

THE ØRSDALEN TUNGSTEN DEPOSIT

BY
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Abstract. The general geology and the type of mineralization are shortly discussed, and the different ore minerals occurring are described. The minerals show a zoning opposite to what is generally considered the rule. Special attention is directed to the tungsten minerals (wolframite and scheelite) and it is shown how wolframite is altered into scheelite. This process is ascribed to a Ca metasomatism, probably brought about by late hydrothermal solutions reacting with the already formed wolframites. Experimental work has proved this reaction to go rather quickly. In the field this process is connected in time with other processes traceable in the history of the rocks. The formation of the ore is very briefly discussed.

Acknowledgement.

This work is a part of a thesis for the degree of cand.real. at the University of Oslo, and I wish to thank all my teachers for their kind help throughout my years of study. I also wish to express my sincere thanks to the director of the A/S Norsk Bergverk, ARNE DROGSETH, for allowing financial support during the summers' field work, and to Dr. HARALD BJØRLYKKE for the many thought-provoking discussions we have had together in the field.

Location and topography.

Ørsdalen is a valley running NE—SW situated at the northeast end of the more than 16 km long lake Ørsdalsvannet, in the parish of Bjerkreim, Rogaland, S. Norway. As there is no road connection, traffic has to go by boat across the lake. The nearest town is Egersund, about 40 km southwest of Ørsdalen.

The valley is about 10 km long and the width never exceeds 700 m, constantly decreasing towards N—E. The valley floor slopes

gently in a south west direction, the altitude varying between 64 and 212 m. On both sides the mountains rise, in some places nearly vertically, to altitudes between 600 and 800 m.

The ore is found along the south-east side of the valley close to Hovland farm, about 6 km back of the lake, Ørsdalsvannet. The altitude of the valley is here 120 m and the top of the mountain plateau about 780 m. The vertical distance between the valley and the mountain plateau is thus around 650 m; the horizontal distance is about the same.

The economically important minerals are wolframite (ferberite), scheelite and molybdenite. Mining started on molybdenite in 1904. Since then mining has been going on at intervals, and by several different owners up to today. No mining is taking place at the present time. After the first world war all the interest was turned to the tungsten minerals. Scheelite was first recognised in Ørsdalen around 1918.

The present owners are the state-owned A/S Nøorsk Bergverk.

The mineralization and geology.

Mineralization has taken place along two closely parallel zones separated by around 240 m at the valley floor, (see fig. 1). The zones converge towards south-east and seem to merge around 750 m south-east of the valley slope. The length of the two zones put together is around 2500 m. The zones are not continuously mineralized, the ore being associated with quartz veins of varying size occurring "en echelon" throughout the entire length of the zones. The richest concentrations of ore have been found at the top of the mountain plateau, along the north-east zone, at, or near the steep mountain precipice down to the valley.

Because of the very steep slope of the mountain the two zones are not continuously accessible from the plateau down into the valley. Here an adit has been driven on each, but the ore is of rather low grade.

The mineralized zones, as indicated by the quartz veins, are always parallel to the foliation of the rocks, the general strike of which is N45°W, and the dip 70°NE. Where the two zones seem to meet in the south-east, the quartz veins and the rock foliation, which describe a kind of a fold, strike EW and dip 50°N. In the valley the

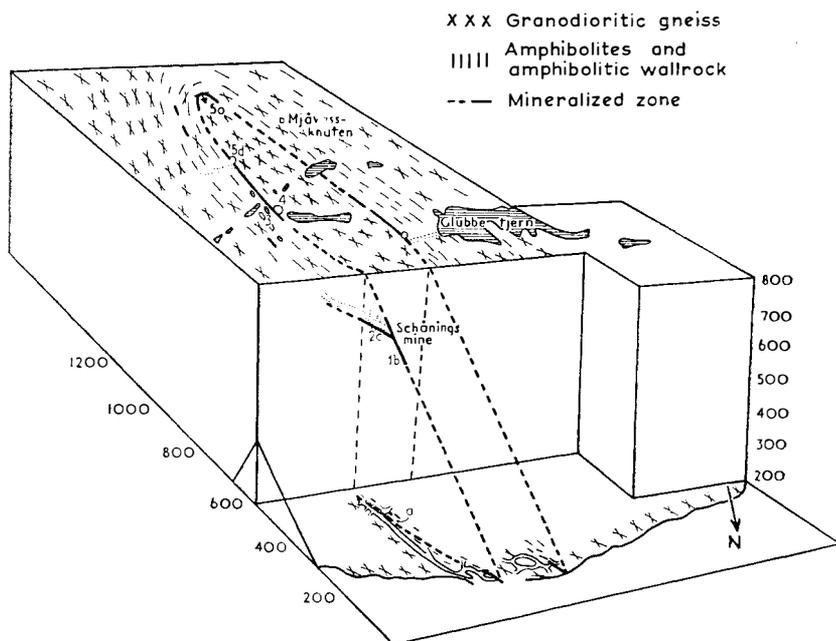


Fig. 1. Schematic block diagram showing the mineralized area in Ørsdalen.

south-western zone seems to have flattened somewhat, the dip being ca. 45° in the usual direction. The north-eastern zone has, however, maintained its rather steep dip which varies between 60° and 70° . In some of the crosscuts towards the south-west in the inner part of the adit along this zone local horizontal layers are observed.

The surrounding rocks represent typical migmatites consisting of pre-Cambrian gneisses of a granodioritic composition, with amphibolitic bands and inclusions showing varying degrees of assimilation. The granodioritic texture varies from fine-grained aplitic to pegmatitic. The bulk is a medium-grained rock. There are no sharp contacts between the different types, and minor pegmatitic parts can be seen well inside the fine-grained ones. As the amphibolites become granitized they often take on an aplitic appearance. A somewhat more detailed description of the petrology will be given in a later section.

Especially along the north-westerly part of the north-eastern zone, where the richest ore is found, there is a marked difference between the hanging and foot-wall rocks. In this part the foot-wall

consists of a medium grained grey homogeneous-looking granodioritic gneiss in which scarcely any foliation can be seen. Just a few small amphibolitic lenses can be seen in the gneiss. The hanging wall, however, consists of a very heterogeneous looking rock with a generally rather dark appearance.

The dark minerals are biotite and amphibole. Granodiorite veins are rather frequent. Inside this complex we often find aplitic-looking rocks of a very homogeneous appearance. These are, however, usually rather rich in dark minerals (biotite), and can often be seen to grade into typically silicified amphibolites. The width of this complex is somewhat variable but can be more than one hundred meters. On the other side of it we again meet with a granodioritic gneiss very similar to the one composing the foot-wall.

The contact between the hanging and foot-wall complexes are not sharp in detail and the two rock types grade into each other. Over a longer distance, however, the contact defines a rather straight line.

The richest concentrations of ore are found close to this contact and grading into the heterogeneous rocks of the hanging-wall. At a distance of about 3 m from the contact the grade is usually too low to be of any economic importance. Minor mineralization and concentrations of scheelite and molybdenite can be found scattered throughout the entire width of the hanging-wall complex. The granodiorite in the foot-wall is usually barren with just a faint mineralization close to the contact.

The mineralization, both of molybdenite and the tungsten minerals, is strongly bound up with quartz veins. These are of two types. The one is of the dark, glassy type and the other typical milky quartz. Using Graton's classification they would respectively belong to the hypothermal and mesothermal types. The first is the one found with the ore while the second is barren, occurring equally well outside and inside the mineralized zones. The quartz veins may extend for more than one hundred meters in the strike direction, but they are usually found as small lenses. Their widths are seldom more than one meter. Inside the mineralized zones they are often found as minor stringers just a few centimeters long usually together with scheelite. They are always parallel to the general foliation of the rocks.

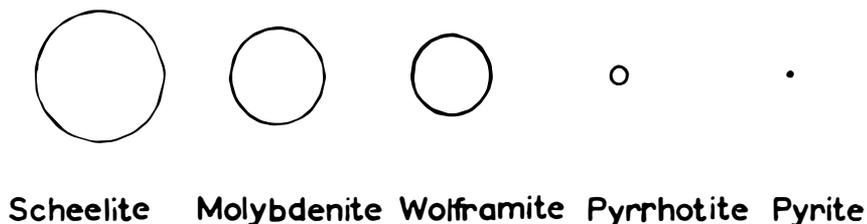


Fig. 2. Relative abundance of the ore minerals in Ørdsalen.

Description of the ore minerals.

The ore minerals found in Ørdsalen are:

1. Molybdenite
2. Pyrrhotite
3. Pyrite
4. Chalcopyrite
5. Wolframite (Ferberite)
6. Scheelite.

No general analyses of the ore have ever been made, and as the relative abundance of the different ore minerals varies from place to place in the field, even to give just an approximate estimate of the relative amounts is rather difficult. Fig. 2 is, as it seems to the author, a roughly correct picture of the mineral ratios. At least the marked difference in the proportions of molybdenite and the tungsten minerals on the one hand and the iron sulphides on the other, beyond doubt conforms to the actual condition.

In the following a general description of the minerals and their mode of occurrence is given.

Molybdenite occurs all over the mineralized zones. There are, marked differences, however, in its vertical distribution. In the two adits down in the valley molybdenite is scarcely seen, while on the top of the mountain plateau its appearance is very striking. It always occurs in connection with quartz veins, either in the veins themselves or as flakes along the contacts. Any impregnation in the rocks can only be seen close to the contact with the veins. Along fractures in

old stopes and drives alteration to molybdc ocher is often observed; this cannot be seen on the surface.

Pyrrhotite is after molybdenite the most frequent sulphide in Ørsdalen. It, also, can occur in connection with the quartz veins. Usually, however, it is found in the amphibolitic rocks and preferably along minor fractures. Its distribution seems to be somewhat opposite that of molybdenite, but the variations in concentration do not seem to be so marked as for that mineral.

Pyrite is found in Ørsdalen in rather small amounts. It usually occurs as thin flakes along irregular fractures in the quartz veins.

Chalcopyrite occurs in even less amount than pyrite and is found only at a few places in the field.

Wolframite (*Ferberite*) is restricted in its occurrence to the higher levels of the mineralized zones and is found in a few separated concentrations at or near the top of the mountain precipice along the north-east zone. The most remote mine 400 m SE of the precipice (5, fig. 1) probably contains wolframite but only two specimens in the dumps have been observed. Nos. 1, 2, 3, 4, 5 in fig. 1 represent the known loci of wolframite occurrences. The different occurrences are not connected with any continuous mineralization. Along the south-western zone wolframite is only found in small amounts in some old dumps not far away from the mountainside. In the two adits down in the valley it has never been detected.

The wolframite is concentrated along a narrow zone, seldom more than a meter broad, at the contact between the foot-wall and hanging-wall rocks, and is always connected with quartz veins. In one place only was it found inside the hanging-wall complex some meters away from the contact. Sporadically, it is found in minor lumps one or two meters away from the contact on the foot-wall side of it.

The wolframite occurs in lumps. The individual lumps can weigh several kilograms but are usually much smaller. The lumps are lens-shaped, with their largest axes parallel to the strike and dip directions of the rocks.

Professor OFTEDAL at the Mineralogical Institute, University of Oslo, kindly informed me that a spectrogram of wolframite from Ørsdalen made by him in 1938 showed the following elements present:

Main parts: W, Fe, Mn.
 1 % : Mg.
 trace : Si, Ti, Mo.

Si and probably also Mg and Ti may be ascribed to impurities. OFTEDAL also ascribes Mo to admixed impurities of molybdenite. However, according to DANA (2) both Ti and Mo occur in spectrographic amounts in wolframite.

Dr. BJØRLYKKE, chief geologist of A/S Norsk Bergverk, informed me that a chemical analysis of the Ørsdalen material made in 1934 gave the ratio $\text{FeWO}_4 : \text{MnWO}_4 = 42$ (mol. %). Using Dana's classification of the Ferberite: Huebnerite isomorphous series the mineral thus must be termed a wolframite.

Analysis of wolframites, made on the author's behalf, from different places in the Ørsdalen deposit do, however, give a different value for this ratio (see table 1). Only Fe and Mn were determined in the analyses. The results obtained from different determinations of material from the same sample could differ somewhat in the Fe: Mn ratio. The reason for this may be found in a possible zonal growth of the wolframites. Any measurable difference in the spacings of X-ray powder diagrams made on powder from different places in the samples could not be detected.

All the new determinations show a marked difference from the 1934 analyses, being much richer in iron. The ratio Fe : Mn is always well inside the limits of the name ferberite according to DANA (2).

The 1934 specimen is not available and the exact locality is not known. However, it must be from one of the 5 localities given in

Table I.

The Ferberite: Huebnerite ratio of different wolframites from Ørsdalen.
 (in mol. %).

| | 1 | 2 | 3 | 4 | 5 |
|----|--------------------|--------------------|--------------------|----------------|-------------------|
| G: | 87.9:16.2 7.302 | 85.5:14.5 7.313 | 84.5:15.5 7.391 | 83.8:16.2 — | 93.9:6.1 7.548 |

Numbers refer to localities indicated in fig. 1.

The specific gravities were determined with a Berman balance.

table 1, and probably from the no. 2. The remarkable differences between the chemical analyses make it highly probable that the old result is due to analytical error.

Scheelite. According to RANKAMA and SAHAMA (3) wolframite is much more common than scheelite. In Ørsdalen scheelite is found scattered over a much wider area than is wolframite. The impregnations are, however, usually fine-grained and poor, and as wolframite is found concentrated within smaller areas of rather rich ore, it may be dominant in weight. Even if scheelite be most abundant in Ørsdalen today, this may not be a primary feature. It can be shown that most of the scheelite found together with wolframite probably is secondary in origin formed by a Ca-metasomatism of wolframite. Scheelite is found at intervals all over the mineralized zones, from the bottom of the valley to the mountain plateau. It forms irregular impregnations all over the heterogenoeus hanging-wall rock complex, but the richest concentrations are together with the wolframite close to the contact between the hanging- and foot-wall rocks. From this it grades into the hanging-wall complex, the amount usually becoming rather small within a distance of 3 m from the contact. The reason for the enrichment of scheelite in the neighbourhood of wolframite is probably not a primary feature. Towards the granodiorite on the foot-wall the scheelite impregnation decreases abruptly in magnitude. Some fine-grained scheelite is, however, also found scattered throughout this rock within a few meters distance of the contact.

Scheelite is closely connected with quartz veins. Even when it occurs as very fine grains scattered in the rocks it seems to be connected to minor quartz stringers.

A spectrogram of scheelite made by professor OFTEDAL in 1938, showed the following elements present:

| | |
|-------------|-----------|
| Main parts: | W, Ca |
| ca. 1 % | : Fe |
| 0,1—1 % | : Mg, Mn |
| trace | : Si, Ti. |

Mo lines were also reported.

Some chemical analyses carried out in the laboratories of A/S Norsk Bergverk are given in table 2.

Table 2.
Chemical composition of scheelite from Ørsdalen.

| | a | b | c | d |
|------------------------|-------|-------|-------|-------|
| CaO | 17.80 | 17.50 | 17.30 | 16.90 |
| WO ₃ | 80.50 | 73.50 | 77.80 | 69.90 |
| MoO ₃ | 0.20 | 1.48 | 0.77 | 1.42 |
| | 98.50 | 92.48 | 95.87 | 88.22 |

Fe was reported present in all the samples.

(Letters a, b, c, d, refer to localities indicated in fig. 1).

The reason for the low sums is that there were impurities of admixed wall-rock material, especially biotite. The determinations of Mo are probably not accurate because of the difficulties introduced by the presence of large quantities of tungsten. As Mo may substitute for W, and there is a partly miscibility from scheelite to powellite (CaMoO₄) it is highly probable that the stated amounts of Mo are present in the scheelite lattice and not in admixed MoS₂. The quantities are not higher than those usually found in scheelite, (DANA 2, p. 1076).

“Scheelitization” of wolframite.

In Ørsdalen the wolframite lenses are *always* surrounded by a rim of scheelite (fig. 3). This can be explained in two ways, either as a late crystallization of scheelite around the already-formed wolframites or as a secondary alteration of wolframite into scheelite. As wolframite is never found without this rim of scheelite the latter possibility seems to be the most probable. The same feature is also known from other wolframite deposits, e.g. specimens received from professor GAVELIN, Stockholms Högskola, showed wolframite with surrounding scheelite zones occurring in quartz veins at Baggetorpa, Östergötland, Sweden. Dana's Mineralogy says (2, p. 1078): “Wolframite sometimes is found as perfect pseudomorphs after scheelite, but scheelite more often is found more or less completely replacing wolframite, in both cases apparently as a result of hypogene processes”.

This process of scheelitization is best understood in terms of late hydrothermal solutions reacting with the already formed wol-

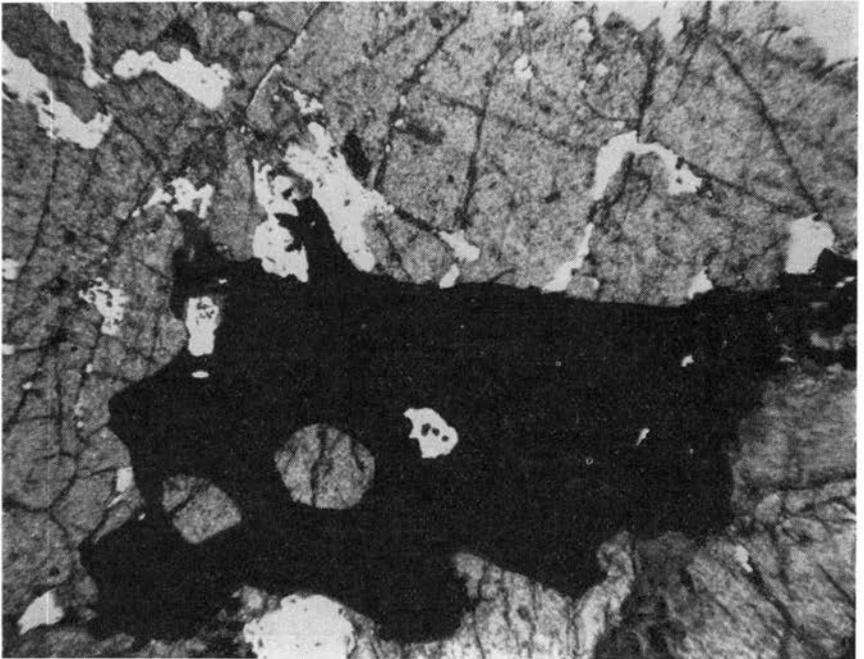


Fig. 3. Microphotograph of wolframite (black) surrounded by scheelite (Schäningsgrube, x 20, crossed nic.) Photo B. Maurits.

framites. As these solutions beyond doubt have to be alkaline the reaction is thought to take place according to the equation:



In order to see if this reaction can be repeated in the laboratory some experiments were carried out.

As working material wolframite from Schäningsgrube, Ørsdalen, (no. 2, table 1) and pure CaO were used. This was crushed, weighed and mixed in the stoichiometrically correct amounts. All the runs were made on the same mixture, and the products were identified by X-ray powder diagrams. The powder was wrapped in small platinum envelopes and put in a little steel bomb open at one end. The apparatus used was one of Tuttle's models (4) in which hydrothermal conditions are reproduced. The temperature was measured with a Pt-Rh thermocouple and the pressure with a manometer.

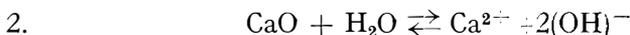
Table 3.
runs under hydrothermal conditions

| Run no. | Temp. C | Hrs. | Pressure (p.s.i.) | Reaction product |
|---------|---------|------|------------------------|-----------------------------------|
| 1 | 200 + r | 168 | 1000—8000 ¹ | scheelite and trace of wolframite |
| 2 | 300 + r | 551 | 10 000 | — |
| 3 | 400 + r | 282 | 10 000 | — |
| 4 | 460 + r | 336 | 10 000 | — |
| 5 | 500 + r | 185 | 10 000 | — |
| 6 | 600 + r | 192 | 10 000 | — |

r is room temperature

¹ The pressure was not stabilised and varied within these limits.

As will be seen from table 3 scheelite was formed throughout the entire temperature range examined. In none of the cases the reaction was complete, and on all the X-ray diagrams the strongest wolframite lines were still to be seen. There is no measurable spacing difference between these lines and those of the wolframite used for the experiments. In fig. 4 a scheelite diagram is compared with the diagram of one of the reaction products and the identity between the two is beyond doubt. Equations 2 and 3 describe the reactions which must have taken place.



The experiments show that eq. 3 defines an equilibrium strongly in favour of the components to the right.

It may seem strange that no trace is seen in the diagrams of the iron which is set free under the reaction. Some of this certainly remains dissolved in the water. As the reaction product, however, contrary to natural wolframite and scheelite, is strongly magnetic, it is probable that some of the ironhydroxide or oxide formed is surrounding the grains in a subcrystalline state. This may also explain the peculiar phenomenon that scheelite formed in this way does not give any fluorescence when examined with ultraviolet light.

Experiments were also carried out in the dry state, but no reaction could be detected.

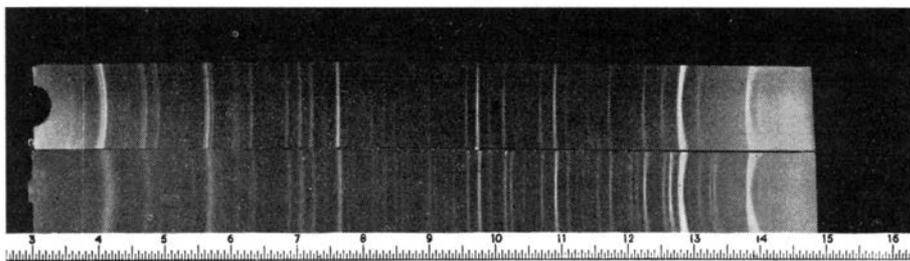


Fig. 4. 1. Scheelite, Øvstebø, Kleppan, Sauland.
 2. Scheelite formed by hydrothermal synthesis of wolframite (Ørtdalen) and CaO. 551 hrs. 300°C + r, 10000 p.s.i. Extra lines are wolframite lines. (Camera diam. 9 cm. exp. 2 hrs. 14 ma. 40KV. Fe-rad. Mn-filter).

There is no reason, however, to believe that the scheelitization of wolframite in Ørtdalen took place in the solid state, and the experiments have shown that under hydrothermal conditions scheelite (at least in the temperature interval from 200—600°C) will be formed by a Ca-metasomatism of wolframite. In this way the scheelite rims surrounding the wolframites in Ørtdalen are given a natural explanation. The wolframite lenses themselves can best be explained as a kind of “armoured relicts”.

Scheelitization and retrograde metamorphism.

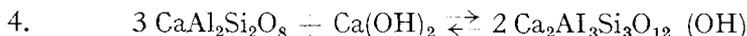
It is possible to connect the scheelitization process chronologically with other events that have taken place in Ørtdalen. In doing so it is necessary to have a little better understanding of the general geology of the area than previously given. As is mentioned before the rocks constitute a typical pre-Cambrian migmatite area consisting of granodioritic gneisses with amphibolitic bands and inclusions. Intense folding has taken place, and all the rocks, except a very young diabase dyke, have been deformed by the same forces which have made a part of the area into a kind of an elongated basin fold. The south eastern part of this, in which the ore occurs, is shown in fig. 1. On both sides the rocks strike conformably around the fold. More amphibolitic inclusions are found inside the folded area than in the surrounding rocks. The folding has not caused any crushing of the rocks. Inside the folded area the foliation of the gneiss is not

very marked, but the quartz grains always show an undulating extinction. The gneisses on the south west side of the fold show an especially marked foliation and the twin lamellae of the plagioclases are often bent but never broken. This serves to indicate that the rocks were reacting to the pressure in a plastic way. In all the acid rock types potash feldspar can be seen replacing plagioclase and they are all thought to have been formed by large-scale granitization processes. Even in the most heavily foliated gneisses the potash feldspar very seldom is deformed, which means that the recrystallization must have taken place simultaneously or after the folding. The ore zones are always parallel to the rock foliation. It is not possible, neither in the field nor in the laboratory, to separate younger granitic intrusions within the gneiss complex. As mentioned before the grain size may vary but the different types always grade into each other and no sharp contacts are ever met with. The fine-grained aplitic types might, as is believed to be the case in similar deposits other places, be explained as younger intrusions, connected with the ore formation. As mentioned, however, the field evidence does not suggest any difference in origin between these and the more coarse-grained types, and they are met with as well inside as outside the mineralized area. All the granodiorites are also, irrespective of the grain size, both mineralogically and chemically identical. As ores of this kind are always associated with acid rocks of such a type, it seems to the author that it is a sound working hypothesis to believe the formation of the ore to be closely associated, in principle as well as in time, with the formation of the rocks.

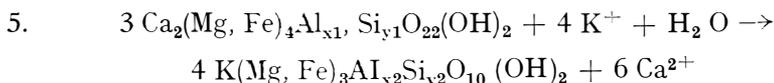
Now it can be shown that the recrystallization of the rocks took place under PT conditions corresponding to the border between granulite- and high amphibolite facies. This holds true for both the rocks inside the folded area and those outside it. In certain zones, which can be explained as tectonical zones of weakness formed during the folding of the area, a retrograde metamorphism has taken place, and the rocks are today found in epidote-amphibolite or greenschist facies. The rocks within these zones are more heavily foliated than otherwise is the rule. As the regional PT conditions must have been the same all over the area the best way to explain this feature is to ascribe it to the influence of late hydrothermal solutions which had a better access in the zones of weakness. The rocks in immediate

contact with the ore in Ørdsalen usually show a lower degree of metamorphism than the rocks some meters away from it. It is easy to understand that the mineralized zones form a better channelway for ascending solutions than the homogeneous, weakly foliated rocks on either side. These solutions appeared sometime after all the rocks in the area had recrystallized under PT conditions corresponding to granulite facies. They were able to penetrate the rocks most easily in the strongly foliated areas and in other places, such as the ore zones, where the pressure upon the water phase was at a minimum. These solutions are thought to be responsible for the alteration of wolframite into scheelite. To this it might be objected that these same solutions were the primary source of the molybdenite and wolframite as well. However, this would separate the formation of the ore from that of the rocks and furthermore we should expect to find tungsten minerals where ever these solutions can be traced, which is not the case.

In the retrograde metamorphic rocks microscopic veins containing quartz, chlorite and epidote are seen to cut through all the other minerals, at the same time as the plagioclase, which in the fresh types usually is an andesine, is heavily saussuritized and takes on the composition of nearly a pure albite. Several equations can be written explaining this process, but BARTH (5) believes that eq. 4 is probably the one best corresponding to natural conditions.



Close to the ore zone the hornblende is altered into biotite. This transformation may take place according to eq. 5. (RAMBERG 6).



The epidote in the quartz veins, the saussuritization of the plagioclase, and the transformation of hornblende into biotite indicate that calcium has been active during the retrograde metamorphism in Ørdsalen and thus has been available for the alteration of wolframite into scheelite.

The age sequence.

Scheelite and wolframite are the only minerals found in immediate contact with each other. It is therefore rather difficult to express anything positive about the relative age of the ore minerals. Molybdenite and wolframite are both closely associated with the dark glassy quartz vein type, and were probably the first minerals formed. Whether or not scheelite was formed at the same stage is not certain. We have seen that some of the scheelite must have been formed by alteration of wolframite. As it also occurs far away from any known wolframite deposit it might also be a primary mineral formed about the same time as the wolframite and molybdenite. Pyrite, which always occurs as thin plates along narrow cracks in the quartz veins must for this reason belong to a late stage of the mineralization. Pyrrhotite is the only mineral not directly associated with quartz veins, but occurs in the mineralized zones along minor fractures in the amphibolitic rocks. As these are neither filled with quartz nor any of the other ore minerals they must have opened at a late stage of the mineralization. Chronologically we then get the following age relationship of the minerals.

1. Molybdenite, wolframite, (scheelite?)
2. Pyrite
3. Pyrrhotite
4. Scheelite (formed by Ca- metasomatism of wolframite).

The mineral zoning.

Ore deposits similar to that in Ørsdalen generally exhibit mineral zoning in vertical sections. The minerals are enriched in different zones superposing each other. Ore deposits characterized by the mineral paragenesis in Ørsdalen would according to the general scheme be expected to show the highest concentrations of molybdenite at the deepest levels superposed by a concentration of wolframite, starting with the iron-rich members and ending with manganian. At still higher levels scheelite would be expected to concentrate. Pyrrhotite and pyrite would show a more uniform distribution with perhaps a slight enrichment at the higher levels. In fig. 5 this kind of zoning is illustrated according to a diagram of FERSMAN (7).

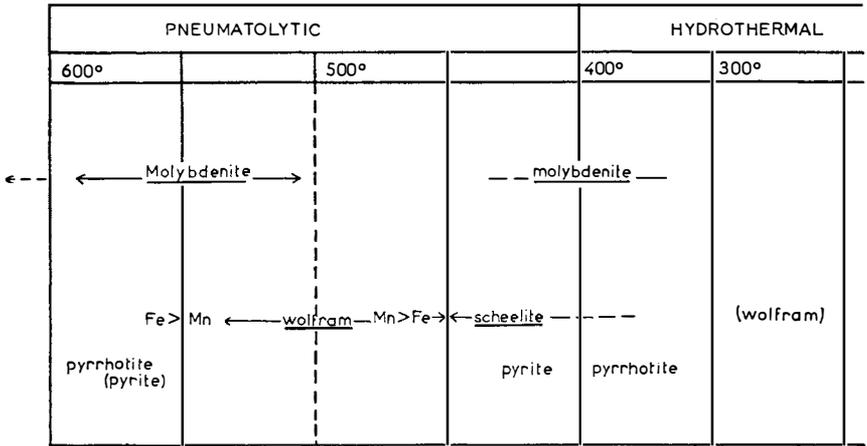


Fig. 5. Part of a diagram by A. E. Fersman indicating the hypothetical temperature relationship for the minerals met with in Ørdsalen.

In Ørdsalen we find a zoning quite opposite to this general picture. The description of the individual ore minerals given earlier show that molybdenite is concentrated at the highest levels and a little below these we find the largest concentrations of wolframite. The variations of the iron and manganese content in the wolframites (table 1) do not, however, show any regularity with depth, but they are all rather rich in iron. Scheelite is concentrated together with wolframite, but this can largely be ascribed to secondary processes. It is more important in this connection to note that scheelite is found in rather appreciable amounts down in the valley more than 400 meters below any known wolframite deposit. Pyrrhotite does not show any marked concentration in a vertical section. It is probable, however, that it is slightly enriched in the lower parts. The amount of pyrite is so negligible that nothing can be said about its concentration pattern.

The reason for this peculiar kind of zoning is not known. May be it is a secondary feature brought about by the late hydrothermal solutions which caused the alteration of wolframite into scheelite.

The process of ore formation.

The classical way of interpreting this kind of ore is to ascribe it to the pneumatolytic or hydrothermal stage of the crystallization

of a granitic magma. As mentioned, the rocks in Ørsdalen are typical pre-Cambrian migmatites. By petrologists today such rocks are more and more looked upon as ultrametamorphites of geosynclinal sediments and lavas. Tungsten (scheelite) and molybdenum (molybdenite) are characteristic elements in the different ore deposits connected with the huge pre-Cambrian Telemark granite, the central part of which is about 120 km NE of Ørsdalen. ADAMSON and NEUMANN (8) connect the Ørsdalen deposit with the formation of this granite, which is recognized by most Norwegian geologists as a metasomatic rock.

How these ores are related to the process of granitization is highly debated among geologists. During recent years some very interesting views have been published by SULLIVAN (9).

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