II. Minerals from the burning Coal Seam at Mt. Pyramide, Spitsbergen.

By

IVAR OFTEDAL

(WITH FIGS 6—7 AND PL. I)

At the request of Professor J. SCHETELIG, director of the Min.-Geol. Museum of the University, I undertook the examination of the minerals orginated during the burning of a coal seam at Mt. Pyramide as mentioned in the preceding paper by WERENSKIOLD. The material is collected by A. HOEL and W. WERENSKIOLD in august 1921.

Although the material looks rather heterogenous, it proves to consist of only 3 mineral species, all showing the character of being easily sublimated.

The bulk of the material consists of *sal-ammoniac*, which was proved chemically and optically. The sal-ammoniac chiefly occurs in 2 different types as to habit of crystals. Exact measurements of the angles are not possible, the faces being mostly very much curved. — The first type shows as prevailing form the Tetragonal Trisoctahedron (211) in a rather regular development, and admitting measurements on goniometer, sufficiently exact for determination of the indices.

The second type is developed in cubes showing mostly very distorted shapes. These cubes seem to have grown on "stalks", turning a corner upwards. The faces are so strongly curved, that the right angles may be identified at the very point of the corner only. (See the Fig. 6, and Plate I, Fig. 2.)

A smaller number of the crystals shows a brighter or darker brown colour. These brown crystals are more regularly developed in cubes and show distinctly right angles. Yet they are often tabular. The brown colour is hardly due to iron compounds, as it might be expected, for the qualitative analysis of the brown crystals gives no iron. Probably it is due to coal dust or bituminous substance derived from the coal, on which the mineral is deposited. This probability is confirmed by some experiments on dry heating of the material.

Further *sulphur* occurs, in very small orthorhombic crystals. A crystal measured on goniometer showed the forms (111) and (101). The measurement gave the corresponding angles very exactly.

The third mineral crystallizes in fine yellow needles, sitting directly on the coal, partly covered by a crust of sal-ammoniac.

The mineral at once showed very striking properties. A determination of the specific gravity (with Clerici's liquid) gave the very low value of 1.43.

By means of the immersion method the refractive index α' was determined to 1.57. The refractive index γ' could not be determined directly, its value widely surpassing the upper limit of refractive indices reached with the scale of liquids available, which is $n = 1.74$. In liquids with $n = 1.74$ the mineral shows, in the α-direction, as well as in the γ-direction, very distinct Becke-lines, which are, naturally, of opposite characters. Assuming that these Becke-lines, as it seems, are of about the same strength, we may extrapolate the refractive index γ' to be located at about 1.9. Thus the birefringence — $(\gamma'-\alpha')$ — probably surpasses the unusually high value of 0.3.

The colour of the mineral is greenish-yellow, and the absorption is much stronger in the γ-direction than in the α-direction. α is located in the longitudinal direction of the crystal needles.

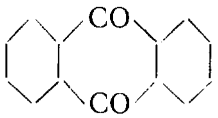
Extinction parallel.

Cleavage observed in a longitudinal direction.

On a crystal needle, measurable on goniometer in spite of its minute dimensions, I found one angle only, and its supplement, in the prism-zone. The average value of this angle was 51° 40′. This measurement, in connection with the parallel extinction, makes it probable that the mineral belongs to the orthorhombic system. Top faces have not been observed on any crystal.

Also in other respects the mineral shows unusual properties. On heating, it sublimates very easily, and deposits again in beautiful long crystal needles. To differentr eagents it is very resistant. Thus it may be dissolved in concentrated sulphuric acid and regenerated from the solution on dilution with water. Further it is easily soluble in chloroform, and somewhat less easily in benzol. The solutions are all yellow.

Many of the properties mentioned above, especially the low specific gravity and the solubility in organic solvents, strongly point towards the organic section of the chemical compounds. Further the unusual optical properties seem to point in the direction of more complex substances. Because of the occurence of the mineral in connection with coal, I looked over descriptions of substances derived from coal-tar, and found out that all the properties mentioned could agree with those of *anthrachinone*:



or $C_{14} H_8 O_2$

The data given in the literature concerning anthrachinone, however, being partly little exact, I applied to Professor H. Goldschmidt, director of the section A of the Chemical Laboratory of the University, who kindly handed me some pure artificial anthrachinone. Thus a comparision could be made between the properties of the mineral on the one hand and the data given in the literature, supplemented by properties determined on the artificial material, on the other. The following table shows some of the properties of the mineral, compared with data given for anthrachinone in the literature.[1] (See also the Fig. 7.)

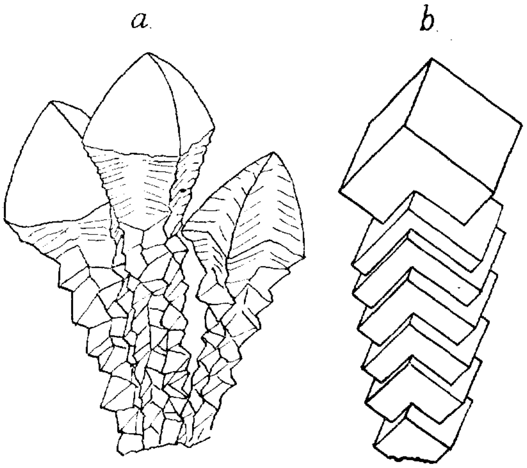


Fig. 6. a) Sal-ammoniac. Drawn from nature. b) Scheme of a).

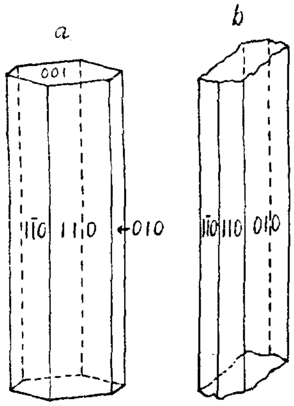


Fig. 7. a) Anthrachinone. Simple development. From Friedländer. b) Crystal of the yellow Spitsbergen mineral. From observations under the microscope.

Mineral, Spitsbergen.	*Anthrachinone.*
Long crystal needles.	Long crystal needles.
System: orthorhombic (?).	System: orthorhombic.
	c-axis parallel to the longitudinal direction.
One angle in the prism-zone = 51° 40'.	110 $\wedge$ 010 = 51° 20'.
	(My own measurement gave 51°23')
Cleavage: in a longitudinal direction.	Best cleavage: 100.
Sp. G. = 1.43.	Sp. G. = 1.419-1.438.
Colour: greenish-yellow.	Colour: sulphur-yellow.
Birefringence: about 0.3.	Birefringence: strong.

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[1] The physical and crystallographic data are taken from Groth: Chemische Krystallographie, Bd. V.

Very resistant to different reagents.	Very resistant to oxidizing reagents.
Sublimates very easily.	Sublimates very easily.
Soluble in benzol.	Soluble in benzol.
Occurence: in connection with burning coal.	Obtained from coal-tar.

Further I have determined the following properties of the mineral and also of the artificial anthrachinone and found perfect agreement between both sets of determinations:

Absorption: $\gamma > \alpha$.
Vibration of α in the longitudinal direction.
Refractive index $\alpha' = 1.57$.
Refractive index γ' very much higher than 1.74.
Soluble in concentrated sulphuric acid.
Soluble in chloroform.

Some other properties of anthrachinone, according to the literature are:

Optic axial angle small.
Acute bisectrix: c-axis.
Plane of optic axes: (100).

These properties I have not been able to determine definitely in any one of the two substances. Yet they are not at all in conflict with my observations. Assuming the plane of optic axes to be parallel to (100), we may draw the following conclusions, concerning both the substances:

The crystal needles being somewhat tabular in the a-c-plane (Fig 7b.), they will mostly rest with the face (010) on the object-glass. Thus a bisectrix will be seen in convergent light. Observations of the extremely indistinct interference figure caused by this bisectrix, show that it can not at all be distinguished from the interference figure caused by an optic normal. The bisectrix observed therefore must be the obtuse one, and we may add, that the optic axes must be located very near the crystallographic c-axis, that is: acute bisectrix = c, optic axial angle small. It follows further that the measured refractive index α' ($= 1.57$) must be identical with the principal refractive index β, and that the principal refractive index α cannot be very much lower than 1.57. The last conclusion also is confirmed by the fact that α' *always* shows the value of 1.57, in spite of the probability that not *all* the crystal needles are resting exactly with (010) on the object-glass. The principal refractive indices α and β thus being only a little different, and γ being very much higher, we may draw the conclusion, that the substances are optically positive.

In hand books of organic chemistry a reaction very characteristic of anthrachinone is given. The anthrachinone is reduced by means of Zn and NaOH, and characteristic changes of colour are observed.

This reaction I tried, on the Spitsbergen-mineral as well as on the artificial anthrachinone, and it passed off quite identically in both cases. Also another reaction I have tried on both the substances, and with the same result.

As melting-point of anthrachinone, the literature gives 273° to 277°. A determination of the melting-point of the mineral failed, because of impurities of organic nature. These impurities also somewhat darken the colour of the mineral. The pure anthrachinone is considerably brighter.

At the suggestion of Mr. A. RØDLAND, chief chemist of the Mineralogical Institute of the University, to whom I am indebted for much valuable advice, I now treated the mineral exactly as anthrachinone intermixed with other organic substances, and let it pass through a purifying process, especially prescribed for anthrachinone in analytic chemistry. This process is carried out by means of chromic acid, that wholly oxidizes all organic compounds except anthrachinone and related substances. Anthracene, in the event of it being present, is oxidized to anthrachinone. As a result of this process I got a very pure preparation, showing the bright yellow colour of the pure anthrachinone. The melting point of this pure substance proved to differ at most 2° to 3° from that of the pure anthrachinone, — a very good agreement.

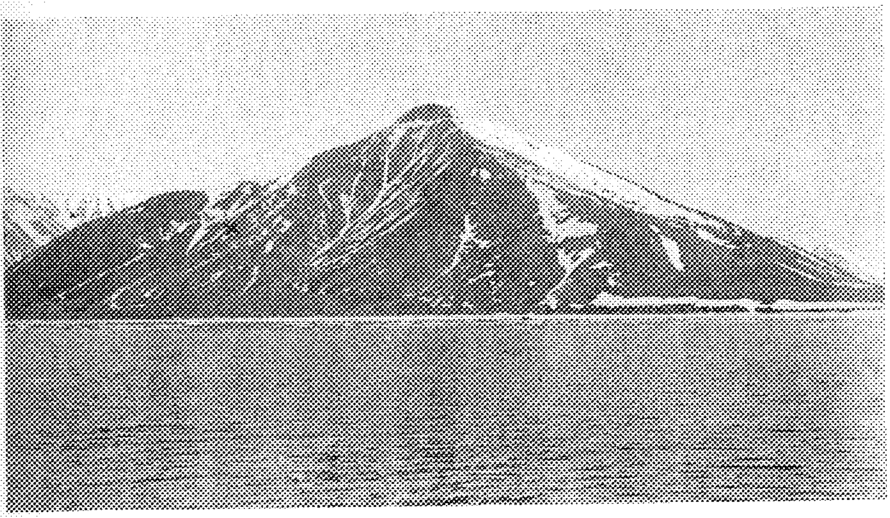
I sent the purified substance, 45 milligrammes, to the Pharmacological Institute of the University (director Professor E. POULSSON) to be analyzed. The analysis was very kindly made by the 'amanuensis' Mr. GUNNAR WEIDEMANN, and the result was the following:

	Analysis.	*Calculated from the formula of anthrachinone.*
C . . .	80.1 per cent.	80.7 per cent.
H . . .	4.5 „ „	3.9 „ „
(O . . .	15.4 „ „)	(15.4 „ „)

The small disagreements are easily explained. My substance may have been a little damp, or it may have been intermixed with traces of substances related to anthrachinone. In both cases the analysis will give a too high amount of H. At any rate, the analysis offers no objection to the identity of the substance analyzed and anthrachinone, and in consideration of all the facts mentioned above, concerning the two substances, it must be correct to conclude that the Spitsbergen mineral is anthrachinone, somewhat intermixed with other organic substance.

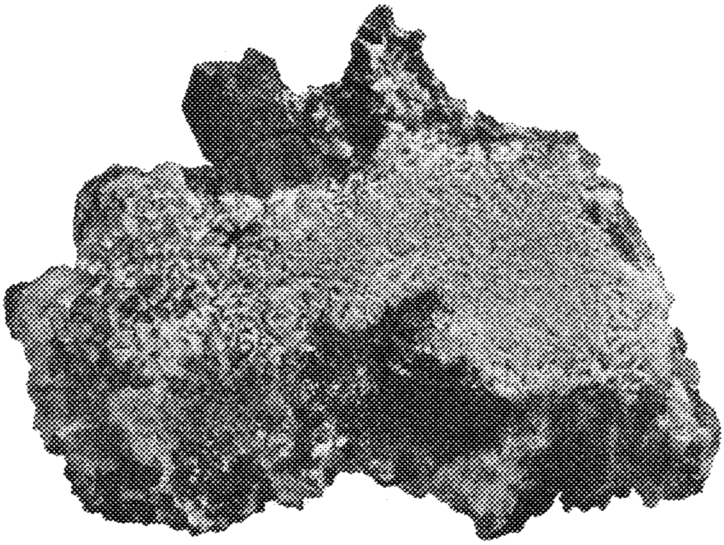
Anthrachinone, originated by a natural process, has thus been observed for the first time. It therefore has to be classed in the system of mineralogy among the organic minerals. As a mineral-name for anthrachinone I will propose *Hoelite*, after ADOLF HOEL, the present leader of the Norwegian Scientific Expeditions to Spitsbergen.

As to the origination of the Hoelite, I am in lack of material for a detailed discussion. Generally, it is well known, that anthrachinone is formed by oxidizing of anthracene, which is a constituent of the coal-tar. Thus the general features seem to be clear. The burning of the coal is going on under a cover of gravel, admitting only a scarce supply of oxygen, — and a partial destillation of the coal takes place. The anthracene thus originated has then been oxidized to anthrachinone in a manner hitherto unknown. Anthrachinone also originates in other ways, but in our case it seems most likely that anthracene has been the primary substance.



Adolf Hoel fot. 18/7 1908.

Fig. 1. Mt. Pyramide seen from Klaas Billen Bay. × indicates the place where the coal-seam is burning.



Borghild Larssen fot.

Fig 2. Sal-ammoniac. Typical specimen.