ON THE SULPHIDES OF THE ALUM SHALE IN OSLO

BY

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Abstract. The alum shale gives difficulties to building constructions in Oslo, both by heaving and by chemical attack on the concrete; a microscope study shows it to carry both pyrite and what is supposed to be pyrrhotite as minute grains. The attacking solutions are considered to be derived from the supposed pyrrhotite, formed during the Caledonian folding of the shale.

«Alum shale» is the name used in Scandinavia for the black, bituminous, Cambrian shale, occurring among other places in the city of Oslo. Here it was used two hundred years ago for producing potash alum. By burning the shale, its sulphides were partly converted to water-soluble sulphates, which were leached from the burnt shale.

All alum shales contain some carbon, from a few per cents to about 15 % as a mean for the carbon-rich beds. The original content of hydrocarbons has been driven off during the Caledonian folding. Then the alum shale served as a lubrication zone, upon which the Ordovician shales and limestones moved during the folding. Thus the whole zone is intensely sheared and slickensided.

The alum shale contains pyrite and calcite in grains visible to the naked eye. The pyrite occurs as scattered cubes or as a fine pigment, often enriched in thin zones or in concretions.

To-day the alum shale presents serious problems to house constructing in the center of Oslo. The shale is dangerous to concrete in two ways; firstly its sulphides produce solutions which attack the concrete itself, and secondly the shale expands when the ground water table changes and oxidation starts.

The present note presents the results of a microscope study of polished sections of alum shales, with determinations of its sulphide minerals. From a preliminary report (OFTEDAHL, 1953) the following results may be summarized:

1. Pyrite is the important sulfide mineral, occurring in large grains; subordinately minute grains of an unidentified ore mineral is seen.
2. X-ray powder films of alum shales give lines only from pyrite besides the lines from the clay substance.
3. Flotation of the shale does not give any important enrichment of sulphides, and no other sulphide than pyrite was identified by X-rays.

At present more careful examinations of polished sections have been carried out. The chief result is that the alum shale contains both pyrite and another ore mineral, supposed to be pyrrhotite, see Fig. 1.

Pyrite occurs usually as cubes or somewhat more rounded grains, the size of which range from 0,03 mm downwards. Large grains may be enriched in zones and aggregated to clots. Compact nodules and zones are also fairly common.

The other ore mineral has a strong anisotropy, and its color is fairly similar to that of pyrrhotite. The micro-hardness is markedly lower than that of pyrite, although the small size of the grains do not permit quantitative measurements. Thus it seems resonable to assume that this mineral is pyrrhotite. As seen from Fig. 1, the larger grains have the shape of long lenses, the smaller grains being more irregular in outline, but always drawn out in the same direction as the lenses, this direction being the bedding plane of the shale. The maximum size of the lenses is: Length 0,1 mm, width 0,01 mm. The grains down to 0,001 mm in length are often numerous, so that part of the pyrrhotite content may be submicroscopic grains. The visible content may ordinarily be about 0,1 %, ranging from 0,01 % to 1,0 %.

The shape of the pyrrhotite grains clearly suggest that their formation is related to the Caledonian folding. Quite often the longer grains and lenses have been cracked up in two ore more pieces and moved apart (see Fig. 1). This fact indicates that the differential gliding in the shale may have continued after the formation of the

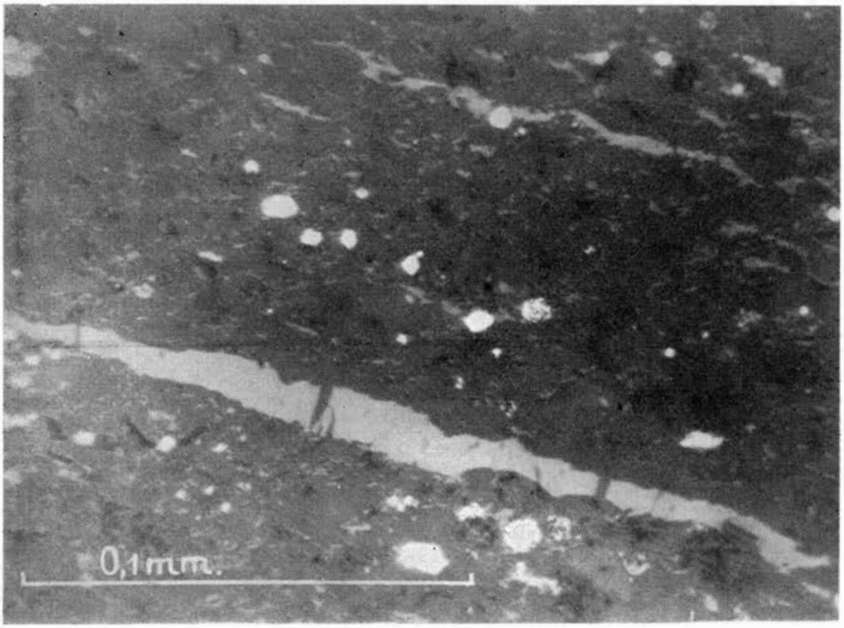

Fig. 1. Microphoto of polished section of alum shale from diamond drill hole 1952, Domkirken, Oslo, 3—4 m. In lower half the largest pyrrhotite lens met with crosses the photo. A smaller lens is seen in the upper half. All the small white threads are pyrrhotite. The rounded, strongly white grains are pyrite.

Mikrofoto av polerslip av alunskifer fra diamantborhull, Domkirken 1952, Oslo, 3—4 m. Det største iakttatte magnetkiskorn krysser nedre halvdel av billedet; en mindre linse sees i øvre halvdel. De fine lyse trådlignende individer er magnetkis. Få rundete, sterkt hvite korn er svovelkis.

pyrrhotite. Thus it seems fairly sound to assume that the pyrrhotite is formed during the Caledonian folding, and, generally speaking, at a fairly low temperature.

By estimation the amount of pyrrhotite is not far below that of pyrite in a few samples, but still no trace of hexagonal pyrrhotite lines could be discovered in the X-ray powder films. Neither could any lines be seen from a pyrrhotite of monoclinic symmetri (see for instance GRØNVOLD and HARALDSEN, 1952), now known to occur in Nature.

It has been assumed in the later years that pyrrhotite has been responsible for the active solutions from the alum shale. This assumption must now be considered very probable. The fact that the pyrrhotite seems to have formed during the folding may explain why there are no difficulties for building constructions with alum shale in Sweden: Here the alum shale is completely undisturbed by the Caledonian folding in the most places.

SAMMENDRAG

Alunskiferutvalget i Oslo utgav i mai 1953 en mangfoldiggjort rapport: «Alunskiferutvalget. Foreløbig rapport». Her redegjøres for hva som etter krigen er gjort av undersøkelser over alunskiferens farlige egenskaper for bygninger. Rapporten inneholder også en foreløbig redegjørelse for undersøkelser over alunskiferens kismineraler, med viktigste resultater: 1) Magnetkis lar seg ikke påvise i røntgen pulverdiagrammer. 2) Svovelkis er viktigste mineral mikroskopisk og kan også forekomme submikroskopisk i betydelig gehalt; slike korn kan være kilden for de aggressive løsninger. 3) Det forekommer meget små korn av et uidentifisert ertsmineral.

Nyere mikroskop-undersøkelser har vist at det uidentifiserte mineral høyst sannsynlig er magnetkis, i korn opp i 0,1 mm lengde. Kornenes form antyder at de er dannet under alunskiferens folding. Dette kan igjen forklare hvorfor den svenske alunskifer ikke har Oslo-skiferens ulemper; den er nemlig ikke foldet. Denne undersøkelse bekrefter således riktigheten av den tidligere antagelse at alunskiferens aggressive løsninger kommer fra magnetkis.

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