of pure rock-salt are formed; consequently in the course of the year alternate layers of rock-salt and clay are deposited. If the water of a bay, in which such a process of evaporation and deposition is going on, contains sulphate of lime, inasmuch as the saturation of water with sulphate of lime occurs earlier than with chloride of sodium, the former must separate before the separation of the salt begins. This commences when the sea water is concentrated to a saturated solution of salt. Consequently beds of rock-salt very commonly rest upon beds of gypsum or anhydrite, so that layers of gypsum and anhydrite appear between the beds of salt, corresponding to the beginnings of the process of evaporation, interrupted from time to time. Therefore, deposits of gypsum over rock-salt always occur in consequence of a new influx of sea water.

If layers of gypsum and anhydrite occur alone and are not accompanied by layers of rock-salt, either the evaporation has not advanced to the saturation point of the brine or the separated rock-salt has been redissolved by an influx of water. That sulphate of lime separates sometimes free from water as anhydrite and sometimes with water of crystallization as gypsum, may depend upon the amount of the pressure and consequently upon the depth of the enclosing basin for it is estimated that a pressure of ten atmospheres is sufficient to cause the sulphate of lime to crystallize as anhydrite. This condition would exist at the bottom of a lake 325 feet deep.

Finally, if the waters of the inland sea, upon the bottom of which the deposit of rock-salt is taking place, contain in solution beside chloride of sodium and sulphate of lime other more soluble salts, such as the chlorides of magnesium, potassium and lime, and the sulphates of potash, soda and magnesia, these will be concentrated in the waters diminishing in bulk by evaporation, and by constant separation of the chloride of sodium a mother liquor is formed from which, when the evaporation is complete, they separate as a solid mass and sink to the bottom.

By the drying up of an inland sea, originally containing salts in solution, according to the principles above noted a deposit of gypsum would first separate, then a complex layer of rock-salt with thin layers of clay, marl or gypsum, and finally on the top a layer of the more easily soluble sulphates and haloid salts. These conditions would, however, produce salt deposits of comparatively small thickness since they are limited to the separation of salt from the sea water contained in a basin which is drying up. The existence of deposits of salt, such as those of Stassfurt and Sperenburg in Germany which have a thickness of 1470 and 3600 feet could only be possible in connection with a continual influx of salt water. This might be due to rivers, as in the case of the Dead Sea, or to the cutting off of bays and gulfs of considerable depth by sand bars, over which only as much sea water can enter as is evaporated from the surface. In this way beds of salt may be formed, of which the thickness depends only upon the duration of the conditions which cause the separation of the salt. Such a continuous process of deposition aided by rivers carrying salt in solution goes on in the Dead Sea. The waters of the latter are in the condition of a mother liquor, resulting from a long continued evaporation of salt water. Of this mother liquor the greater proportion of chloride of magnesium (65% of the salt contents and this 25% of the water) indicates that a great deal of chloride of sodium has already separated from it. Inasmuch as this sea has inlets and no outlets, the water brought in can only escape by evaporation and consequently leaves its salt behind it. The Jordan, the principal river which flows into the Dead Sea, is extraordinarily rich in dissolved constituents, and especially in chloride of sodium and chloride of magnesium of which it contains in 100,000 parts 52 parts of the former and 30 parts of the latter and with which it increases the saline contents of the sea. From this, rock-salt first separates, while chloride of potassium and chloride of magnesium remain behind; but water loses its capacity for dissolving rock-salt in proportion as its contents of chloride of magnesium increase, consequently the deposition of rock-salt goes on continuously as a result of the present composition of the waters of the Dead Sea, for this salt is brought in continuously by the Jordan and the other tributaries, but the amount of chloride of sodium remaining in solution is only from 8.41% to 15.95%. We see consequently in the Dead Sea a continual deposition of rock-salt, caused by the introduction of salt by rivers and the evaporation of water from its surface, and at the same time the presence of a mother liquor which at a depth of 600 feet contains in 1000 parts, 253 parts of dissolved salts consisting of

Chloride of Sodium	25.2 %
Chloride of Magnesium	64.75
Chloride of Potassium	3.4
Chloride of Lime	4.3
Bromide of Magnesium	2.
Sulphate of Lime	.3
	99.95

From the final drying up of this liquor by a possible cutting off of all tributary streams a deposit of salt would result consisting essentially of chloride of magnesium and, in addition, of chloride of sodium, chloride of lime, chloride of potassium and bromide of magnesium. Similar conditions exist in lakes Elton and Bogdo which lie between the Volga and Ural rivers in a broad steppe in which there is a rock-salt deposit. From this a number of streams carrying salt flow into these lakes. As they have no outlet and the water which comes in is removed by evaporation the salt separates upon the bottom and borders of the lakes in solid beds. The streams bring into the lakes chloride of potassium, and sulphate of magnesium, beside chloride of sodium, as well as mud in the spring time. The latter forms thin layers between the strata of salt, while the more easily soluble salts have enriched the lake water to a concentrated mother liquor, which in the Elton lake contains

Sulphate of Magnesium	5.32
Chloride of Sodium	3.83
Chloride of Potassium	.23
Chloride of Magnesium	19.75
Water	70.87
	100.00

The Great Salt Lake in Utah is also a saturated brine depositing salt, as proved by the incrustations of salt about its margin in dry seasons.

As an example of the continuous deposit of salt in a basin where evaporation and separation of salt is continually replaced by an influx of sea water over or through a sand bar; we may mention the Adschi-Darga bay of the Caspian Sea, of which the bottom is covered with a continually thickening deposit of salt and gypsum.

The formation of salt beds in the geological past must have occurred in a precisely similar manner and consequently they represent former inland seas, or bays cut off from the ocean by the upheaval of sand bars and of which the fluviatile or marine influx contained salt in solution, but yet was not greater in quantity than the amount of the evaporation from the basin. From this it is evident that the conditions for the formation of rock-salt were always present when seas and continents existed. In fact rock-salt occurs throughout the whole list of geological formations as shown in the preceding list of localities. A very instructive example of a salt deposit formed in the manner above described, and chemically, the most complete in the world, is that of Stassfurt in Germany. This interesting deposit is in the Permian formation and its thickness has been ascertained to be at least 2700 feet. Its lower principal mass consists of rock-salt which is divided by thin parallel layers of anhydrite into beds from 2 to 5 inches in thickness. Upon it rests a stratum, 200 feet thick, of impure rock-salt mingled with easily soluble compounds such as chloride of magnesium which is divided by thin layers of polyhalite. Upon this is a stratum 180 feet thick in which rock-salt and sulphates, principally Kieserite (sulphate of magnesia), occur in alternate layers, some of which are a foot thick. The uppermost bed, about 135 feet thick, is composed of a succession of reddish layers of rock-salt and salts of magnesia and potassium (Kainite, Kieserite, Carnallite and Tachyhydrite) in addition to which are also masses of snow white Boracite. The boundaries between these four principal divisions are not exact, and the change from one to the other is gradual. This deposit is of wide extent.

SALT IN NEW YORK STATE

As the presence of salt in New York was first made manifest through saline springs it is proper to begin this discussion with the history of their discovery and utilization.

The most important of these are in Onondaga Co. at Syracuse.

About the middle of the seventeenth century several of the Jesuit missionaries during their journeys among the Indians, in what is now the State of New York, heard of certain springs which were regarded with superstition and said to be possessed of demons. Upon investigation these were found to be salines and the Indians were shown that the demons could be exorcised by means of fire. In the "*Relations*" of the Jesuit fathers we find the earliest records of these salt springs.

Father Jerome Lallemant says in his *relation* 1646: "The fountain from which very good salt is made, springs up in a beautiful plain surrounded by a fine wood. At eighty or a hundred paces from this salt spring is another one of fresh water, and these two take their birth from the bosom of the same hill."

Charlevoix says (1646): "The Canton of Onondaga has a very beautiful lake called Ganentaha around which are several salt springs and of which the borders are always covered with very fine salt."

Creuxius says (1655) speaking of the shores of Lake Ganentaha: "The meadow is intersected by two fountains situated about a hundred paces from one another: of the one the salt water furnishes an abundance of the best salt; the pure water of the other is good to drink, and what is remarkable, is that both spring from one and the same hill."

Father Simon Le Moyne says in his *relation* of the return voyage from the Iroquois nations August, 1664: "We arrived at the inlet of a small lake, in a great basin half dry. We tasted the water of a spring which they (the Indians) dared not drink, saying that there was in it a demon which rendered it fetid, and having tasted it I found that it was a fountain of salt water; and in fact we made from it salt as natural as that from the sea, of which we carried a specimen to Quebec."

This discovery of salt by the Jesuits led to its manufacture by Indians and traders. In 1770 salt was in common use among the Delaware Indians. The traders were, at that time, in the habit of bringing it to Albany along with their furs.

DEVELOPMENT OF THE ONONDAGA SALT FIELD

The systematic manufacture of salt in the vicinity of Syracuse by white men was begun in 1788. In a letter from Colonel Comfort Tyler to Dr Jeremiah Van Rensselaer* he says that in May, 1788, his family needed some salt and he obtained about a pound from the Indians which they had made from the springs near the shore of the lake. The Indians offered to show him the location of the brine springs and accordingly he went to the lake with a guide. The guide in his canoe took Col. Comfort out of the mouth of Onondaga Creek easterly into a pass since called Mud Creek. After passing over the marsh then covered by about 3 feet of water and starting toward the bluff upon which was afterward founded the village of Salina, he fastened his canoe and pointed to a hole in the ground which had apparently been dug there and said that there was the salt. In the same year Asa Danforth and Col. Tyler undertook the manufacture of salt in a very primitive way, their only outfit being a 5-pail kettle suspended by a chain from a pole resting upon two crotched stakes.

In 1789 Nathaniel Loomis started a small establishment with a number of kettles and during the winter of 1789–90 made from 500 to 600 bushels of salt which he sold for $1 a bushel.

William Van Vleck made salt at Salt Point and Jeremiah Gould afterwards made salt in kettles on arches.

In 1793 Moses Dewitt and William Van Vleck entered into partnership, erected an arch containing 4 potash kettles and manufactured salt enough for the wants of the inhabitants of the neighboring country. In the same year James Geddes began manufacturing salt at the place which now bears his name, and shortly after John Danforth begun to make salt at Liverpool.

In 1797 the legislature of the State of New York passed

---

* Essay on Salt.

the first laws relating to the manufacture of salt at the Onondaga salt springs and William Stephens was appointed superintendent. Details of this act may be found in the laws of that year.

In 1798 an association called the Federal Company was organized. It erected the largest plant known at that period, consisting of 32 kettles which were set in blocks of 4 each. The brine was pumped by hand from the shallow wells, less than 30 feet deep, into reservoirs made of hollow logs. The first well of any large size was sunk under the direction of William Kirkpatrick who was appointed superintendent in 1806. This well was at Salina. It was 20 feet square and 30 feet deep. Each manufacturer had his own pump which was worked by hand and the brine was carried in conduits to the different works.

In 1810 under Sup't John Richardson, the water of Yellow Brook was conducted from Syracuse to Salina in order to drive a wheel for pumping the brine. Shortly afterward the pumps were worked by horse-power.

In 1820 the legislature authorized Benajah Byington to bore for rock-salt on the reservation, offering a premium for any salt produced. His explorations were chiefly made on the high grounds east of Salina and were entirely unsuccessful. In 1838 an appropriation was made to enable the superintendent to sink a shaft or well 600 feet deep. A well was sunk to this depth but without finding any rock salt.

The further history of the Onondaga Salt Reservation may be found in detail in the works quoted in the preface.

The brine springs of Montezuma in Cayuga Co. were only second in importance to those of Onondaga Co. and for a time were utilized in the manufacture of salt. In 1823 the salt made there amounted to between 16,000 and 20,000 bushels.

The following additional list of brine springs is taken from the report of Lewis C. Beck on the mineralogy of

New York 1842. As the matter has not since been investigated no later record is accessible.

Up to the date of that report no salt springs had been found east of Saltspringville, about 14 miles from Cooperstown near the line between Otsego and Fulton Counties. These springs were very weak in brine containing only 3% or 4 %, but were of sufficient importance to furnish salt to the people residing in that region.

In 1833 a brine spring was discovered in Delaware Co. on Elk brook, about 4 miles from Delhi. In Oneida Co. salt springs occur near Vernon Centre and again near Oneida. According to Eaton these are the first brine springs in the Salina group. Brine has also been found at Lenox in Madison Co. At the Triangle in Broome Co. salt water occurs which yields salt of great purity, and brine is also said to exist in the County of Cortland. In Oswego Co. are several weak brine springs. One of these is in a marsh two miles square in the town of Hastings. Two miles west of this is another spring. At Central Square is still another. There are other salines in the towns of Constantia, Richland and Hannibal. From the eastern part of Oswego Co. to the Niagara River numerous brines are found in the red sandstone.

In Wayne Co. are several salines. They are at Galen in the town of Savannah on the western edge of the Cayuga marshes. This brine contains somewhat less than 9% of salt. There is also a spring about 2 miles from Lockville. Another brine spring is near the head of Little Sodus Bay. Weak brine has been reported from the village of Clyde. A few salines, not of economic importance, are found in Monroe Co. One of these is on Irondequoit Bay 2 or 3 miles from Lake Ontario. Salt was at one time manufactured from this brine. Another spring, also somewhat worked formerly, is in the town of Greece 2 miles north of the ridge road and 9 miles west of the City of Rochester. To these may be added the 3 springs on the banks of the Salmon creek near Clarkston 2 miles north of Ladd's Corners. Salt springs are moreover of frequent occurrence along almost all creeks and small streams, and salt was formerly manufactured from some of them in small quantities.

In 1834 brine was found in Livingston Co. 2½ miles southwest of York. This supply after a time, ceased to flow. Salt water was found by boring, in the town of Elba 8 miles northwest of Batavia. A number of brine springs have been observed in Orleans Co. In Carlton, at Kendall and at Holley, salt has been manufactured from saline springs. At Oak Orchard also, salt has been made from the natural brine. In Niagara Co. several brine springs occur on Eighteen-Mile creek between Lockport and Lake Ontario.

DISCOVERY OF ROCK SALT

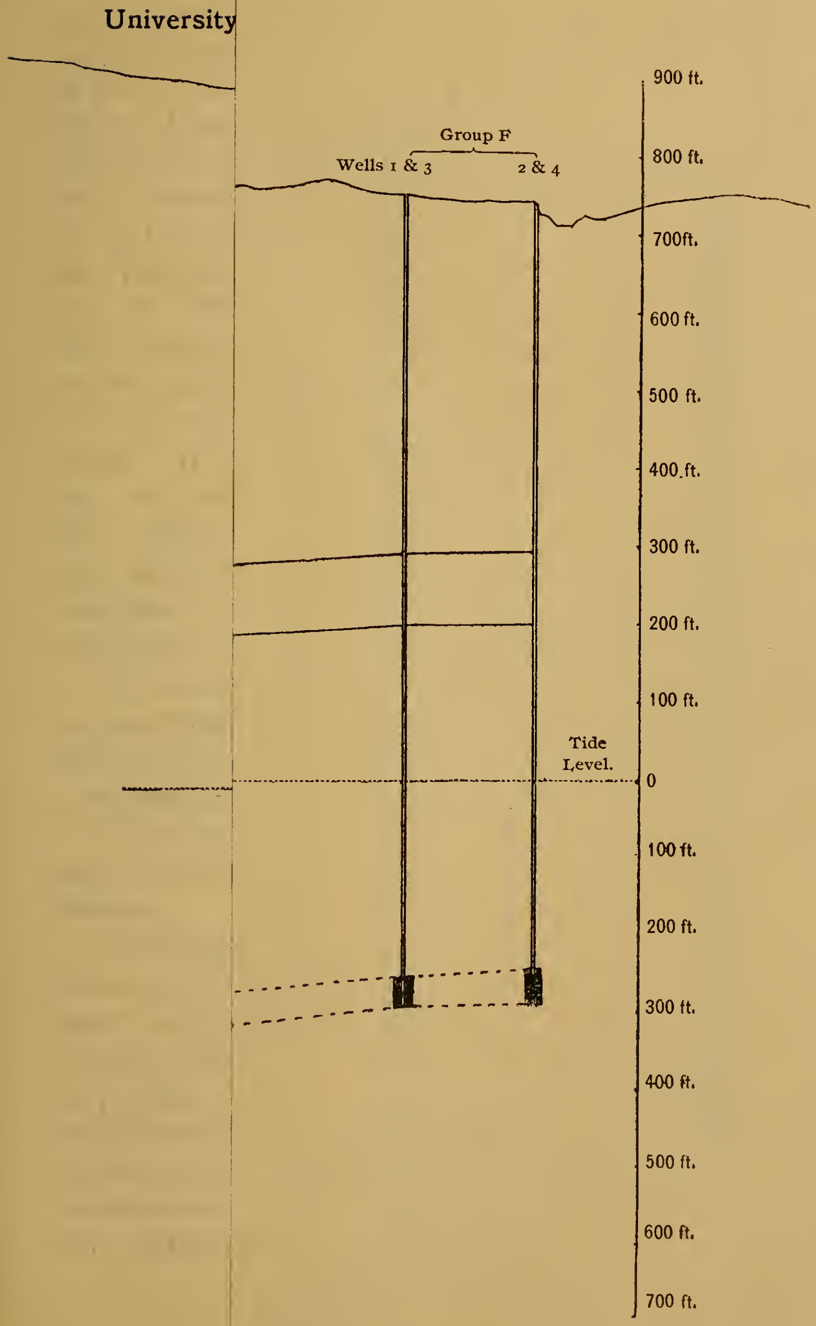
It had been recognized by the New York geologists that the Onondaga salt springs must be supplied from the leaching of beds of rock-salt, and for a time efforts were made to find it in the immediate vicinity of Onondaga Lake. The various borings made on the reservation however showed conclusively that no salt was there. With a more careful study of the rocks of the Salina group it became manifest that those enclosing the gravel-filled basin from which the salt springs flowed were not the ones in which salt could be expected, and the conclusion was drawn that the brine came from the south through an old river channel now filled with gravel and sand and into which flowed the salt water produced by the leaching of beds of salt interstratified with the salina shales. It remained for the existence of rock-salt thus inferred in this geological horizon to be demonstrated accidentally in the boring of an oil well in Western New York. The history of the discovery and development of the salt beds of western New York has been discussed at length by Mr I. P. Bishop.*

---

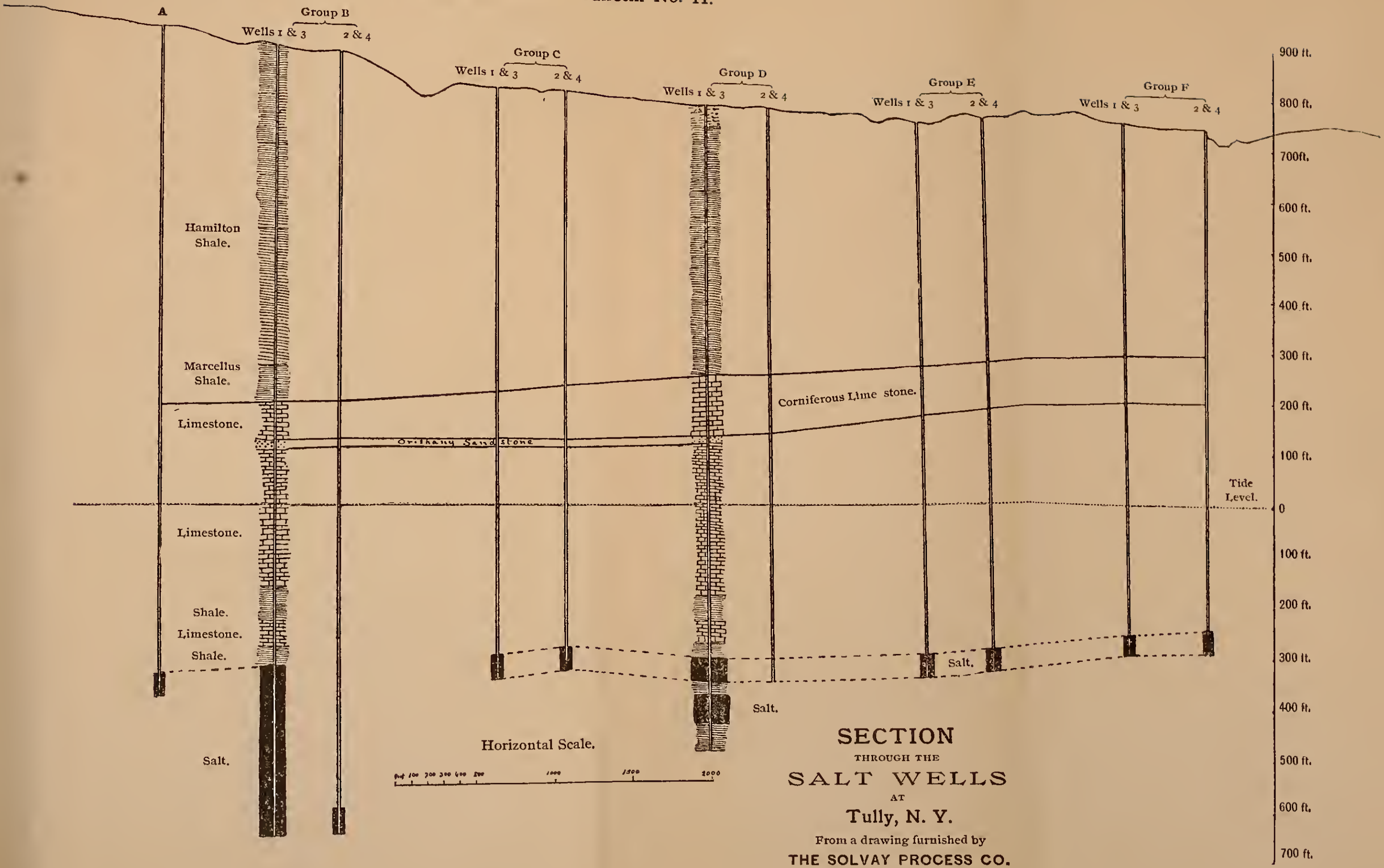
* Report of the State Geologist for 1884.

In 1878 salt was found at a depth of 1279 feet in a well bored for oil in the village of Wyoming, Wyoming county. This well was one of a number bored by order of the Vacuum Oil Co. of Rochester at various points in the western part of the state. In this boring a bed of salt 70 feet thick was found. As a result of the discovery of salt at Wyoming a well was bored at LeRoy under a contract between the citizens of that place and the Vacuum Oil Co. by the terms of which the expense was borne by joint subscription. This well was started in December 1878 and no considerable mass of rock-salt was found, but in March 1879, at a depth of 610 feet a copious supply of brine entered the bore.

In August 1881 a company was organized at Warsaw for the purpose of investigating the deposits underlying that place, and in October salt was found at a depth of 1620 feet in a well bored near the Buffalo, Rochester and Pittsburg R. R. The stratum of salt here proved to be 80 feet in thickness. In 1882 another company, the Crystal Salt Co. of Warsaw, sank a well at the locality now known as Saltvale. Here a satisfactory deposit of salt was also found. In 1883 a well was bored by Dr W. C. Gouinlock near the Buffalo, Rochester and Pittsburg R. R. station. There salt was found on May 5 at a depth of 1640 feet, and on the same day it was reached in the Stedman, Humphrey and Webster well near the Erie station. Following these pioneer explorations a number of companies sank wells and began operations in making salt. The Empire and Hawley Companies located near the Erie R. R. track south of Warsaw, and at Wyoming and Castile salt factories were established during the same year. Works of considerable capacity were also erected at Silver Springs and began operation in January 1885. Other wells were sunk near the Erie R. R. at Warsaw and the Eldridge well between Warsaw and Rock Glen was bored. Alexander Kerr Bros. & Co. of Philadelphia bored a well at Rock Glen. In 1883 salt was



University
Group F
Wells 1 & 3
2 & 4
900 ft.
800 ft.
700ft.
600 ft.
500 ft.
400 ft.
300 ft.
200 ft.
100 ft.
Tide Level.
0
100 ft.
200 ft.
300 ft.
400 ft.
500 ft.
600 ft.
700 ft.



SECTION

THROUGH THE

SALT WELLS

AT

Tully, N. Y.

From a drawing furnished by

THE SOLVAY PROCESS CO.

found in the Genesee valley. In the vicinity of Greigsville a series of test wells were sunk under the direction of Mr C. Q. Freeman, and in September 1884, a shaft was begun in that locality. In September 1885, salt was reached at a depth of 995 feet. This deposit is now operated by the Retsof Salt Mining Co. Near the Genesee river salt works were erected at Piffard by the Livingston Salt Co. and about two miles south of Mt Morris by the Lackawanna Co. At Piffard also, works were established by the Genesee Salt Co. In 1885 works were completed at Lakeville. In 1886 salt factories were completed at York and others were erected at Cuylerville.

At Pavilion a well was bored reaching a salt bed 64 feet thick. At Pearl Creek station a factory was established with two wells. About two miles south of Le Roy station the Lehigh Salt Mining Co. has sunk a shaft reaching salt at a depth of 765 feet, and is now sinking a second shaft in compliance with the law. At Livonia and Greigsville other shafts have been sunk.

To enumerate further, the various wells and their history is unnecessary to the purpose of the present report. The growth and development of this industry is best shown by a complete list of producers at the end of this report.

As shown on the accompanying map explorations for salt have been made at many points outside of the Oatka Genesee district.

The locality which is of most interest to the geologist on account of the completeness of the records kept and the large number of wells bored is Tully in Onondaga Co. Through the courtesy of Mr Wm. B. Cogswell, I am enabled to publish a section of the strata penetrated by the thirty wells bored by the Solvay Process Co. at this point. These borings are of especial interest because they confirm the conclusions of Prof. Jas. Hall regarding the presence of rock salt south of Syracuse.

GEOLOGY OF THE SALT AND GYPSUM

The salt of New York occurs almost exclusively in the Salina Group or as it is also called the Onondaga Salt Group of the Upper Silurian Period which was described by Vanuxem as follows:*

"This important group contains all the gypsum masses of western New York, and furnishes all the salt water of the salines of the counties of Onondaga and Cayuga. From the point where the Niagara group terminates at the east, it rests upon the Clinton group; and as the latter group also comes to its end near the first district, it reposes there upon the Frankfort slate, upon which it continues to near the Hudson river.

It forms a part of the high range on the south side of the Mohawk; appearing at the north end of Otsego county, and in Herkimer and Oneida, being its northern outcrop. It makes its first appearance by the side of the Erie canal at the east end of Madison county, and from thence west the canal was excavated in the group.

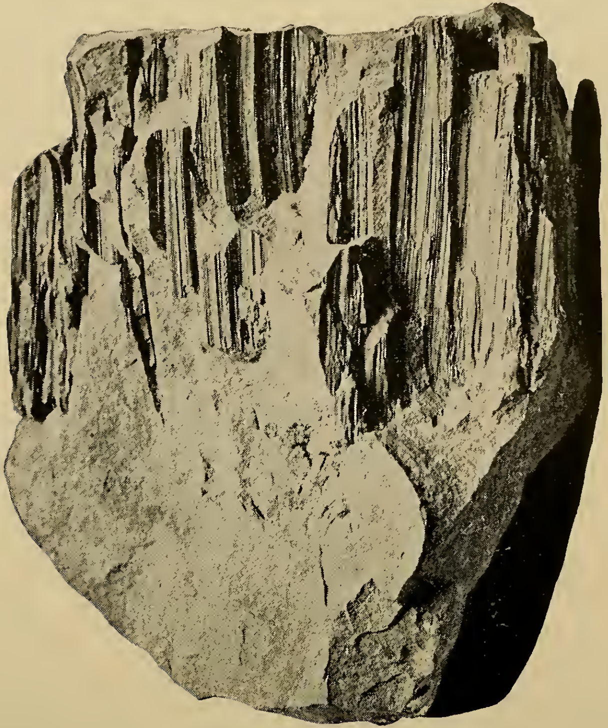
The Onondaga salt group may be divided into four deposits. There are no well defined lines of division between the deposits; but for practical purposes the divisions are sufficiently obvious.

The first or lowest deposit is the red shale, showing green spots at the upper part of the mass. 2d, The lower gypseous shales, the lower part alternating with the red shale, which ceases with this mass. 3d, The gypseous deposit, which embraces the great masses quarried for plaster, consisting of two ranges, between which are the hopper-shaped cavities, the vermicular limerock of Eaton, and other porous rocks. 4th and lastly, Those rocks which show groups of needle-form cavities placed side by side, caused by the crystallization of sulphate of magnesia,† and which may from that circumstance be called the magnesian deposit.

---

* Report on the Geology of the 3rd District of N. Y.

† Sulphate of lime most probably.



NEEDLE-LIKE CAVITIES.

The whole of these deposits are found between Oneida creek and Cayuga lake. To the east of the creek, they do not all occur, as will subsequently be made known. They thin out to the eastward and probably terminate entirely a few miles east of the Hudson river; from which point their thickness gradually increases towards the west, and reaches its maximum in the counties of Onondaga and Cayuga, where it is not less than seven hundred feet. The gypsum has not been seen east of the western part of Oneida county. The red shale comes to its end at the east end of Herkimer county; and the whole group is reduced, in the Helderberg in Albany county to a few feet of light grey or lavender-colored compact calcareous rock with pyrites, separating the Frankfort portion of the Hudson river group from the water-lime series."

The outcrop of the Salina shales as shown on the accompanying map is copied from the geological map of New York published in 1844.

The red shale is fine grained, earthy in fracture and without regular lines of division. It breaks or crumbles into irregular fragments. This deposit is not found east of Herkimer County and varies in thickness from 100 to nearly 500 feet. The second member of the series consists of shale and calcareous rock of a light green color intermingled with a red shale at its lower part. But little gypsum occurs in this member. The rock is extremely porous, easily penetrated by water and falls to pieces at once on exposure to the air. The third or gypseous deposit, which is important commercially on account of its plaster beds, is also the horizon from which the brine springs of Onondaga, Cayuga and Madison counties were supposed by Vanuxem to have been derived. The mass of the deposit consists of rather soft yellowish or brownish shale and slate, both argillaceous and calcareous. It may be called a gypseous marl. It falls to pieces when exposed to the weather, breaking in a series of joints nearly at right angles to each other which give the rock a rhombic cleavage. In the third district the gypsum of this horizon does not often occur in layers or veins, it usually occurs in isolated masses of irregular form. At many points there appear to be two ranges or levels of these plaster beds as they are called, separated by shale containing hopper-shaped cavities. These cavities are of much interest for they represent the external casts of salt crystals which were probably formed during the evaporation of the water from the basin in which the Salina deposits were laid down. These cavities are from one to ten inches in diameter. But few fossils are found in the Salina group, for at the time when the shale and gypsum were deposited the water contained too high a percentage of soluble salts to support animal life.

The fourth deposit was called the magnesian deposit on account of the assumption that the needle-like cavities were due to the crystallization of sulphate of magnesia. As needle-like crystals of sulphate of lime are well known, and as gypsum is abundant in this horizon, it seems more probable that these needle-like crystals were crystals of gypsum.

Prof. James Hall* describes the Salina group as follows: Succeeding the Niagara group is an immense development of shales and marls with shaly limestones including veins and beds of gypsum. The general color is ashy approaching drab with some portions of dark bluish green. The lower part is of deep red with spots of green. Succeeding this, where protected from atmospheric influences, the rock is blue like ordinary blue clays, with bands of red or brown. This portion and that succeeding it are often green and spotted, and contain seams of fibrous gypsum and small masses of reddish selenite and compact gypsum. From this it becomes gradually more gray with a thin stratum of clayey limestone, which is sometimes dark, though generally of the same color as the surrounding mass. The formation terminates upward with a gray or drab limestone called by Vanuxem the

---

* Geology of the 4th District.

'magnesian deposit." The red shale forming the lower division of the group is well developed, but in the third district has not been found west of the Genesee river. It appears in the eastern part of Wayne county as indicated by the deep red color of the soil which overlies it.

At Lockville a greenish-blue marl with bands of red has been quarried from the bed of the Erie Canal. West of the Genesee this is the last of the visible mass. The red shale has either thinned out or lost itself, gradually becoming a bluish green, while otherwise the lithological character remains the same. On first exposure it is compact and brittle, presenting an earthy fracture. But few days are necessary to commence the work of destruction, which goes on until the whole becomes a clayey mass. The prevailing features of the second division of the group are the green and ashy marl with seams of fibrous gypsum and red or transparent selenite often embracing nodules of compact gypsum The third division comprises all the gypsum beds of the fourth district which are of economic importance. In this third division hopper-shaped cavities occur in Wayne and Monroe Counties, but rarely in Genesee or Erie.

There is scarcely any well defined division between the shales and shaly limestones of the third division and the so-called magnesian deposit which overlies it. This limestone in the western part of the state is used extensively for hydraulic cement and is now worked by the Buffalo Cement Co.

In their studies of the Salina group, Profs. Hall and Vanuxem found no rock-salt because this soluble mineral cannot remain at the surface. However from various wells and shafts, sunk during the past 11 years, we have sections of the Salina group which show the position and relation of the salt beds.

Through the courtesy of Prof. James Hall, State Geologist, I am permitted to quote the following synopsis of the record of the Livonia salt shaft, made under Prof. Hall's direction by Mr D. D. Luther.

EXTRACT FROM THE REPORT OF D. D. LUTHER ON THE LIVONIA SHAFT

The mouth of the shaft is 260 feet above Conesus lake, 170 feet above Hemlock lake and 1082 feet above sea level. The first 10 to 12 feet of the drift penetrated was a fine loamy gravel with large boulders of gneiss and smaller blocks of limestone, principally from the corniferous or water-lime groups. Below that deposit veins of clay and quicksand saturated with water were encountered. At 64 feet the bed rock was reached.

Depth	Thickness	SYNOPSIS OF RECORD
380 feet		Beginning of recorded section.
386	6	feet bluish gray shale.
415	29	feet compact dark blue shale.
416	1	foot hard gray limestone.
427	11	feet hard medium dark blue shale, somewhat calcareous.
429	2	feet blue gray limestone.
430	1	foot soft blue gray shale.
431	1	foot fine pinkish gray limestone.
438	7	feet blue shale with concretionary layers.
440	2	feet hard limestone containing considerable pyrites.
447	7	feet soft blue compact, pyritiferous shale.
467	20	feet soft blue gray shale.
476	9	feet dark blue, slightly pyritiferous shale.
478	2	feet concretionary layers with silicified fossils.
495	17	feet blue shale, hard and calcareous.
515	27	feet dark brownish bituminous shale.
543	28	feet dark bluish gray soft shale.
547	4	feet soft bluish pyritiferous shale.
555	8	feet harder arenaceous and pyritiferous shale.
560	5	feet sandy shale with thin layers of impure limestone.

Depth	Thickness
562	2 feet light gray limestone.
566	4 feet sandy shale, quite hard.
570	4 feet fine bituminous shale.
604	34 feet soft dark rock.
604′ 6″	6 inches hard sandy dark bluish gray shale.
607′ 10″	3 feet 4 inches soft dark bluish shale.
609′	1 foot 2 inches hard calcareous sandy layer.
615	6 feet dark bluish soft shale.
626	11 feet harder dark blue shale.
629	3 feet sandy layer, quite hard.
650	21 feet dark brownish and bluish gray shale.
797	147 feet dark brown or black shale, with bluish or olive layers.
812	15 *feet very bituminous shale, bottom of Hamilton.*
823	11 feet black bituminous shale.
825	2 feet compact gray limestone.
829	4 feet of black bituminous shale.
851	22 feet of black shale, very bituminous.
852	1 foot bluish black shale.
854	2 feet black impure limestone.
856	2 feet blue black grayish limestone.
857	1 foot impure limestone.
863	6 feet black shale.
866	3 *feet black hard shale, bottom of Marcellus.*
888	22 feet gray limestone with chert.
954	66 feet gray limestone containing chert.
978	24 feet gray limestone full of chert very hard.
998′ 6″	20 *feet* 6 *inches gray limestone containing less chert, bottom of corniferous. (Gas.)*
1001′	2 feet 6 inches gray limestone, no chert.
1006	5 *feet hard green and gray sandstone (Oriskany).* Containing pebbles and fragments of hydraulic limestone.
1010	4 feet bituminous dark colored hydraulic limestone.

Depth	Thickness
1024	14 *feet hydraulic limestone, light colored, bottom of water-lime.*
1030	6 feet very light gray sandstone.
1069	39 feet hydraulic limestone.
1078	9 feet hard bluish gray shaly rock, with black seams.
1087	9 feet blue gray hard shale, with nodular layers of gypsum.
1093	6 feet fine brownish gray limestone, with light blue gypsum in masses from 1 to 4 inches thick.
1118	25 feet hydraulic limestone, with gypsum in crystals and nodules.
1135	17 feet dark bluish gray shales; gypsum in nodules
1138	3 feet reddish brown limestone, with dark gypsum in nodules.
1183	45 feet *gypsum bed* dark bluish gray marl, intercalated with gypsum in layers and nodules, sometimes one foot or more in thickness.
1192	9 feet light reddish gray limestone; gypsum in layers from one-half inch to one foot.
1197	5 feet layers of limestone and gypsum.
1198	1 foot of reddish gray limestone.
1201	3 feet bluish gray marl with gypsum in nodular layers.
1203	2 feet red gray limestone.
1205	2 feet bluish gray marl.
1220	15 feet limestone.
1226	6 feet bluish marl; gypsum in nodular layers.
1233	7 feet reddish brown limestone.
1234	1 foot bluish gray marl, with nodular layers of gypsum.
1238	4 feet reddish gray limestone.
1240	2 feet yellowish gray, very hard, limestone, gypsum in small crystals.

Depth	Thickness
1241	1 foot limestone.
1249	8 feet limestone, gypsum in crystals.
1255	6 feet red and yellow limestone, with layers of bluish gypsum from one to six inches thick.
1258	3 feet yellowish gray limestone.
1266	8 feet bluish gray marl; gypsum in layers some of them from 6 to 12 inches thick.
1278	12 feet yellowish and reddish limestone; gypsum in seams and veins, hopper shaped crystals, at 1274 feet.
1285	7 feet marl, much gypsum in nodules and masses.
1287	2 feet light brown marl; gypsum abundant in nodules.
1296	9 feet soft light bluish marl, much gypsum in masses and nodules.
1299	3 feet hard fine brownish gray limestone; (*gas in small quantity*).
1300	1 foot light gray soft limestone; gypsum in seams.
1311	11 feet dark gray hard limestone.
1314	3 feet hard fine slightly reddish limestone, gypsum in thin seams.
1316	2 feet yellow gray bituminous limestone.
1317	1 foot bluish gray marl.
1323	6 feet light gray, reddish gray limestone, hopper shaped crystals; gypsum in thin seams and veins.
1325	2 feet yellow and light gray limestone; gypsum in seams and veins.
1328	3 feet of limestone, bluish gray. Gypsum in thin veins.
1331	3 feet yellow bituminous limestone; thin veins of light gypsum.
1337	6 feet very hard gray limestone.

Depth	Thickness
1339	2 feet yellowish gray limestone, white crystallines; gypsum in small thin veins.
	4 feet pinkish gray limestone; gypsum in seams and veins.
1343	11 feet brownish-gray hard limestone.

At 1348 feet the first salt found was observed in a few thin veins, in some of which the vein matter was of salt, in others the wall matter was crystalline gypsum with which a thin layer of salt was intercalated. The salt was pinkish or cream color; the gypsum was white or pink.

Depth	Thickness
1354 1355′ 6″	1 foot 6 inches marl bluish gray, salt and gypsum in veins.
1356	6 inches nodular layer of gypsum.
1358	2 feet dark gray limestone containing a large percentage of salt and crystals in nodules.
1360	2 feet bluish gray marl, with many seams and veins of salt.
1360′ 6″	6 inches very thinly laminated limestone, with salt in seams.
	8 feet 6 inches bluish gray marl, with many cracks filled with white and pinkish crystalline salt; considerable gypsum.

At 1369 feet at the south end of the shaft a bed of nearly pure coarsely crystalline salt was reached, which on the east wall of each shaft showed a dip of 1 foot on the upper line of contact, and 4 feet 8 inches on the lower toward the north, the layer being 8 inches thick at the south end and 3 feet at the northeast corner. A small proportion of shale is mixed with the salt.

Depth	Thickness
1369 1375	4 feet marl with pink, milk colored salt in veins and seams, gypsum present, not abundant.
5377	2 feet transparent salt in large fine crystals, mingled with marl.

Depth	Thickness
1378′ 6″	1 foot 6 inches bluish marl, becoming light blue on exposure; little salt; gypsum abundant.
1390	11 feet mixed salt, coarsely crystalline, and marl in flakes and small fragments present throughout the bed.
1403	13 feet salt.
1406′ 6″	3 feet 6 inches dark gray hard limestone containing much salt in veins, seams and crystals.
1409	2 feet 6 inches gray limestone soft; pinkish salt in veins and seams.
1410′ 6″	1 foot 6 inches very soft bluish marl; pinkish and white salt in seams and veins.
1426	15 feet six inches white and pink salt in large crystals with fragments and flakes of marl in varying proportions.
1428	2 feet dark gray hard limestone.
1432	4 feet green marl with red and pink salt in thin layers.

In this section 408 feet of Salina strata are penetrated below the bottom of the water-lime formation, the bottom of the well being 566 feet below the bottom of the Corniferous. Probably there is as much as 500 feet of Salina strata with salt beds below the bottom of the shaft. It is, therefore, not certain that more than the upper half of the group is exposed in this section. It is noteworthy that much gypsum overlies the salt.

ALTITUDE OF THE SALT BEDS

In the Oatka-Genesee salt district the number and wide distribution of the wells and shafts supply data with regard to the altitude and attitude of the salt deposits which permit of certain generalizations. The measurements of the various wells make it possible to construct a map of the underground contours of the salt measures, which accompanies this report.

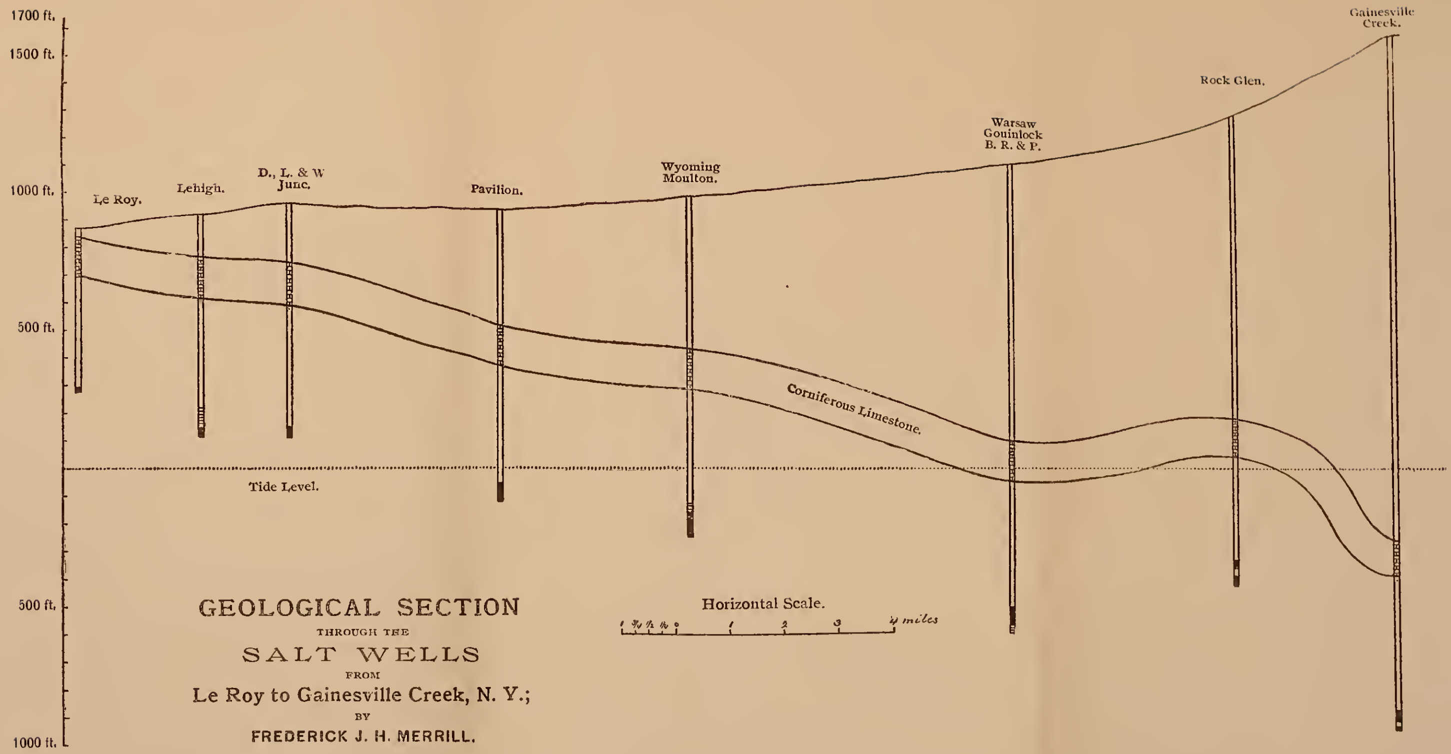
In constructing this map the contours have been located 610 feet below the upper surface of the corniferous limestone; for the salt beds vary greatly in their thickness and position in the Salina group, and it is necessary to assume an horizon at which the occurrence of salt can be expected. The contour line at the altitude chosen intersects the principal salt bed in nearly every well and shaft.

Throughout the Oatka-Genesee district, salt is usually found at levels varying from 550 to 750 feet below the upper surface of the corniferous limestone. The exceptions to this are very few; the only ones which have come to the notice of the writer being the wells at Nunda and Bliss, in the former of which, salt was found between 450 and 500 feet below the corniferous, and in the latter it was first met at a depth of 900 feet. In the Ithaca well the lowest bed of rock salt was over 1000 feet below the upper surface of the corniferous. The testimony of the two latter wells would suggest that as a rule the wells and shafts of western New York have penetrated little more than half way through the salt measures. The upper surface of the corniferous limestone has been taken as the datum plane from which to determine the relative positions of the salt beds, because it is invariably recognized by the driller as soon as reached. Its persistent character and the abundance of chert distributed through it, form a marked contrast with the comparatively soft shales and thin limestones which overlie it. From the underground contours as shown on the map, it will be seen that the dip of the strata in western New York is not directly to the south, but nearly south-east at the rate of about 60 feet to the mile. The section as plotted between Le Roy and Gainesville Creek shows that the beds do not slope uniformly to the south east but undulate in that direction.

te Museun

ION

N. Y.;



GEOLOGICAL SECTION

THROUGH THE

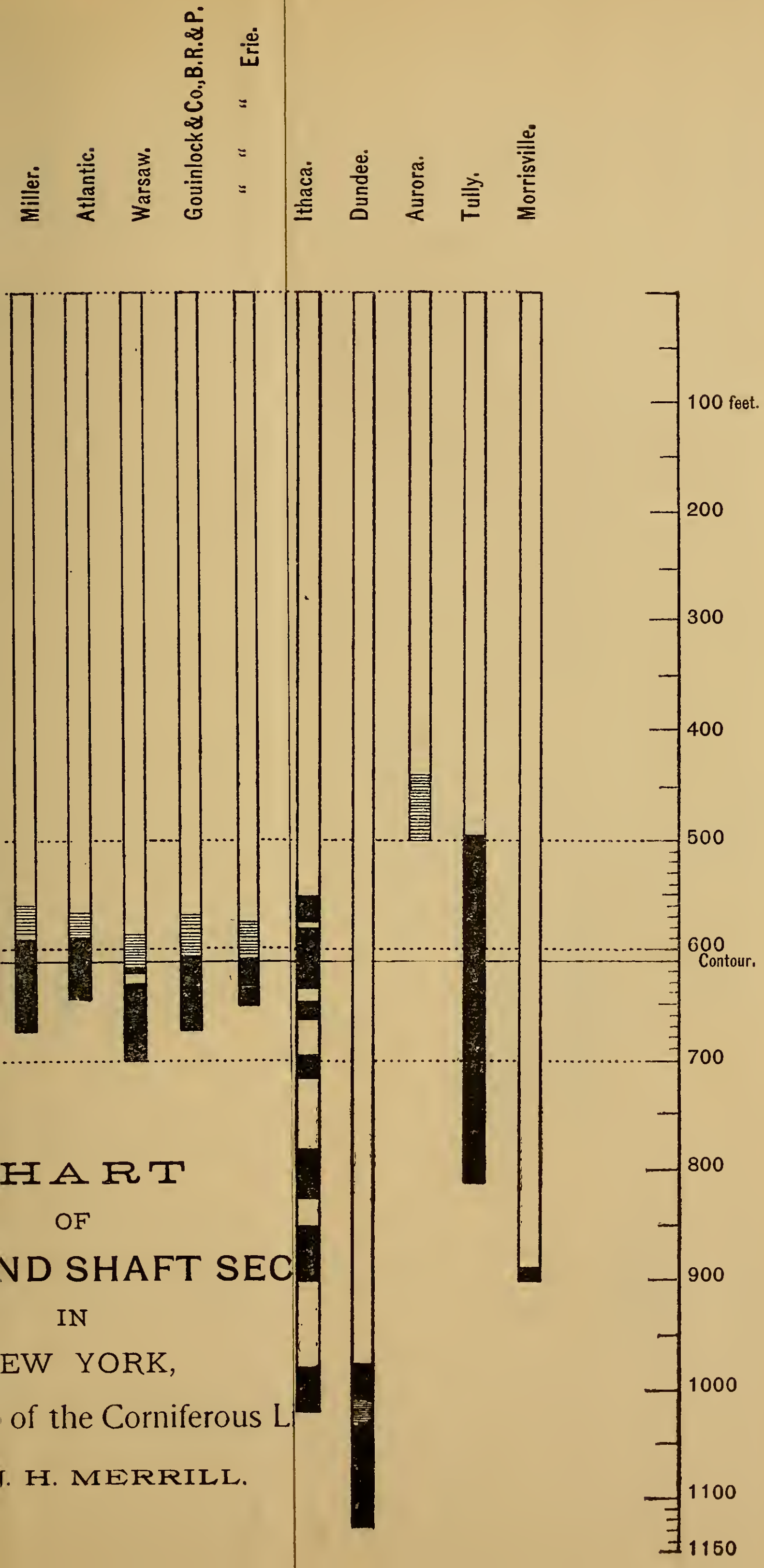
SALT WELLS

FROM

Le Roy to Gainesville Creek, N. Y.;

BY

FREDERICK J. H. MERRILL.



HART

OF

ND SHAFT SEC

IN

EW YORK,

of the Corniferous L

. H. MERRILL.

University of the State of New York. State Museum. Bulletin No. 11.

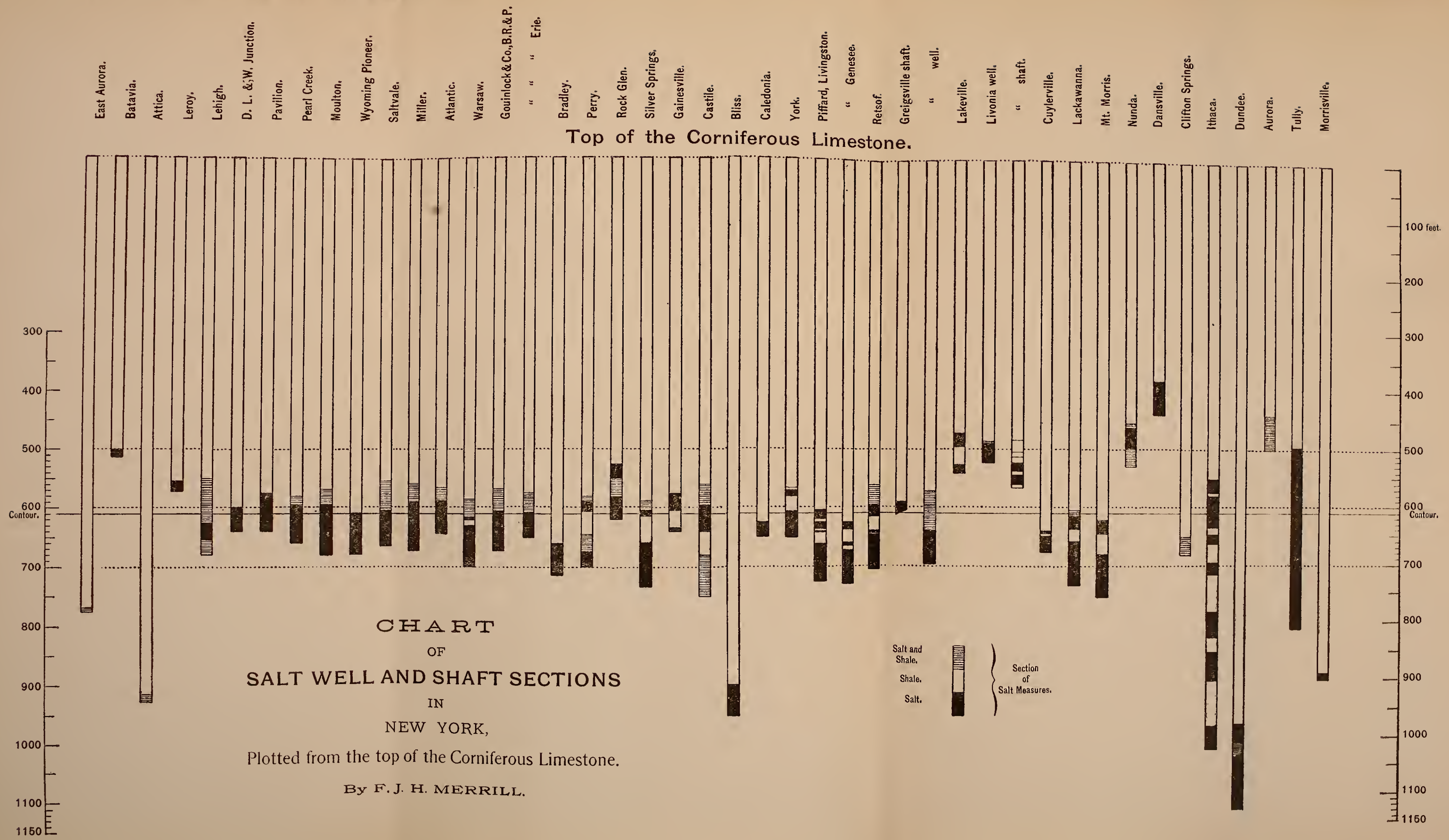


CHART
OF
SALT WELL AND SHAFT SECTIONS
IN
NEW YORK,
Plotted from the top of the Corniferous Limestone.

By F. J. H. MERRILL.

The chart of well sections shows the relations of the salt beds to each other and to the corniferous limestone.

WELL BORING AND TUBING

The method of boring wells for salt is similar in every respect to that in use in boring for oil or gas. The matter of principal importance is the method of tubing the well.

This subject has not been exhaustively studied for this report and only a few details are here given.

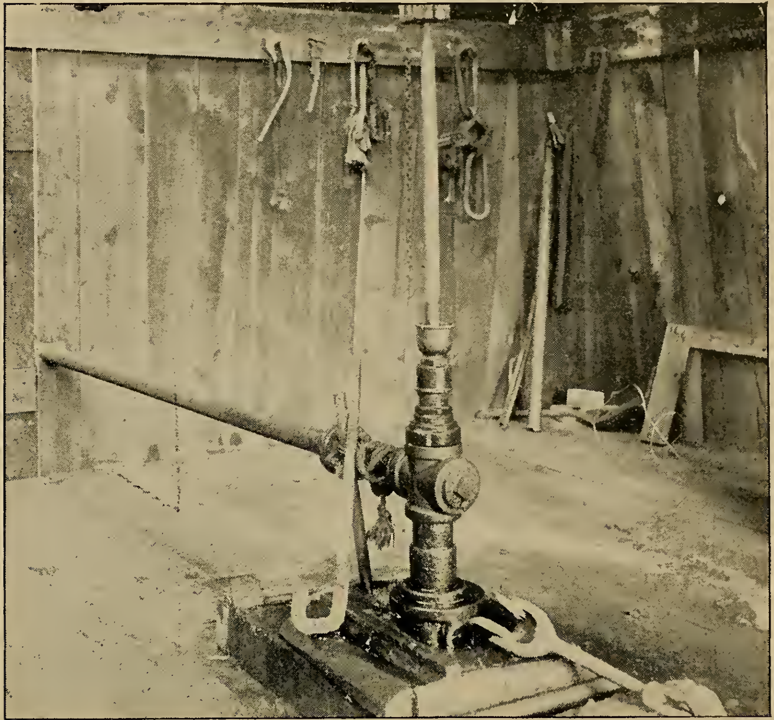
At Tully an 8 inch pipe is first sunk through the surface drift to the bed rock; inside of this a 6 inch hole is drilled through the salt deposits. This hole is tubed sufficiently far to cut off all surface water from the well. Inside of this 6 inch pipe a 3 inch pipe is suspended, being coupled to the pipes for brine and water in such a manner that water may flow down through the 3 inch pipe and up through the 6 inch or vice versa. The well is then operated by forcing water down one pipe into the salt beds where it takes salt into solution and becomes more or less nearly a saturated brine. The brine under pressure, rises to the surface through the other pipe, flows through a conduit to Geddes and is used in the manufacture of soda-ash. For the first six months after a well is bored the fresh water passes down through the 3 inch tube and the brine rises through the space between the tubes; afterwards the method is reversed.

At Tully water is brought to the wells with a natural head sufficient to force the brine to the surface without the use of pumps. In the Warsaw district it is sometimes customary to allow the surface water to flow into the well and pump out the resulting brine. This is done by the Miller Salt Co.

The Miller Salt Co. runs the pipe down to the bottom of the well in order to secure only the saturated and heavier brine. The water is outside of the pipe furnished and comes both from above and from springs tapped in the hole. The brine is pumped up inside the pipe. This method necessitates but one hole, differing from the plan of having holes, one for forcing the water in and the other for the saturated brine to rise in.

The wells of the Kerr Salt Co. are what are known as "forcing wells," i. e. the wells are combined and the water from the Oatka Creek being forced down by means of a common Cameron or Deane pump. These wells are arranged to prevent the back pressure on the pump, which would result if there were only one well, as the amount of water is distributed over several wells instead of one. The wells have an outside ring of iron called the "casing" and an inside ring called the "tubing" through which the fresh water is forced in. The rock on which the casing rests is reamed out level to fit the end of the casing and cement is used to make the joints tight. The tubing is secured in a collar at the top which rests at the upper end of the casing. This is what supports the weight of the rods and this weight serves to prevent the brine at a pressure of 250 lbs. or so, from escaping. The water becomes saturated and is forced up the pipe in the other well to the tanks.

At the Duncan Salt Company's works at Silver Springs, fresh water is taken from springs and is pumped into the wells. The method of forcing in at one well and out at another is employed for connected wells. In all cases the water is forced down on the outside of the tubing between the casing and the tubing, and comes up through the tubing whether one well is used or whether the wells are connected. The fresh water from the springs is first pumped through a Cameron pump. It goes down the wells outside the tubing, dissolves the salt layers, rises in the tube as saturated brine and is discharged in a tank. The method of tubing is as follows: A 12 inch pipe is first sunk down to the rock. Then a drill of about 6 inches diameter is used and the hole bored deeper to firm rock and the casing is put in. Then the tube hole of 4 or 5 inches is bored. The casing is put in and the lower part packed with rubber which fits in between the rock and the casing and prevents the leakage of



Neg. by I. P. Bishop.

BRINE PUMP. ATLANTIC SALT CO'S WORKS, WARSAW, N. Y.

brine as well as the inflow of surface water. The rubber has the whole weight of the casing to support and therefore fills all crevices. This is brought about by breaking joints in the casing so that the whole weight comes on the rubber. The weight of the tube comes on the thread of the collar and tube above, the collar resting on the casing head. This weight is enough to keep the brine from leaking out at the top, at a pressure of about 300 lbs. If the pressure of the brine should happen to be sufficient to overcome the weight of the tube the collar would rise in its seat and the brine flow off at the top.

Wells which are connected are reversible, that is to say, water can be pumped down one and up the other alternately.

At Saltvale the process of pumping employed by the Crystal Salt Co. is based on the theory that it is preferable to take the brine from as low a depth as possible, because there is a tendency for the strong brine to become stronger at the expense of the weaker brine above, and besides, the brine on account of greater specific gravity sinks to the bottom below the water. For this reason it is better to pump brine up the tubing rather than up the casing because the tube is forced to take the saturated brine while the casing, not being down to the bottom, as it ends several hundred feet above, is forced to take the less saturated brine.

The forcing principle, i. e. the forcing down one and up another, is said to have been invented by the Crystal Salt Co. and is used by them for connected wells and isolated wells. The capacity is obviously greater for there is no limit to the amount of water which may be forced into a well except the capacity of the pumps and the size of the cavity already made, a larger cavity producing a greater degree of saturation, on account of a longer period of contact with the salt. In the old method in which a lifting pump is used the capacity depends on the cylinder and length of stroke.

Caving in of the rock frequently causes much trouble. The rock becomes undermined by the dissolving out of the brine and falls down, blocking the work and often breaking the pipe for some hundreds of feet.

MINING OF ROCK-SALT

The mining of rock-salt is briefly described by F. E. Englehardt, Ph. D. as follows:

Rock-salt mining in the State of New York dates from November 1885, when the first shaft belonging to the Retsof Mining Company, situated near Piffard, Livingston Co., reached the underlying salt bed. Since then and within the last two years a second shaft has been sunk about 2 miles south of Le Roy in Genesee County by the Lehigh Salt Mining Company. A third one was finished several months ago at Livonia, Livingston County, and a fourth one is just finished at Greigsville in the same county, about 2 miles west of the Retsof shaft.

The sinking of the shafts is done in the usual manner. The sides are protected from caving in by heavy timbers and to prevent water from entering the shaft a heavy layer of cement is put between the walls of the shaft and the timber. The size of the shafts vary somewhat, the usual dimensions are 12 feet by 18 to 24 feet square in the clear. The main galleries are about 30 feet wide, their height depending on the thickness of the salt beds. Some salt must always be left as a roof and floor, hence in a vein of salt 24 feet thick an allowance of 6 feet for the roof and 4 feet for the floor would give a gallery or chamber 14 feet in height. From the main chambers cross sections or galleries are run every 30 feet, thus the roof above is supported by pillars 30 feet square. The salt is blasted out with dynamite. The drills are run by compressed air about 6 feet into the solid salt and they are set in such a manner that when the blast takes place as much as possible of the salt remains in lumps. The salt is loaded into small cars which are run on tracks laid on the floors of the chambers to the shaft on to the cages, by which they are carried or hoisted

Neg. by I. P. Bishop.

LOADING LUMP SALT. RETSOF MINE, RETSOF, N. Y.

Neg. by I. P. Bishop.

SALT BREAKER. RETSOF MINE, RETSOF, N. Y.

to the top of the breakers, similar to those used in coal mining and from 100 to 145 feet above the surface of the ground. To separate the lump salt from the finer material the contents of the cars are dumped on a set of iron bars, which permit all the salt to fall through into the crusher below except the lumps, which are loaded onto other cars and run down an incline to the ground, where they are stored, usually in the open air, for shipment. The finer material passes through the crushers on to sieves and from the latter into the bins. Of the crushed and sifted salt there are four kinds according to size. The lump salt is mainly used for stock, the other grades for the same purposes for which sea or solar salt is used.

The quality of the mine salt may be learned from the following analysis of an average sample (A) and perfectly white salt (B).

	A	B
Moisture	a trace	a trace
Insoluble	0.7430 per ct	0.0584 per ct
Sulphate of lime (calcium sulphate)	0.4838 " "	0.0793 " "
Calcium chloride	0.0180 " "	0.0358 " "
Magnesium chloride	0.0546 " "	0.0888 " "
Pure salt	98.7006 " "	99.7410 " "

TECHNOLOGY OF MANUFACTURE

The salt of commerce is derived from sea water, from natural brine, from artificial brine made by dissolving rock salt, and directly from the latter by crushing and grinding.

Salt is derived from sea water in three principal ways: by solar evaporation in pits, by the aid of frost and by heat. The separation of salt from sea water by solar evaporation is carried on along the Atlantic coast of Europe, i. e. in Portugal, Spain and France as far north as 48° of latitude. On the Mediterranean coast the separation of salt from sea water is carried on in France and Spain, in Italy on the Tyrrhenian and Adriatic Seas, and by Austria on the shores of Istria and Dalmatia. In these regions the sea water is allowed to flow into a series of tanks formed by excavation or by building dykes. In the first of these the water stands for a time in order that all material in suspension may settle. From the settling tank the water flows into smaller basins where, by evaporation, the salt crystallizes out. Salt may also be separated from sea water by the application of the principle that at a temperature of 1° below the freezing point of water, brine separates into ice which is nearly pure and a strong fluid brine. If the ice be removed and the remaining fluid be allowed to freeze again, another portion of the water separates as ice and there finally remains a brine from which salt separates after slight evaporation. In order to procure a cleaner product before evaporation the brine may be purified with lime, by which the salts of magnesia are decomposed. The separation of salt from sea water by the aid of fuel is carried on in Normandy and also at several places in England, at Ulverstone, Lancashire, at Lymington on the coast of Hampshire and on the Isle of Wight.

According to Charles A. Goessman all known brines as well as rock salt may be divided into two classes, those which contain besides common salt, chloride of calcium, chloride of magnesium, and sulphate of calcium and those which contain only chloride of magnesium and chloride of calcium, sulphate of magnesia and sulphate of soda All brines east of the Mississippi including those of Goderich belong to the 1st class, while the 2nd class occurs in Nebraska. Sea water also belongs to the 1st class. Sulphate of lime and soda within proper limits are far less objectionable than chlorides of lime or magnesia. The brines of Syracuse, Goderich and Saltville, Va., contain less of the latter than those of Michigan, Ohio and Pennsylvania.

THE MANUFACTURE OF SALT IN THE STATE OF NEW YORK

By F. E. Englehardt, Ph. D

The practical manufacture of salt from salt brines in the state of New York dates from the year 1788, when an Indian discovered to Col. Comfort Tyler a salt spring at

alyses by F. E. Englehardt, Ph. D.

WYOMING VALLEY BRINES.

50	1.19705	Pearl Creek 1.1924	1.20446	Warsaw. 1.2045	Le Roy 1.1920	1.19544	1.17106
rm.	not determ.	not determ.	not determ.	not determ.	not determ.	0.0038	0.0027
70	0.3840	0.433	0.401	0.443	0.3083	0.4307	0.51336
80	0.1370	0.069	0.140	0.135	0.5268	0.1074	0.15070
50	0.0370	0.142	0.322	0.053	0.1034	0.0408	0.07167
0	25.3630	25.008	25.564	25.711	23.5819	24.6749	21.55320
00	74.1790	74.342	74.573	73.958	75.4796	74.7424	77.70837

GENESEE VALLEY BRINES.

14	1.1913	1.2033	1.1931	Livingston Salt Co. 1.1891
56	0.0109	not determ.	not determ.	not determ.
91	0.4555	0.5790	0.3394	0.3780
60	0.5951	0.4650	0.3565	0.1913
26	0.1536	0.2125	0.1860	0.1897
11	23.8983	25.3199	24.2827	24.1221
56	74.8866	73.4234	74.8399	75.1189

ONONDAGA BRINES.

22	1.14311	1.13362	1.1444	1.1420	1.1486	1.1470
rm.	not determ.	not determ.	not determ.	not determ.	not determ.	not determ.
40	0.4969	0.4399	0.3632	0.5531	0.5141	0.4232
40	0.2140	0.2009	0.5701	0.0966	0.1693	0.2615
90	0.1031	0.1876	0.2852	0.1368	0.1547	0.1551
60	18.9430	17.4662	18.4277	18.5595	19.0646	19.0525
70	80.2430	81.7054	80.3538	80.6540	80.0973	80.1077

e and is given as such.
is withheld by Dr. Englehardt because the analyses were made in a confidential capacity.

Brine Analyses by F. E. Englehardt, Ph. D.

WYOMING VALLEY BRINES.

Specific gravity ……	1,18984	1.19933	1.2050	1.19705	Pearl Creek 1.1924	1.20446	Warsaw. 1.2045	Le Roy 1,1920	1.19544	1.17106
Ferric oxide* …….	not determ.	0.00266	not determ.	not determ.	not determ.	not determ.	not determ.	not determ.	0.0038	0.0027
Calcium sulphate ….	0.3754	0.34257	0.2570	0.3840	0.433	0.401	0.443	0.3083	0.4307	0.51336
Calcium chloride ….	0.2717	0.31507	0.0680	0.1370	0.069	0.140	0.135	0.5268	0.1074	0.15070
Magnesium chloride..	0.0990	0.07863	0.0050	0.0370	0.142	0.322	0.053	0.1034	0.0408	0.07167
Sodium chloride…..	24.5282	25.16640	26.300	25.3630	25.008	25.564	25.711	23.5819	24.6749	21.55320
Water……………	74.7257	74.90467	73.3700	74.1790	74.342	74.573	73.958	75.4796	74.7424	77.70837

GENESEE VALLEY BRINES.

Specific gravity ……	1.1820	1.18399	1.20114	1.1913	1.2033	1.1931	Livingston Salt Co. 1.1891
Ferric oxide*… ….	not determ.	0.00159	0.00156	0.0109	not determ.	not determ.	not determ.
Calcium sulphate ….	0.3739	0.36623	0.41391	0.4555	0.5790	0.3394	0.3780
Calcium chloride …	0.4714	0.27980	0.20260	0.5951	0.4650	0.3565	0.1913
Magnesium chloride..	0.1970	0.07762	0.05126	0.1536	0.2125	0.1860	0.1897
Sodium chloride…..	22.8077	23.40173	25.33911	23.8983	25.3199	24.2827	24.1221
Water.. …………	76.1500	75.87303	73.99156	74.8866	73.4234	74.8399	75.1189

ONONDAGA BRINES.

Specific gravity ……	1.1456	1.1420	1.1422	1.14311	1.13362	1.1444	1.1420	1.1486	1.1470
Ferric oxide*……..	not determ.	not determ.	not determ.	not determ.	not determ.	not determ.	not determ.	not determ.	not determ.
Calcium sulphate ….	0.5401	0.5431	0.5440	0.4969	0.4399	0.3632	0.5531	0.5141	0.4232
Calcium chloride ….	0.1373	0.1453	0.1340	0.2140	0.2009	0.5701	0.0966	0.1693	0.2615
Magnesium chloride..	0.1618	0.1197	0.1790	0.1031	0.1876	0.2852	0.1368	0.1547	0.1551
Sodium chloride…..	18.3440	17.7673	18.0560	18.9430	17.4662	18.4277	18.5595	19.0646	19.0525
Water……………	80.8168	81.4246	81.0870	80.2430	81.7054	80.3538	80.6540	80.0973	80.1077

* The ferrous carbonate was determined as ferric oxide and is given as such.

N.B.— The source of most of the above brines is withheld by Dr. Englehardt because the analyses were made in a confidential capacity.

the foot of Salina heights now in the city of Syracuse. Col. Tyler commenced at once the manufacture of salt. In the same year, on September 12, the Onondagas sold to the state of New York the so-called "Salt Reservation," comprising the lands for one mile round Onondaga lake, for the purpose of making salt. Thus the state became the owner of the lands and the salt brine. In the year 1793 the first laws regulating the manufacture of salt were passed and William Stephens was appointed the first superintendent of the "Onondaga Salt Springs." In the same year the first arch with four potash kettles was erected by William Van Fleck and Moses De Witt. Strange as it may seem, the same method for the manufacture of boiled salt is practiced to-day on the Reservation, with this difference, that now one arch contains from 30 to 50 kettles and that there are two arches. The next method for the manufacture of salt was brought from the sea coast of Massachusetts in the year 1821–22. It was the manufacture of a coarse salt by solar evaporation in shallow wooden vats. When, in the western part of the state, rock salt was discovered in 1878 the Michigan Grainer and the European pan soon made their appearance.

The processes employed to-day in the manufacture of salt in the state of New York are as follows:

1 Solar evaporation.
2 Direct fire evaporation.
    - Pan process
    - Kettle process

3 Steam evaporation.
    - Kettle with steam jacket
    - Grainer process

4 Vacuum pan evaporation.

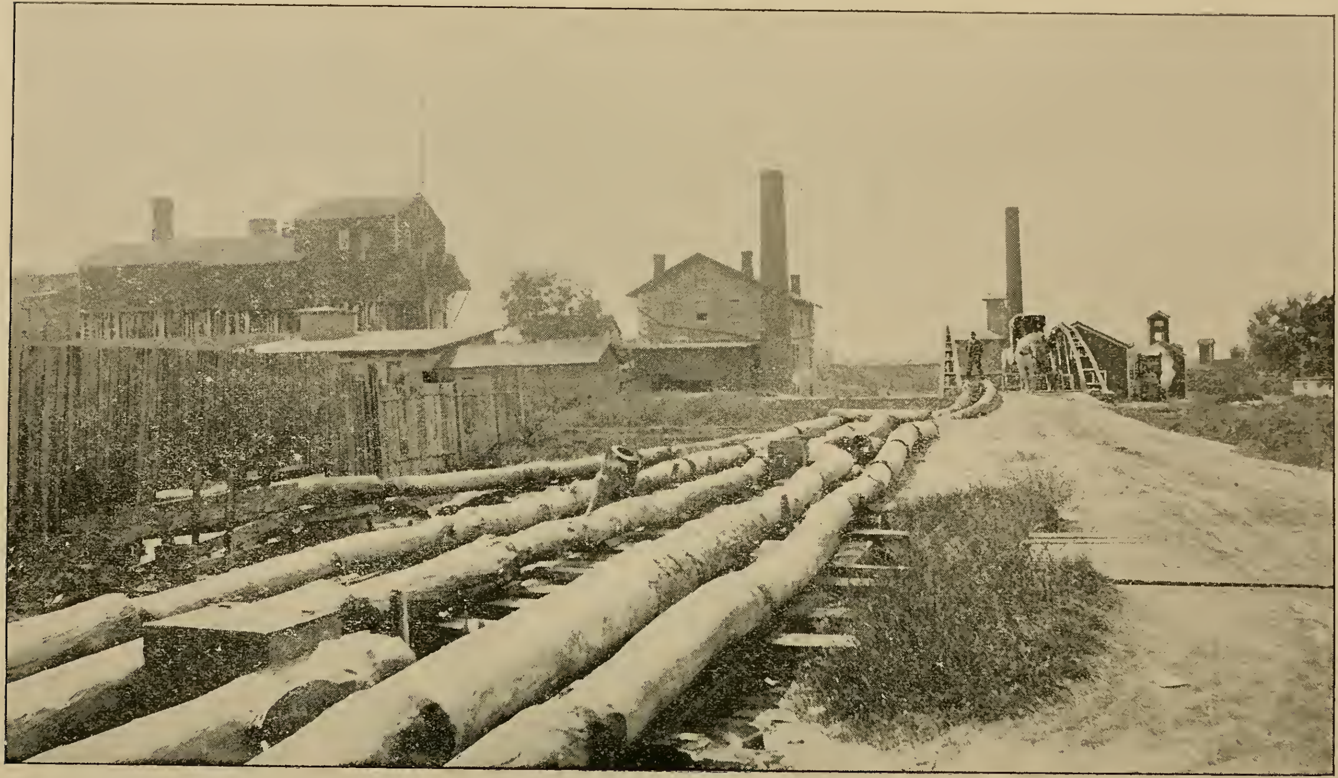
I SOLAR EVAPORATION

The manufacture of solar salt, or as it is often called, coarse salt, is carried on in shallow wooden vats which, in order to protect the contents against rain, are provided with movable wooden covers, running on wooden rollers. At the end of the season the wooden rollers are removed and the covers or roofs fastened securely on the vats.

There are three sets of these vats, or as they are more familiarly called, rooms. The first are called "deep rooms," and serve for the reception of the brine as it comes from the wells or pumphouse. The brine when received in these rooms is usually perfectly clear, but soon it becomes turbid and of a yellowish red color. This change is due to the escape of carbonic acid gas with which the brine is highly charged when it comes from the wells and by which the trace of ferrous carbonate present is held in solution. The solvent escaping, the ferrous oxide takes up oxygen and separates from the brine as a hydrated ferric oxide in a very finely divided state, causing a yellowish turbity, which disappears gradually as the ferric oxide settles to the bottom of the vat, and leaves the brine clear again. The deep rooms are constructed higher above the ground than the following set, which are called "Lime rooms," — (this is a misnomer, since in the manufacture of solar salt lime is never used) — in order to enable the workmen to draw from them into the lime rooms as occasion requires. The evaporation of water from the brine which commences in the deep rooms, continues in the lime rooms till the brine reaches its point of saturation which is recognized by the workman, when small cubic salt crystals make their appearance. While the brine is evaporating and becoming saturated a second change takes place in it, namely, a certain amount of sulphate of lime or gypsum separates from it in beautiful crystals on the sides and bottom of the room. This separation is especially marked when the brine is near its point of saturation. The now fully saturated brine is called pickle and is drawn into the third or lowest set of rooms, called the salt rooms. Here another change takes place. Salt and a portion of the remaining sulphate of lime crystallize out, the former in more or less perfectly developed cubic crystals, the latter in fine slender crystals often twinned. As the evaporation of the water from the pickle progresses, the salt crystals first

Neg. by I. P. Bishop.

SOLAR SALT PLANT, SYRACUSE, N. Y.



Neg. by I. P. Bishop.

PUMPING WORKS AND PUMP-LOGS, SYRACUSE, N. Y.

formed increase in size, new ones make their appearance and soon the entire bottom of the room is covered with them. It is the custom of the manufacturer, while this is going on, to introduce a sufficient amount of saturated pickle from the lime rooms to replace the evaporated water and thus keep the salt well covered.

Since the brine contains besides salt, ferrous carbonate and gypsum, other constituents; namely, potassium, calcium and magnesium chlorides and magnesium bromide; a comparison of the chemical composition of the brine with that of the pickle is but proper in this place. From Dr. Goessmann's* experiments it appears that a brine having the chemical composition given under No. 1, produces a pickle of the composition given under No. 2.

	No. 1 Brine	No. 2 Pickle
Specific gravity	1.1225	1.2062
Calcium sulphate	0.5772 per cent	0.4110 per cent
Calcium chloride	0.1533 " "	0.2487 " "
Magnesium chloride	0.1444 " "	0.2343 " "
Potassium chloride	0.0119 " "	0.0194 " "
Magnesium bromide	0.0024 " "	0.0039 " "
Ferrous carbonate	0.0044 " "	
Sodium chloride	15.5317 " "	25.7339 " "
Water	83.5747 " "	73.3488 " "

In this experiment Dr. Goessmann employed 1010 parts of the above brine and obtained 623 parts of pickle, while 3.28 parts of calcium sulphate had crystallized out and 383 parts of water evaporated. While, then, the ferrous carbonate had been entirely removed and the calcium sulphate decreased more than one half, the salt and the soluble calcium and magnesium chlorides had increased in the proportion of their original quantities. Whenever a sufficient amount of salt has accumulated in the salt rooms it is harvested. This occurs about three times during a season. The process consists in raking it together on the side of the room next to the road and putting it into small perforated

---

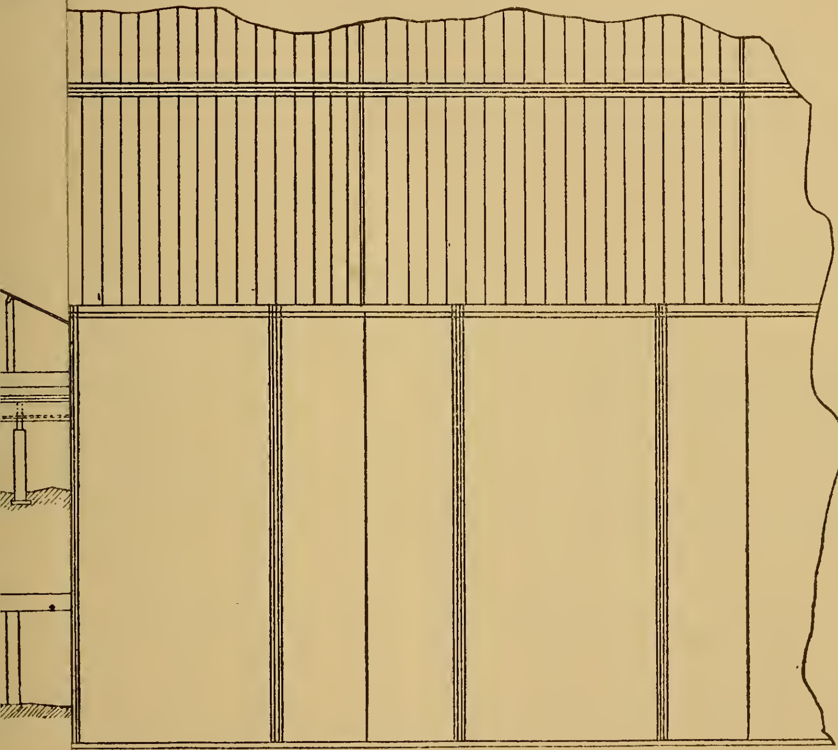
* "Report on the manufacture of solar salt, etc." Syracuse 1864.

tubs, to drain off as well as possible the adhering calcium and magnesium chlorides, since they impart to the salt a sharp bitter taste and keep it from becoming properly dry, as they are very deliquescent, absorbing moisture rapidly from the air. This being accomplished the salt is dumped into the salt cart and drawn to the storehouse. Since the gathered salt consists of crystals of various sizes, many manufacturers pass it, as it comes from the salt yard (the name given to these works) into the storehouse, over a wire screen with 2½ meshes to the square inch, kept in motion by hand or steam power. While the unscreened salt is called ‘Standard Coarse,” that which passes over the screen is known as “Diamond C. ⟨C⟩.” and the portion passing through the meshes “Diamond F. ⟨F⟩.”

Of the three kinds of rooms belonging to a salt yard about one-third are deep and lime rooms, the rest are salt rooms. These rooms are usually 18 feet wide; their length depends often on the extent of the yard, and it may be therefore from 100 to 500 feet and more. In a properly constructed salt yard, where the salt rooms are of great length, they are built in a number of sections in such a manner that the floor of the first one is some 6 or 8 inches higher than that of the next one, and the floor of this one again the same number of inches higher than the third one and so on. The advantage of this arrangement is obvious, for it enables the manufacturer to keep the fresher pickles separated from the older ones, since, when the time of harvesting arrives he can discharge the pickle from the lowest section and draw onto the salt the pickle from the section above less charged with the deliquescent chlorides, for the purpose of removing as far as possible from the salt with this newer pickle the adhering chlorides and fine needle like gypsum crystals.

The depth of the rooms varies from 6 inches for lime and salt rooms to 12 and 14 inches for deep rooms. The movable covers are in 16-foot sections, capable of protecting a

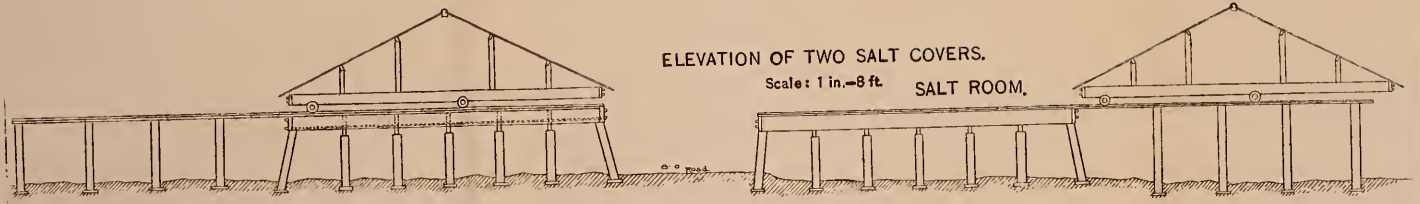
Muse



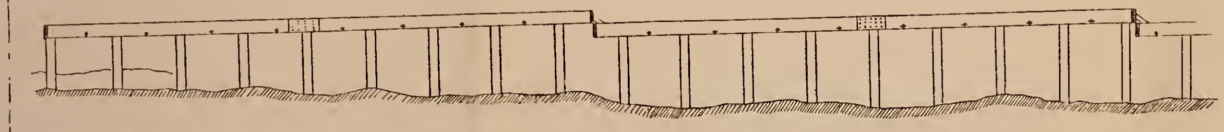
LAN OF ROOMS AND COVERS.

Scale : 1 in.=4 ft.

SOLAR SALT PLANT.

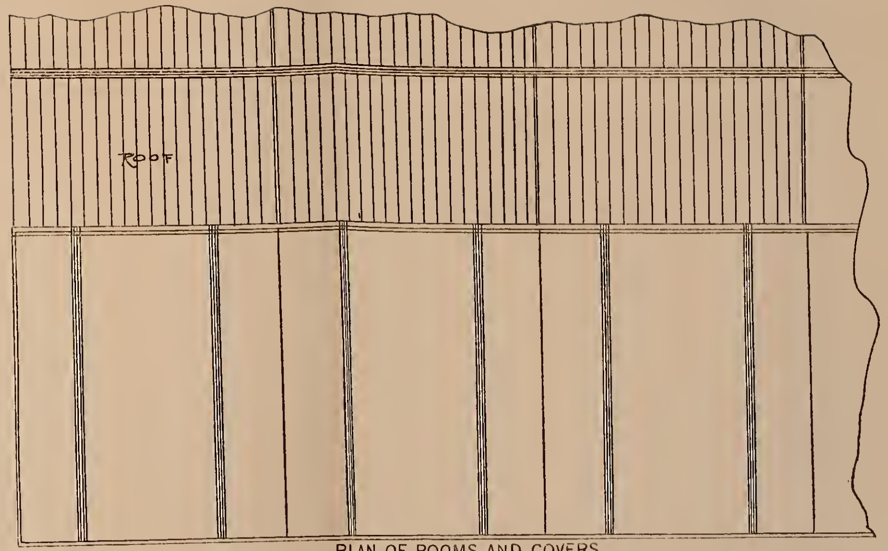


ELEVATION OF TWO SALT COVERS.
Scale: 1 in.—8 ft.



ELEVATION SHOWING A NUMBER OF SECTIONS OF A SALT ROOM.

F. E. Englehardt, del.



PLAN OF ROOMS AND COVERS.
Scale: 1 in.—4 ft.

space of 16 x 18 feet square or 288 square feet. The size of the yard is estimated by the number of covers it has. During fair weather the covers are pushed aside wooden frames constructed for that purpose beside the rooms.

SOLAR SALT "APRONS"

Within the last 15 years, the Onondaga solar salt manufacturers have adopted a plan by which some of them have increased their evaporating surface to a considerable extent, namely, they have added to their works, according to the space at their disposal, very large shallow vats from 20 to 100 feet wide by 200 to 2000 feet long and about 3 inches deep. Wherever practicable they are erected over the deep rooms (serving instead of roofs) thus making the latter practically store rooms. These vats or aprons, as they are called, are built in a similar manner to the vats previously described, on piles or posts. At certain distances from each other are two sets of holes provided with wooden plugs. The surface of these flat vats is so constructed that any brine or rain water on them will run rather slowly towards these holes. One set of holes communicates with the deep room. During fair weather a small quantity of brine is allowed to run into these vats, not exceeding one half inch in hight and it often becomes entirely saturated in one day, when it is discharged into the deep room below, and its place is taken by a fresh portion of brine to be evaporated. In case rain is expected the plugs over the deep rooms or cisterns are drawn, the brine runs off, the plugs are again inserted and those drawn out of the other holes, through which the rainwater runs off.

The advantages of this method are: first, a much more rapid evaporation due to the shallow layer of brine, and secondly, the gain of all the lime rooms for salt rooms. Ordinarily a solar salt yard with 2700 "Covers" 10 by 18 feet square, consists of 1800 salt rooms, 800 lime rooms and 100 deep rooms. By this improvement the salt rooms are increased to 2600. Moreover the iron (ferrous carbonate) and the sulphate of lime (calcium sulphate) separate very quickly. When rain prevents the lime from becoming saturated, before it is discharged into the deep rooms or cisterns, it is returned to these aprons by a pump. The increase in the yield of salt per cover by this method over the old one is about 15 to 20 bushels per season according to the size of the aprons belonging to a yard.

The amount of salt produced in a solar field during a season depends not only on the state of the weather but also on the composition of the pickle from which the salt is deposited, since if the latter is too highly charged with calcium and magnesium chlorides due to keeping the old pickle over from season to season, evaporation may be greatly retarded thereby; in fact it may cease almost entirely, since whatever evaporation of water may take place in clear warm weather from a pickle overcharged with these chlorides, will be reabsorbed again by them during the prevalence of a damp moist atmosphere. The quality of the salt depends on the weather to a certain extent, but mainly on the intelligence and care of the workman. Supplying the salt rooms with perfectly saturated pickle, allowing the harvested salt (after properly washing it with newer pickle from the section above to remove adhering gypsum crystals and chlorides) to drain properly both in the tub and the storehouse and finally to discharge the old pickle at the proper time, are of the utmost importance in the manufacture of a good commercial solar salt.

According to the laws of the state the freshly harvested salt must remain 14 days in the storehouse before it can be put on the market.

There are at Syracuse about 43,000 covers with over 12 million square feet evaporating surface capable of producing 3,500,000 bushels during a season, which usually extends from the middle of March to the middle of November, according to the weather.

2 DIRECT FIRE EVAPORATION

There are two processes in use for the manufacture of salt by direct heat, namely:

A. The Pan Process
B. The Onondaga Kettle Process

A. Pan Process

Usually several pans are placed under one roof. They are constructed of large wrought iron plates riveted together. The thickness of the plates is from $\frac{1}{4}$ to $\frac{3}{8}$ inch. The usual dimensions are: width 20 to 24 feet, length 100 feet in two sections and depth 12 inches. The front section is 70 feet and the back one 30 feet long, separated by a loose-fitting, wooden or iron partition, to allow the brine from the back section gradually to enter the front one. Adjoining the front pan is a back pan 30 feet long by 20 to 24 feet wide and 12 inches deep. The walls under this pan are from 12 to 16 inches higher to enable the easy transfer of the brine by syphon from the back to the front pan. The ends of these pans are at right angles to the bottom while the sides are oblique. The front pan is usually supported by two central and two outside walls (though there are some pans differently supported and constructed) which are 3 feet wide at their base and grates, tapering to one foot in width under the pan bottom. The distance from the top of the grate to the bottom of the pan is between 6 to 8 feet. The grates are 3 to 4 feet wide by 5 to 6 feet long. The walls are built in the most substantial manner and lined on the inside with fire brick in the front portion and with ordinary bricks farther back, where the heat is less intense. To protect the pan bottom against a too intense heat directly over the fires, a fire brick arch is built, the crown of which is between 2 and 3 feet below the pan bottom. This arch is solid from the front wall to about 2 feet beyond the grates, where an open space of 6 to 8 inches wide is followed by a second arch from 12 to 16 inches wide, and this again after an interval by a third arch only a foot wide and so on. These arches are called rings and their width decreases from the front of the pan towards the end while the air spaces increase in width in the same direction. Beyond 20 feet from the front of the first section of the pan they cease altogether. To convey the heat as close to the pan bottom as possible, beyond the last arch, the flues are usually filled in with earth or plaster, and thus the distance between the pan and flue bottom is between 3 and 4 feet or even less, at the end of the first pan where a perpendicular wall, a so-called bridge wall, reduces the space to about 1½ to 2 feet, through which the products of combustion pass under the back pan and finally into a common chimney.

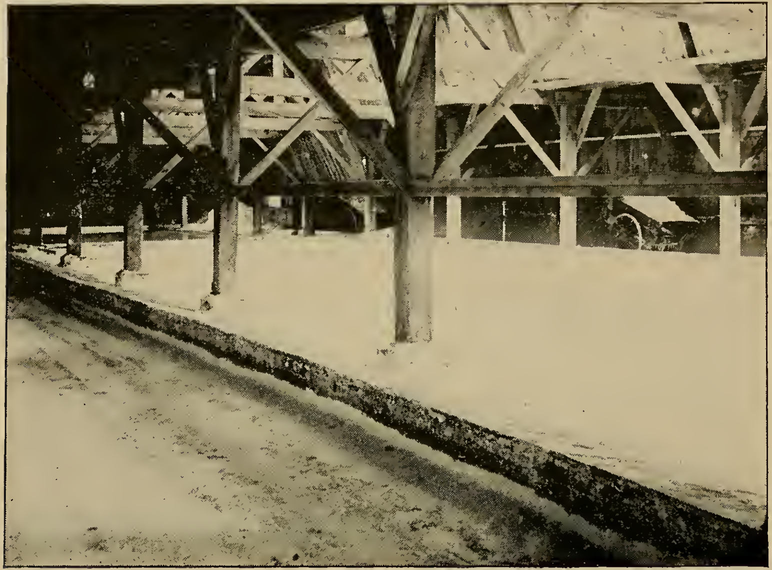
For the purpose of draining the salt, before it is conveyed to the storehouse an inclined wooden platform, the so-called "drip" is constructed along the entire length of both pans on either side, resting on the inclined iron sides of the pan.

The so-called settling of the brine is the same as in the kettle method, with this difference, that the settled brine in consequence of the greater number of cisterns and their greater capacity remains for 4 to 5 days undisturbed. If it is the intention of the manufacturer to make the so-called "Factory Filled Salt" used for the dairy and the table, the settling with caustic lime is followed by a second settling with a certain quantity of carbonate of soda or soda ash as it is usually called by the workmen. The sodium carbonate is dissolved in salt water and the solution mixed with the brine. The carbonic acid unites with any caustic lime in solution in the brine, while the resultant caustic soda together with the greater quantity of undecomposed sodium carbonate decomposes the calcium and magnesium chlorides forming calcium and magnesium carbonates and common salt. Between the settlings with lime and sodium carbonate 12 hours are usually allowed to intervene.

After the pans are properly cleansed they are white-

Neg. by I. P. Bishop.

WARSAW SALT CO'S WORKS, WARSAW, N. Y.
Settling tanks are shown at the left.



Neg. by I. P. Bishop.

SALT PANS. GENESEE SALT CO'S WORKS, PIFFARD, N. Y.

washed with a thin milk of lime to prevent their rusting until they become thoroughly heated; the fires are started and the pans are filled by syphons to a depth of about 6 inches with brine from the back pans. The former are so inserted that a constant flow of brine passes from the back pans into the last section of the front pans and from these under the partition into the first section. Into the back pan flows a constant stream from the outside cistern until the front pans are sufficiently full, when the flow is stopped. After a sufficient amount of salt has collected in the first section of the front pan it is removed to the "drip" for drainage. This is called drawing or raking the pans. The front pans are refilled from the back pan, in which the brine has become considerably heated, and thus is prevented a too rapid cooling of the brine in the front pan which would seriously interfere with the formation of a properly grained salt. For the same reason the partition is placed in the front pan since it prevents any cold brine from coming suddenly into the first section, it being compelled to enter at the bottom of the pan where its temperature is the highest. The first drawing or "drip" usually contain traces of caustic lime in consequence of the white-washing of the pans and since this would be detrimental to butter, cheese, provisions, etc. salted with it, it is always kept separate and sent into the market as "agricultural" salt.

The following table gives the results of a series of analyses made on the contents of a pan to determine the relative increase of the chlorides of calcium and magnesium and the decrease of sulphate of calcium:

	Calcium sulphate	Calcium chloride	Magnesium chloride
Original brine	0.3739 per ct	0.4714 per ct	0.1970 per ct
After running 24 hours....	0.2658 "	1.2263 "	0.3611 "
" " 48 "	0.2009 "	2.0213 "	0.6895 "
" " 72 "	0.1819 "	2.6357 "	0.9634 "
" " 96 "	0.1116 "	3.3843 "	1.3197 "
" " 120 "	0.0976 "	4.9861 "	1.8343 "
" " 144 "	0.0686 "	6.3569 "	3.2316 "

Total amount of deliquescent chlorides in the fresh brine	0.6684 per ct
Total amount of deliquescent chlorides in the mother liquor...	9.5885 per ct

An increase of the chlorides of 14.345 times if we take 0.6684 equal to 100.

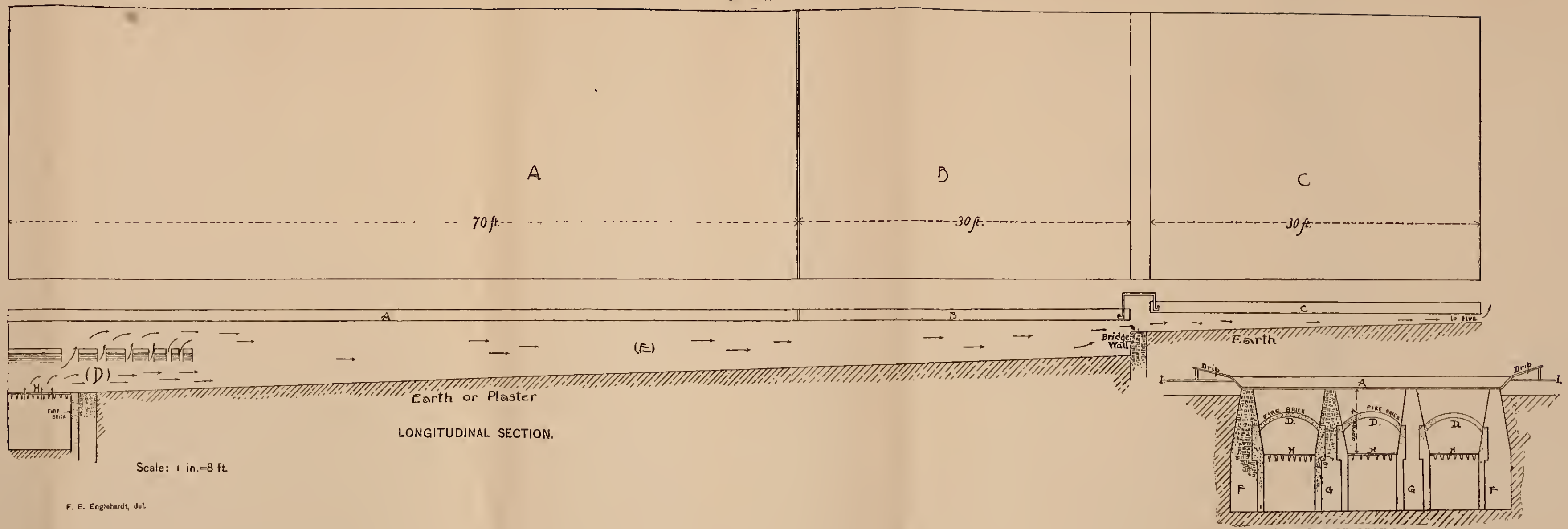
Thirteen hours of the 144 hours the pan was not boiling; this time being required to bring the pan to the boiling point and cool it again.

The great advantage of the pan process over any other is mainly in the controlling of the grain. According to the object of the manufacturer the salt can be made of any desired grain in a pan. When a fine-grained salt is desired, the fires are increased so that the brine in the first section boils over its entire surface. To aid in the formation of a fine grained salt (very desirable for dairy and table use) some artificial means are employed. Butter, specially prepared soft soap (of course made of the best lard or tallow and alkali) gelatine and white glue, are some of the substances added, and the quantities used are so insignificant in proportion to the amount of salt that they could not be detected even if they remained, but the hard soap, the lime soap, floats on the brine and is very carefully skimmed off. When this kind of salt is made the pans are "drawn" every 45 or 60 minutes. In the manufacture of coarser grained salt the "drawing" of the pans takes place at intervals of 2, 3, 4, 5, 6, or 12 hours according to the size of the grain, and the temperature of the brine is reduced from 229° Fahr. to 200° or even 148° Fahr. The storage room for the salt is usually in a separate building.

The amount of salt and its quality depends on the same conditions given under the kettle method. With good average coal dust and fair weather 80 to 90 bushels of salt per ton can be made in a well constructed pan during the summer season from saturated brine, which quantity will be reduced to 68 bushels during the winter months. A good average proportion for the entire year is about 1 ton to 72 bushels per ton with brine "up to saturation." The pan salt is always lighter than the kettle salt, bulk for bulk, since a pan never boils as rapidly as a kettle. Consequently the


B
30
B

PLAN OF PAN BLOCK.



LONGITUDINAL SECTION.

Scale: 1 in.=8 ft.

TRANSVERSE SECTION

Pan Block.

- A. Front pan, first section.
- B. Front pan, second section.
- C. Back pan.
- D. Fire brick arches.
- E. Flues.
- F. Side walls.
- G. Central walls.
- H. Grates.
- I. "Drip."

F. E. Englehardt, del.

calcium sulphate in the former is very rarely deprived of its water of crystallization, and therefore the pan salt will usually dissolve perfectly clear in water.

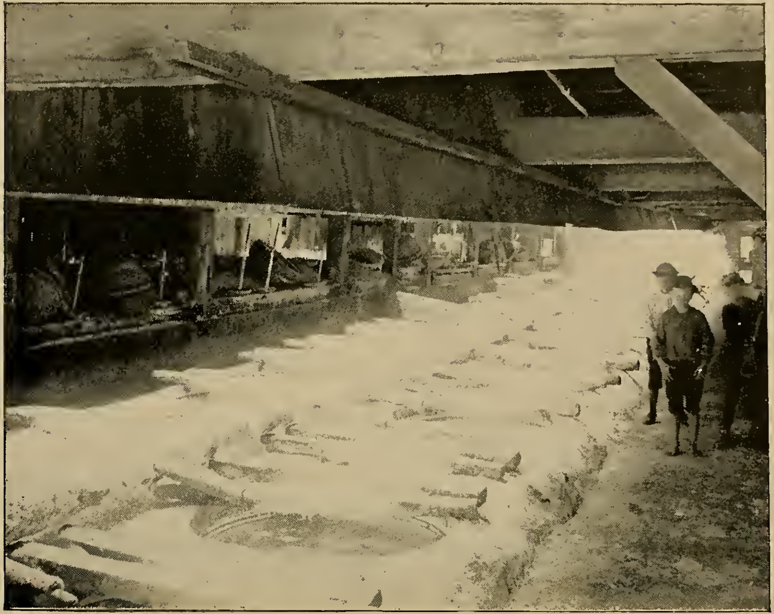
At the works of the Globe Salt Co. at Wyoming and at those of the Leicester Salt Co. at Cuylerville a modified pan process was used which is described as follows by Mr. I. P. Bishop:

The Lewis Process

"The Lewis process is a modification of the pan process, and is so called from its inventor, Mr. Sylvester Lewis, of Rochester. The evaporating apparatus consists of ten pans 20 x 10 feet, each on an arch with its own grate and flue. There is also one long pan 15 x 100 feet with a grate at each end. The hot gases from the smaller flues are made to pass under the larger pan and thus lose the greater part of their heat before passing to the chimney. The brine is heated to 220° Fahr., in the larger pan to precipitate the gypsum, and then drawn to the smaller pans to be evaporated. The principal advantage claimed for this process over the preceding, is that any pan can be removed for repairs or for cleaning without stopping the work in the others."

B. The Onondaga Kettle Process

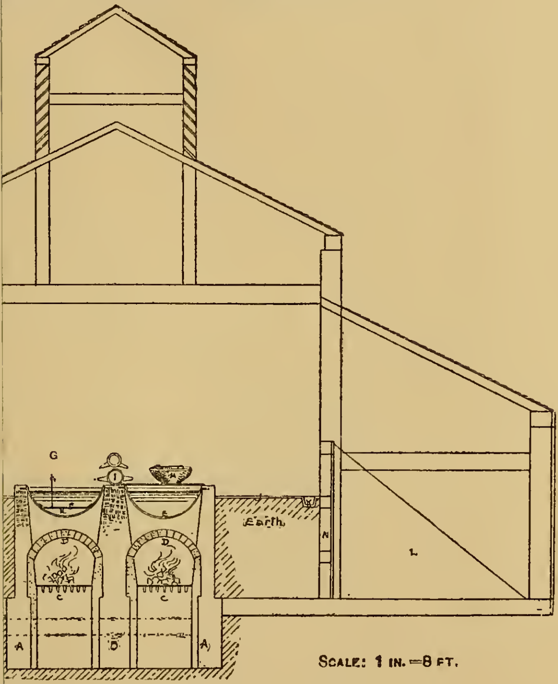
This is exclusively employed on the Onondaga Salt Reservation. A "Salt Kettle Block" usually called a "Kettle block" consists of from 60 to 100 hemispherical cast-iron kettles suspended or hung on "lugs" or pins in two parallel flues, called arches, ending in one chimney, which has a height of 50 to 100 feet according to the length of the flues. In front the arches are provided with cast-iron flat-topped grates 3 feet in width and 5 feet long, perforated with holes $\frac{3}{8}$ inch in diameter and one inch apart. These are well adapted for the burning of anthracite dust or culm which is now exclusively used for this purpose. The necessary artificial draft is furnished by a pressure blower. The kettles are from 22 to 26 inches in depth and from 3 feet 10 inches to 4 feet 2 inches in diameter, with a capacity of 100 to 150 gallons. The metal at the bottom of the kettle is 1¾ inches, and at the rim ¾ inch thick. The two lugs are 5 inches long by 1½ inches in diameter, situated about 4 to 5 inches below the rim and opposite each other. The arches or flues are formed by a central wall, 3 feet wide at the base and grate, and one foot wide on top, battering an equal amount on both sides and two side walls 18 inches wide at base and grate, battering on the inside to 8 inches on top. These walls are built of ordinary stone and lined on the inside with bricks. That portion of the walls which is especially exposed to an intense heat is lined with fire bricks, which is usually up to the 15th kettle from the front. The distance from the bottom of the kettle to the top of the grate is 3 feet 6 inches with a solid fire brick arch in each, extending somewhat beyond the length of the grate. The distance from the bottom of the kettle to the crown of this arch is 10 to 12 inches. Beyond the grate the fire brick arches are constructed in sections, the so called "rings" with air spaces between, which increase in size with the advancing distance from the grates. This construction allows the heated gases to pass through these spaces without striking the kettle bottoms directly. While the distance between the bottom of the front kettle and the top of the grate is 3 feet 6 inches, these flues decrease in depth as they advance towards the chimney, so that under the last kettle the distance is but 6 or 8 inches. The kettles are hung as close as possible with their rims against each other and the space between the walls and kettles above the lugs is properly covered by masonry, etc. for the purpose of confining all the heat as much as possible within the two arches. The two lugs enable the workman to hang the kettles perfectly free in the arches or flues, leaving an open space of several inches between the walls of the kettles and arches. Thus the heated gases in their passage from the grate to the



Neg. by I. P. Bishop.

INTERIOR OF A KETTLE BLOCK, SYRACUSE, N. Y.

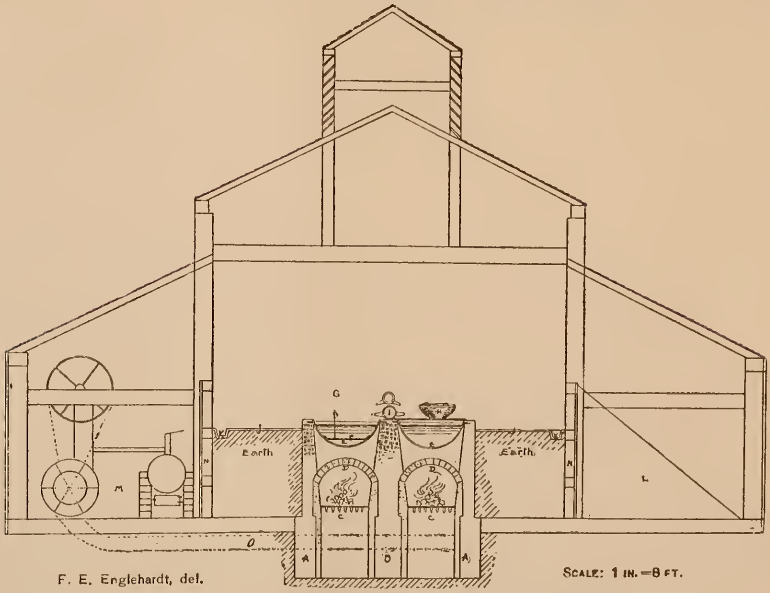
te of New York.
tate Museum. Bulletin No. II.



SECTION OF KETTLE BLOCK.

J. Walk.
K. Gutters.
L. Salt bins.
M. Engine room with Boiler, Engine and Blower, back of which is the salt bin.
N. Air space between walk and lining of salt bins.
O. Conduit for blast.

m outside



F. E. Englehardt, del.

Scale: 1 in. = 8 ft.

TRANSVERSE SECTION OF KETTLE BLOCK.

A. A.	Side walls.
B.	Central wall.
C. C.	Grates.
D.	Fire brick arches.
E. E.	Kettles.
F.	"Bittern Pan."
G.	Handle to "Bittern Pan."
H.	Salt Basket.
I.	Conduit for the brine from outside cisterns.
J.	Walk.
K.	Gutters.
L.	Salt bins.
M.	Engine room with Boiler, Engine and Blower, back of which is the salt bin.
N.	Air space between walk and lining of salt bins
O.	Conduit for blast.

chimney are most effectually brought in contact with the entire heating surface of the kettles confined in the arches. The slanting of the walls and the gradually decreasing distance between the kettle and arch bottoms is specially designed to further this object. Lengthwise and a few inches above the central wall is a wooden conduit placed, provided with one faucet, and the necessary plug for each salt kettle, in the block. The entire arrangement is such that the workman when standing on the walk can with ease fill the kettles by means of these faucets with brine from the conduit. The latter is connected with two large wooden cisterns situated outside of the building and sufficiently elevated to supply the brine contained therein by gravity to the kettles in the block. Their capacity varies in accordance with the amount of brine required for the block in 24 hours. Usually they are from 20 to 25 feet wide, 6 feet deep and from 25 to 40 feet long, having a capacity from 30,000 to 40,000 gallons or about the quantity required in 24 hours, while the salt block is in operation. A smaller tank which holds fresh water is also connected with the conduit. Thus the workman is enabled to draw, as occasion requires, either salt brine or fresh water from the same faucets by closing the gate of the one or the other tank. On both sides of the double row of kettles is a walk made of earth and from 12 to 18 inches below their rims, for the use of the workmen in attending to the various operations connected with the manufacture of salt. It is from 5 to 6 feet wide extending the entire length of the block with a gutter running lengthwise of it and on the side farthest from the kettles to carry off any bitter water ("bitterns"), etc. requiring removal. Next to these gutters are the so-called "salt bins," having usually a depth from 6 to 8 feet below the level of the walk, a width of 10 to 14 feet and a length of nearly 100 feet and over, according to producing capacity of the block. They are always divided into several compartments and serve as storage rooms for the manufactured salt. Their bottoms are made of 2 in. plank and are from 8 to 12 inches above the ground to permit the circulation of air under them and in order to provide for a proper drainage of the salt — the planks are not closely fitted. Since the heat in the front portion of the arch is so intense that it not only penetrates through the 18 inch brick wall and the five to six feet of earth adjoining but would also pass through the wooden lining of the bins, an air space of 8 to 12 inches is left between them to prevent any discoloration by "baking" of the salt stored in these bins. When the salt has been removed from these bins they are washed with fresh water for the purpose of dissolving any salt that may remain in the crevices of the bottom planks. The time during which these blocks are in operation extends from the middle of April to the first of December. Originally there were 316 salt blocks. Their number to-day is less than 100 and of these about 20 are in active operation.

The brine employed in the manufacture of boiled or common fine salt, as it is usually called, is the same as that used in the solar fields. Since the object of the manufacturer is to use the brine in the shortest possible time, and since there is present in it, as previously explained, carbonic acid gas, holding in solution some ferrous carbonate, it becomes necessary on the part of the workman to use some means to remove them both, since otherwise the salt would be discolored by ferric oxide. For this purpose he takes a small amount of quick lime, and slackens it with brine into a very thin milk, which he distributes evenly over the entire surface of the fresh brine. The lime unites with the carbonic acid to form calcium carbonate and the ferrous oxide takes up the necessary oxygen and water to form the hydrated ferric oxide, which gradually sinks to the bottom of the cistern. To assist this process as much as possible, the brine is well stirred whereby the caustic lime is brought in better contact with the brine and the removal of the carbonic acid gas is more quickly accomplished. This being done the brine is allowed to stand from 20 to 24 hours, when the dirty yellowish color, which is soon visible after the addition of the lime milk, has disappeared, and a clear, slightly blue color takes its place. Thus prepared the brine is ready for the manufacture of salt. This process is called the settling of the brine. The manufacture proper of salt is commenced by lighting the fires under the kettles and filling them partly with brine from the faucets as soon as they become warm, and within 3 to 4 inches of the top when evaporation has well commenced. At the same time a wrought iron pan is inserted into the kettle, having its handle near the center instead of on the side to allow its easy insertion and withdrawal from the kettle. Otherwise it is like an ordinary frying pan, with very slanting sides, so that when it is inserted into the kettle it covers its bottom and fits as close as possible to the sides. This is known as the "bittern pan." Its purpose is to collect the sulphate of lime, "plaster" or "bitterns," which soon separates. This separation becomes more rapid with the increase of temperature and concentration especially near the boiling and saturation point of the brine. From the time the pan is first inserted till the brine actually boils or salt commences to separate, it is several times drawn out of the kettle and the sediment collected therein (the "plaster or bitterns") is thrown into the gutter beside the walk. That portion of the brine contained in the kettle which is nearest to its bottom and consequently becomes more strongly heated and therefore specifically lighter ascends along the inner side of the kettle. When it reaches the surface it is cooled by the cold air, becomes again specifically heavier and sinks back to the bottom of the kettle, but this time through the center, carrying with it into the pan the separated and finely divided calcium sulphate. When salt commences to separate the pan is withdrawn and the evaporation is allowed to go on undisturbed till a sufficient amount of salt has separated, when the contents of the kettle are well stirred with the ladle and dipped into the basket resting on the so-called basket sticks laid across the rim of the kettle. While the process of taking the salt from the kettle is going on, the workman opens the faucet for a few minutes to add some fresh brine to the concentrated pickle of the kettle and washes the salt, so to speak, with this mixture, thereby freeing it as much as possible from the adhering calcium sulphate and the calcium and magnesium chlorides. The basket with its salt remains usually on the kettle for drainage till the kettle has to be "drawn" a second time, when the contents are dumped into the salt-bins beside the walk. The advantage of this method of drainage is readily understood when we bear in mind the fact that the rising steam or vapor given off from the brine of the refilled and boiling salt kettle below penetrates the salt in the basket, condenses to water and in its descent through the salt carries along some of the still adhering calcium and magnesium chlorides. The panning process, previously described, though carried out in the best possible manner will not completely remove from the kettle all the separated calcium sulphate, but some of it together with separated salt, will bake on the bottom and sides, forming an incrustation* constantly increasing in thickness, though at every refilling of the kettle with fresh brine, considerable of this adhering salt redissolves. This incrustation increases much more rapidly in the front kettles than in those nearer to the chimney, since a front kettle is usually drawn every 4 to 5 hours while a back kettle often requires from 24 to 36 hours before a sufficient amount of salt has separated. Moreover a front kettle holds 150 gallons of brine while those nearest the chimney contain but 100 gallons. Usually in 5 or 6 days the incrustation becomes so thick that it interferes very materially with the evaporation, causing a great

---

* The calcium sulphate left in the kettle after a good panning together with that which separates with the salt becomes in almost all the kettles heated sufficiently high to loose its water of crystallization and changes into so-called plaster of Paris, the workmen call it plaster of bitterns.

loss of fuel, as gypsum or plaster of Paris is one of the poorest conductors of heat. The workman therefore draws the salt from the kettle, removes the remaining salt brine, called pickle, to within a few gallons and refills the kettle with fresh water. After a continuous boiling of about half an hour the greater part of the adhering salt has dissolved and the rest of the incrustation can be readily removed.

The kettles properly cleaned are washed with fresh brine, refilled with the same and the boiling, panning and drawing of the kettles continues till the incrustations have accumulated not only in the kettles nearest the source of heat but also in those farther away towards the chimney. Now the fires are allowed to go out and at the same time the accumulated salt is removed from all the kettles. The old pickle or the mother liquor as it is also called, is dipped out as far as practicable into the gutter and the kettles are then refilled with fresh brine from which in the front kettles a considerable quantity of salt crystallizes, due to a partial evaporation of the brine by the heat retained in the arches. This salt is called "cool down salt;" it is much coarser than the boiled salt and usually kept separate. The time a salt block is in operation is between 10 to 15 days, a "10 or 15 days run." The manufactured salt having been all deposited in the bins, it is "leveled off" and according to the state law remains undisturbed for 14 days for drainage, when it is ready for the market. A salt block usually cools sufficiently in 12 hours, when the kettles, grates, arches, etc., are properly cleaned and made ready for the next "run." The time required for this is 24 hours, so that about two runs can be made in one month. The quantity of salt produced in 24 hours in a good salt block with average good coal dust and brine on the "Onondaga Salt Reservation" is from 500 to 600 bushels of 56 pounds each and the amount obtainable by the burning of one ton of 2000 pounds of this fuel varies from 45 to 50 bushels. These results depend mainly on the quality of the brine employed,* on the quality of the fuel,† the physical conditions of the latter, on the state of the weather, the temperature of the air, amount of heating surface, height of brine in the kettle, thinness of metal through which the heat has to be transmitted, on the more or less perfect combustion of the fuel, on the temperature at which the brine is evaporated, etc.

3 STEAM EVAPORATION

Steam Kettle Process

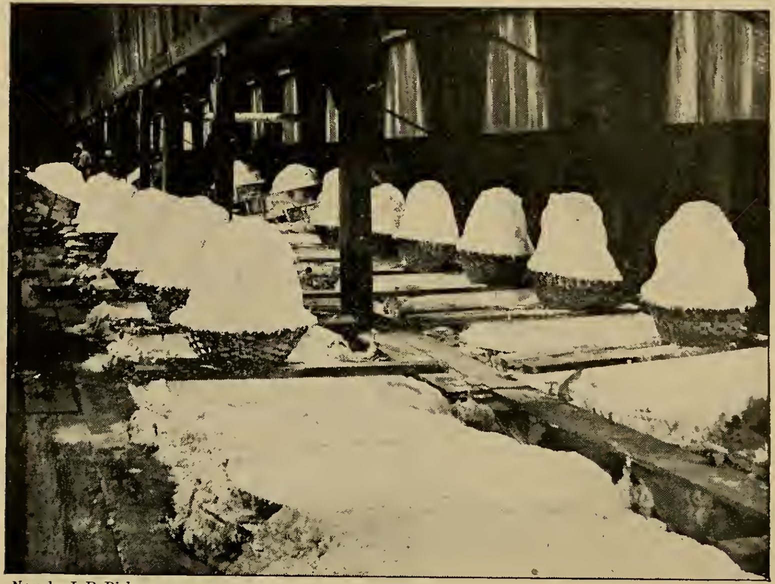
There are two salt blocks in the Wyoming Valley at Warsaw in which the Onondaga kettles are used for the manufacture of salt, but these kettles are heated by steam instead of direct fire. Hence in place of the brick arches in which the kettles are hung at Syracuse, they are supported by a frame work, and each kettle is surrounded by a steam jacket covered with a non-conductor. Moreover the metal of the kettle is made much thinner for the better transmission of the heat. The steam enters the jacket at the upper end of the kettle and at one side and the condensed water escapes by a valve below it, to be returned to the steam boiler. The method of manufacture of the salt does not differ in any particular from the Onondaga method. The heat of the steam being uniform for all the kettles, the salt produced is uniform in grain and very good in quality. The number of the kettles under one roof or in one salt block can be varied according to the wish of the manufacturer and the steam capacity of the boilers.

The quality of the salt is primarily dependent on the attention of the workman, on the chemical composition of the brine, on its proper settling, on the length of time a block has been in operation, and on the amount of calcium and magnesium chlorides present in the pickle, since an excessive heating of the front kettles, especially when they are

---

* See table of brine strength, etc., No. 1.

† See table 2. This table was compiled from Prof. W. B. Johnson's experiments made for the navy.



Neg. by I. P. Bishop.

STEAM KETTLES AND SALT DRYING IN BASKETS, ATLANTIC SALT CO'S WORKS, WARSAW, N. Y.

low in the pickle will cause a decomposition of the magnesium chloride into magnesium oxide and hydrochloric acid, the latter readily attacks the iron forming ferrous chloride, the slightest trace of which when present in the salt will cause a decided discoloration of the latter at the time the salt becomes ready for the market.

The grain of the salt, namely the size of the crystals, depends on the temperature at which the salt is made, and consequently on the quickness or slowness of the evaporation. The separation of the salt or its crystallization in a heated brine begins at the moment when the latter has reached its point of saturation. This crystallization always takes place on the surface of the brine and never at the bottom, since there the temperature is highest, and salt is more soluble in the hotter brine. The little cubes will increase in size as long as they remain on the surface of the brine but not when they have once sunk to the bottom of the heated liquid. Hence, to produce a coarse salt, the brine must remain as much as possible undisturbed in order to allow the crystals to grow, which is impossible in a very hot brine.

The salt made by the ordinary kettle method is not of a uniform grain or crystal, since the front kettles, which usually boil very rapidly yield a heavy salt of which the crystals are small, hard and sharp to the touch, while the back kettles produce a very light, flaky and coarse grained salt very soft to the touch. By mixing both a good grained average salt is obtained, which is known in the market as "common fine salt."

The average composition of this is about as follows:

Sulphate of lime (calcium sulphate)................	1.30	per cent.
Calcium chloride....................................	0.16	"
Magnesium chloride............	0.15	"
Sodium chloride salt	95.49	"
Moisture...	2.90	"

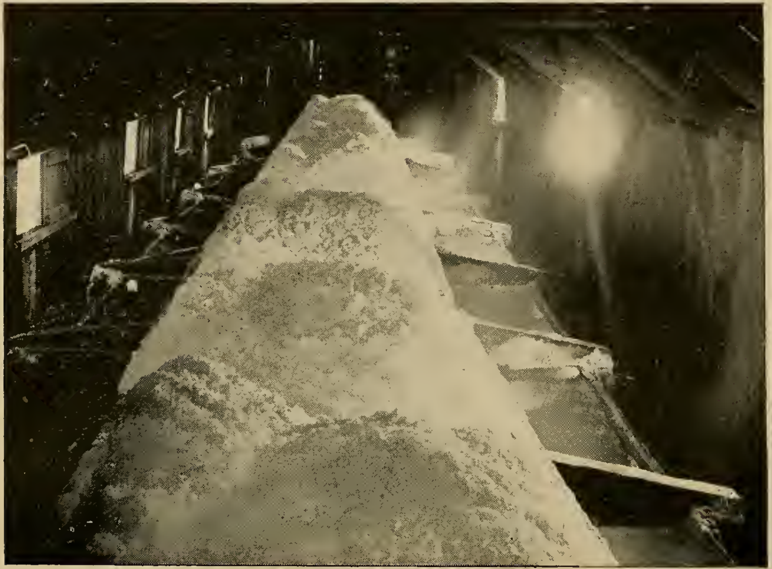
Since the year 1862 there has been produced at Syracuse a salt of very superior quality for the dairy and table, the manufacture of which has of late been abandoned. The process consisted in washing the common fine salt described above in a machine with a pure salt pickle holding in solution the necessary amount of sodium carbonate for the decomposition of the small percentages of calcium and magnesium chlorides, yielding salt and calcium and magnesium carbonates in a very fine state of subdivision, which readily floated off with the brine or pickle together with some of the calcium sulphate adhering to the salt. After proper drainage the salt was dried in large iron dryers lined with wood (the so-called "Hersey Dryer"), ground and sifted. The peculiar tendency of Onondaga boiled salt, when dissolved in water, to impart to the latter a milky appearance, is due to the presence of calcium sulphate in the anhydrous state, known as plaster of Paris. If the solution be allowed to stand for some time this plaster will take up its water of crystallization and redissolve.

There are at present about 40 separate wells in 5 groups on the reservation. The brine comes within 18 to 22 feet of the surface. They are all tubed with 6 or 8 inch tubes and the brine is drawn from them by plunger pumps. The brine obtained from them is very similar in chemical composition, as the following examples prove.

	Gere well	Hoffman well	S. Smith well	Dewolf well	McCrain well	Backer well
Depth	256 ft.	309 ft.	285 ft.	386 ft.	344 ft.	235 ft.
Calcium sulphate......	0.57	0.5860	0.8307	0.5150	0.55	0.5446
Calcium chloride......	0.09	0.0907	0.1851	0.1950	0.12	0.0926
Magnesium chloride...	0.15	0.1413	0.1717	0.1380	0.17	0.1609
Salt	15.85	17.4840	17.1222	18.2000	17.97	14.9009
Total saline matter	16.66	18.3020	18.0097	19.0480	18.81	18.6990
Water	83.34	81.5407	81.9903	80.9520	81.19	84.3010

The Grainer Process

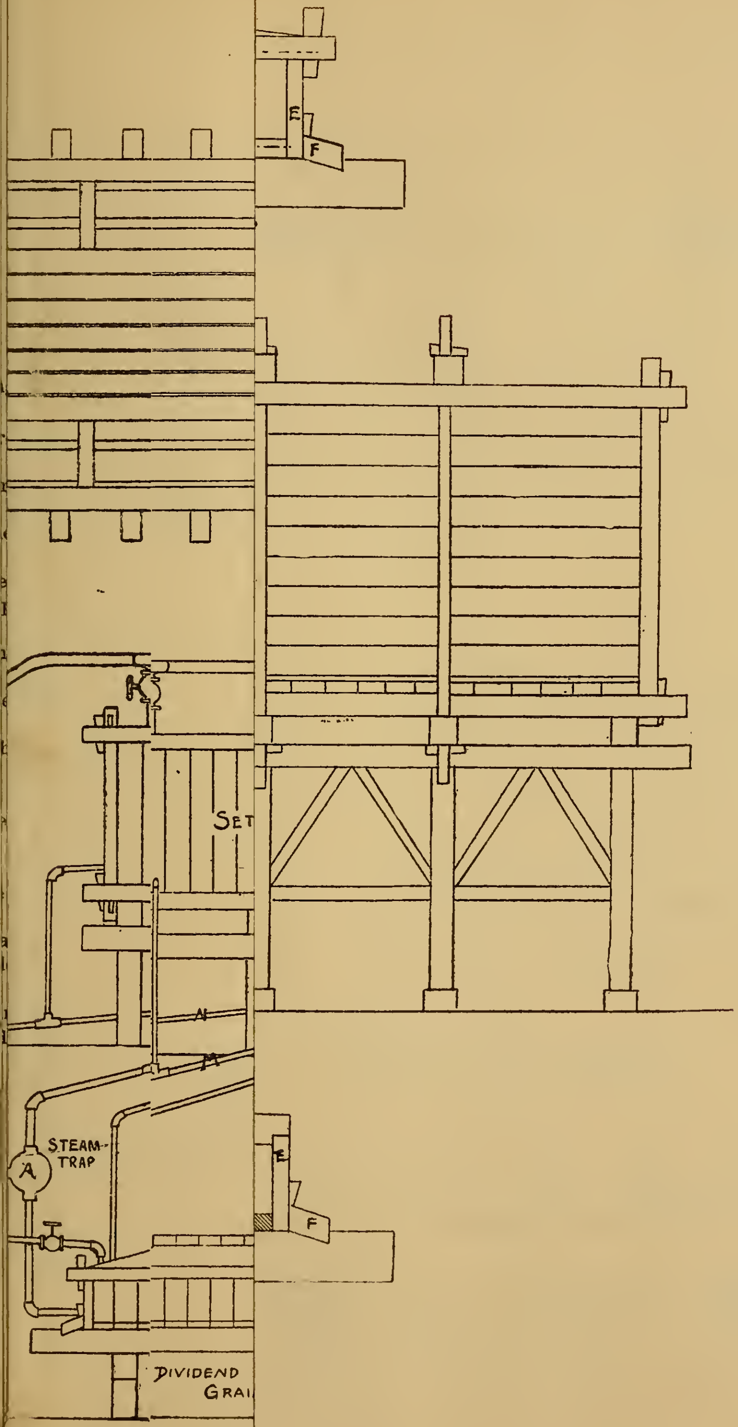
The grainer or Michigan process is, like the "kettle method," a purely American invention and consists in passing live or exhaust steam through a set of iron pipes



Neg. by I. P. Bishop.

GRAINER SALT. ATLANTIC SALT CO'S WORKS, WARSAW, N. Y.

immersed in long shallow wooden or iron vats. These vats rest on a strong wooden frame. They are from 100 to 150 feet long usually 12 feet wide and from 20 to 24 inches deep; provided with 4 to 6 steam pipes having a diameter of 4 to 5 inches and hung on pendants 4 to 6 inches above the bottom of the vats. These pipes are within a few feet of the same length as the grainer, and so arranged that the salt can be conveniently removed towards the outer side of the grainer. Over the top of the grainer is a strong platform to receive the salt taken from it for proper drainage; this also supports the pendants holding the steam pipes in their position. In most of the grainer blocks the salt is removed from the grainers by attendants called "lifters." In others an ingenious device called a "raker" does this work, automatically moving the salt constantly from the front end of the grainer to the back where it drops into properly constructed "conveyors" which deposit it in the salt bins. Where no rakers are employed the salt is removed every 24 hours. The brine which is "settled" in exactly the same manner as that treated by the kettle and pan methods is allowed to run into the grainers at the front end in the same proportion as the water evaporates from the brine. The only attention required, when the salt is not "lifted" is to pay proper attention to the supply of brine and the regulation of the steam which is all attended by one man. In most work soft coal is used as a fuel under the boilers, that and the expense for the fireman being a considerable item in the grainer plant. To obtain the best effect in a grainer system, the temperature of the heated brine should be kept at or near the boiling point when no lifting or removal of salt is in progress. To do this we must first supply to the grainers an abundance of high pressure steam, and secondly the constant supply of brine required for the grainers while evaporation is going on must enter at a temperature but little lower than that of the brine in the grainer. For this purpose two large tanks, so-called settlers, are employed, which are usually as long and wide as the grainers but 6 feet deep and provided with 4 rows of steam pipes about 1 foot above the floor to heat the cold brine drawn into them from the outside cisterns as required. Although the 6 rows of steam pipes in the grainer have an entire length of from 550 to 750 feet (suspended in the brine 4 to 6 inches above the bottom of the grainer and with 8 to 10 inches of brine above them) and a heating surface of from 700 to 1000 square feet, a great deal of the steam supplied to them is not condensed, and therefore passes from the grainer pipes into the settler pipes (sometimes passing through a steam trap to separate the condensed water) to heat the brine of the settlers. Whenever there is a surplus of steam, for instance while the lifting of the salt from the grainers is going on, the direct steam is used for the same purpose. To produce the best quality of salt the pickle in the grainers must not become overcharged with calcium and magnesium chlorides, which can only be done by removing from time to time the inferior pickle. Since this pickle contains from 18 to 20 per cent of salt, too valuable to go to waste, it is discharged into a set of grainers on the ground floor of the building, called lower or divided grainers. They are placed either directly under the upper grainers, in which case they are but 8 feet wide with 4 steam pipes, or in some other convenient place. The pickle is heated in them by uncondensed steam and condensed water coming from the steam pipes in the settlers and upper grainers. The product of these lower or divided grainers in consequence of the low temperature at which the salt is made in them, is very coarse, often having an inferior color. The salt is removed from them at longer intervals — every 6 or 10 days according to circumstances and the remaining pickle is discharged as useless. The removal of the salt into the bins, etc. does not differ in any essential from what has been stated in regard to the other methods.


E
F
K
SET
N
M
STEAM-
TRAP
A
E
F
DIVIDEND
GRAI

A. Posts or piles, 12 inches by 12 inches, 8 feet apart; length according to ground.

B. Longitudinal sills, 12 inches by 12 inches; length according to size of grainer.

C. Cross sills, 17 feet by 12 inches by 10 inches; 3 feet apart from center to center.

D. Bottom planks of grainer, 16 feet or 12 feet long, 12 inches wide, 4 inches thick.

E. Side-boards, 26 feet by 4 inches by 22 inches to 24 inches wide; held together by one-inch dowel-pins or water-stays and in position by the timbers F and wedges.

F. Longitudinal wedge timber, 10 inches by 6 inches; length according to length of grainer.

G. End-boards, 24 inches high if the side boards are 24 inches wide; 12 inches wide and 4 inches thick.

H. Ingripe timbers, 14 feet by 8 inches by 6 inches, with one 2 inches by 4 inches groove which is 12 feet long.

I. Upper cross-beam for holding platform and suspended steam-pipes, 12 feet 8 inches long, 8 inches thick and 14 inches wide, 8 feet apart.

J. Steam-pipes, six rows, 3 inches to 4 inches in diameter.

K. Platform planks, seven in number, 16 feet by 1 foot by 4 inches.

L. Iron pendants to hold the pipes.

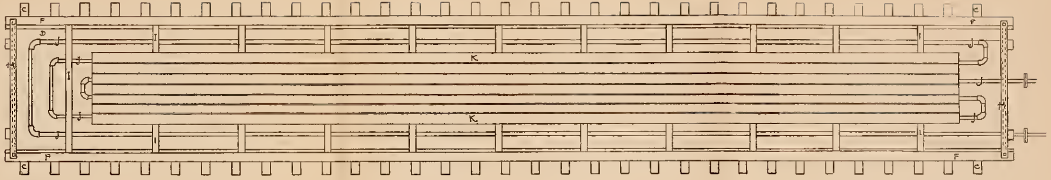
M. Pipe for conducting steam and condensed water to steam-trap A. From there the steam is conveyed to the pipes in the settlers and the hot water to the pipes in the dividend grainer.

N. Pipe for conducting brine from brine settlers to the grainers.

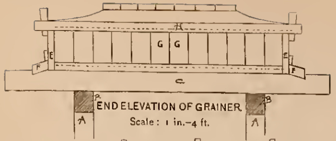
O. Pipe to convey discharged pickle from grainer to dividend grainer.

P. Pipe to bring steam and condensed water from settlers to dividend grainer.

TOP VIEW OF GRAINER.



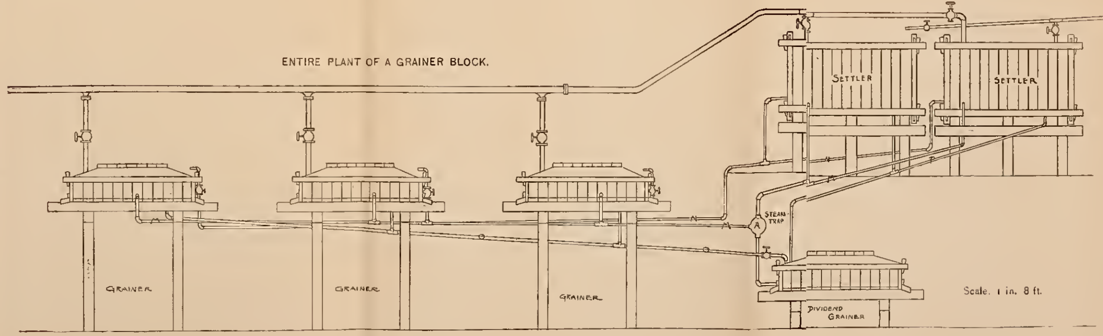
SCALE 1 IN = 8 FT



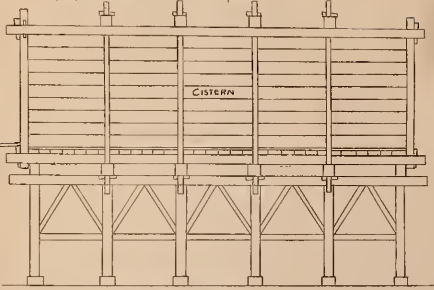
END ELEVATION OF GRAINER.

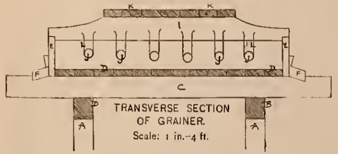
Scale: 1 in.–4 ft.

ENTIRE PLANT OF A GRAINER BLOCK.



Scale. 1 in. 8 ft.





TRANSVERSE SECTION OF GRAINER.

Scale: 1 in.–4 ft.

F. E. Englehardt, del.

4 VACUUM PAN EVAPORATION

or the evaporation of water from brines by steam, with a reduction of atmospheric pressure over the heated brine has been successfully introduced into two localities in this state, namely at the Duncan Salt Company's works, Silver Springs, Wyoming Co., and at Ludlowville, Tompkins Co. At the former place the process is carried on under the Duncan patents and at the latter under the Alexander Miller patents. Their product is a very handsome salt with a fine luster and very even grain, well adapted for table and dairy salt. The following generalized description of the former is furnished by Mr W. C. Clarke, E. M.

The vacuum process consists in evaporating the brine in a large vertical cylindrical iron vessel in which a vacuum is produced. By withdrawing the atmospheric pressure the boiling point of the brine is lowered whereby a quicker crystallization is produced and consequently a finer grain. In the pan are 17 or 18 groups of copper tubes, 20 tubes in each, the latter being parallel to each other and in one plane. At each end they are connected with an iron tube or heading at right angles to the copper tubes and in the same plane, through which steam from the outside connections is admitted to supply heat for evaporation. The copper tubes are surrounded by brine. The salt as it crystallizes collects in a large pipe at the bottom of the pan and when it is seen through a peep hole in the latter a valve is closed above the salt and it is dumped into a cylindrical screen revolving at about 600 revolutions per minute. The water is thrown against the screen and goes through by centrifugal force. The salt when dry, is ready for packing. This is the Worcester brand and a price much above that of the ordinary grainer salt is obtained for it.

COMPARISON OF BRINES AND PROCESSES

As the brines used in the western part of the state — where the pan and grainer methods are exclusively employed —

are derived from the same salt deposits that supply Syracuse and which are situated in the Salina Group, they do not differ materially in their chemical composition, the main difference being rather one of concentration. The amount of calcium sulphate present in the brines is dependent, as at Syracuse, upon the quantity of calcium chloride contained in them. There is one remarkable fact to be recorded in this connection, namely, that while the brine from a new well usually contains calcium and magnesium chlorides in very small quantities, an increase of them is noticed after a time, especially when several wells very near to each other become connected under ground. The most plausible explanation which can be offered for this is that the shales above the rock-salt — almost all the wells in the western part of the state are sunk in the rock-salt — may be highly charged with these soluble chlorides and that when the salt surrounding the tubing of the well has been dissolved up to these overlying shales the chlorides of the alkaline earths find easy access to the brine. Mr I. P. Bishop states that he was informed by Mr C. Q. Freeman, vice president of the Retsof Mining Co., that a number of analyses of salt were made under his direction and that the samples taken from the top of a salt bed contained a greater proportion of deliquesent chlorides than those taken from the bottom. Whenever two or more wells belonging to the same company are found to be connected under ground the so-called forcing process is resorted to, which consists in pumping fresh water to the salt bed below by powerful pumps. Through one well (tubing) the water is forced down while the brine comes up through another. This may possibly have some influence on the overlying shales. As examples to show the quality of the western brines the following two analyses may serve :

13.....	3.38	1.023	3.445	8.522	.293	190.72	1,509.54	201.59	7.045
81.....	[illegible]	[illegible]	[illegible]	[illegible]	2.074	26.99	[illegible]	34.14	[illegible]
82.....	21.32	1.163	21.730	9.689	2.105	26.59	201.70	33.61	59.471
83.....	21.58	1.165	21.995	9.705	2.134	26.23	198.60	33.10	60.421
84.....	21.84	1.167	22.260	9.722	2.164	25.87	195.57	32.59	61.359
85.....	22.10	1.170	22.525	9.747	2.195	25.50	192.61	32.10	62.301
86.....	22.36	1.172	22.790	9.764	2.225	25.16	189.72	31.62	63.250
87.....	22.62	1.175	23.055	9.789	2.256	24.81	186.89	31.14	64.206
88.....	22.88	1.177	23.320	9.805	2.286	24.48	184.13	30.68	65.168
89.....	23.14	1.179	23.585	9.822	2.316	24.17	181.44	30.24	66.137
90.....	23.40	1.182	23.850	9.847	2.348	23.84	178.80	29.80	67.113
91.....	23.66	1.184	24.115	9.864	2.378	23.54	176.22	29.37	68.096
92.....	23.92	1.186	24.380	9.880	2.408	23.24	173.69	28.94	69.085
93.....	24.18	1.189	24.645	9.905	2.441	22.93	171.22	28.53	70.086
94.....	24.44	1.191	24.910	9.922	2.471	22.65	168.80	28.13	71.086
95.....	24.70	1.194	25.175	9.947	2.504	22.36	166.44	27.73	72.105
96.....	24.96	1.196	25.440	9.964	2.534	22.09	164.12	27.35	73.114
97.....	25.22	1.198	25.705	9.980	2.565	21.82	161.85	26.97	74.140
98.....	25.48	1.201	25.970	10.005	2.598	21.55	159.63	26.60	75.172
99.....	25.74	1.203	26.235	10.022	2.629	21.29	157.45	26.24	76.212
100.....	26.00	1.205	26.500	10.039	2.660	21.04	155.32	25.88	77.259

This brine table was constructed on the assumption, that a pure saturated solution of salt has a specific gravity of 1.205 at 60° Fahrenheit and contains 26.5 per cent of pure salt. The salometer introduced in most all the salt works of the state of New York is an areometer with a scale divided into 100 parts or degrees. The density of distilled water at 60° Fahrenheit is indicated by 0° and that of saturated brine by 100°. With a reduction of temperature the brine becomes specifically heavier, hence the salometer will not sink so low, while when the temperature of the brine is above 60° Fahrenheit and therefore specifically lighter it will sink lower. It is usually sufficient for all practical purposes to add or deduct one degree to or from the reading for every ten degrees the temperature is above or below the normal.

BRINE TABLE.

By F. E. Englehardt, Ph. D.

Salometer, degrees.	Beaumé, degrees.	Specific gravity.	Per cent of salt.	Weight of a gallon of this brine in pounds of 7,000 grains each.	Pounds of salt in a gallon of brine of 231 cubic inches.	Gallons of brine required for a bushel of salt.	Pounds of water to be evaporated to produce a bushel of salt.	Pounds of coal required to produce a bushel of salt, one pound of coal evaporating six pounds of water.	Bushels of salt that can be made with a too of coal of 2,000 pounds.
1.....	.26	1.002	.265	8.347	.022	2,531.45	21,076.07	3,512.67	.569
2.....	.52	1.003	.530	8.356	.044	1,264.47	10,510.03	1,751.67	1.141
3.....	.78	1.005	.795	8.372	.066	841.30	6,988.02	1,164.67	1.717
4.....	1.04	1.007	1.060	8.389	.088	629.72	5,227.03	871.17	2.295
5.....	1.30	1.009	1.325	8.406	.111	502.77	4,170.41	695.06	2.877
6.....	1.56	1.010	1.590	8.414	.133	418.56	3,466.01	577.66	3.462
7.....	1.82	1.012	1.855	8.431	.156	358.06	2,962.87	493.81	4.050
8.....	2.08	1.014	2.120	8.447	.179	312.68	2,585.50	430.91	4.641
9.....	2.34	1.016	2.385	8.464	.201	277.39	2,292.00	382.00	5.235
10.....	2.60	1.017	2.650	8.472	.224	249.41	2,057.20	342.86	5.833
11.....	2.86	1.019	2.915	8.489	.247	226.29	1,865.09	310.84	6.434
12.....	3.12	1.021	3.180	8.506	.270	207.02	1,705.00	284.16	7.038
13.....	3.38	1.023	3.445	8.522	.293	190.72	1,569.54	261.59	7.645
14.....	3.64	1.025	3.710	8.539	.316	176.76	1,453.43	242.23	8.256
15.....	3.90	1.026	4.975	8.547	.339	164.81	1,852.80	225.46	8.870
16.....	4.16	1.028	4.240	8.564	.364	154.21	1,264.75	210.79	9.488
17.....	4.42	1.030	4.505	8.581	.386	144.86	1,187.06	197.84	10.108
18.....	4.68	1.032	4.770	8.597	.410	136.54	1,118.00	186.33	10.733
19.....	4.94	1.034	5.035	8.614	.433	129.11	1,056.21	176.03	11.361
20.....	5.20	1.035	5.300	8.622	.457	122.54	1,000.60	176.76	11.992
21.....	5.46	1.037	5.565	8.639	.480	116.47	950.28	158.38	12.627
22.....	5.72	1.039	5.830	8.656	.504	110.96	904.54	150.75	13.266
23.....	5.98	1.041	6.095	8.672	.528	105.93	862.78	143.79	13.908
24.....	6.24	1.043	6.360	8.689	.552	101.33	824.50	137.41	14.554
25	6.50	1.045	6.625	8.706	.576	97.09	789.28	131.54	15.202
26.....	6.76	1.046	6.890	8.714	.600	93.26	756.77	126.12	15.856
27.....	7.02	1.048	7.155	8.731	.624	89.64	726.66	121.11	16.513
28.....	7.28	1.050	7.420	8.747	.649	86.27	698.71	116.45	17.173
29.....	7.54	1.052	7.685	8.764	.673	83.14	672.69	112.11	17.838
30.....	7.80	1.054	7.950	8.781	.698	80.21	648.40	108.06	18.507
31. ...	8.06	1.056	8.215	8.797	.722	77.48	625.67	104.27	19.179
32.....	8.32	1.058	8.480	8.814	.747	74.92	604.37	100.72	19.855
33.....	8.58	1.059	8.745	8.822	.771	72.58	584.36	97.39	20.535
34.....	8.84	1.061	9.010	8.839	.796	70.31	565.53	94.25	21.218
35.....	9.10	1.063	9.275	8.856	.821	68.17	547.77	91.29	21.906
36.....	9.36	1.065	9.540	8.872	.846	66.15	531.00	88.50	22.598
37.....	9.62	1.067	9.805	8.889	.871	64.24	515.13	85.85	23.294
38.....	9.88	1.069	10.070	8.905	.896	62.44	500.10	83.35	23.983
39.....	10.14	1.071	10.335	8.922	.922	60.72	485.84	80.97	24.699
40.....	10.40	1.073	10.600	8.939	.947	59.09	472.30	78.71	25.407
41.....	10.66	1.075	10.865	8.925	.973	57.54	459.41	76.56	26.120
42.....	10.92	1.077	11.130	8.972	.998	56.07	447.14	74.52	26.837
43.....	11.18	1.079	11.395	8.989	1.024	54.66	435.44	72.57	27.558
44.....	11.44	1.081	11.660	9.005	1.050	53.32	424.27	70.71	28.283
45.....	11.70	1.083	11.925	9.022	1.075	52.04	413.60	68.93	29.013
46.....	11.96	1.085	12.190	9.039	1.101	50.82	403.39	67.23	29.747
47. ...	12.22	1.087	12.455	9.055	1.127	49.64	393.61	65.60	30.486
48.....	12.48	1.089	12.720	9.072	1.154	48.52	384.25	64.04	31.229
49.....	12.74	1.091	12.985	9.089	1.180	47.44	375.26	62.54	31.977
50.....	13.00	1.093	13.250	9.105	1.206	46.41	366.64	61.10	32.729
51.....	13.26	1.095	13.515	9.122	1.232	45.42	358.34	59.72	33.487
52.....	13.52	1.097	13.780	9.139	1.259	44.46	350.38	58.39	34.247
53.....	13.78	1.100	14.045	9.164	1.287	43.50	342.71	57.11	35.015
54.....	14.04	1.102	14.310	9.180	1.313	42.62	335.35	55.89	35.783
55.....	14.30	1.104	14.575	9.197	1.340	41.77	328.21	54.70	36.560
56.....	14.56	1.106	14.840	9.214	1.367	40.95	321.35	53.55	37.341
57.....	14.82	1.108	15.105	9.230	1.394	40.16	314.74	52.45	38.126
58.....	15.08	1.110	15.370	9.247	1.421	39.39	308.34	51.39	38.917
59.....	15.34	1.111	15.635	9.264	1.448	38.66	302.17	50.36	39.712
60.... .	15.60	1.114	15.900	9.280	1.475	37.94	296.21	49.36	40.512
61.....	15.86	1.116	16.165	9.297	1.502	37.26	290.43	48.40	41.317
62.....	16.12	1.118	16.430	9.314	1.530	36.59	284.84	47.47	42.129
63.....	16.38	1.121	16.695	9.339	1.559	35.91	279.42	46.57	42.945
64.....	16.64	1.123	16.960	9.355	1.586	35.29	274.18	45.69	43.765
65.....	16.90	1.125	17.225	9.372	1.614	34.68	269.10	44.85	44.591
66.....	17.16	1.127	17.490	9.389	1.642	34.10	264.18	44.03	45.423
67.....	17.42	1.129	17.755	9.405	1.670	33.53	259.40	43.23	46.260
68.....	17.68	1.131	18.020	9.422	1.697	32.98	254.76	42.46	47.102
69.....	17.94	1.133	18.285	9.439	1.725	32.44	250.26	41.71	47.949
70.....	18.20	1.136	18.550	9.464	1.755	31.89	245.88	40.98	48.802
71.....	18.46	1.138	18.815	9.480	1.783	31.39	241.63	40.27	49.662
72.....	18.72	1.140	19.080	9.497	1.812	30.90	237.50	39.58	50.526
73.....	18.98	1.142	19.345	9.514	1.840	30.42	233.47	38.91	57.397
74.....	19.24	1.144	19.610	9.530	1.868	29.96	229.56	38.26	52.272
75.....	19.50	1.147	19.875	9.555	1.899	29.48	225.76	37.62	53.153
76.....	19.76	1.149	20.140	9.572	1.927	29.04	222.05	37.00	54.041
77.....	20.02	1.151	20.405	9.589	1.956	28.62	218.44	36.40	54.934
78.....	20.28	1.154	20.670	9.614	1.987	28.17	214.92	35.82	55.834
79.....	20.54	1.156	20.935	9.630	2.016	27.77	211.49	35.24	56.739
80.....	20.80	1.158	21.200	9.647	2.045	27.38	208.14	34.69	57.650
81.....	21.06	1.160	21.465	9.664	2.074	26.99	204.88	34.14	58.568
82.....	21.32	1.163	21.730	9.689	2.105	26.59	201.70	33.61	59.471
83.....	21.58	1.165	21.995	9.705	2.134	26.23	198.60	33.10	60.421
84.....	21.84	1.167	22.260	9.722	2.164	25.87	195.57	32.59	61.359
85.....	22.10	1.170	22.525	9.747	2.195	25.50	192.61	32.10	62.301
86.....	22.36	1.172	22.790	9.764	2.225	25.16	189.72	31.62	63.250
87.....	22.62	1.175	23.055	9.789	2.256	24.81	186.89	31.14	64.206
88.....	22.88	1.177	23.320	9.805	2.286	24.48	184.13	30.68	65.168
89.....	23.14	1.179	23.585	9.822	2.316	24.17	181.44	30.24	66.137
90.....	23.40	1.182	23.850	9.847	2.348	23.84	178.80	29.80	67.113
91.....	23.66	1.184	24.115	9.864	2.378	23.54	176.22	29.37	68.096
92.....	23.92	1.186	24.380	9.880	2.408	23.24	173.69	28.94	69.085
93.....	24.18	1.189	24.645	9.905	2.441	22.93	171.22	28.53	70.086
94	24.44	1.191	24.910	9.922	2.471	22.65	168.80	28.13	71.086
95.....	24.70	1.194	25.175	9.947	2.504	22.36	166.44	27.73	72.105
96.....	24.96	1.196	25.440	9.964	2.534	22.09	164.12	27.35	73.114
97.....	25.22	1.198	25.705	9.980	2.565	21.82	161.85	26.97	74.140
98.....	25.48	1.201	25.970	10.005	2.598	21.55	159.63	26.60	75.172
99.....	25.74	1.203	26.235	10.022	2.629	21.29	157.45	26.24	76.212
100.....	26.00	1.205	26.500	10.039	2.660	21.04	155.32	25.88	77.259

This brine table was constructed on the assumption, that a pure saturated solution of salt has a specific gravity of 1.205 at 60° Fahrenheit and contains 26.5 per cent of pure salt. The salometer introduced in most all the salt works of the state of New York is an areometer with a scale divided into 100 parts or degrees. The density of distilled water at 60° Fahrenheit is indicated by 0° and that of saturated brine by 100°. With a reduction of temperature the brine becomes specifically heavier, hence the salometer will not sink so low, while when the temperature of the brine is above 60° Fahrenheit and therefore specifically lighter it will sink lower. It is usually sufficient for all practical purposes to add or deduct one degree to or from the reading for every ten degrees the temperature is above or below the normal.

	Wyoming Valley Brine.	Genesee Valley Brine.
Specific gravity	1.20446	1.1891
Calcium sulphate	0.4430	0.3780
Calcium chloride	0.1380	0.1913
Magnesium chloride	0.0530	0.1897
Pure salt	25.7110	24.1221
Water	73.6550	75.1189
	99.9500	100.0000

The following two analyses of the same brines after the lapse of considerable time exemplify the above statement:

	Wyoming Valley Brine		Genesee Valley Brine	
Specific gravity	1.1924		1.20446	
Calcium sulphate	0.433	per cent.	0.407	per cent.
Calcium chloride	0.069	"	0.140	"
Magnesium chloride	0.143	"	0.322	"
Pure salt	25.008	"	25.564	"
Water	74.347	"	73.567	"
	100.000		100. 000	

Before considering the special advantages of the various methods it is but proper to offer a few general remarks on evaporation. Water when it comes in contact with air yields vapor and the amount of the latter is always dependent on the temperature of the former. The formation of vapor always takes place on the surface of the water so long as the boiling point is not reached. If spontaneous or assisted by artificial means and it can only occur with the assistance of heat, and if there is not a direct outside source for this heat it is extracted either from the parts surrounding the water or from the latter, thereby reducing its temperature.

When the formation of vapor takes place, not only on the surface of the liquid but also within it at the bottom and sides of the vessel exposed to a source of heat, the liquid boils. In evaporation the formation of vapor takes place on the surface; in boiling within the liquid. The former is a slow, the latter a quick method of evaporation. When water is heated in an open vessel to its boiling point, its temperature becomes stationary, and while a more intense heat increases the rapidity of evaporation it can not raise the temperature, therefore the quicker we can supply the amount of heat required for the evaporation of a given quantity of water, the shorter must be the time in which it can be accomplished. A given quantity of water, exposed in two vessels, in one of which it is but 1 inch high and in the other 10 inches, to the same amount of heat on their heating surfaces, will evaporate in different spaces of time. The water in the vessel with the larger heating surface evaporates in one-tenth of the time of that in the other vessel, since the former has ten times more heating surface, and therefore transfers the heat ten times faster, hence we may say ; that the quantity of water that can be evaporated in a given time and at a given temperature is directly proportional to the area of the heating surface.

We assumed before that we supplied both vessels with the same amount of heat, could we raise the temperature under the vessel with the smaller heating surface, so as to impart to the water it contains as much heat as to our large vessel in exactly the same time, the result would be the same. Two vessels with equal heating surfaces and containing equal quantities of water, will show unequal results if one be heated more strongly than the other, the one more strongly heated evaporating more water in the same given time. With equal heating surfaces the amount of water evaporated in a given time is directly proportional to the temperature of the heated surfaces. The temperature at which water boils under ordinary circumstances at sea level is 212° Fahrenheit, but at high elevations where the air is lighter it boils at a lower temperature, and in deep mines at a higher temperature caused by the increased pressure of the air, hence it follows that the boiling temperature of water is dependent on the pressure of the air resting on the boiling liquid.

The fact is well known that water in an open vessel under an air pump where a vacuum is maintained, boils near its freezing point. The heat required for it is taken by the water from the surroundings namely, the air pump. But to do this requires almost a perfect vacuum which we can not produce in practice, but we can readily boil water in a vacuum pan at 135° Fahr. If the steam employed for this purpose is 230° Fahr. then the difference between 135° Fahr. at which the water boils and the temperature of the steam supplied is 95° and we can produce a very rapid evaporation provided we have sufficient heating surface at our disposal. Hence steam at any temperature will cause the evaporation of a liquid, of which the boiling point is below the temperature of the steam.

From the description given of the methods employed in the manufacture of salt, it is evident that a perfect comparison in regard to the practical results is a most difficult problem, since the quality of the brine and the fuel will often vary from week to week in the same work. Taking therefore the average results for a season or a year we find that with proper attention, good condition of the works and fuel, a kettle-block can produce 45 bushels (56 pounds each) of salt with a brine of 67° Salometer *per ton* of anthracite dust or, one pound of fuel evaporates 5.83 pounds of water, while a pan under the same conditions but with a brine of 96° Salometer yields 73 bushels of salt, hence a pound of fuel evaporates 6 pounds of water. The results with the upper (direct) grainer together with that of the lower or dividend grainer using a brine of 96° Salometer is 70 bushels, corresponding to an evaporation of 5.74 pounds of water per pound of fuel. These results are very low indeed as compared to those obtained in good steam boilers, but it must be taken into consideration that the conditions in both cases are very different. The expense for labor is greatest in the kettle method, next comes the pan and finally the grainer method. The wear and tear is very heavy in all salt works but especially in kettle and pan block. Allowing a kettle or pan block to lie idle for a year, almost ruins it, hence it is often cheaper to make salt for a season without profit, than to leave the works to themselves.

The main difficulty with which the salt manufacturers of our state have to contend is the calcium sulphate or, as it is called by them, and very properly, the plaster. In fact it is this impurity, as I stated previously, which causes the interruption of the process and the laborious cleaning out, whether we use the kettle, the pan, the grainer or the vacuum pan. It not only entails a great loss of heat in consequence of its low conductivity, but it also causes the overheating of the metal exposed to direct fire wherever this is employed. While this is of little consequence in regard to kettles, it is of great importance in regard to salt pans, since their bottoms have usually only a thickness of $\frac{1}{4}$ to $\frac{3}{8}$ inches, and wherever they become coated with this plaster, especially above and near the fires, overheating and unequal expansion of the iron results they warp and become uneven. It can easily be understood, that a proper removal of the salt from an uneven pan bottom is very difficult and where the warping is bad it is impossible. In consequence the salt bakes on, is of inferior color, and the pan becomes leaky and has to be repaired, which involves often not only heavy expense but loss of time. The heating of the brine as much as possible in the back pan and the raising of its temperature near to the boiling point, in the second section of the front pan before passing it into the front section are of great service in the removal of all the calcium sulphate that can be removed under ordinary circumstances.

Suggestions and experiments have been made to overcome this difficulty, involving the expenditure of great sums of money, but without any practical results as far as mechanical means are concerned.

The chemical means proposed, especially the use of sodium carbonate and trisodium phosphate for the removal of the calcium sulphate from the brine, would involve not only a much heavier expense than the present price of ordinary salt will warrant, but by their use we would substitute sodium sulphate for calcium sulphate, which when present in the salt would be more objectionable than the latter. Moreover the decomposition of the calcium sulphate by sodium carbonate or trisodium phosphate would involve at the same time the decomposition of the calcium and magnesium chlorides into calcium and magnesium carbonates or phosphates, thus bringing the expense for these chemicals up to such a high figure per bushel of salt that their use is out of the question.

The other impurities found in the salt brines of the State of New York which have an important bearing on the manufactured product are the very soluble and deliquescent calcium and magnesium chlorides. Although only present in the brines in small quantities, namely from about 0.15 to 0.75 per cent, they accumulate in the pickle or bitter water as the salt is removed, no matter by what method we obtain the salt. Thus in the solar salt fields they accumulate (gradually) in the pickle to such an extent, as previously stated, that evaporation practically ceases, when such a pickle contains only about 8 per cent of salt but nearly 21 per cent of the chlorides. In properly attended salt works the pickle is removed before such an accumulation of the calcium and magnesium chlorides takes place. It is usually discharged whenever it becomes necessary to scale the kettles, pans or grainer pipes, though in some grainer works a certain portion of the pickle is removed every two or three days from the upper into the lower grainers. When a certain ratio exists between the salt and these chlorides (especially the magnesium chloride) in a pickle evaporated by artificial heat a thin film is formed over the heated but not boiling liquid, which greatly retards evaporation and forms again as soon as removed. This is an indication that the chlorides of the alkaline earths should be removed.

The accompanying list of the salt manufacturers of New York State gives an idea of the magnitude of this industry, but it is not possible to obtain any accurate statistics concerning the amount and value of the total product of salt in New York. This is estimated for 1892 by Dr. F. E. Englehardt as follows:

Western part of the state	11,500,000	bus.
Mined salt	7,000,000	“
Onondaga reservation	4,406,000	“
Grand total	22,906,000	“

Value per bushel between 7½ to 8 cents, dairy salt somewhat higher.

NAMES AND LOCALITIES OF SALT MANUFACTURERS IN NEW YORK

Company	Location	Process	No. of wells
LeRoy Salt Co	LeRoy, Genesee Co., N. Y.	Grainer	9
Lehigh Salt and Mining Co	Lehigh, Genesee Co., N. Y	Mining	..
Pavilion Salt Co	Pavilion, Genesee Co., N. Y	Pans & grainers.	2
Pearl Salt Co	Pearl Creek, Wyoming Co., N. Y	Grainer	2
Crystal Salt Co	Salt Vale, Wyoming Co., N. Y	Large pans	2
Miller Salt Co	Warsaw, Wyoming Co., N. Y	Kettles with steam jackets.	2
Atlantic Salt Co	“ “ “	Kettles with steam jackets.	1
Warsaw Salt Co	“ “ “	Pan	6
Gouinlock & Humphrey	“ “ “	Pan	4
Hawley Salt Co	“ “ “	Pan	3
Empire Salt Co	“ “ “	Grainer	4
Bradley Salt Co	“ “ “	Grainer	5
Alex. Kerr Bros. & Co	Rock Glen, Wyoming Co., N. Y	Grainer and pan.	7
Perry Salt Co	Perry, Wyoming Co., N. Y	Grainer	2
Duncan Salt Co	Silver Springs, Wyoming Co	Vacuum pan and grainer	6
Castile Salt Co	Castile, Wyoming Co., N. Y	Pan	2
Gainesville Salt Co	Gainesville Creek, Wyoming Co., N. Y.	*	1
Bliss Salt Co	Bliss, Wyoming Co., N. Y	†	1
York Salt Co	York, Livingston Co., N. Y	Grainer	2
Livingston Salt Co	Piffard, Livingston Co., N. Y	Grainer	2
Genesee Salt Co	“ “ “	Pan	5
Phœnix Salt Co	Cuylerville, Livingston Co., N. Y	Small pans	1
Lackawanna Salt Co	Mt. Morris, Livingston Co., N. Y	Grainer	2
Royal Salt Co	“ “ “	Grainer	3
Cayuga Lake Salt Co	Ludlowville, Tompkins Co., N. Y	Grainers & pans.	1
Greigsville Salt and Mining Co	Greigsville, Livingston Co., N. Y	Mining	..
Livonia Salt and Mining Co	Livonia, Livingston Co., N. Y	“	..
Retsof Mining Co	Retsof, Livingston Co., N. Y	“	..

* Process in use not ascertained.

† Works not yet in operation.

1813	....	226,000	226,000	William Kirkpatrick.
1814	....	295,000	295,000	William Kirkpatrick.
1815	....	322,058	322,058	William Kirkpatrick.
1816	....	348,655	348,655	William Kirkpatrick.
1817	....	408,655	408,655	William Kirkpatrick.
1818	....	406,540	406,540	William Kirkpatrick.
1819	....	548,374	548,374	William Kirkpatrick.
1820	[illegible]	[illegible]	[illegible]	William Kirkpatrick.
1879	2,957,744	5,364,418	8,322,162	A. C. Powell, eight months. C. G. Hinkley, four months.
1880	2,516,485	5,482,265	7,998,750	N. Stanton Gere.
1881	3,011,461	4,905,775	7,917,236	N. Stanton Gere.
1882	3,032,447	5,307,773	8,340,180	N. Stanton Gere.
1883	2,470,533	5,432,439	7,902,972	P. J. Brummelkamp.
1884	2,353,860	4,588,409	6,942,259	P. J. Brummelkamp.
1885	2,439,332	4,494,967	6,934,299	P. J. Brummelkamp.
1886	2,772,348	3,329,409	6,101,757	P. J. Brummelkamp.
1887	3,118,974	2,576,823	5,695,797	P. J. Brummelkamp.
1888	3,115,314	2,542,053	5,657,367	P. J. Brummelkamp.
1889	2,916,923	2,448,138	5,365,061	P. J. Brummelkamp.
1890	2,726,471	2,201,651	4,928,122	P. J. Brummelkamp.
1891	2,113,727	1,735,186	3,948,914	P. J. Brummelkamp.
1892	3,122,789	1,282,885	4,405,674	P. J. Brummelkamp.
Total amount since 1797	85,852,095	270,570,483	356,422,095	

Or about 142½ million cubic feet (nearly ten millions tons of 2,000 pounds each).

This table gives the amount of salt inspected by the State officers for each year, but not the amount actually made, in other words the amount of salt sold in each year.

TABULAR STATEMENT OF THE NUMBER OF BUSHELS OF SALT MADE AT THE ONONDAGA SALT SPRINGS SINCE JUNE 20, 1797, WHICH IS THE DATE OF THE FIRST LEASES IN LOTS:

DATE.	Solar.	Fine.	Aggregate bushels.	Superintendent.
1797	....	25,474	25,474	William Stevens.
1798	....	59,928	59,928	William Stevens.
1799	....	42,704	42,704	William Stevens.
1800	....	50,000	50,000	William Stevens.
1801	....	62,000	62,000	Sheldon Logan.
1802	....	75,000	75,000	Asa Danforth.
1803	....	90,000	90,000	Asa Danforth.
1804	....	100,000	100,000	Asa Danforth.
1805	....	154,071	154,071	William Kirkpatrick.
1806	....	122,577	122,577	William Kirkpatrick.
1807	....	175,448	175,448	P. H. Ransom.
1808	....	319,618	319,618	Nathan Stewart.
1809	....	128,282	128,282	John Richardson.
1810	....	452,050	452,050	William Kirkpatrick.
1811	....	200,000	200,000	William Kirkpatrick.
1812	....	221,011	221,011	William Kirkpatrick.
1813	....	226,000	226,000	William Kirkpatrick.
1814	....	295,000	295,000	William Kirkpatrick.
1815	....	322,058	322,058	William Kirkpatrick.
1816	....	348,655	348,655	William Kirkpatrick.
1817	....	408,655	408,655	William Kirkpatrick.
1818	....	406,540	406,540	William Kirkpatrick.
1819	....	548,374	548,374	William Kirkpatrick.
1820	....	458,329	458,329	William Kirkpatrick.
1821	....	526,049	526,049	William Kirkpatrick.
1822	....	481,562	481,562	William Kirkpatrick.
1823	....	726,988	726,988	William Kirkpatrick.
1824	....	816,634	816,634	William Kirkpatrick.
1825	....	757,203	757,203	William Kirkpatrick.
1826	....	811,023	811,023	William Kirkpatrick.
1827	....	983,410	983,410	William Kirkpatrick.
1828	....	1,160,888	1,160,888	William Kirkpatrick.
1829	....	1,129,280	1,129,280	William Kirkpatrick.
1830	....	1,435,446	1,435,446	William Kirkpatrick.
1831	....	1,514,037	1,514,037	N. H. Earll.
1832	....	1,652,985	1,652,985	N. H. Earll.
1833	....	1,838,648	1,838,648	N. H. Earll.
1834	....	1,943,252	1,943,252	N. H. Earll.
1835	....	1,209,867	1,209,867	N. H. Earll.
1836	....	1,912,858	1,912,858	Rial Wright.
1837	....	2,167,287	2,167,287	Rial Wright.
1838	....	2,575,033	2,575,033	Rial Wright.
1839	....	2,864,718	2,864,718	Rial Wright.
1840	....	2,621,305	2,621,305	Thomas Spencer.
1841	220,247	3,120,230	3,340,767	Thomas Spencer.
1842	163,021	2,128,882	2,293,908	Thomas Spencer.
1843	318,105	2,809,395	3,127,500	Rial Wright.
1844	332,418	2,968,136	4,300,554	Rial Wright.
1845	353,455	3,408,903	3,762,358	Enoch Marks.
1846	331,705	3,507,146	3,838,851	Enoch Marks.
1847	262,879	3,688,476	3,951,355	Enoch Marks.
1848	342,497	3,994,629	4,737,126	Robert Gere.
1849	377,735	4,705,824	5,083,569	Robert Gere.
1850	374,732	3,894,187	4,268,919	Robert Gere.
1851	378,967	4,235,150	4,614,117	Robert Gere.
1852	633,595	4,288,938	4,922,533	Hervey Rhodes.
1853	577,947	4,826,577	5,404,524	Hervey Rhodes.
1854	734,474	5,068,873	5,803,347	Hervey Rhodes.
1855	498,124	5,584,761	6,082,885	Vivus W. Smith.
1856	709,391	5,257,419	5,996,810	Vivus W. Smith.
1857	481,280	3,830,846	4,312,126	Vivus W. Smith.
1858	1,514,554	5,518,665	7,033,391	Vivus W. Smith.
1859	1,345,022	5,549,250	6,894,271	Vivus W. Smith.
1860	1,452,565	4,130,682	5,593,247	Vivus W. Smith.
1861	1,884,697	5,315,549	7,200,391	Vivus W. Smith.
1862	1,983,022	7,070,852	9,053,874	Vivus W. Smith.
1863	1,437,656	6,504,727	7,842,383	Vivus W. Smith.
1864	1,971,122	5,407,712	7,378,884	Vivus W. Smith.
1865	1,886,760	4,499,170	6,385,930	George Geddes.
1866	1,978,883	5,180,320	7,158,503	George Geddes.
1867	2,271,892	5,323,673	7,595,565	George Geddes.
1868	2,027,490	6,639,126	8,666,616	George Geddes.
1869	1,857,942	6,804,285	8,662,237	George Geddes.
1870	2,847,691	6,260,422	8,748,115	George Geddes.
1871	2,464,404	5,910,492	8,374,956	John M. Strong.
1872	1,882,604	6,048,321	7,930,925	John M. Strong.
1873	1,691,359	5,768,998	7,460,357	John M. Strong.
1874	1,667,368	4,361,932	6,029,300	A. C. Powell.
1875	2,655,955	4,523,491	7,179,546	A. C. Powell.
1876	2,308,679	3,083,998	5,392,667	A. C. Powell.
1877	2,525,335	3,902,648	6,427,983	A. C. Powell.
1878	2,788,754	4,387,443	7,176,1[illegible]	[illegible]ell.
1879	2,957,744	5,364,418	8,322,162	A. C. Powell, eight months. C. G. Hinkley, four months.
1880	2,516,485	5,482,265	7,998,750	N. Stanton Gere.
1881	3,011,461	4,905,775	7,917,236	N. Stanton Gere.
1882	3,032,447	5,307,773	8,340,180	N. Stanton Gere.
1883	2,470,533	5,432,439	7,902,972	P. J. Brummelkamp.
1884	2,353,860	4,588,409	6,942,259	P. J. Brummelkamp.
1885	2,439,332	4,494,967	6,934,299	P. J. Brummelkamp.
1886	2,772,348	3,329,409	6,101,757	P. J. Brummelkamp.
1887	3,118,974	2,576,823	5,695,797	P. J. Brummelkamp.
1888	3,115,314	2,542,053	5,657,367	P. J. Brummelkamp.
1889	2,916,923	2,448,138	5,365,061	P. J. Brummelkamp.
1890	2,726,471	2,201,651	4,928,122	P. J. Brummelkamp.
1891	2,113,727	1,735,186	3,948,914	P. J. Brummelkamp.
1892	3,122,789	1,282,885	4,405,674	P. J. Brummelkamp.
Total amount since 1797	85,852,095	270,570,483	356,422,095	

Or about 142½ million cubic feet (nearly ten millions tons of 2,000 pounds each).

This table gives the amount of salt inspected by the State officers for each year, but not the amount actually made, in other words the amount of salt sold in each year.

SYRACUSE SALT MANUFACTURERS

Fine Salt

F. Beagle & Co.
L. Gleason
C. A. Stilwell
Edward Lynch
William J. Killian
Andrew Martin
Michael R. Hayes
James Salmon
A. L. Mason
Martin Salmon
H. H. Freeman
John Maloney
M. Prell
P. Prendergast

Solar Salt

Western Coarse Salt Co.
James M. Gere
Theo. L. Poole
Draper & Porter
W. B. Boyd
Turks Island Coarse Salt Co.
Geddes Coarse Salt Co.
W. & D. Kirkpatrick
Foster Ely
Union Coarse Salt Co.
Cape Cod Coarse Salt Co.
L. Stevens & Co.
Syracuse Solar Salt Co.
Empire Coarse Salt Co.
Salina Coarse Salt Co.
S. Jaquett & Co.
Salina Coarse and Fine Salt Co.
Robert Young
Thomas Gale
Highland Coarse Salt Co.
C. B. Murray
Phillip Corkings
John White & Co.
Salt Springs Solar Coarse Salt Co.

Soaa Ash Manufacturers

Solvay Process Co., Geddes, N. Y. Wells at Tully.

THE GYPSUM INDUSTRY OF NEW YORK STATE

By William C. Clarke, E. M.

Gypsum is the sulphate of lime and contains lime 32.6%, sulphuric acid 46.5%, water 20.9%. Its specific gravity when pure varies between 2.314 and 2.328.

The crystallized variety is known as selenite. The pure mineral is $CaSO_4 + 2_2H_2O$. Oxides of iron and silica are also present. The crystalline variety occurs in the quarries in but small quantities. It has a pearly lustre and a cleavage similar to that of mica and splits into very thin plates. The pure massive mineral resembles marble in texture and color and is quarried under the name of alabaster.

When exposed to a heat of not over 260° F. gypsum loses its water of crystallization and if reduced to powder it has the property of recombining with water when mixed with it and forming a solid mass. This recombination does not take place if the material is overheated.

The geological occurrence of gypsum has already been described and its geographical distribution is shown on the accompanying map.

Selenite and anhydrite have been found in Niagara Co. near Lockport.

The gypsum occurs in beds of considerable regularity, plainly showing in places its original deposition from water. No evidence of gypsum can be found east of Hobokenville, Madison Co. Toward its eastern limit the gypsum is of a much darker and earthy type. The dark color of the gypsum is said to be due to the presence of carbonaceous matter and not to metallic oxides, but it is probable that the whiter variety of the west will analyze much higher in pure gypsum than the darker and more earthy gypsum of the east end of the belt. It is noted in quarrying the mineral that the dark variety is not usually covered with much rock and can be found at a comparatively small depth by removing the overlying drift, while the white variety is quite generally heavily capped with rock, is found at a considerable depth, is not nearly as thick as the dark kind and is worked entirely underground. This is probably due to the inferior solubility of the earthy variety.

The following parties quarry gypsum in New York state:

Cyrus Warlock,	Perrysville,	Madison Co.
Irving Tuttle,	Hobokenville,	"
R. D. Buttons,	Cottons,	"
L. D. Sherman,	Marcellus Falls,	Onondaga Co
Lansing & Son,	Fayetteville,	"
W. W. Condee,	"	"
A. W. Edwards,	"	"
Richard Rod,	"	"
F. M. Severance, Mgr.,	"	"
Robert Dunlop,	Jamesville,	"
Simon Reals,	"	"
A. E. Alvord,	Syracuse,	"
Cayuga Plaster Co.,	Union Springs,	Cayuga Co.
A. D. Miller,	Phelps,	Ontario Co.
Ezra Grinnell,	Port Gibson,	"
Theodore Conover,	Victor,	"
Samuel Weeks,	Garbuttsville,	Monroe Co.
J. W. Garbutt,	"	"
Wheatland Land Plaster Co.,	Mumford,	"
—— Olmstead,	Oakfield,	Genesee Co.
S. Gilmore,	Indian Falls,	"

Of these the Cayuga Plaster Co. operates on the largest and most approved scale; their openings are the largest, their deposit is extensive and the work is conducted in economical and sound business principles. The deposit controlled by Mr Severance at Fayetteville is the largest so far as actual thickness is concerned, and the same is nearly true of the Mr Lansing's adjoining bed. The gypsum of Mr Olmstead's quarry at Oakfield is the whitest and apparently the purest, closely followed by that operated by the Wheatland Land Plaster Co. The most westerly deposits are found at some depth and are worked underground, while in Ontario Co. and to the east the gypsum is all worked in open cuts.

DESCRIPTION OF GYPSUM QUARRIES

The most extended operations in the quarrying of gypsum in New York are now being conducted by the Cayuga Plaster Co., whose offices are at Union Springs. The plant is on the Lehigh Valley R. R. at the junction of the Cayuga branch and the Auburn branch. The mills are near the tracks and shipping facilities are excellent. The beds have been worked more than 50 yrs. The work at present is being conducted on the S. E. dip of a roll or fold. The slate and crane rock are used for making and maintaining the roads of the quarry. The gypsum is covered by earth varying in thickness from a few feet to 20 or 25 ft. The gypsum is rarely covered with rock although in one old opening two or three feet of a water lime were visible. The dirt is "stripped" and removed to the dump heap, and the "plaster rock" is worked from projecting caps to the limestone below. The gypsum is drilled with ordinary jumper drills, the holes are fired with black powder and the blocks broken up by sledges. The material is carted in one horse carts and piled up in store houses near the mill ⅛ of a mile distant, ready for grinding. The mill begins running in January and runs about 7 months now, although they have in the past worked continuously and even in double shift.

In working to the north an underground water course was struck and work was begun in a S. E. direction in which position they are now driving, the deposit having been proved in that direction. To show the greater regularity and persistence of this bed the fact may be mentioned that in searching for the gypsum no particular attention is paid to knolls or rises of ground as at other localities, but the attack of the deposit goes steadily on without reference to surface inequalities, the gypsum being found regularly in depressions as well as on knolls, although not so thick. The amount quarried this year by the company as stated by the secretary of the company would be 10,000 or 12,000 tons. Their product has fallen off considerably in late years, due to causes which I will try to explain later on. The selling price of the plaster F. O. B. is $2.50 per ton ground. The company ship either in bulk or in bags and either in the lump or ground, the latter of course costing more. It is said that the company ships most of this plaster to other sections of the state and also to adjoining states. The plaster is all of one grade and is called Cayuga Land Plaster. A fair day's work for the mill is 50 tons, but this can be increased considerably if necessary. Mr C. T. Backus of Union Springs is the president of the company. Mr Amos Clark of Union Springs is the treasurer.

The operation of the mill is as follows: The gypsum is first put through a Blake crusher, crushing to egg size and smaller. Thence it goes to the "cracker" which is of the coffee mill type of grinder. It is then elevated by conveyors of the link belt type to a hopper; from this the material goes to the burr stones, which crush it to a powder which is grayish white in color. This powder is then conveyed to a large store room and when this room is full a conveyor transports the material to another large store room. From the store room the plaster is loaded on small cars, weighed and run into railroad cars for shipment. At present the material is all used for fertilizer. Mr Backus states that he intends to experiment on calcining his gypsum in the near future. The regular force of employees is 18 or

20, their pay being $1.50 per working day. The plaster is easily handled, breaking up with hammer and sledges along planes of cleavage into masses resembling paving blocks. A few small faults are observable in the workings and slips are frequent. The general color of the quarried gypsum or "rock" is gray, with plates of selenite coating the blocks and more or less intermingled with the impure mineral. Large crystals are occasionally found. The weather has a disintegrating effect on the gypsum tending to break it up into dirt and small pieces which are thrown away as only the blocks are carted away for grinding. The burr stones for fine grinding are in five sets, three sets being 3½ ft. in diameter and the remaining two sets 4½ ft. in diameter and all about 10″ thick. The 3½′ set have the understone running, while in the 4½′ set the upper stone runs. The latter is a new arrangement and is claimed by some to give better results than the under run. It may be stated that the store houses before mentioned serve also as drying houses, the considerable amount of moisture present in the stone when taken out preventing the best results in grinding. The burr stones are notched or ground to allow disposal of the crushed stone. 40 ft. of thickness is the maximum reached in this quarry and that is in an old working. 8 ft. of top rock and 8 ft. of bottom rock with about 3 ft. of shale is being worked at present. This varies however with the rise and fall of the surface. Several old quarries are found in the vicinity that are known as the Fitch and Patterson quarries, neither are working, however, although at the Fitch quarry a little gypsum was ground last winter.

The next point west where quarrying is done is in the town of Phelps, by A. D. Miller. He has a mill which runs with water. His price is $2.75 per ton. The quarry is on Canandaigua outlet and is well exposed, making the attack very easy.

The next point west is Victor where Theodore Conover has a quarry some distance from the village. He has a mill worked by steam. His gypsum sells for $3 per ton to phosphate companies and $4 per ton to the retail trade.

At Port Gibson, which is about 4 miles from Mr Miller's quarry and mill at Phelps, and to the north on the border between Ontario and Wayne Cos., Mr Ezra Grinnell has a quarry of plaster and a mill worked by water. Mr Grinnell has not worked any this year. The characteristic of this rock is that it is disseminated with crystals of gypsum or "isinglass" as it is locally called. The plaster is found in the bed of a stream near Mr Grinnell's residence. The greatest thickness he has worked is 18 ft. The stream is diverted for the use of a mill leaving the bed in condition, to work with some pumping. Large blasts are put in and a large amount of rock is loosened at a blast.

The next locality west where plaster is quarried is in Garbuttsville in Monroe Co. where Mr Samuel W. Weeks and Mr J. W. Garbutt are operating. The quarries here are all underground, and the product is known commercially as Caledonia White Land Plaster. Mr Weeks is at present operating only one pit but two have been worked this year. The pit now working was dug last spring and the shaft is 53 ft. deep. The thickness of the plaster rock varies between 4 and 8 ft. averaging perhaps 6 or 7 ft. The material is a gray plaster. Mr Weeks does a business of about 2000 tons per year. FF black powder is used for blasting and wheelbarrows are used for handling the product underground. The rock above the plaster is a kind of water lime and the rock under is a lime stone. A few feet below a second plaster bed is known to exist. These beds are known in places but they are run out in places to two, one or none. Short drills are used. The product is drawn to the mill in wagons. The gypsum is harder towards the bottom layer and is sometimes difficult to loosen from the associated rock. The bottom layer of gypsum or "hard plaster" will average from 18 ft. to 20 ft., then comes a bed from 14 ft. to 18 ft. thick, both of these are more or less whitish in appearance.

The rest is gray plaster to the roof, sometimes solid and sometimes interrupted by much loose dirt and by hollows. The mill is run by steam power.

Mr John W. Garbutt operates 3 pits and works 20 men in the season. His capacity is about 4000 tons per year his pits being operated similar to Mr Weeks'. His shafts however are only from 25 to 30 ft. deep and he operates the second bed only, his bed running about 6 ft. thick. According to Mr Garbutt gypsum has been worked in this locality for 80 years. He states that the presence of three plaster beds here is well known their respective thicknesses being about 6 ft.

Mumford, the next gypsum locality to the west, is only a few miles from Garbuttsville. The rock quarried is whiter than at Garbuttsville. The Wheatland Land Plaster Co. owns three pits here, of which two are now working. The officers of the company are Sylvester Brownell, President; W. D. Strobell, Treasurer; Warren H. Pease, Secretary. The other members of the company are D. P. Campbell and George C. Haaly, all residents of Mumford. The product for October and November, 1892, each, was 380 tons. Four men are employed at each pit and 3 men in the mill. This company has just begun to operate this year, although these quarries have been worked before some years. It expects to do a business of some 10,000 tons per year when well started, the present capacity being about 5,000 tons per year. The plaster rock will average 6 ft. in thickness, the roof being of water lime which is solid. The existence of three plaster beds here is confidently believed. The plaster is very flat here; wheelbarrows are used to handle the material. Four men are the regular force in each pit. In a new pit dug recently, considerable difficulty was met with in the quantity of water, so it was closed up until dry weather, when it is proposed to operate it. The beds run as follows: 18 ft. of hard bottom, 18 ft. of white gypsum, and the rest up to about 6 or 7 ft. is mostly gray. Sometimes the stone is solid with the roof; sometimes "ashes" or earthy gypsum are found up to perhaps 2 ft. in thickness. The mill which the company have put up is a new one this year. The material is broken into suitable pieces with sledges, is then put through a crusher, from which it is elevated to a set of burr stones. From these it is carried by an elevator to hoppers where it is weighed automatically and is dropped through a chute into cars. The material is largely shipped to Buffalo the local trade being small. The amount paid to miners is 60 cents per ton on the bank, the powder being provided by the company. Some dynamite of a low grade is also used. A twist drill was noticed in one of the pits and the quarrymen rather like its operation and ease of working. No. 1 shaft has been worked for several years. No. 2 was opened this year and No. 3 is not yet completed.

No. 1 pit is about 200 ft. from the No. 2, and No. 2 about 100 ft. from No. 3. The ground plaster of this company is of excellent quality and color and the deposit will probably be operated in future on a larger scale.

The next point west is Oakfield in Genesee Co. There are three plaster quarries here owned or leased by Mr Olmsted of Oakfield. Only two are working, both underground. They are almost 1½ miles north of the village. The most easterly pit is worked by four men. The shaft is 8 x 12 and 31 ft. deep. A former owner ran a tunnel to the north which is now closed up. There are two tunnels at present, one 75 ft. long, the other 55 or 60 ft. long. These are separated 80 or 85 ft. at the ends. The 55 ft. tunnel is at present being worked. The deposit is only about 4 ft. thick, not so much as this in many places. The only timbering is a few short stalls. The rock is very much the whitest plaster rock seen in New York, and when ground is like flour. The material is loaded in flat cars running on a track made by laying stringers and nailing cross pieces, and covering with hoop iron. This lessens the labor of handling and increases the output. At the bottom of the pit the material is loaded into an iron bucket fastened to an iron chain which is operated by a horse whim and derrick at the surface. Mr Olmsted states that the second plaster bed is about 15 ft. thick and lies over 100 ft. below the surface. He expects to drill for the second plaster bed and may work it. He is at present experimenting in calcining his gypsum for stucco, the material calcined and mixed with water setting in 10 minutes to a very hard, compact mass. A favorite place for prospecting for gypsum is on the knolls or rises in ground; in fact this custom is very generally adopted throughout the state in working gypsum deposits. The capacity of Mr Olmsted's pits is about 15 tons per day. Mr Olmsted claims 90% of pure gypsum in his rock.

Two miles and a half south of Alabama Station, W. S. R. R. in Genesee Co. Mr Gilmore quarries some gypsum in the Tonawanda Indian reservation. Last year he quarried about 200 tons. This is the most westerly locality where gypsum is worked.

At Halfway, town of Elbridge, Onondaga Co. Mr Kennah owns a quarry of plaster but has not worked it for two years.

At Marcellus Falls in Marcellus township, Onondaga Co. about 2 miles from the station, Mr L. D. Sherman produces 200 to 300 tons of plaster per year. His quarry is along the railroad not far from the station.

Two miles and a half south of Syracuse is a plaster quarry owned by A. E. Alvord of Syracuse. The quarry is worked open and the caps are exposed by stripping some 8 or 10 ft. of drift. The gypsum is about 30 or 35 ft. thick.

It may be stated that about all the rest of the good plaster in Onondaga Co. outside of the Syracuse bed just mentioned lies in the town of De Witt. The material is known as Onondaga Land Plaster. All combined the product obtained from the vicinity of Fayetteville will make the second largest producer of plaster in New York state.

Mr H. H. Lansing has 24 acres of plaster now working and 50 acres not yet worked. He produces about 2,000 tons per year.

Mr Clark Snook owns a quarry near Mr Lansing's but this is not in operation.

Bangs & Gaynor own a quarry adjoining Snook's but have not done any quarrying for some time. At present they are only buyers and millers, buying largely of local producers and shipping to points at a distance.

F. M. Severance is working a quarry on the Wm. Heard estate. This has the greatest consecutive thickness of gypsum rock in the state, the adjoining quarry of Mr Lansing's perhaps equaling it in places. A detailed report of this property will be found later as it is extensive and valuable property.

The Adamant Plaster Co. of Syracuse has a quarry adjoining Severance's but as yet has done no work in it. These quarries contain the best material of this section, the other quarries in the vicinity yielding a more earthy, darker and poorer variety.

Simon Reals states that he quarried 600 tons last summer He does not grind, but sells to Weston & Alvord in Kamesville for grinding. Mr Reals works a 9′ bed on top and a 3′ and a 6′ on bottom with shale between each bed.

Mr Robert Dunlop of Jamesville does a business of perhaps 2,000 tons yearly.

W. W. Candee owns a quarry on Dutch Hill road about ½ mile west of Lansing's quarry. He works 9 ft., 5 ft. and 3 ft. This plaster is quite dark in color. James Rehan of Manlius and T. W. Sheedy of Fayetteville own quarries adjoining each other not worked at present and probably will not be unless trade revives and prices hold better. Their rock is not well thought of locally.

Mr George Taylor owns a small quarry of dark plaster from which he occasionally produces a few tons.

The same may be said of the quarries owned by Richard Tod and A. W. Edwards. Horace Wheeler and Amos Clark each own quarries of same kind as above. All of the last five mentioned are on the other side of the railroad from the plaster and all lie in the town of Manlius. I believe Mr Edwards said he quarried 300 tons this year from 9 ft. and 5 ft. beds.

Mr Severance states that he believes the plaster business of the section will improve because he believes the wall plaster people will eventually use the material near at hand and thus save heavy expense although the material may be less pure and darker colored than the material now used. As to the cost of obtaining the rock he stated he could quarry for 15 cents per ton when the stripping was off. From that figure the cost might vary to 25 cents per ton and occasionally as high as 50 or 60 cents per ton. The cost of carting to the canal is given as 20 cents per ton.

At Hobokenville 2 miles south of Wampsville on the N. Y. C. Mr Irving Tuttle does a small business in land plaster. He has a quarry on his own farm which however he does not work. His gypsum is obtained from the quarry of John Stisser and is dug by Mr Tuttle. B. F. Winchell also has a quarry from which he digs stone himself and sells to Tuttle. The total product which Tuttle grinds is about 200 tons per year. The plaster is of fair quality and is sold for local use.

Mr Cyrus Werlock of Perryville owns a quarry about 1 mile from Cottons on the E., C. & N. R. R. His quarry is quite large and the gypsum of fair quality.

R. D. Buttons near Cottons has a quarry of plaster from which he gets perhaps 800 tons yearly.

The following brief synopsis of the qualities, etc. of the rock operated by F. M. Severance is submitted. This quarry as stated is on one of the largest, certainly the thickest, and one of the most persistent of the plaster beds in New York state.

The gypsum is in some places 60 ft. thick and is divided into eight well marked layers varying in thickness from eighteen inches to thirty feet. The deposit is covered with some 30 or 40 ft. of shaly rock and limestone. The amount of gypsum ($CaSo_4$) is greatest in the crystalline layers and least in the brown layers. The rock varies in color from light drab in the cap to a dark brown and all layers appear to become lighter from weathering. The so called slate consists of fibrous, scaly and other forms of crystalline gypsum and is essentially the purest gypsum of the series. The composition is stated to be by analysis:

1	Calcium sulphate	80–90%
2	Calcium carbonate	trace
3	Magnesium carbonate	5% or less
4	Clay	10% or less

The amount of carbonates appears to be the greatest in the brown layer showing effervescence in the mass and considerable also in the cap. It is least in the crystalline mass or slate beds. The rock appears to be suitable for plaster of Paris or stucco for walls as samples shown were hard and not brittle. Where whiteness is essential the material cannot be used as the material has a gray color.

As to the actual tonnage of gypsum per year the following is an approximate list:

Cayuga Plaster Co	10 to 12,000	tons
Wheatland Land Plaster Co.	5,000	"
J. W. Garbutt	4,000	"
Samuel Weeks	2,000	"
Olmsted	2,000	"
F. M. Severance	4,000	"
Lansing & Son	2,000	"
Robert Dunlop	2,000	"
All others not exceeding	4,000	"
Approximate tonnage max	37,000	"

Value of product ranges between $2.50 and $4.00 per ton. Taking $2.75 as a fair average the value of the product or the selling price is about $100,000. The gypsum business is not as a general thing conducted on an all the year round basis. The quarrying is to a large extent done by farmers who work their farms in the season and employ their hands in the quarries when there is little farm work to do. This may account to some extent for a variation in the tonnage each year. No trouble with water is experienced. The employment of skilled miners with modern and improved implements would effect great economy in the cost of producing the gypsum. Even the use of a light track of hoop iron and small cars would be of advantage in transportation. The introduction of steam drills, the drilling of larger holes, and the use of larger blasts would increase the output greatly with the same force of men. It is well known that a considerable amount of the plaster goes into the composition of the high grade fertilizers. With the increase of the adamant wall plaster business there will probably be an increase over present production of the gypsum business of New York state but as this business is hardly well started yet the effect may not be noted for some time.

THE USES OF GYPSUM

(1) On land.

The advantage claimed is the increase it gives to many crops to which it is applied, the ease with which it is applied and the small amount which is required, also the cheapness of the article. The manner of action is said to be as follows; the plaster acting as an indirect fertilizer: Ammonia is an alkali capable of decomposing plaster and forming with the acid the sulphate of ammonia. Ammonia is an important element of plant food, is produced in the decomposition of organic bodies, and being a gas lighter than air it is difficult to hold. The sulphate of ammonia is not volatile and is kept in the soil ready for use. The lime is supposed to combine with the carbonic acid which is in the air and is also formed by decomposition, forming carbonate of lime. The ammonia is supposed to be washed out of the air by rain and to come into contact with the plaster. The potash of the surface soils largely formed in dry seasons is also supposed to combine with the sulphuric acid in the gypsum and form sulphate of potash. Plaster may be used on land for crops of wheat, oats, rye, buckwheat, corn, potatoes and other root crops. It is said to be particularly valuable as a top dressing for clover and timothy.

(2) As a deodorizer, and on compost heaps as an absorbent of the ammonia and in cities and towns to allay the pungent odors of stables, privies and drains.

(3) As the basis or foundation of the adamant or hard plaster for walls, stucco, reliefs etc. (for method of calcining and boiling see article in Grand Rapids *Democrat*, Mich., Nov. 6, 1892). Three companies, the Eureka, the Paragon and the Adamant companies of Syracuse are at present engaged in the manufacture of this hard wall plaster.

As is well known, $CaSo4+2H_2O$ when subjected to heat or "boiling" in kettles will lose its water of crystalization if heated to a certain point. The product when ground and mixed with water sets to a hard, firm mass. Various ingredients are used according to the patent, the processes being recent ones, but it is known that among the hardeners of gypsum are lime-water, gum-arabic, alum, borax and cream of tartar. Whether any of these are used could not be ascertained. The advantages claimed for this wall plaster is that it is hard, durable, fire proof, sets quickly and does not need covering with wall paper. A disagreeable feature is that it is a good conductor of sound, and makes slight noises audible, arising probably from the solid and homogeneous nature of the wall.

The Adamant Manufacturing Co. is the largest of the three concerns and has a capital stock of $150,000. The patent and invention were the work of Prof. Carl Straub of Syracuse. The advantages claimed for this stone by the company are: that it is "cleanly and easy to work, takes a beautiful polish, can be applied winter as well as summer, frost not affecting it. It prevents swelling or cracking and never falls off; it adheres equally well to lath, brick, stone, or iron, and will not cleave off even in case of breakage of water pipes or heavy leakage; its resonant properties render it desirable for churches, halls, opera houses, etc.; it is impervious to rats, does not harbor vermin or the germs of disease, as it is not porous; it can be frescoed, papered, painted, etc. and costs but little more than ordinary hair and mortar plaster." If half of these qualities are real it would seem the company have a good article for sale.

The use of gypsum as the basis of wall plaster is noted not because the gypsum of New York is used in the process (it is not so far as known) but because of a well founded belief among quarrymen that the manufacturers will be compelled to get their raw material near at hand in the future. Also because Mr Olmsted of Oakfield has a stucco works in the experimental stage.

INDEX

The superior figure tells the exact place on the page, in ninths; e. g., 53^4 means four ninths of the way down page 53.

DR

r Morris,

University of the State of New York, State Museum Bulletin No. 11.

TABLE OF SALT WELL AND SHAFT SECTIONS IN NEW YORK.

N. B. The sections at the Greigsville shaft and the Ludlowville and Dundee wells are omitted for want of accurate information.

GOWANDA, CATTARAUGUS COUNTY — (Bishop).

	Feet.
Soil	0
Shale	450
Sand, with oil and gas	4
Shale to "second sand," when more oil and gas were found	450
Shale	390
Hard rock (corniferous and Helderberg)	400
	1,700

EDEN VALLEY, ERIE COUNTY — (Bishop).

	Feet.
Shale	125
Blue hard rock	200
Black slate	300
Flint, lime and sand	400
Brine in salt rock at 1,075	50
Total depth	1,750

EAST AURORA, ERIE COUNTY (Bishop).

	Feet
Shales, black and light colored	695
Corniferous limestone	165
From corniferous to salt	605
	1,465

GARDENVILLE, ERIE COUNTY — (Bishop).

	Feet.
Marcellus shales	60
Limestones (upper and lower Helderberg)	205
Shale to Niagara limestone	535
	800

LEROY, GENESEE COUNTY — (Bishop).
*(Surface height, 875 feet.)**

	First well, ft.	Second well, ft.
Soil, etc	23	22
Marcellus shale	10	11
Corniferous limestone	150	137
Water-lime (hydraulic limestone)	40	440
Soft rock, saline shales	427	
	650	610

BATAVIA, GENESEE COUNTY — (Prosser).
*(Surface height, 805 feet.)**

	Feet.
Drift	40
Marcellus shale	60
Helderberg Limestones	150
Salina group	500
15 inches salt 600 feet below surface.	
Niagara	250
Medina	1,000

ATTICA, WYOMING COUNTY — (Bishop).
*(Surface height, 983 feet.)**

	Feet.
Soil	200
Slate, Hamilton	375
Corniferous limestone	150
Limestone (lower Helderberg) about	300
Slate	104
	1,135

At 1,490 feet some salt in rock till 1,500 feet. Total depth, 1,900 feet. For more details see Bishop's Salt Fields of Western New York.

LEHIGH SALT MINING CO., LEHIGH, GENESEE COUNTY.
*(Surface height, 918 feet.)**

	Feet.
Soil	50
Shale	100
Corniferous limestone, with flint	150
Hydraulic limestone	30
Cement stone	20
Gypsum	100
Gypsum, shale and limestone in layers four inches to six inches thick	250
Salt and shale	75
Rock salt	30
	805

JUNCTION OF THE E. & P. WITH D., L. & W. R. R., GENESEE COUNTY — (Bishop).
*(Surface height, 953 feet.)**

	Feet.
Gravel	46
Shale	192
Corniferous limestone	146
Lower Helderberg limestone	464
Pure salt (41)	40
	878

PAVILION SALT CO., PAVILION, GENESEE COUNTY — WELL NO. 2 — (R. D. White).
*(Surface height, 935 feet.)**

	Feet.
Soil	50
Soft limestone	375
Corniferous limestone	150
Soft limestone	375
Shale	50
Salt and shale, mixed	19
Salt mixed with some shale	100
	1,119

Bottom in shale rock.

MOULTON WELL, WYOMING COUNTY — (Th. Avery).
*(Surface height, 946 feet.)**

	Feet.
Soil	3
Sand, etc.	50
Slate and soft rock	50
Shale	452
Corniferous limestone	152
Slate, indications of salt brine	60
Limestone, salt brine	323
Slate	34
Shale and rock salt	27
Rock salt	85
Slate	5
	1,241

PIONEER WELL, WYOMING COUNTY — (C. H. Matthews).
*(Surface height, 992 feet.)**

	Feet
Soil and clay	40
Bluish shales	40
Black shales	220
Limestone	10
Slates of variable color	363
Limestone	100
Corniferous limestone, bitter water below	92
Gypseous shales	405
Rock salt at 1,270 feet	70
Red shale	190
	1,530

SALT VALE NO. 1, CRYSTAL SALT COMPANY, WYOMING COUNTY — (Bishop).
*(Surface height, 983 feet.)**

	Feet.
Sand, gravel and quicksand	136
Shale	634
Corniferous limestone	146
Shale	15
Upper and lower limestone	304
Shale and salt	50
Solid salt	01
	1,436

MILLER WELL, WARSAW, WYOMING COUNTY — (Bishop).
*(Surface height, 1,099 feet.)**

	Feet.
Shale, Lower Portage and Hamilton	935
Corniferous limestone	147
Shale	12
Lower Helderberg limestone	400
Shale and salt	80
Solid salt	85
	1,659

ATLANTIC SALT COMPANY, WARSAW, WYOMING COUNTY — (Th. Avery).
*(Surface height, 1,064 feet.)**

	Feet
Surface soil, clay, etc	26
Shale	874
Corniferous limestone	148
Limestone, shale and salt	440
Rock salt	57
Red shale (or sandstone)	104
	1,649

WARSAW SALT COMPANY, WARSAW, WYOMING COUNTY — (Englehardt).
*(Surface height, 1,098 feet.)**

	Feet.
Surface soil, clay	18
Shale	940
Corniferous limestone	156
Lower Helderberg and shale	430
Shale and salt, mixed	30
Salt	0
Shale	10
Salt	70
	1,658

DR. W. C. GOUINLOCK, WARSAW, WYOMING COUNTY — (Th. Percy).
*(Surface height, 1,122 feet.)**

	Feet.
Clay	17
Shales	1,011
Corniferous limestone	148
Shales	75
Lower Helderberg limestones	300
Shales	45
Salt and shale, mixed	37
Main salt bed	68
	1,701

GOUINLOCK AND HUMPHREY, WARSAW, WEST SIDE OF THE VALLEY — (Bishop).
*(Surface height, 1,322 feet.)**

	Feet.
Shales	1,230
Corniferous limestone	150
Struck salt at	1,808
Salt and shale	10
Shale	3
Salt and shale	12
Salt	24
Shale with a little salt	2
Salt	10
	1,879

BRADLEY, WARSAW, WYOMING COUNTY — (Th. Percy).
*(Surface height, 1,320 feet.)**

	Feet.
Soil	9
Shale (sandstone)	450
Slate	850
Corniferous limestone	225
Flint rock	70
Lower Helderberg	365
Salt	64
"Pocket"	10
	2,089

ROCK GLEN (ALEX. KERR, BRO. & CO.), WYOMING COUNTY — (Bishop.)
*(Surface height, 1,312 feet.)**

	Feet.
Soil, etc	128½
Sandstone and shale	1,361½
Corniferous limestone	140
Lower Helderberg	335
Salt	26
Shale	81
Salt	40
	2,111

PERRY, WYOMING COUNTY — (Bishop).
*(Surface height, 1,335 feet.)**

	Feet.
Slate	1,462½
Limestones	580
Salt and shale	10
Solid salt	15
Slate with little salt	40
Salt and shale in about equal parts	30
Solid salt	25
Slate	18
	2,180½

DUNCAN SALT CO., SILVER SPRINGS, WYOMING COUNTY — (Bishop).
*(Surface height, 1,354 feet.)**

	Feet
Gravel and quicksand	222
Slate and sandstones	1,299
Corniferous limestone	140
Limestone (Helderberg)	320
Slate	128
Salt and shale, mixed	15
Pure salt	10
Slate	45
Salt, pure	75
	2,254

CASTILE, WYOMING COUNTY — (Bishop).
*(Surface height, 1,367 feet.)**

	Feet
Soil	49
Argillaceous sandstone 175 or	180
Blue shale, nearly uniform in color and hardness	780
Flint shell	10
Building-stone, nearly like the first	650
Black shale, nearly like coal, lower part much darker than upper (Marcellus shale)	100
Corniferous limestone	140
Alternate layers of hard and soft rock, two-thirds of which was as hard as flint and the rest shale	320
Soft slate saturated with brine	100
Salt and shale mixed, some salt crystals	35
Clear salt	45
Slate	40
Salt and slate, five feet of which was salt	70
	2,525

GAINESVILLE SALT COMPANY'S WELL, GAINESVILLE CREEK, WYOMING COUNTY — (R. D. White).
*(Surface height, 1,010 feet.)**

	Feet
Soil	358
Soft rock	460
To corniferous limestone	1,875
Corniferous limestone	125
Helderberg rock	450
Pure salt	30
Shale	28
Salt	6
Shale down to Niagara	

BLISS SALT & OIL COMPANY, BLISS, WYOMING COUNTY — (R. D. White).
*(Surface height, 1,729 feet.)**

	Feet
Soil	65
To gas sand	580
First gas sand	40
Rock	525
Second gas and oil sand	100
Shale and black rock	400
Third gas sand	14
Black and white shale	286
Flint	100
Lime rock and flint (solid)	800
Salt (very pure)	56
Lime rock (solid)	
	2,956

NUNDA, LIVINGSTON COUNTY — (Mr. Hambly).
*(Surface height, 859 feet.)**

	Feet.
Blue shale	65
Black shale, with some gas	408
Argillaceous sandstone	10
Light-colored slate, with a small show of oil	478
Hard shell-rock	8
Slate	544
Iron pyrites	40
Corniferous limestone	210
Slate	182
Sand-rock	60
Salt and shale, mixed	10
Pure salt	35
Salt and shale, mixed	35
Black shale without salt	85
	2,226

CALEDONIA, LIVINGSTON COUNTY — (C. L. Goodwin).
*(Surface height, 918 feet.)**

	Feet
Surface soil	6
Marcellus shale	20
Corniferous limestone	148
Gypsum and shale	50
Hydraulic lime and Helderberg	151
Shales and rock	225
Saline shale (brine at 600 feet)	50
Salt	25
Rock	73
	748

YORK, LIVINGSTON COUNTY, YORK SALT COMPANY — (M. B. Gilman).
*(Surface height, 608 feet.)**

	Feet.
Clay	52
Hamilton shale	128
Corniferous limestone	140
Helderberg limestone	330
Red shale	10
Blue and green shales	84
Salt and shales, mixed	6
Salt	10
Shale	27
Salt	41
	828

PIFFARD, LIVINGSTON COUNTY, LIVINGSTON SALT COMPANY. — (Englehardt).
*(Surface height, 561 feet.)**

	Feet.
Soil, etc	183
Shale	77
Corniferous limestone	150
Lower Helderberg and shales	458
Salt	18
Shale	6
Salt	11
Shale	4
Salt	2
Shale	20
Salt	62
	991

PIFFARD, LIVINGSTON COUNTY, GENESEE SALT COMPANY — (Englehardt).
*(Surface height, 568 feet.)**

	Feet
Clay and gravel	64
Limestone and shale	180
Corniferous limestone	142
Slate	8
Gray lime (water-lime)	318
Slate and shale	107
Rock salt	13
Shale	24
Rock salt	6
Shale	7
Rock salt	58
Shale	4
	987

Brine of 68° Salometer at 708 feet.

PIFFARD, LIVINGSTON COUNTY, RETSOF MINING CO.
First well sunk on the property where the shaft is now.

	Feet.
Shale and slate	28
Shales, Hamilton	373
Corniferous limestone	140
Shale (water-lime)	68
Helderberg, upper and lower	332
Shale	80
Salt	4
Shale	12
Salt	18
Shale	82
Salt	68
	1,141

WELL SHORT DISTANCE ABOVE GENESEE COMPANY'S WORKS — (Englehardt.)

	Feet.
To rock salt	936
Rock salt	2
Shale	4
Rock salt	12
Shale	28
Rock salt	6
Shale	0
Rock salt	64
	1,051

PIFFARD, LIVINGSTON COUNTY — RETSOF MINING CO. (Ch. Coeber).
*(Surface height, 714 feet.)**

	Feet.
Encrinal limestone	8
Hamilton shale (Moscow shale)	40
Dark shales	98
Limestone	8
Ludlow shales (Hamilton shale)	216
Limestone	4
Marcellus shale	30
Corniferous limestone	2
Shale	1
Corniferous limestone	140
Onondaga limestone	1
Hydraulic limestone (water-lime)	18
Sandstone	14
Gypsum	4
Hydraulic limestone	35
Gypsum	47
Magnesian limestone (water-lime)	68
Hydraulic limestone	14
Blue shales	25
Helderberg limestone	10
Blue shales	12
Helderberg limestone	17
Limestone and sandstone	31
Hydraulic limestone	10
Limestone and cement	15
Hydraulic limestone	6
Blue shale	10
Red shale	12
Limestone	41
Red shale	5
Blue shale	12
Limestone	12
Salt shale	51
Rock salt	2
	1,012

GREIGSVILLE, LIVINGSTON COUNTY — (Ch. Coeber).

	Feet
Alluvial deposit sand, clay, etc	60
Rocks belonging to the Hamilton group	112
Limestone	10
Marcellus shale, etc	260
Corniferous limestone	150
Onondaga limestone	10
Water-lime	40
Gypseous shale	75
Red shale	12
Limestone	12
Green and red shales, alternating	269
Total depth to the salt	1,010
First salt vein, followed by shale	2
Second salt vein, with shale below	4
Third salt vein, with shale below	19
Fourth salt vein	58
Shale between salt veins	45
	1,138

ANOTHER WELL, THREE-FOURTHS MILES SOUTH.

	Feet
Alluvium	105
Hamilton shales	145
Limestone	12
Marcellus (etc.) shale	182
Corniferous limestone	148
Onondaga limestone	10
Water-lime	73
Gypseous shale	90
Green and red shale	275
First salt bed	19
Second salt bed	6
Third salt bed	6
Fourth salt bed	0
With shale between veins	63
	1,145

PHŒNIX SALT COMPANY, CUYLERVILLE, LIVINGSTON COUNTY — (Rev. Bipply).
*(Surface height, 568 feet.)**

	Feet
Soil, etc	184
Hamilton shales	286
Corniferous limestone	140
Water-lime and shale	500
Salt	4
Shale	3
Salt	28
	1,145

LACKAWANNA SALT COMPANY, MOUNT MORRIS, LIVINGSTON COUNTY — (Bishop).

	Feet.
Hamilton shale	600
Corniferous limestone	140
Lower Helderberg limestone and shale	463
Salt and shale, mixed	12
Salt, pure	23
Hard rock	20
Salt	75
	1,350

MOUNT MORRIS, LIVINGSTON COUNTY, ROYAL SALT COMPANY — (Graham).

	Feet.
Soil	191
Shale	479
Corniferous limestone	150
Water-lime	50
Lower Helderberg	250
Salina shales	170
Salt and shale, mixed	4
Salt	20
Slate	36
Salt (drills stopped in salt)	73
	1,423

LAKEVILLE, LIVINGSTON COUNTY, CONESUS LAKE SALT AND MINING COMPANY — (Bishop).
*(Surface height, 824 feet.)**

	Feet
Soil	54
Shale, lower part bituminous, with gas and some oil	454
Corniferous limestone	140
Helderberg limestone	335
Shale	6
Salt (very clear)	25
Soft shale	30
Salt 15 or	20
	1,053

LIVONIA WELL, BORED BY MR. TOWNSEND, ONE-HALF MILE NORTH OF LIVONIA.
*(Surface height, 1,008 feet.)**

	Feet.
Gravel	99
Sand and clay	250
Slate rock	95
.....	6
Sandstone	10
Slate rock	284
Flint rock	140
Limestone	345
Slate and salt	5
Salt	32½
	1,227½

LIVONIA SHAFT — (D. D. Luther).
*(Surface height, 1,083 feet.)**

	ft.	in.
Drift	64	
Hamilton shales and limestones	743	
Marcellus shales and limestones	54	
Corniferous cherty limestone	135	
Water lime	23	
Gypseous shales and limestones	321	
First salt in thin veins		
Shales and limestones with salt and gypsum in small proportion	21	
First salt bed 8 in. to 3 ft. thick		
Shale	4	
Shale, with salt in seams and veins	2	
Crystalline salt	2	
6 in. shale	1	
Salt with fragments of shale	11	
Salt	13	
Limestone	6	
Shale	1	6
Salt with fragments of shale	15	6
Limestone	2	
Shale with thin layers of salt	4	
Bottom of shaft	31	6
	1,481	6

DANSVILLE OIL, GAS AND MINING CO., DANSVILLE, LIVINGSTON COUNTY — (Mr. Burgess).

	Feet
Soil	20
Gravel	10
Hard gritty shale	70
Gritty slate	20
Dark sand like Bradford	15
Slate and shale	1,565
Hard limestone (dark color)	80
Hard "granite" (corniferous)	80
Hard limestone	40
Limestone (very hard)	200
Solid salt (dry rock)	60
Hard limestone	70
Crooked hole	10
	2,240

BRISTOL, ONTARIO COUNTY, AT MUTTONVILLE — (Y. W. Smith).

	Feet.
Shale about	550
Limestone about	450

Then more than 800 feet of shale and salt, with rock salt at the bottom — (Bishop).

CLIFTON SPRINGS, ONTARIO COUNTY — (J. S. Hanna).

	Feet.
Corniferous limestone	70
Limestone	6
Corniferous limestone	65
Hard sand-rock	12
Slates and shales	497
Salt (reported, but not there)	20
Shale and slate	40
	710

ITHACA, TOMPKINS COUNTY — (Prosser).

	Feet.	Depth of well, ft.
Lower Portage shales	340	340
Genesee shale	100	440
Tully limestone	30	470
Hamilton group	1,142	1,612
Marcellus shale	82	1,694
Corniferous limestone	78	1,772
Oriskany sandstone	13	1,785
Lower Helderberg limestone	115	1,900
Shale	344	2,244
First rock salt	24	2,268
Shale	6	2,274
Second rock salt	54	2,328
Shale	12	2,340
Third rock salt	17	2,357
Shale	31	2,388
Fourth rock salt	21	2,409
Shale	67	2,476
Fifth rock salt	42	2,518
Shale	24	2,542
Sixth rock salt	48	2,590
Shale	82	2,672
Seventh rock salt	42	2,714
Green shale	308	3,022
Mottled red and green shale	6	3,028
Green shale	157	3,185
	3,185	....

AURORA, CAYUGA COUNTY — (W. B. Cogswell).

	Feet.
Soil	5
Blue clay	10
Gravel and shale	95
Slate	245
Fine black sand	20
Slate (cased off at 485 feet)	110
Slate	15
Corniferous limestone	175
Slate (strong flow of brine, 500 feet)	30
Limestone (gives sand)	25
Slate	100
Gypsum (strong brine, 810 feet)	108
Salt rock, later found to be salt shale	60
Shale	45
Gypsum	25
	1,068

SYRACUSE, ONONDAGA COUNTY, DEEP STATE WELL OF 1884 — (Englehardt).

	Feet.
Red shales, followed by sand gravel, etc.	578
Niagara limestone and shales	72
Limestones and shales	345
Clinton iron ore	5
Shales	5
Shales, magnesian limestone with quartz particles first noticed	8
Shales with quartz and sand alternating	67
Red-brown sandstone alternating with gray, brown, green, etc., with shale	374
Sandstone of various colors predominating with some shale and slate mixed in layers	520
	1,960

For fuller particulars in regard to this well and the Gale well, see report for 1884.

CARDIFF, ONONDAGA COUNTY, SOLVAY PROCESS COMPANY — (Englehardt).

	Feet.
Hamilton shales	244
Corniferous limestone	148
Upper and lower Helderberg	352
Red shales	100
	844

JAMESVILLE, ONONDAGA COUNTY — (Englehardt).

	Feet.
Water lime and gypseous shales	587
Red shales	453
Stopped in the red shales at	1,040

TULLY, ONONDAGA COUNTY, SOLVAY PROCESS COMPANY — (Englehardt).

	Feet.
Hamilton shales	678
Marcellus shales	40
Corniferous limestone	150
Water-lime	60
Helderberg limestone	294
Rock salt	47
	1,259

GREEN POINT, ONONDAGA COUNTY, "GALE" WELL. — (Englehardt).

	Feet
Red shale	586
Niagara limestone and shales	60
Limestone and shales	871
Clinton ore	10
Shales with some limestone	10
Dirty brown and gray sand-mixed quartz first noticed	4
Shales, sandstone and quartz alternating	55
Sandstones and shales of various colors mixed with quartz, etc., to bottom of well	545
	1,600

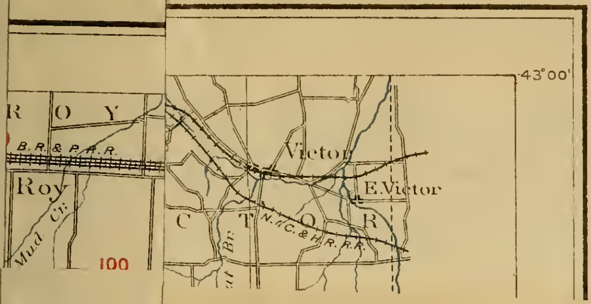
MORRISVILLE, MADISON COUNTY — (Prosser).

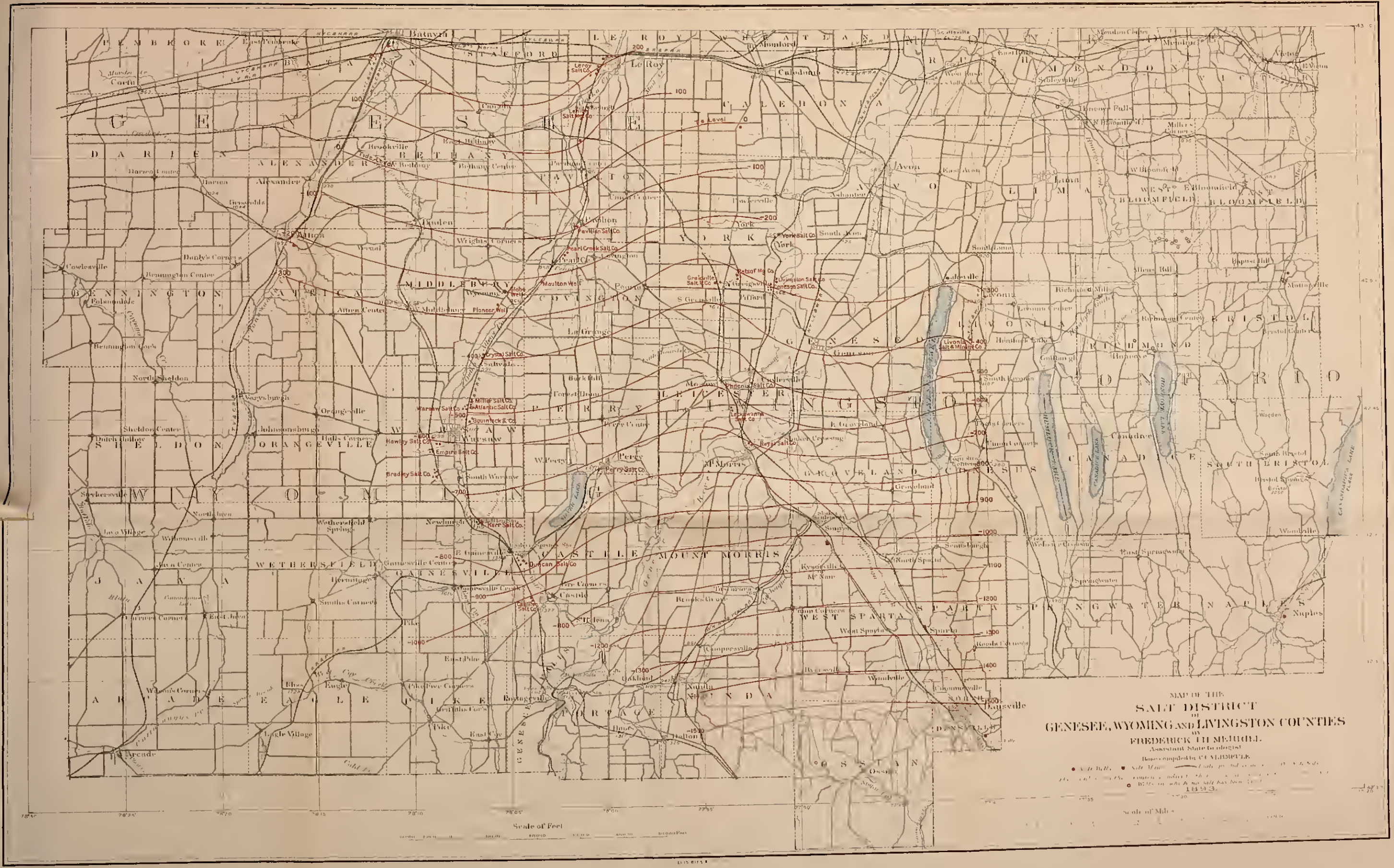
	Feet.	Depth.
Hamilton shales	340	340
Marcellus shales	31	371
Corniferous limestone	70	441
Lower Helderberg limestone	209	650
Hydraulic limestone	325	975
Light gray shale	43	1,018
Dark red shales	5	1,023
Green and blue marls	87	1,110
Green and blue marls with 30 feet of limestone	140	1,250
Rock salt	10–12	1,271
Red and green variegated marls	129	1,400
Red marl	60	1,460
Green and blue marls	105	1,565
Red shale	225	1,790
Blue shale and limestone, Niagara formation	59	1,849
Blue shales	22	1,874
Blue shale and limestone, Clinton	15	1,889
	1,889	.....

---

* Altitude measured from railroad track with hand level or aneroid barometer by Wm. C. Clarke, E. M. Railroad levels furnished by the various railroad companies.

State Museum, Bulletin Nº 11.





MAP OF THE
SALT DISTRICT
OF
GENESEE, WYOMING AND LIVINGSTON COUNTIES
BY
FREDERICK J. H. MERRILL.
Assistant State Geologist
Base compiled by C. C. VERMEULE.

● Salt Wells. ■ Salt Mines

○ Wells in which no salt has been found

1893.

University of the State of New York

NEW YORK STATE MUSEUM

The New York State Museum, organized by act of legislature in 1870 under the title of the "State Museum of Natural History," and placed under the trusteeship of the Regents of the University, is the result of the geological survey of the state commenced in 1836. In that year, pursuant to a resolution passed by the legislature of 1835, Hon. John A. Dix, Secretary of State, formulated a plan for a complete natural history survey of New York. The collections made in the course of this survey form the nucleus of the present State Museum. In 1843 these collections were placed in the old State Hall for safe keeping in charge of a curator. In 1865 the legislature passed resolutions tending toward the expansion of the museum. In 1866 the Cohoes mastodon was discovered and added to the state collection. In 1867 an appropriation was made for the purchase of the Gould collection of shells, and the curator of the state cabinet was directed to make a report upon the building stones of New York. In the preparation of this report specimens were collected which form the nucleus of the present large collection of building-stones. In 1870 the museum was organized by law and an annual appropriation of $10,000 was voted to provide for the salaries of the director and his assistants and for the maintenance of the museum. In addition to this an annual appropriation of $1,500 was made for the salary of a state botanist. In 1881 a state entomologist was appointed who became, in 1883, a member of the museum staff. At this time the annual appropriation was increased to $15,000. In 1889, the State Museum was made an integral part of the University, and the fifth floor of the new capitol was formally assigned for its use. As the new quarters are not yet completed, most of the museum remains on the four floors of Geological Hall in State street, corner of Lodge. Here are the collections in mineralogy, geology, paleontology, zoology and ethnology, and the offices of the assistant director and assistant state geologist, and of the assistant zoologist. The state geologist and paleontologist and the state botanist have their offices in State Hall in Eagle street, and the state entomologist in the north east section of the fourth floor of the capitol. The State Museum in addition to its work of collecting material representative of the natural resources of the state, is also the seat of the geological and natural history survey which has been in progress since 1836 and under the auspices of which numerous reports have been published on geology, paleontology, zoology and botany. The museum is open to the public from 9 a. m. till 5 p. m. daily except Sundays, including vacations, Saturday afternoons and all other holidays.