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THE GENESIS OF THE PRECAMBRIAN SO-CALLED IRON FORMATIONS (SYDVANGER TYPE) WITHIN THE GNEISS OF THE DESNÀ DOME, HRUBY JESENÌK MOUNTAINS, CZECH REPUBLIC

Apart from iron ores of the Lahn-Dill type, magnetite ores occur within the gneiss of the Desna Dome, high Jesenìk Mountains. These ores were mined between the 17th and 19th century, but were not mentioned in the literature. In the 20th century, when mining activities were renewed, the first reports were published (Kretschmer 1911, Sellner 1930 and Bederke 1938). Detailed investigations of the magnetite mineralisations were carried out by Pouba (1960, 1970 and 1985). He identified them as banded iron formations and characterises them as the Sydvanger type (according to the Norwegian iron formation of Early Karelian age of 2.5 – 2.6 Ga) which is of sedimentary origin and was formed in connection with submarine volcanism. These environmental conditions refer to the well-known Algoma type iron formation. However, Pouba (1960) does not exclude a genetic relationship between the iron ores and the Sobotin gabbro-amphibolite massif, stating that the ore deposits are symmetrically arranged around it. These deposits occur in three settings which are: 1) embedded within the Sobotin massif (Rudna hora and Sylvani); 2) in close contact to the Sobotin massif (Kosare, Bridlicna, Svagrov and Zadni hutisko); and 3) located relatively remote to the Sobotin massif (Kyzovy dul and Mnisske jami).

The above-mentioned deposits were investigated by us. The material was collected from old dumps or originated from the Mineralogical Museum of Brno. A first report of Mücke and Losos (2000) has shown that the magnetite ores are genetically related to the gabbro of the Sobotin massif and thus of magmatic origin.

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The deposits can be differentiated into two groups: 1) amphibole-free and chlorite-rich group (Mnisske jami, Kyzovy dul and Bridlicna); and 2) amphibole-bearing group. This group has two subgroups: 2.1) chlorite-free (Sylvani and Rudna hora); and 2.2) chlorite-bearing (Svagrov, Zadni hutisko and Kosare). <u>Magnetite</u> is the main mineral of the deposits and forms either xenomorphic, polycrystalline aggregates arranged parallel to the rock foliation or occurs in compact masses which may be interlayered with quartz bands (Rudna hora, Sylvani

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and Mnisske jami). Magnetite contains trace elements up to 0.89 wt% TiO_2, 0.25 wt% MnO, 0.15 wt% V_2O_3, and 0.34 wt% Al_2O_3. Ilmenite may be associated, but not intergrown with magnetite and contains always V_2O_3 (on average 0.4 wt%) and up to 50 mol% pyrophanite $MnTiO_3$ in solid solution. Amphibole forms elongated aggregates parallel to the rock schistosity and is often interlayered or intergrown with magnetite. The amphibole composition varies from tschermakite via magnesio-hornblende to actinolite and tremolite. Their Mg-numbers are always higher than 0.55. Biotite observed at Mnisske jami, Kyzovy dul, Bridlicna, Sylvani, Svagrov and Zadni hutisko occurs in two types which can be chemically differentiated: 1) MgO-rich members corresponding to biotite compositions of the gneiss and 2) annite-richer members corresponding to biotite compositions of the Sobotìn massif. Chlorite is mainly ripidolite, rarer has clinochlore composition. Garnet can also be chemically differentiated into two types: the 1st type is composed of grossularite-almandine solid solutions and may occur sporadically; and the 2rd type, composed of varying proportions of spessartite and almandine that contain also grossularite and andradite end-members in the solid solution, occurs in the form of quartz-bearing garnetiferous rocks. These rocks are abundant in Zadni hutisko and rather rare in Svagrov and Kosare. Apatite which is nearly pure F-apatite occurs in all the locations and may occupy up to 20 vol% of the rock composition, being either associated with amphibole or magnetite or both. Depending on their stability, quartz replaces all the other minerals in varying degrees and occurs in the form of polycrystalline bands which are arranged parallel to the rock foliation.

DISCUSSION

Rocks and minerals

- The iron ores contain on average 23.5 wt% Fe_2O_3, 10.5 wt% FeO and 0.14 wt% MnO (the latter varies between 0.07 to 0.25 wt%). The associated garnetiferous rocks have contents of 11 wt% Fe_2O_3, 10 wt% FeO and 7.2 wt % MnO. Under the assumption that these two rock types originated from submarine exhalations, a sharp in-situ separation of Mn from Fe must be postulated. Due to chemical reasons this assumption cannot be applied here. In Nigeria, iron-bearing manganese-rich iron formations form a continuous transition to low manganese iron formations with high iron over the distances of some 100 kilometres.
- Amphiboles of the magnetite ores have the same chemical compositions as those of the Sobotin massif (Fiala et al., 1980). Additionally, the amphiboles with Mg-numbers higher than about 0.5 are not known in iron formations and are restricted to the amphiboles of the grunerite-cummingtonite series.
- Apatite is a common constituent of the iron ores and may be concentrated up to 20 vol.%. In iron formations, apatite does not occur or is a very rare mineral. The high F-content of more than 3 wt% in apatite points to its magmatic origin.
- In banded iron formations chlorite is of minor abundance or absent. Chlorite in the investigated iron ores may reach up to 20 and more vol.% and its composition is different than that of the chlorites found in iron formations.

Genesis

Contemporaneously to the sedimentation of the gneiss protolith, submarine volcanogenic exhalations occurred, leading to the enrichment of manganese-rich mud-like precipitates. During the subsequent metamorphism of Assyntian or Caledonian age, gneiss and garnetiferous rocks (gondites which are manganiferous analogues of the Algoma type iron formations) developed.

The emplacement of the Sobotìn gabbro was associated with the formation of apophyses preferrentially arranged parallel to the foliation of the gneiss. These apophyses contain magnetite, amphibole (tschermakite and magnesio-hornblende) and apatite. The occurrence of mineralogically different rocks (e.g. amphibole- or magnetite-dominated with or without apatite enrichments) can be explained by high differentiation within the emplaced gabbro intrusion and by processes which are known as filterpressing.

During a second tectono-metamorphic event of Variscian age all the discussed rock units were overprinted: the gabbros were transformed into amphibolites, in the gneiss chloritization was the most prominent reaction, the iron ores recrystallized and various minerals were newly formed (e. g. actinolite, tremolite, chlorite and epidote). The intense silicification of the rocks is also a result of this metamorphic event.

CONCLUSION

By definition iron formations are of sedimentary origin. However, the magnetite ores of this study were formed under magmatic conditions and are metamorphosed and silicified equivalents of iron-rich basic rocks and thus similar to the Itakpe type deposit of Nigeria (Mücke and Neumann, 1986) which was previously described as iron formation (Olade 1982).

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