

material was obtained. Sulfur was determined by precipitation with  $\text{BaCl}_2$  and weighing as  $\text{BaSO}_4$ .  $\text{Na}_2\text{O}$  was determined by the difference in weight of the combined chlorides of sodium and potassium after the latter had been found as the chloro-platinate ( $\text{K}_2\text{PtCl}_6$ ). The analysis and the ratios calculated therefrom establish conclusively that the substance under consideration is the mineral mirabilite ( $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ ).

TABLE 1

	1	2	3	4	5
$\text{Na}_2\text{O}$	17.84	19.02	19.25	0.3067	} 0.3148
$\text{K}_2\text{O}$	0.72	0.77	.....	0.0081	
$\text{CaO}$	trace	.....	.....	.....	
$\text{SO}_3$	23.81	25.37	24.86	0.3168	1.006
$\text{Cl}$	trace	.....	.....	.....	
$\text{H}_2\text{O}$	51.4	54.84	55.89	3.0466	9.677
Insoluble	5.69	.....	.....	.....	
	99.50	100.00	100.00		

1. Results of analysis. 2. Same, after removing insoluble matter and recalculating to 100%. 3. Theory for  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ . 4 and 5. Ratios shown by 2.

This is further confirmed by the determination of the optical constants. By using the immersion method a mean index of refraction of  $1.437 \pm 0.005$  was obtained. This compares very favorably with the value given by Miller<sup>1</sup> of approximately 1.44 for  $\beta$ . The double refraction is very weak, low gray interference colors predominate and only the thicker sections show distinct colors. The optical character of the mineral is negative as is also its principal zone. The apparent optic angle ( $2E$ ) is large.

It is thought that this is the first time mirabilite has been reported as occurring in Michigan. Except for its formation in large quantities in the salt lakes of the west, it is a mineral met with rather infrequently because of its great solubility and unstable character.

## THE ORIGIN OF THE MIRABILITE FROM THE ISLE ROYALE MINE.

ALFRED C. LANE

*Tufts College*

The water of this mine, like that of all Michigan copper mines, runs very high in calcium chloride. The nearest samples analyzed to the place where the mirabilite was found give the following results, in parts per thousand.<sup>2</sup>

<sup>1</sup> *Trans. Cambridge Phil. Soc.*, 7, 215, 1842.

<sup>2</sup> *Mich. Geol. Biol. Survey, Publ.* 6, *Geol. Ser.* 4, II, 823.

	1	2
Cl.....	45.178	7.626
Ca.....	22.201	3.249
Na.....	3.837	1.204
Br.....	0.320	
SO <sub>4</sub> .....	0.234	
Cu.....	<sup>a</sup>	
Sum.....	71.770	12.079
Difference.....	0.330	0.241
Total solids.....	72.100	12.320
Sp. gr.....	1.057	1.009

<sup>a</sup> Estimated as 2 to 8 mg. per liter.

The sample is, however, somewhat nearer a fault which crosses the lode obliquely striking E and W and having 30° or less to the N and it is conceivable that a certain amount of water may circulate along this fault. These faults or crossings also contain more sulfides so that the water near them may well contain more sulfates.

The interesting thing about this occurrence of mirabilite is that while it seems to have deposited from water so high in lime, it is yet so free from lime. To explain this we may note that calcium sulfate is much less soluble than sodium sulfate, and still less so in the presence of calcium chloride. For instance at 0° C. 0.241 gram of gypsum is dissolved by 100 grams of water, and at 18°, 0.259 gram; whereas in a solution containing 15.90% calcium chloride at 25°, only 0.092 gram of gypsum is dissolved in 100 cubic centimeters.<sup>3</sup> Calcium sulfate is more soluble in sodium chloride solutions, because sodium sulfate is formed, and this is enormously more soluble.

Unfortunately I did not observe the temperature of the mine and rock at the time we took the sample, but the normal temperature cannot be far from 15° C. (61° F.). At that temperature we find the following peculiar behavior of sodium sulfate: 37.43 grams of sodium sulfate or 105.79 grams of sodium sulfate + 7 aq. can exist away from the air, but by exposure to air (or the inoculation with crystals) it is converted to the sodium sulfate with 10 aq., of which only 35.96 grams (corresponding to 13.20 grams of anhydrous sodium sulfate) are soluble. *This solubility decreases markedly* with the drop in temperature, so that at 10° but 9 grams and at 0° but 5.02 are dissolved. Therefore both exposure to air and cooling would tend to promote crystallization of mirabilite more than gypsum. A study of the occurrence of this efflorescence with reference to the season and its relation to upcast and downcast currents in the mine circulation would show if temperature were the more important factor. The rock of the upper levels is down to 6° C. (43° F.) and the air temperature of the downcast shaft generally below 15° C. (60° F.).

<sup>3</sup> *Chemiker Kalender*, Pt. I, 323 and 332, 1916.