

OCCURRENCE OF HALOTRICHITE AT SÖR-FRON (OPPLAND)

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CAILLERE, S. & PROST, A.: Occurrence of halotrichite at Sör-Fron (Oppland). Contributions to the mineralogy of Norway, No. 38. *Norsk Geologisk Tidsskrift*. Vol. 48, pp. 253-258. Oslo 1968.

Orange-yellow concretions, formed by superficial alteration processes can be observed on the surface of a very late Precambrian black shale exposed in the Sör-Fron area. X-ray, thermal, and chemical studies on these concretions have shown that they consist of halotrichite. This is the first known occurrence of halotrichite in Norway.

At Sör-Fron (Oppland district), the Bröttum formation, of very late Precambrian age, is exposed on the south side of the river Lågen in the Gudbrandsdal valley, where it is represented by a black pyritic shale. Under the microscope, this shale shows phyllitic streaks of pale green muscovite, associated with a small amount of chlorite and separated by quartz aggregates. Occasional small cubic crystals or cryptocrystalline veins of pyrite are also observed. Some samples show calcite and dolomite as well.

Where the shale is exposed it has a rusty patina and in some areas it is covered by a thin yellow film. Near Tofte farm, at 650 m above sea level, at reference point 508217 (50.8 km E, 21.7 km N) on Nord-Fron sheet (AMS Series M711, Sheet 1718 II, 1:50,000), the rock assumes an argillaceous aspect and nearly disappears under a pale orange-yellow, finely botryoidal crust about one millimeter thick. A depth of 10 cm must be reached before the rock becomes compact and shows pyritic streaks along schistosity planes.

This astringent and salty-tasting crust is soluble in hydrochloric acid and also in water. Its mineralogical constitution was investigated by various techniques, including X-ray diffraction, differential thermal, thermogravimetric, and chemical methods.

X-RAY STUDY

As only a small quantity was available, we first examined the concretions by means of X-ray diffraction. The pattern shows numerous reflections and reminds one of pickeringite, a mineral discovered at Fåvang by O. A. Broch (1931). The pattern was then compared with those of two minerals of the

same family (pickeringite and halotrichite) from the collection of the Muséum National d'Histoire Naturelle.

Column 1 in the following Table gives the pattern of the unidentified mineral, column 2 that of a yellowish halotrichite from Peru, and column 3 that of a fibrous white pickeringite from Tarapaca in Chile. These diagrams are indexed (according to L. G. Berry), on the basis of a monoclinic lattice, as P_2 sub-group. Examination of this Table shows a great similarity between the three diagrams; however, the pattern is nearer that of the Peruvian mineral than that of the Chilean one.

Table 1

(1) Norway			(2) Peru 68-50			(3) Chile 91-116		
I	d	hkl	I	dÅ	hkl	I	d	hkl
3	13,51							
3	10,49	200	2	10,57	200	2	10,41	200
3	9,48	210	2	9,67	210	3	9,55	210
						1	8,72	
3	7,90	220	2	7,94	220	2	7,95	220
1	7,07							
						1,64	6,64	
4	6,06	040	3	6,07	040	4	6,08	040
1	5,81					1	5,82	
2	5,48		2	5,49		2	5,48	
2	5,26	240	2	5,26	240	2	5,21	240
7	4,91	211	6	4,92	211	5	4,93	211
8	4,80	420	7	4,81	420	7	4,77	420
4	4,55	231	4	4,58	231	4	4,57	231
10	4,31	141	10	4,32	141	8	4,29	141
8	4,12	241	8	4,14	241	8	4,11	241
4	3,98	160	1	3,99	160	1	3,96	160
2	3,87					1	3,88	
3	3,76	151	2	3,78	151	1	3,74	151
2	3,64	251	1	3,63	251	1	3,62	251
10	3,49	251	10	3,50	251	8	3,48	251
1	3,33	161	1	3,35	161	1	3,32	161
1	3,28	161	1	3,27	161	1	3,26	161
2	3,16	521	1	3,17	521	2	3,16	521
2	3,04		2	3,05		1	3,04	
2	2,95		2	2,96		2	2,95	
2	2,85		3	2,87		2	2,87	
1	2,76		1	2,76		2	2,76	
2	2,67		3	2,68		3	2,68	
2	2,60		2	2,61		1	2,60	
2	2,55		2	2,55		3	2,55	
1	2,44		1	2,44		1	2,45	
1	2,38		1	2,39		1	2,37	
			1	2,28		1	2,27	
			1	2,05		1	2,05	
1	2,00		1	2,00		1	2,00	

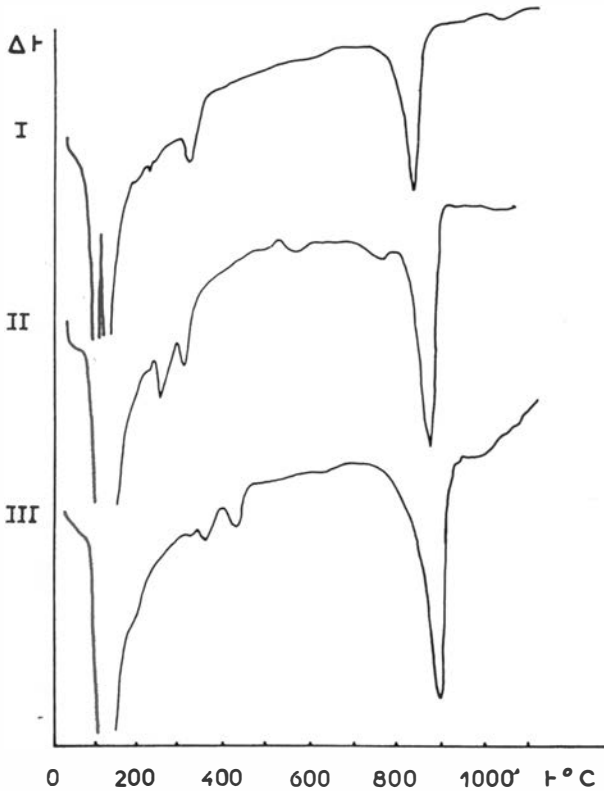


Fig. 1. Differential thermal curves (heating speed: 600°C/h).

- I. Mineral from Norway
- II. Halotrichite from Peru No. 68.50
- III. Pickeringite from Tarapaca in Chile No. 91.116.

DIFFERENTIAL THERMAL ANALYSIS

A differential thermal curve for the Norwegian mineral (curve 1, Fig. 1) shows a succession of endothermic peaks. The first of these, which is very large, begins at 100° C and is followed by two peaks at about 200° C and 300° C. A large inflection is also observable at 700° C. For comparison, the curves of halotrichite No. 68.50 from Peru (curve II) and that of pickeringite No. 91.116 from Chile (curve III) are also reproduced. The last shows well marked peaks at about 330° C and 400° C — i. e. at much higher temperatures than the corresponding inflections on the curve for the mineral being studied. On the other hand, there is a great similarity between curves I and II.

THERMOGRAVIMETRIC STUDY

The thermogravimetric curves (Fig. 2) show considerable similarity. They are characterized by the presence of two steps, the first of which begins at around 100° C and finishes at 400° C, and the second of which finishes at 1000° C. The first corresponds to water loss, the second to SO₃ emission. Total weight loss is extremely important, as available values are lacking in precision. The thermogravimetric values are listed in Table 2.

Table 2

Samples	Weight loss (%)		Total loss
	1st loss	2nd loss	
Norway	42	34	76
68.50 Peru	42	34	76
91.116 Chile	46	37	83

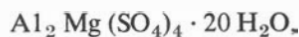
These results clearly confirm the similarity between the first two samples, already shown by X-ray and differential thermal analysis. Moreover the temperature of SO₃ emission is 600° C for the mineral from Chile (curve III, Fig. 2), whereas it is 550° C for the Norwegian (curve I) and the Peruvian (curve II) minerals. The last two, therefore, begin to decompose slightly earlier.

It is also interesting to note the water loss obtained at ambient temperature in a dessicator over calcium chloride; in three months the mineral from Norway lost 22.6 percent of its weight.

CHEMICAL ANALYSIS

The chemical analyses of the three minerals are assembled in Table 3.

It is immediately apparent that the mineral from Chile is totally lacking in iron and that it corresponds exactly to the formula,



which has two molecules of water less than the generally accepted formula (Palache Ch., Berman H. & Frondel C1. 1960).

The other two minerals only contain a small quantity of magnesium, this element being very largely replaced by ferrous iron. Their very similar structural formulae are closely related to the theoretical formula,

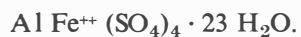


Table 3

	Norway	Peru	Chile
SO ₃	34.0	34.0	38.3
Al ₂ O ₃	10.6	9.6	12.0
Fe ₂ O ₃	5.4	1.3	-
FeO	5.4	8.9	-
CaO	0.5	0.5	0.7
MgO	1.0	0.4	5.9
SiO ₂	1.0	1.0	-
H ₂ O ⁺	42.0	44.0	43.6
	99.9	99.7	100.5

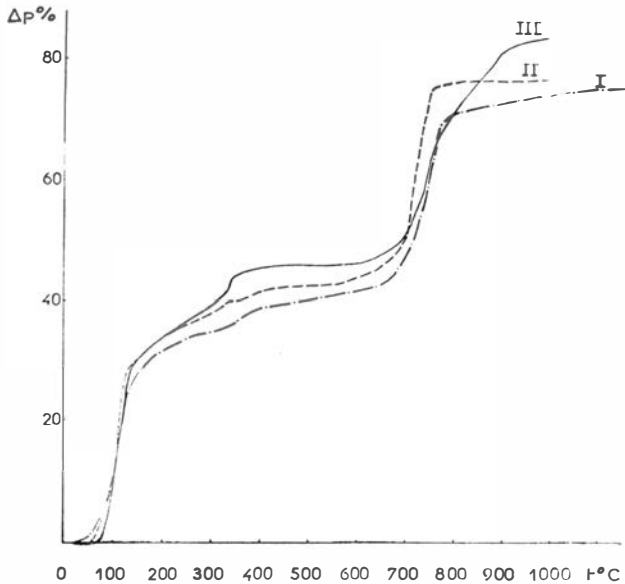


Fig. 2. Thermogravimetric curves.

- I. Mineral from Norway
- II. Halotrichite from Peru No. 68.50
- III. Pickeringite from Chile No. 91.116.

The mineral from Peru, in which magnesium is almost totally replaced by ferrous iron, is definitely halotrichite.

The mineral from Norway is also a halotrichite, the composition of which is, as indeed are all its properties, intermediate between those of the other two. It is possibly slightly contaminated with hematite.

The mineral has density of 1.765; it appears to consist of very fine needles of a creamy-white colour with a positive elongation and an extinction angle of 20° . The refractive indices are low; $Z = 1.48$, $X = 1.475$. The birefringence corresponds to grey of the first order. Fiber diagrams for pickeringite and halotrichite gave the parameters 6.23 \AA and 6.30 \AA , respectively.

It is interesting to note once again the presence in Norway (O. A. Broch 1931) of a double sulphate, this time of iron and aluminium, resulting from the alteration of pyrite. The aluminium probably originates from surrounding sheet silicates (Brondy M. C. 1938). It is also interesting that this alteration results here in Norway in a similar species to that found in Peru, where the climate is warm and dry. This surprising coincidence is due to special conditions operative in Norway. Thus, the temperature is very low during part of the year and the mineral is preserved from water action, just as in warm and dry climate. During the period of thawing, water runs away quickly without dissolving the mineral, because of its occurrence on a vertical face, with a small overhang and with a northern exposure which shelters it from the rain. Similar conditions at other localities allow the formation of gypsum.

ACKNOWLEDGEMENTS

The authors wish to record their gratitude to Dr R. C. Mackenzie (Macaulay Institute for Soil Research, Aberdeen) for reading and criticizing the manuscript.

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23 February, 1968*

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