

THE GYPSUM DEPOSITS OF THE SALINA GROUP OF WESTERN NEW YORK

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Introduction

Although New York is the richest state in the Union, its mineral production accounts for only a fraction of the total wealth. Because of this New York is not usually associated with significant mining production. It is not generally known, even by geologists, that New York leads the country in the production of titanium, talc, soapstone, pyrophyllite, emery, abrasive garnet and calcined gypsum, besides being the third largest producer of zinc and salt (Minerals Yearbook, 1962). Significant contributions are made in the production of lead, silver, iron, cement, lime, peat, petroleum, natural gas, stone, sand and gravel. New York ranked approximately eighteenth among the states in the production of total mineral wealth.

Gypsum Mining in New York

One of the least known of these mineral products is gypsum, which is produced only in the western part of New York from the Salina Group of late Silurian (Cayuga) age. Only five gypsum mines are now operating in New York, three in Erie County, and one each in Genesee and Monroe Counties. All are underground operations, working at shallow depths ranging between 30 and 60 feet below the surface. The three mines in Erie County are located about 15-20 miles due east of the city of Buffalo; two are near the town of Clarence Center and the other near Akron. The Bestwall Gypsum Division of the Georgia-Pacific Corporation operates the mine at Akron and manufactures plaster of Paris, which is processed into plaster wall board, lath and other finished building products. The National Gypsum Company operates a mine at Clarence Center which also produces gypsum for manufacturing building materials. The Universal Atlas Cement Division of the U. S. Steel Corporation produces mostly raw gypsum for use as a retarder in Portland cement at its Clarence Center plant. Near the town of Oakfield in Genesee County, the U. S. Gypsum Company produces gypsum for conversion into plaster building products, as does the Ruberoid Company in Monroe County at the town of Wheatfield.

The gypsum is mined by room and pillar methods from a 4 foot thick [about 3-1/2 to 4-1/2 foot thick] layer of gypsum which is interbedded between limestone layers. The room and pillar technique leaves pillars of gypsum about 30 feet square standing to hold up the roof while 30-foot squares around the pillar are removed. This permits recovery of about 75% of the gypsum. Because the workings extend under the towns and adjoining valuable farm lands, the pillars are not removed later as is often done in coal mining.

After the gypsum rock is blasted, it is loaded into electric shuttle cars, then transferred to mine cars which convey the gypsum to the primary crusher. The coarsely crushed rock is taken to the surface by bucket where it is further crushed and delivered to large calcining kettles where the dihydrate of calcium sulfate is converted to the hemihydrate, $\text{CaSO}_4 \cdot 1/2 \text{H}_2\text{O}$, known as plaster of Paris or "stucco". From the calcining kettles the plaster is sent to storage and later either bagged as plaster or processed into finished building products of which plaster wall board comprises by far the greatest volume.

The wall board is made in a continuous process on large machines. The plaster is mixed with water, spread on a sheet of paperboard which is fed from giant rolls, passed between rollers which squeeze the plaster to the desired thickness, and a second layer of paperboard placed on top. The "sandwich" is then carried along a conveyor belt at such a speed that by the time the end is reached, the plaster has set. The continuous sheet is cut to length, edges are bound and the boards are conducted through a continuous drying oven. The wall-board moves along these conveyors at a speed about equal to a rapid walk, and the machines run 24 hours a day. On emerging from the oven they are thoroughly dry and are ready for shipment. Other machines make the lath and block by automatic casting in molds.

History of Gypsum in New York State

The first discovery of gypsum in the United States occurred in 1792, near the town of Camillus, New York, a few miles west of Syracuse, followed shortly by discoveries to the east near Chittenango, New York (Newland, 1929; Withington and Jaster, 1960). These deposits were brought into commercial importance during the War of 1812 when Nova Scotia gypsum supplies were cut off. Later, the low cost transportation available in the Erie Canal led to the opening of markets along the Hudson Valley and shipments were made as far as Philadelphia. Almost all the early production was used in agriculture as a fertilizer, providing needed sulfate to the soil. In 1835 gypsum was first calcined (dehydrated) in small quantities in the U. S. It was used for making figurines which were cast, painted and sold on the spot by itinerant peddlers. These figurines, the most famous of which are called the "Rogers' Group", achieved great popularity, rivaling the lithographs of Currier and Ives, and are now highly valued by antique collectors.

By 1838, when the first geological survey of N. Y. was under way, gypsum quarries had been established in Monroe, Ontario, Cayuga, Onondaga and Madison Counties. The yearly production at that time was estimated at 50,000 tons.

Because pure gypsum plaster sets in only 5 or 6 minutes, it was not much used for interior wall and ceiling coatings; builders preferred to use lime instead. However, in 1888, it was discovered that the

addition of animal glue retarded the setting to a more practical length of time. Soon, by proper mixing of additives, plaster with any setting time between 5 minutes and 5 hours was made available. In 1892 the first large scale calcining plant in New York was built for the manufacture of plaster of Paris. This product soon displaced lime in the construction industry and by the turn of the century almost all interior walls and ceilings were being coated with gypsum plaster. Since 1890 the value of gypsum products has increased from \$412,000 to almost a half billion dollars a year in 1965.

Occurrence

In New York State, workable deposits of gypsum occur only in the Salina Group (old "Onondaga salt group" of early writers) of evaporite deposits formed during late Silurian (Cayugan) age. The large salt production of New York also comes from the Salina Group. The type locality is in the vicinity of Syracuse, New York, formerly known as Salina (Buehler and Tesmer, 1963). Near Syracuse the Salina includes three formations, the Vernon shale (oldest), the Syracuse formation, and the Camillus shale (youngest). Only the Camillus is found in western New York where the thickness is about 400 feet; the thickness increases to the east. The Camillus in western New York is largely shale with intermittent thin layers of limestone, gypsum and anhydrite. Outcrops are rare and contacts with the overlying Bertie formation and underlying Lockport formation are few and difficult to define.

The outcrop belt of the Salina group (see map in Newland, 1929, fig. 3) extends from Madison County, near Albany, westward to the Niagara River and well into Ontario. It also extends from Albany southward along the west side of the Hudson River into New Jersey. The outcrop area of the Salina beds is represented by a topographic depression across the state, with few outcrops visible. The beds dip gently to the south at the rate of 20 to 50 feet per mile. Gypsum is present from Herkimer County in the east into Ontario to the west. In only a few places are the gypsum beds of sufficient thickness and purity to justify mining at present. A drill hole in the Buffalo area penetrated three beds of gypsum 4, 2 and 4 feet thick, respectively, at a depth of about 35 feet. They are of high quality and remarkably uniform in thickness. When traced eastward, these gypsum beds thicken to about 30 or 40 feet but become more impure and more discontinuous, occurring as pods or lenses.

Origin

The gypsum is thought by Newland (1929) and by most later workers to be an alteration product of anhydrite, although Dana and Grabau favored the theory of alteration of limestone beds by acid sulfate water. The latter theory is not generally accepted for extensive sedimentary beds of gypsum. Below a cover of about 100-150 feet, only

anhydrite is found in the Camillus shale. It appears (Newland, 1929) that ground-water has caused the hydration of the uppermost portions of anhydrite beds to form gypsum. Below depths of 100-150 feet no gypsum is found when the beds are traced southward down dip. It is apparently not possible, therefore, to add to future supplies of gypsum by simply following extension of the beds at depth. As of 1951, reserves of gypsum in western New York were estimated at 66 million tons, although some producers refuse to give any information at all about their operations or reserves. The actual amount is undoubtedly greater.

Although gypsum is sometimes found associated with ore deposits where it has evidently formed by the action of sulfate-bearing waters on calcium carbonate, by far most gypsum and anhydrite is found as sedimentary deposits interbedded with other sedimentary rocks. Gypsum and anhydrite are classified among the evaporites, the rocks formed by the deposition of the salts which were once dissolved in sea water. Many authors have studied the origin, significance and mechanism of formation of evaporite deposits (see Withington and Jaster, 1960). It is the consensus of modern opinion that evaporite deposits form when a portion of the sea is isolated, as in restricted lagoons or embayments, where high rates of evaporation and a continuous inflow of sea water to replace that evaporated, cause a gradual increase in salinity. Eventually, the water will become saturated with the various components in solution, and precipitation will occur.

Actual crystallization of a natural brine is very complex, and depends not only on the solubility of the salts involved, but also upon the concentration of the salts present, the temperature of the solution, material brought in by feeder streams, intermittent replenishment by sea water, climatic change, etc. Hence, many exceptions are known to the ideal sequence or order of precipitation, which is believed to be iron oxide, calcium carbonate, calcium sulfate, sodium chloride, magnesium salts, and lastly potassium salts (Pettijohn, 1957).

Sea water contains about 3.5% of dissolved solids, of which 3.6% is calcium sulfate. This means that to produce a four foot thick bed of gypsum, as is found in western New York the equivalent of about 8,000 feet of sea water would have to be evaporated.

Departures from a normal evaporation cycle are common in the geologic column. A common deviation is alternating beds of limestone and gypsum and shale, indicating intermittent replenishment of sea water and inflow of clastic sediment, seldom reaching the stage where the original volume is reduced to 1/10 at which point salt would be deposited.

One of the puzzling problems of gypsum-anhydrite formation is the difficulty of determining which formed originally or if one form has inverted to the other. It is well known that gypsum can be dehydrated at low temperatures to form anhydrite and that anhydrite can form gypsum by taking up water. Experiments by MacDonald (1953) on the

equilibrium relations between gypsum and anhydrite in pure water and brine solutions lead to a clear picture of the reasons why either gypsum or anhydrite or mixtures of the two can form under natural conditions.

Below 40° C gypsum is the stable phase in the presence of pure water and above 40° C anhydrite is the stable form at 1 atmosphere. In a buried deposit, then, if the temperature goes above 40°C, gypsum will dehydrate to form anhydrite. An increase in pressure lowers the dehydration temperature 1°C for every 40 bars. At a pressure of 500 bars, the dehydration temperature is 270C.

If the water in contact with the gypsum is not pure, but is a brine containing about 29% NaCl (saturated brine contains about 36% NaCl at 20° C), the equilibrium temperature is reduced to 21°C. At temperatures below 21° C, gypsum is deposited. The greater the amount of salt in solution, the lower the transition temperature between gypsum and anhydrite. Normal sea water contains about 1.26 parts per thousand of calcium sulfate. In an environment of saturation, where the sea water has a chlorinity of 65 parts per thousand, gypsum will precipitate from sea water below 34°C, and anhydrite above 34° C. Pressure has little effect on this temperature, the effect of the salt concentration being predominant. As an example, the following history is given. At 25° C, salts are concentrated until the chlorinity reaches 65 parts per thousand. At this point gypsum is precipitated. In addition, gypsum that is in contact with sea water of chlorinity above 113 parts per thousand will be unstable and break down to form anhydrite. In saturated NaCl solutions, gypsum will precipitate only at temperatures below 14° C. The maximum depth in the earth at which gypsum will be found is controlled by the temperature gradient over a region, the composition of the water and the ratio of hydrostatic to lithostatic pressure.

Thus, it can be seen that either gypsum or anhydrite or both can be precipitated from sea water, given the proper temperature and/or composition. In addition, one form can invert to the other should conditions change. Scruton (1953), Sloss (1953), Douglas and Goodman (1957) and Pettijohn (1957) give excellent detailed discussions of the formation of evaporite deposits and their relation to climate, salinity, temperature of formation, and mechanism of reflux between the restricted basin and normal sea water (MacDonald in Withington and Jaster, 1960).

Uses of Gypsum

Today gypsum has three major uses and a score of minor ones. The major applications are in the manufacture of plaster building products, as a fertilizer in agriculture, and as a retarder in Portland cement. Some minor uses include: the manufacture of toothpaste, face powder, paint, rubber, sulfuric acid (in Europe), fireproofing, acoustical tiles, wine and beer. It is also used to make molds and casts for bathroom fixtures, dental plates, dinnerware and in the arts.

Production

Today raw gypsum is produced in the U. S. at the rate of about 10 million tons per year, valued at \$127 million in the raw form. Of this, about 8.8 million tons are calcined into plaster and fabricated into construction materials valued at \$327 million. New York produced more calcined gypsum than any other state, its share amounting to 1,153,000 tons valued at about \$115 million (Minerals Yearbook, 1962).

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