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WITH XIV PLATES.

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(IV.) Conclusions.

The red rock on Pigeon Point is not an altered gabbro nor an altered sedimentary rock, but is the result of the solidification of a magma, which under certain conditions gave rise to a rock with the characteristics of a granophyre. These two rocks contain a sodium-potassium feldspar, and thus should be classed among the quartz-keratophyres.

Upon the contact of the quartz-keratophyre with an olivine-gabbro is a series of rocks, which possess a composition intermediate between those of the keratophyre and the gabbro. They may be regarded as the result of contact action at great depths

Irving's augite-syenites are similar to the Pigeon Point quartz-keratophyre, in some instances, and in others are like the intermediate rocks. They are neither altered gabbros nor altered forms of a previously existing augite-syenite.

Geological Laboratory of Colby University, June 25, 1888.

Art. VII.—*On the occurrence of Hanksite in California;* by Henry G. Hanks.

The best known locality of hanksite in California is Borax Lake, owned by the San Bernardino Borax Company. This lake lies in township twenty-five South, range forty three East, Mount Diablo base and meridian, and in the northwest corner of San Bernardino county, the largest in the state, very near the Inyo county line. This vast deposit of soluble salts was discovered and located February 14, 1873, by Dennis Searles and E. M. Skillings. Up to the present time it has produced 10,500 tons of borax, and is still far from being exhausted. When the state becomes more populous, and facilities for cheaper transportation multiply, other minerals will also be extracted, to the benefit of those interested, as well as to the State.

The so-called "Dry Lake," "Alkali Flat" or "Salt Marsh," is a pan-like depression in the desert, ten miles long and five wide more or less. It is the sink of a wide spread water-shed and a small stream which heads some fifty miles south. It is the opinion of those who have long resided at or near the locality, that it is a secondary sink of Owens Valley and is partly fed by seepage from Owens and Little Lakes. The climate is generally very dry, but during some seasons, considerable water finds its way to this depression. Having no outlet, the water spreads out and forms a shallow lake or marsh. In the dry season the surface is covered with an alkaline incrustation, which is principally common salt. On the

western margin of the large depression lies a small basin known as "Borax lake proper," which has approximate dimensions of one mile and a half in length by half a mile in width. From this secondary lake, and the dividing ridge referred to below, most of the borax produced has been taken.

Between Borax Lake, which is a few feet higher than the general level, and the wide alkali flat, there is a slight ridge, which acts as a natural dam and prevents the water from flowing away. It is covered with crude borax which is believed to be of semi-volcanic or solfataric origin. This barrier prevents the water of the borax lake from flowing to still lower depressions on the great alkali flat beyond. The water of Borax Lake is a dark brown highly concentrated alkaline liquor, having a density of 28 degrees Beaumé. The salts obtained from it by crystallization contain carbonate, chloride and bi-borate of sodium, with much organic matter. There has never been an exhaustive analysis made, which would, no doubt, be very interesting.

For a number of years it was planned to explore or prospect the underlying formations both as a matter of general interest, and in the hope of finding the source of the borax and other salts. After much delay, work was finally commenced in 1887, and carried on under many difficulties, owing to the nature of the ground. The bottom of the lake was found to be of a remarkably sticky, tenacious, plastic clay, described as being "tough as wax." To avoid the difficulty of keeping back the alkaline water by coffer dams or other similar contrivances, the first experimental well was commenced on the ridge before mentioned. It was sunk by spring-pole drills to a depth of three hundred feet. The following is a section carefully kept by Mr. Searles:

1. Two feet salt and thenardite.
2. Four feet clay and volcanic sand containing a few crystals and bunches of hanksite.
3. Eight feet volcanic sand and black tenacious clay with bunches of trona of black shining lustre from inclosed mud.
4. Eight-foot stratum, consisting of volcanic sand in which is found glauberite, thenardite and a few flat hexagonal crystals of hanksite.
5. Twenty-eight feet of solid trona of uniform thickness. Other borings show that this valuable mineral extends over a large area.
6. Twenty-feet stratum of black, slushy, soft, mud, smelling strongly of hydrosulphuric acid, in which there are layers of glauberite, soda and hanksite. The water has a density of 30° Beaumé.
7. Two hundred and thirty feet (as far as explored), of brown clay, mixed with volcanic sand, and permeated with hydrosulphuric acid.

Overlying No. 5, is a thin seam or stratum difficult to penetrate, to which the name "hard stuff" has been given, the exact nature of which is unknown.

Borax is produced at these works by three different methods. By evaporating natural solution of borax; by lixiviation of crude material; and by solution and re-crystallization of tincal. What is known as "crude material" is a somewhat pulverulent, slightly yellowish, amorphous incrustation which yields about eight per cent. of borax when worked on a large scale.

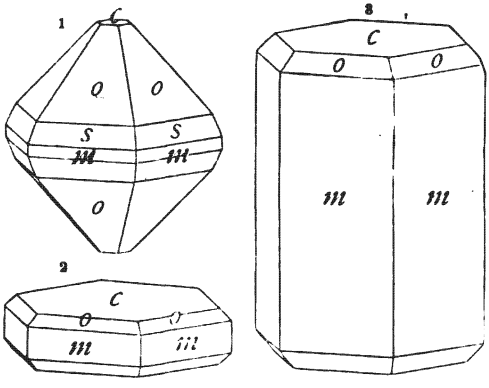
Borax is obtained from this crude material by solution and evaporation The plant, which is very extensive, and owing to the distance and isolated position of the deposits, costly, consists of a large steam flue boiler, and a multitude of boiling and crystallizing tanks, of wood and boiler iron. Steam is conveyed in pipes to the various tanks, instead of utilizing the heat of the sun, which would be more economical and the yield and quality quite as good. The peculiar dryness of the climate is specially favorable for solar evaporation and graduation. Fifty men and thirty-five animals are employed in these works. The product is hauled in wagons to Mohave station, a distance, of about seventy miles, over a sandy desert, so dry and sterile that a supply of water must be hauled in other wagons for the use of men and animals. The fuel used has been generally the sage-brush which is gathered at heavy cost, and thrown under the boilers with pitchforks, like hay into a barn: but recently, California crude petroleum has been substituted.

Hanksite first came to San Francisco in the massive form and was called by the borax miners "Ice," which it certainly resembled. It was examined in the usual manner and found to be an anhydrous sulphate of soda, and was labelled thenardite. No analysis was made and the small proportion of carbonic acid was overlooked in the blowpipe examination. The next specimens received were small hexagonal plates, found in the highly concentrated waters of the lower lake. These went to New Orleans with the California exhibit, and were shown at the exposition of 1884–5, where they attracted the attention of Mr. William Earl Hidden, who was the first to suspect a new species. The results of his study of the crystals led to a paper by him, which he read before the New York Academy of Sciences, May 25, 1885.*

The magnificent crystals recently discovered were taken from the sandy clay No. 2 of the section, and No. 7, seventy feet or more below the surface. There were not more than

* This Journal, xxx, 133, 1885.

thirty in all. About the time of their discovery, work was suspended. It will not be resumed for several months, when it is to be hoped that enough will be obtained to supply the scientific world with specimens. The form of these crystals is shown in figure 1,* the planes present are: *c* (0001, *O*), *m* ($10\bar{1}0$, *I*), *o* ($10\bar{1}1$, 1), *s* ($20\bar{2}1$, 2).



What Mr. Searles calls "bunches of hanksite" are aggregations of flat hexagonal plates joined together in a confused irregular manner. They vary in size from an inch or less in diameter to eight inches or more. One of these crystals is shown in figure 2. The crystals also vary in size, the largest being three inches, and the smallest half an inch or less in diameter. Some of the bunches have been accidentally subjected to the action of comparatively pure water, by which partial solution has taken place, not only marring the beauty of the individual crystals, but leaving the clusters in a dilapidated, cavernous condition. In the dark, concentrated, amber-colored water of the borax lake, they remain unchanged. A rare prismatic form is shown in figure 3.

Hanksite is known to occur also in the borax fields of Death Valley, Inyo County, and there are several known localities in the state of Nevada.

The following minerals have been found associated with borax in San Bernardino County:

Anhydrite, calcite, celestite, cerargyrite, colemanite, dolomite, embolite, gay-lussite, glauberite, gold, gypsum, halite, hanksite, hydrosulphuric acid, natron, soda niter, sulphur, thenardite, tincal, trona.

It is the opinion of the writer that instead of being a rare mineral, hanksite will be found in great abundance, and it will be proved that it plays an important and active part in the metamorphoses that produce gay-lussite, thinolite and perhaps borax.

San Francisco, October 20, 1888.

* These figures have been drawn by Mr. E. F. Ayres of Yale University.