SVERIGES GEOLOGISKA UNDERSÖKNING

SER. C. Avhandlingar och uppsatser. N:o 324.

ÅRSBOK 17 (1923) N:o 5.

EULYSITIC IRON ORES IN NORTHERN SWEDEN

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Pris 0:50 kr.

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Introduction. Recent field work in the eastern part of the Archean iron-bearing region of northernmost Sweden has brought out the fact that there occur in several places lean iron ores of a type not previously recognized in this region. It is characterized by the presence of iron silicates (mostly together with magnetite) in a quartzy gangue, generally shows a good stratification, and has the field relations of beds interstratified in the supracrustal rocks. The first indication of the existence of this type was found by the writer when examining the Välivaara part of the chain of ore fields near Masugnsbyn. Later, the study of specimens and field notes from Pajala, presented to the Geological Survey by Dr. V. Tanner, who there spent the field season of 1918 in prospecting, showed the probable existence of several representatives of the same type within the district covered by Dr. Tanner's work. Finally, in a series of specimens from certain parts of the ore-bearing region, collected by Dr. B. Högbom in the course of prospecting operations, and by him presented to the Survey, I identified one specimen, from Marjarova in Pajala, as a fayalite rock. This fact brought in the »eulysite problem», which in recent years has received particular interest from our geologists. To obtain more complete data on these occurrences, a couple of days last summer were devoted to a field examination of Käymäjärvi, most important among the localities visited by Dr. Tanner, and to Marjarova, while a study of Välivaara formed part of an examination of the whole Masugnsby district.

The purpose of the present paper is to point out this particular type of ore, and the general geology of the region will not now be touched upon more than is necessary to bring out its geological setting.

Masugnsbyn is situated 70 km NE of Gellivare. In this district,[1] a strip of leptite formation is bordered on the east by a large mass of granite, referred to the Lina group. The contact runs nearly parallel to the bedding of the leptite formation, the dip is steep and westerly. The main mass of the formation is made up of leptites, showing considerable variations in their quartz content and in the character of their feldspar. Locally, graphitic layers are encountered. A broad belt of limestone and dolomite follows the contact with the granite, but just along this contact it is replaced by magnetite ore, with a gangue of skarn silicates (pyroxene, amphibole, olivine or chondrodite). To the north, where the contact deviates somewhat from the strike of the leptite formation, the carbonate belt — more narrow there — and the associated

[1] An account of the geology of the whole Masugnsby district will be published later.

skarn ores are bordered by leptite on both sides. The chain of ore deposits is not entirely continuous, and one distinguishes between the fields Junosuando[1] (in the south), Vähävaara, Välivaara, and Isovaara, on a stretch of 7 km. The rocks now to be considered are best developed at Isovaara and Välivaara.

At Isovaara, the carbonate rock with associated ores is in part accompanied by a well stratified quartzitic rock with amphibole, pyroxene, and garnet, and carrying also a considerable percentage of magnetite, and some pyrrhotite. At Välivaara, again, most of the prospecting pits — or, rather, the heaps of broken ore at them, for the pits have generally collapsed — do not show any skarn ores,[2] but a lean siliceous magnetite ore, well stratified and partly banded with glassy quartz. Considerable pyrrhotite is associated with the magnetite. There are also the same silicates as in the quartzitic rocks of Isovaara: amphibole, pyroxene, and garnet.

The garnet of these siliceous magnetite-bearing rocks from Isovaara and Välivaara is red, and in thin sections either light pink-coloured, probably indicating almandite, or yellow and then presumably somewhat manganiferous. The amphibole is of two kinds. One shows dark green colours in thin sections and is similar to the ordinary hornblendes of amphibolites, but has a very low optical axial angle and therefore probably belongs to the noralite group, high in CaO and FeO (compare 6, p. 147).[3] Together with it, or alone, there appears a cummingtonitic amphibole, showing in thin sections weak green colours, with at tinge of yellow for α, of brown for β, and of blue for γ. The angle $\gamma : c$ is $18^1/_2°$ to 20°, the optical character negative. While these characters show that it is not a pure member of the monoclinic amphibole series $(Fe,Mg)SiO_3$, it exhibits very well the characteristic 001 parting of this series. Sometimes portions of a grain are colourless, but the optical orientation and the birefringence are the same as in the coloured portions.

The pyroxene varies. In one specimen it is light yellow in thin section, optically positive, with a very small axial angle, $\gamma : c = 32°$, $\gamma - \alpha = 0.014$. This must be a member of the clinoenstatite series, the monoclinic $(Mg,Fe)SiO_3$ pyroxene, but one cannot determine its exact position in the series, as both Mn and Ca may be present in sufficient amounts to influence the optical properties. In another specimen, the pyroxene has a stronger, greenish yellow colour, and a much higher birefringence (about 0.025), the extinction angle amounts to 42°. While probably related to the other type, this one may contain a higher proportion of $CaSiO_3$. Finally, there is to note the presence of apatite in small grains, a little mica, and sometimes a considerable amount of feldspar (microcline and albite), marking a transition to the leptite. The texture is that of a crystalline schist, as in the leptites.

Clearly the most characteristic feature of these rocks is the occurrence of silicates high in iron. This, and their pronouncedly siliceous character, and also to some degree their regular banding, mark them apart from the closely

[1] Not to be confounded with the village J., from which it originally takes its name.

[2] Skarn ore has been found with a drill hole, and appears to lie in the foot-wall of the siliceous ore.

[3] Numbers in parenthesis refer to the literature list on page 15.

associated skarn ores with their gangue of lime-magnesia-silicates (with but little iron) and carbonate, and their irregular or stripe-wise distribution of mineral components.

In the southeastern continuation of the Masugnsby ore fields, the leptite formation is largely made up of bedded amphibolitic rocks. The presence of abundant cummingtonite and some garnet shows the admixture of material of the kind that makes up the iron-silicate-bearing rocks of Isovaara and Välivaara.

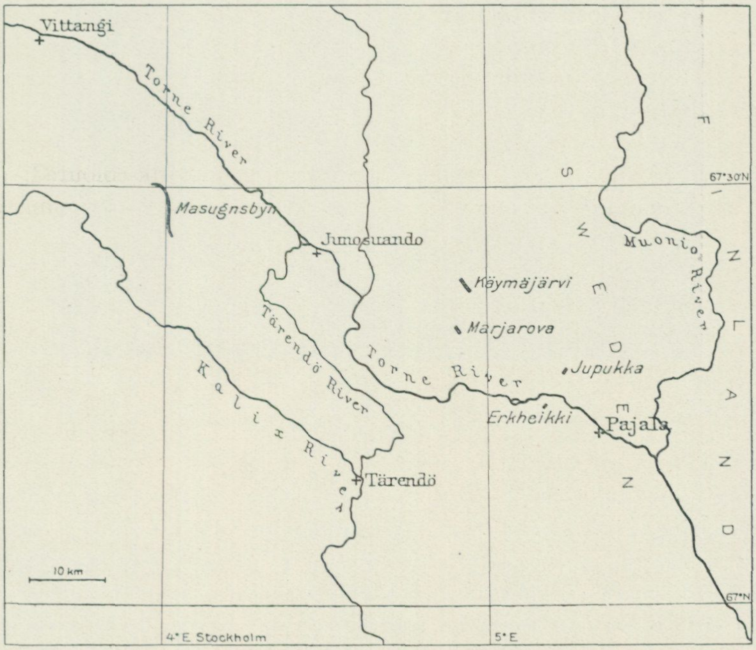
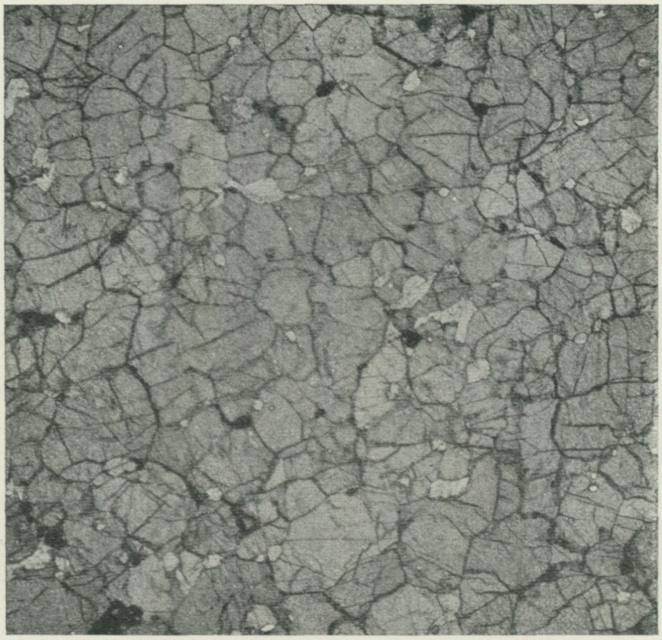


Fig. 1. Key map, showing the localities referred to in the text. Scale 1 : 1 000 000.

Marjarova. On this recently discovered field there are no outcrops. The discovery, as generally in these parts, was made with the miner's compass. A series of prospecting pits has been made. They show only the ore zone, the wall rock is nowhere exposed. The length of the ore zone, which is almost straight and strikes NW—SE, is about one kilometer. The dip appears to be nearly vertical. About 1.5 km N of the northwestern end of the Marjarova field, the ore field of Pellivuoma begins. This is a fairly typical representative of the skarn ores proper in this region, a replacement deposit in crystalline limestone. To the north of the Marjarova field, limestone is reported to outcrop, while Tanner has found granite in the east, at a distance of about 1 km. It is, in fact, quite possible that the granite occurs in the immediate neighbourhood of the southeasternmost pit on Marjarova. This granite belongs to the same group as that of Masugnsbyn, and is younger than the leptite formation, to which the limestone and the Marjarova ore zone are referred.



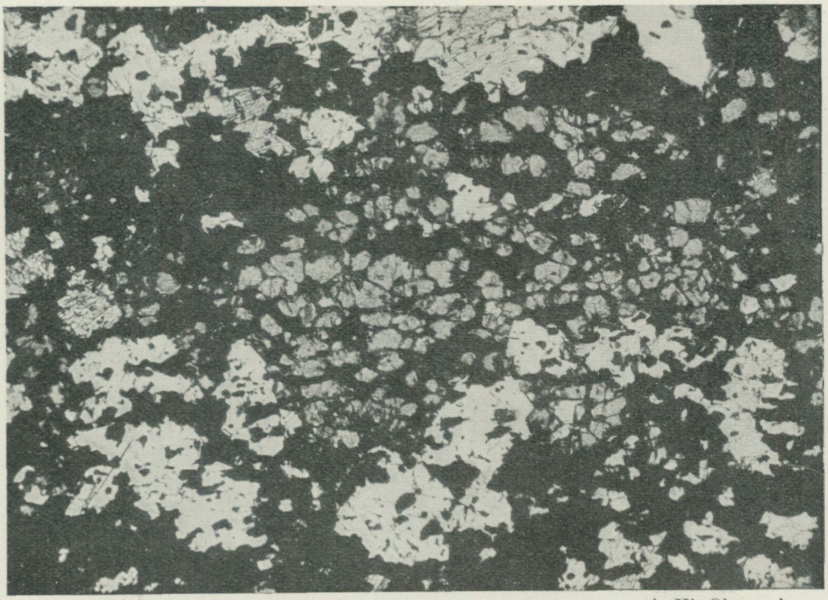
A. Hj. Olsson photo.

Fig. 2. Fayalite rock, Marjarova, Pajala. Microphoto in ord. light, × 16. Shows mangan-fayalite and a little grünerite (white).

In most exposures, this ore zone exhibits skarn and associated magnetite ore, alternating with bands of a glassy quartzite. The skarn is fine-grained and mostly fibrous, green or grayish brown in colour, often varying within a single hand specimen. The grayish brown mineral is an amphibole, which in thin sections shows the following properties: colour very light yellow, polysynthetic twinning common, $\gamma : c = 14°$, optically negative with a large axial angle. The refraction was determined with the immersion method to $\alpha = 1{,}650$, $\gamma = 1{,}684$. These data identify it as a member of the grünerite-cummingtonite series, the monoclinic amphiboles $(Fe,Mn,Mg)SiO_3$. A comparison with the data published by Sundius (16) indicate a composition about 65 % $(Fe,Mn)SiO_3$ and 35 % $MgSiO_3$.

A section of green skarn shows an aggregate of green pyroxene grains, enclosing small patches of the grüneritic amphibole skarn. The mutual relations indicate that the latter were earlier formed, and may be replacement relics. The pyroxene must be high in iron and near hedenbergite, as it has $\gamma > 1.74$.

Some of the bands that are high in magnetite do also contain much biotite. In the southeasternmost pit, the developement of the ore zone is somewhat different from the rest. Most of it is a massive, dark greenish brown, fine-grained fayalite rock, alternating with bands of the usual glassy quartzite. In thin sections, the dark rock is seen to consist almost exclusively of fayalite in grains about 0.4—0.8 mm in diameter, with simple outlines (fig. 2). There are also a few short stalks of the grüneritic amphibole, and some aggregates



A. Hj. Olsson photo.

Fig. 3. Iron ore, Marjarova, Pajala. Microphoto, ordinary light, × 16. Magnetite black, manganfayalite gray, grünerite white.

of a deeply coloured mica, associated with bluish green flakes that are probably hornblende. A dark substance, translucent with a brown colour, is seen to partially replace the fayalite. Magnetite is sometimes present in considerable amounts, and there are bands where it forms the main constituent, accompanied by fayalite and grüneritic amphibole. The fayalite is gathered in patches (fig. 3).

To obtain an idea of the proportion between the main components of the fayalite, a specimen of typical fayalite rock was analyzed. The analysis, made by Dr. Naima Sahlbom, gave the following figures:

	I	I a	II
SiO_2	29.89	498	28.22
Al_2O_3	none		none
Fe_2O_3	1.74	11	»
FeO	56.90	790	63.20
MnO	8.00	111	5.19
MgO	3.43	86	2.32
CaO	0.41	7	0.50
	100.37		99.43
	δ 4.07		4.32

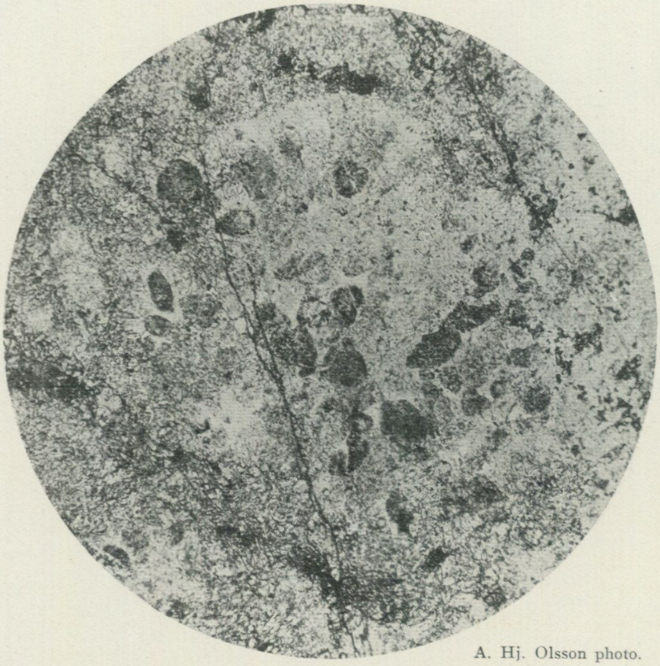
I. Fayalite rock, Marjarova, Pajala. N. Sahlbom analyst.

I a. Molecular proportions of I, × 1000.

II. Manganfayalite from the Gillinge eulysite. John Palmgren analyst (14, p. 117).

It is apparent that the fayalite rock of Marjarova has practically the same composition as the ordinary fayalitic constituent of the eulysites of Södermanland, of which the Gillinge mineral is a typical example.

A few hundred meters N of the ore zone, skarn of the kinds characteristic of Marjarova has been encountered in a prospecting pit. The relations to the main iron-bearing zone are not known.



A. Hj. Olsson photo.

Fig. 4. Lean phase of siliceous iron ore, Vinsa at Käymäjärvi, Pajala. Microphoto, ordinary light, × 16. Shows granules rich in magnetite, in a mass of quartz; much grünerite and iron pyroxene in the other parts of the figure.

Käymäjärvi. The ore-bearing rocks of Käymäjärvi are most nearly associated with an extensive formation of limestone and dolomite, sometimes well stratified. An agglomeratic greenstone occurs with the carbonate rock but does not appear to be directly connected with the iron-bearing zone.

The outcrop of low-grade iron ore on Vinsa, on the southern side of lake Käymäjärvi, has been known for centuries, in spite of the remote situation. It shows a steeply inclined banding of very fine-grained, siliceous magnetite, brownish gray amphibole skarn, and fine-grained gray quartz. The microscopic examination shows that the quartz, which also forms a matrix in the silicate bands, is developed in a pavement structure with the size of grain about 0.03—0.08 mm. In portions with a low or moderate magnetite content, the distribution of this mineral is very striking. When viewed in ordinary light, the thin sections show rounded spots that are darker than the surrounding quartz mass (fig. 4). This is caused by a pigmentation that is often very fine, but generally coarse enough to allow the identification of the dark mineral as magnetite.

The spots are well rounded, or seldom a little angular, and reach a diameter of about 0.7 mm. They are sharply defined by the distribution of the magnetite. Between crossed nicols, they can be discerned only with difficulty.

The silicates partly appear as branching streaks. The amphibole is essentially similar to the grüneritic one of Marjarova. There is also some pyroxene,

A. Hj. Olsson photo.

Fig. 5. Lean phase of the siliceous iron ore, Vinsa at Käymäjärvi, Pajala. Microphoto, ord. light, × 60. Detail showing relations of granules with magnetite pigment (see text); magnetite, grünerite and iron pyroxene in the surrounding quartz mass.

light yellowish in thin sections, with $\gamma : c = 34°$, $\gamma - \alpha = 0.014$, optically positive, with a very small axial angle. It is evident that this pyroxene is practically the same as the one that was described above from Isovaara at Masugnsbyn, a member of the monoclinic pyroxene series $(Fe,Mg,Mn)SiO_3$. Fayalite has been observed, but seems to be rare. Locally there are aggregates of the mica that has been noted also in other iron-bearing rocks of this group, pleochroic in reddish yellow (or reddish brown) and dark green.

The spots with magnetite form the most remarkable textural feature in this ore zone.[1] It is quite clear that they represent one-time granules, whose identity has otherwise become more or less obscured by the recrystallization of the quartz, and is preserved only in the distribution of the magnetite. This is particularly well brought out by the case shown in fig. 5, where the relations between two of the spots show their individuality and admits of no other

[1] There are also some aggregates of grünerite that may be related to them, forming radial groups of about the same size as the spots with magnetite pigment.

explanation than the section's having cut two individual granules, the one lying partly above the other and pressed into it.

The original nature of these granules is indicated by their identity with the products resulting from moderate metamorphism of greenalite granules in the iron sediments of the Lake Superior region. A comparison with the illustrations and descriptions that Leith (13) has given of phases of the Mesabi »taconite», shows the same form and size, the same distribution of iron pigment (although in this case oxide), the absence of any corresponding texture in the quartz mass, and also the presence of grünerite in the same rock. The original granules of the hydrous iron silicate greenalite are regarded by Leith as formed primarily, at the deposition of the greenalite (compare also Van Hise, Leith, and Mead, 17, p. 521).

From the eastern part of the same range (Mesabi), Grout and Broderick (9 and 10) have more recently described the same phenomena, in an apparition even more similar to the Käymäjärvi rock, as the iron is present as magnetite, not as oxide. Grout and Broderick follow the authors previously quoted in regarding part of the smaller granules as primary, but are inclined to explain the majority as pebbles of intra-formational conglomerates, formed when wave action in the shallow waters broke up the iron-bearing precipitate that covered the bottom. They also reckon with a certain amount of relative enrichment in iron (by leaching of silica) during this period, to explain the varying magnetite content. In the Käymäjärvi rock, only the variable content of magnetite in the supposed granules would seem to furnish an argument for an application of these views. It seems safer not to stretch this detail as to prove a shallow-water deposition, but instead limit conclusions to the fact that the iron-bearing zone at Käymäjärvi was in all probability once deposited as granules of an iron silicate in a matrix of colloidal silica.

The other exposures in this neighbourhood need only a brief mention. Some hundreds of meters to the northwest of the old prospect, in the direction of the strike, a small outcrop of the same character has been found. Further away, about 2 km from the original discovery, there is a group of outcrops that certainly belongs to this zone. The development is different, however: the magnetite content is low, the quartzitic bands are almost glassy, and portion of the zone are made up of a more irregular alternation of green skarn and white quartz.

Erkheikki and Jupukka. According to Tanner's field notes and specimens, banded quartzitic rocks with amphibole and magnetite form the hill in the village of Erkheikki, and the summit of the mountain Jupukka, 5 km NNE of Erkheikki and in the direction of the strike at the latter place. A specimen from Erkheikki has been studied microscopically by the writer. The main mass is a finely crystalline quartzite, with grains about 0.03 mm in size. There is also amphibole of two kinds, one grüneritic and the other strongly coloured (bluish green), and some apatite. In this particular section the amphiboles form veinlets in the quarts mass. At Jupukka, the ore zone contains bands of a fine felt of grüneritic amphibole.

Summary and discussion. It is evident that the various occurrences described above are very closely related to each other. It is not necessary to assume that they mark one exact stratigraphical level in the Archean, but it is probable that they do so in a broader sense. Both at Masugnsbyn and at Käymäjärvi, they occur in immediate connection with the limestone, and above it (tectonically, and, probably, also stratigraphically). At Marjarova, limestone occurs in the neighbourhood, although not exposed so near the iron silicate rock, and the same holds true also of Erkheikki and Jupukka.

In all cases, the iron-bearing zone is stratified, and is made up of quartz, magnetite, and iron-magnesia-manganese silicates. These silicates are metasilicates (either amphibole, which is the most common, or pyroxene) or, mainly in a part of Marjarova, the orthosilicate, fayalite. Sometimes, silicates containing an essential proportion of calcium are absent. In other cases, at Isovaara and Välivaara, the optical properties of the silicates make it probable that at least certain of them contain also some calcium. Still more frequently, beds of green pyroxene (and probably in part also amphibole), certainly high in calcium, are intimately associated with the purer iron-magnesia silicate bands.

As to the origin of these iron-bearing rocks, it seems almost certain that they represent metamorphosed chemical sediments. An igneous origin is entirely excluded, both by the characters of the rocks themselves and by their relations to the other members of the leptite formation. For the possibility of an origin by metasomatic alteration no other reasons can be cited than a certain chemical and mineralogical similarity to rocks elsewhere that are so interpreted, and the rather close association with the skarn ores in limestone that are undoubtedly formed by replacement. However, the geological reasons that have led investigators, among them the present writer, to ascribe such an origin to certain ore-bearing rocks in Central Sweden, do not apply to the siliceous ores here. Also, the analogy in mineral composition is limited: the combination orthosilicate (fayalite) + quartz is not recorded from replacement deposits. As to the association with skarn ores in limestone, it is apparent from the relations at Käymäjärvi, where skarn ores are lacking, that it is with the limestone, and not with the skarn ores, that the siliceous ores are originally associated.

An origin by sedimentation, on the other hand, is suggested both by the characters of the iron-bearing rocks themselves, by their geological associations, and by analogies. The generally regular stratification is decidedly in favour of this explanation, as is also the appearance in bands of a strike length to be measured in kilometers. The association with stratified limestone, and sometimes, although less intimately, with graphitic rocks, is suggestive. Finally, sediments of the same character are not rare in many formations. In fact, the most common development of the rocks described here is parallelled by the »grüneritic cherts» of the Lake Superior region, while the fayalite rock has its counterparts at those places in the same region where unoxidized iron sediments were recrystallized through the contact action of intrusives. Particular interest is attached to the probable pseudomorphs of greenalite granules in the ore zone of Käymäjärvi.

Therefore, it can hardly be doubted that the iron-bearing rocks considered here are metamorphosed chemical sediments. A local admixture of clastic material is indicated by the feldspatic portions at Masugnsbyn. The iron was probably deposited as a ferrous compound, either silicate (greenalite) or carbonate. An original hydrous oxide could not have reacted with the silica present to form the ferrous silicates that are now so characteristic of these rocks. No increase in temperature short of melting appears to make this reaction possible, as is illustrated by the numerous inclusions of quartz-banded iron ore in granites in Central Sweden, showing a transformation of hematite to magnetite, but never any reaction between the iron-oxygene compounds and the quartz.

The particular reason for the appearance of the fayalite is not clear. It cannot be lack of silica, as the fayalite rock is in contact with quartz bands. Our knowledge of the paragenetical relations of fayalite and grünerite suggests a higher temperature as the condition that brought about the crystallization of the orthosilicate. This, again, makes it probable that the crystallization was caused by the neighbouring granite. It is also probable that the recrystallization of the iron sediments in general took place at the same time. Otherwise it would be necessary to suppose that the whole of the Marjarova ore zone had been recrystallized, and magnetite and ferrous anphibole formed, leaving only the southeastern end with its original iron compounds unoxidized, so that they could react with the silica when heated by the intruding granite. It seems more probable that the development of the fayalite represents the more immediate contact action of the granite, while amphibole and pyroxene were formed under the conditions reigning in the vast outer contact zone of the granite masses, blending into what is generally styled regional metamorphism. No safe conclusion can be drawn, however. The relations between fayalite and grünerite as illustrated in fig. 3 admit of several interpretations. Either the grünerite is a later mineral, formed perhaps at the expense of the fayalite as the temperature in the contact zone decreased, or the fayalite aggregates represent portions in a »grüneritic chert» that were still unoxidized at the time when the full influence on the contact action began to be felt.

The calcic silicates were probably formed at the same time as the grünerite and the iron pyroxene, and in a similar way, by reactions between calcareous or dolomitic layers and the quartz. It is also p o s s i b l e that substances have been contributed from the outside, as in the skarn ores, but there are no direct reasons to suspect an addition of this kind. During the crystallization of the silicates there must have been a local movement of compounds, as witnessed by the appearance of veinlets of iron silicates (Käymäjärvi, Erkheikki), or by the relations of hedenbergitic pyroxene and grünerite at Marjarova.

Remain to be considered the analogies to the eulysites. As originally described by A. Erdmann (4), the eulysite is a rock consisting essentially of an iron-manganese olivine, and interstratified in the garnet gneiss complex of Södermanland. This occurrence (Tunaberg) and some others have later been studied in detail by Palmgren (14). A new group, with several occurrences of eulysite, was recently discovered by von Eckermann (3), within the gneiss territory of Hälsingland. These eulysites are partly very low in manganese, and may then be described as fayalite rocks. von Eckermann interpretes the eulysites as magmatic, or rather pegmatitic, intrusive rocks, younger than the associated gneisses and limestones. They shall represent pegmatitic residual solutions of a basic magma.

This interpretation has been criticized by Carstens (2), who points out the chemical identity between the eulysites, the magnetite-stilpnomelane rocks described by Carstens himself (2), and also, apart from the oxidation stages of the iron, ordinary quartz-banded magnetite or hematite ores. Carstens concludes that the various silicatic iron ores represent different metamorphic conditions. Starting from unoxidized iron-silica sediments, the magnetite-stilpnomelane rock shall represent the epi zone of Grubenmann (11), the eulysites the kata or meso zones. The quartzy hematite or magnetite ores are believed to represent the metamorphic products of o x i d i z e d sediments.

Already in 1913, the present writer (7, p. 455—456) called attention to the fact that fayalite rocks were then known to originate in three different ways: as segregations from fayalite-bearing igneous rocks, by contact metamorphism of siliceous iron sediments, and by replacement of limestone. The magmatic way was represented by the ore prospect of Rackberget in northern Sweden, previously described by the writer (5). Examples among metamorphosed chemical sediments were quoted from the Gunflint Lake district of Minnesota (18). To this has later been added the eastern part of the Mesabi Range (9, 10); recently, an interesting example has also been found in the Harz in Germany (15). For the metasomatic origin, finally, the Tunaberg eulysite was cited from Högbom (12, p. 40). This interpretation of the Tunaberg eulysite can hardly be upheld any more, but the orthosilicatic skarn of certain ore deposits in limestone supplies other examples.

As already mentioned, the writer holds the opinion that the fayalite rock of Marjarova belongs to the group of metamorphosed sediments. Whether this also applies to the eulysites proper may be doubtful. Among the arguments for an igneous origin that have been produced by von Eckermann, the one that, in the judgment of the present writer, carries most weight, is the presence of some inclusions of other rocks. Without a personal experience of this highly important detail, one must hesitate to doubt the conclusions that are the results of von Eckermann's detailed study. On the other hand, the study of the group here described has added a number of new arguments for a sedimentary origin to those already marshalled by Carstens. The analogies are not restricted to the iron rocks themselves. The intimate, but not immediate association with limestone beds is characteristic of the north Swedish silicatic iron ores, and of the eulysites. One feature of the eulysites that has been rather puzzling from the sedimentary point of view, is the homogeneity of the ortholisicate mass. In this respect, however, Marjarova is comparable to the eulysites proper.

In sum, while Marjarova does not justify a definite conclusion that the eulysites of the gneiss territories are metamorphosed chemical sediments, it certainly forms a most important addition to the sum of facts that are pointing in this direction.

If the eulysites of the gneisses should have been formed in the way here supposed for the Marjarova fayalite rock, it would mean that their iron had reached the realms of »deep metamorphism» while still in its ferrous stage. To form fayalite from magnetite and quartz, without first reducing the ferric iron, seems to be impossible, as exemplified by cases already referred to. A quartz-banded hematite or magnetite ore, of the type common in the leptite formation of Central Sweden, then, would not yield a eulysite under any conditions of metamorphism, except in the presence of a reducing agent. The graphite of the gneisses indicates that one has to reckon with the presence of this factor, but it is doubtful if it has occurred in sufficient quantities.

So far, no fayalite has been found in the stratified siliceous ores of the leptite formation of Central Sweden, and the occurrences of grüneritic amphibole that indicate a similar chemical composition are rare. Examples on a small scale have been described by the writer (8, p. 32—33) from the neighbourhood of Falun.

The title of this paper speaks of the ores as »eulysitic». This is done to emphasize their analogies to the original eulysites. Carstens (2) is inclined to extend the use of the term to all sedimentary iron silicate ores, using prefixes to denote the metamorphic facies. According to this proposal, the Marjarova fayalite rock would be a kata-eulysite, the grüneritic forms the same, or perhaps meso-eulysites. This is very well for classification purposes, but has its disadvantages in other ways, as eulysite is an old term with a clear definition. The writer, therefore, would prefer to restrict this term to those iron silicate rocks that contain fayalite (manganiferous or not) and occur as concordant bodies in stratified rock series, while »eulysitic» may perhaps be used, as partly here, to indicate a particularly close relationship to the eulysites.

Practical considerations. The ore deposits that have been described here are always of a low grade, and it is hardly probable that any one of them could be worked, even if they had been situated close to centres of consumption. The skarn ores that so often appear in their vicinity are much richer, and partly contain very large ore quantities. The practical interest in this study of the eulysitic ores lies in the explanation that can now be given of certain features that have proved puzzling in the exploration of the skarn ores, as it is now known that the closely associated ores are of an entirely different origin.

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