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IRON-COPPER MINERALIZATION RELATED TO SKARNS OF THE ISAR SITE – RADOVIS, EASTERN MACEDONIA

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Abstract. The iron and copper occurrence is located in a metamorphosed suite composed of metamorphosed basic rocks, amphibole schists and amphibolites, chlorite-amphibole-mica schists and metamorphosed sediments (marbles and cipolines). The series is in contact with the crystal schists composed of gneisses and micaschists. At the contact between basic rocks and marbles ascendant alterations have developed characterized by skarn formation.

Skarns are accompanied by a number of alterations of which the most important are silicification, epidotization, opalitization etc. Skarn here occurs in several places being the most developed at the southwestern part where it was revealed by drilling to depth.

Based on explanations offered so far, supplemented by investigations carried out by the present authors, it has been inferred that the mineralization at Isar contains intramagmatic minerals developed in gabbroic rocks such as pyrrhotite, pyrite, rutile, ilmenite, sphen, linnaeite and petlandite.

On the other had, there is mineralization in skarns related to postmagamtic processes or to skarning. Minerals distinguished in this skarn mineralization include pyrite, chalcopyrite, molybdenite, bornite, sphalerite and galena. Garnets, green pyroxene, epidote, rutile, calcite and quartz accompanied by ore minerals have been determined as skarn minerals. Intramagmatic minerals preceded the skarn mineralization. However, it is believed that they are not related to the skarn mineralization.

Mineral assemblages in skarns are typical of calcite skarns, most probably being exoskarns formed at the contact between gabbroids and carbonates.

Key words: Ore minerals, Isar, iron, copper, skarns, mineralization, magnetite.

Introduction

The Isar copper and iron occurrence is situated 3 km north of Radovis. The area under consideration is situated on the right side of the River Radoviska.

The first data on the lithologic composition of the wider area were given by Cvijic and Boncev and are of informative nature. In 1958 geological mapping 1:25000 was completed by the Geological Institute in Skopje. In 1978 geophysical investigations were carried out with the use of method of magnetism, and in 1979 three exploration drill holes were drilled near the occurrence of which two gave positive results and determined the presence of skarn copper mineralizations related to basic rocks.

Geological characteristics

Based on investigations carried out so far and those by the present authors, several rock types have been distinguished: two mica gneisses, micaschists, marbles and cipolines, amphibole schists and amphibolites, chlorite-amphibole-mica schists, chlorite-talc schists, metaporphyres and metagabbros (Fig. 1).

Two mica gniesses were found in the western portion of the terrain, and micaschists in the gneiss complex. Marbles and cipolines concordantly lie with the other metamorphosed rocks as platy bands strictly and delineated by them. Marbles and cipolines lie concordantly with the other metamorphosed rocks as platy bands being strictly delineated by them.

Amphibole schists and amphibolites occur in several places and are characterized by green colour. Chlorite-amphibole-mica schists can be found in many parts along the river. Chlorite-talc schists occur in the gneiss complex as a band of northwest – southeast strike. Metaporphyrics occur as elongated bodies of northwest – southeast strike. Metagabbros have been determined by deep drilling as an intrusion.

Ore minerals

It has been proved that the most important minerals are magnetite and chalcopyrite. Most common accompanying minerals are pyrite, pyrhotite rutile, molybdenite, bornite sphalerite, galena, coveline, chalcocite, cuprite, malachite azurite, limonite, sphen, ilmenite, cubanite, markasite, petlandite and lineite. The mineral assemblage indicates that this is a very interesting and genetically important paragenesis in which most of the minerals are mainly of genetic importance. The most important minerals and their composition will be analyzed. The results have been obtained by electronic micro probe.

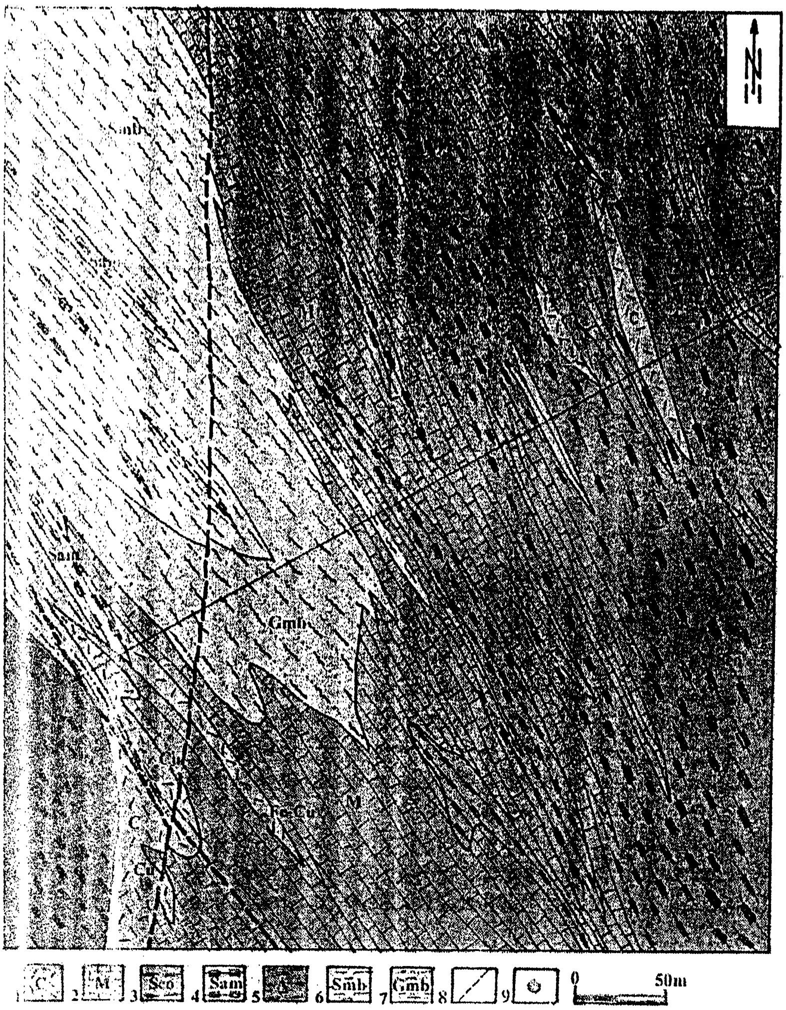

Fig. 1. Geologic map of the Isar occurrence (BANDILOV *et al.*, 1979; modified by SPASOVSKI, 1999). 1. Skarns, 2. Marbles and cipolines, 3. Chlorite-amphibole-mica schists, 4. Chlorite-talc schists, 5. Amphibolites, 6. Micaschists, 7. Two mica gneisses, 8. Fault, 9. Fe–Cu occurrences.

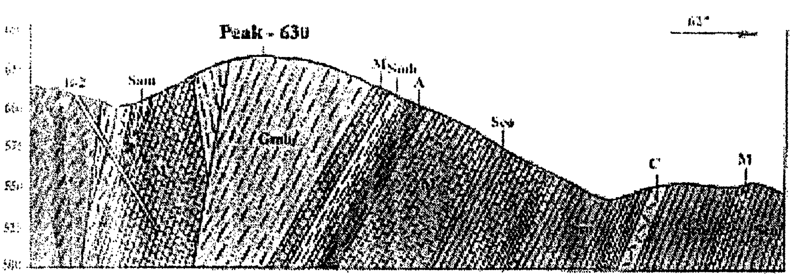

Fig. 2. Cross-section of Isar. S – skarns, M – marbles and cipolines, Sco – Chlorite-amphibole-mica schists, Sam – chlorite-talc schists, A – amphibolites, V – metagabbros, Smb – micaschists, Gmb – two mica gneisses, B-2 – drillhole.

Magnetite occurs as individual grains or as an aggregate. It often occurs as irregular grains of 0.05 to 0.15 mm, in some cases up to 0.5 mm in size. It often occurs as impregnations of idiomorphic or hipidiomorphic grains the size being 0.3 mm (Fig. 3 a). Martitization process occurs along the rim, the process being less pronounced with small magnetite grains. The martitization process is more intense with larger grains. Some grains are elongated with preservation of earlier hematite which has been translated into magnetite or there was magnetite pseudomoprhoses along hematite – mushcetovite. Chalcopyrite inclusions of irregular shapes have been noticed. Most of the magnetite grains have been affected by metamorphic processes, when magnetite was oriented along schistosity of parent rocks with no alterations in the chemical composition.

Chacopyrite often occurs as small and irregular grains of 0.006 to 0.012 mm in size, seldom as larger hipidiomorphic and irregular grains. It often occurs as impregnations along some fissures. Chalcopyrite often includes pyrite and petrogenic minerals, sometimes chalcopyrite included in sphalerite and magnetite. Occasionally chalcopyrite replacement by sphalerite can be seen.

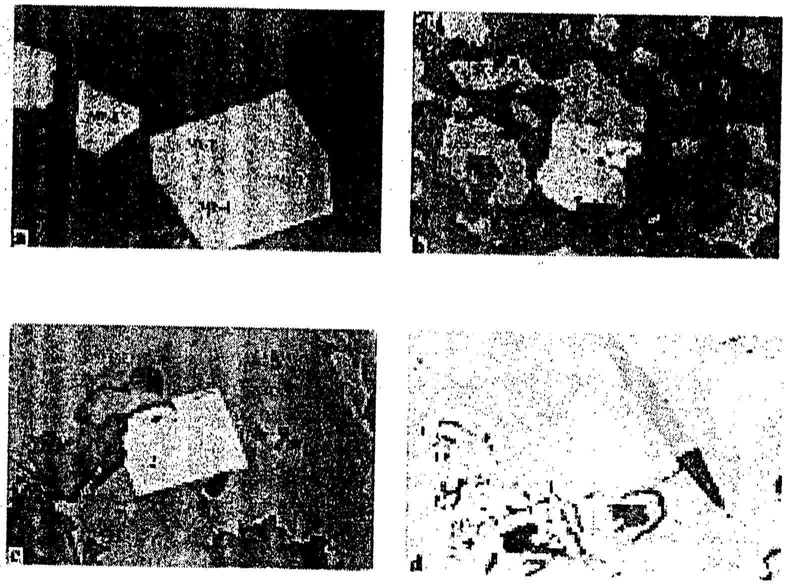

Fig. 3. Micromorphologic shapes and occurrence mode of major minerals in Isar. a. Individual and isomorphic magnetite grains (grey), b. corroded sphalerite (grey) by chalcopyrite (yellow), c. idiomorphic grain like limonite (grey) with small and irregular relics of pyrite (white) and included chalcopyrite (yellow), d. coarse-grained limonite (grey) with relics of chalcopyrite (yellow).

Chalcopyrite has been slightly affected by descendent alterations grading into coveline that is poorly developed along the rims of chalcopyrite grains together with chalcosite. Chalcopyrite oxidation is common and so is its grading into cuprite and limonite. Relics of chalcopyrite and limonite (Fig. 3 g) are occasional.

Pyrite is a common mineral. However, it is present in low amounts occurring as small submicroscopic grains. Pyrite grains the size of 0.05 mm can also be found. Most of the grains have been affected by oxidation processes that grade into limonite. Limonite contains pyrite relics, some grains being totally transformed into limonite so that only the forms of pyrite grains can be seen. Their mutual relationship and occurrence mode indicate that pyrite formed earlier than chalcopyrite.

Sphalerite is not very common and only contributes to the complexity of the mineral assemblage. It often occurs as medium-size grains that replace magnetite and chalcopyrite.

Limonite is the most common secondary mineral being product of oxidation of primary sulphides and their transformation into limonite. It often occurs as coarse hipidiomorphic and alotriomorphic grains that according to the occurrence mode correspond to chalcopyrite grains totally replaced by limonite. In some limonite grains relics of primary sulphides, first of all pyrite and chalocpyriye (Fig. 3 c, d).

Other minerals occur either as traces or locally in some samples increasing the complexity of the mineral paragenesis in the mineralization.

From what has been said above, it can be inferred that the Isar mineralization consists of a variety of minerals. The minerals, no doubt, create complex paragenetic relationships in which, and based on the evaluation of the processes that caused the mineral formation, several mineral types and parageneses can be distinguished:

Minerals of intramagmatic paragenesis formed in gabbro rocks (pyrrhotite, pyrite, rutile, ilmenite, magnetite, sphen, petlandite and lineite);

Minerals of skarn paragenesis (pyrite, hematite, martite, mushketovite, chalcopyrite, molybdenite, bornite, sphalerite, galena, amphibole, garnet, pyroxene, epidote, rutile calcite and quartz);

Minerals formed in cementation processes (coveline and chalcocite);

Minerals of the oxidation phase (cuprite, malachite, azurite and limonite).

As said before, the paragenetic relationships in Isar are very complex. These relationships indicate that the formation of individual minerals and mineral paragenesis have undergone a very complex genetic process of mineral formation in which individual mineral components were deposited, in part in carbonate, and in part in silicate media and in most part in silicate-carbonate medium.

Genetic characteristics

Fe–Cu mineralization in Isar was formed in complex processes that started in intermagmatic stage, continued to the skarn stage and ended in the supergene stadium. Pyrrhotite, pyrite, rutile, ilmenite, magnetite, sphen, petlandite and lineit presence points to the intramagmatic phase related to gabbroic rocks. On the other hand, there is skarn mineralization in skarns related to post magmatic process or skarning. The following minerals have been distinguished in the skarn paragenesis: pyrite, chalcopyrite, molybdenite, bornite, sphalerite and galena, a paragenesis that is typical of skarns. If we take into account that skarn minerals such as garnets (andradite), clynopyroxene, epidote, rutile, calcite, amphibole (actinolite) and quartz accompany ore minerals, it is very likely that this is an exoskarn at the contact between gabbroic and carbonate rocks.

Based on the distinguished petrogenic minerals it can be inferred that this is high temperature clinopyroxene-actinolite-garnet-epidote skarn. Intramagmatic minerals preceded skarn minrelization and there is no relationship to the skarn paragenesis. In skarns, mineral assemblages have been found that are typical of calcite skarns – two kinds of garnets of which one comprises the main mass and the other, occurring as veinlets, has not been defined yet.

The processes of skarn formation probably took place by intrusion of gabbros into marbles of calcite composition. Ore phase is present in skarn, which occasionally occurs as veinlets and impregnations.

Cementation processes were slightly developed in the occurrences when chalcocite and coveline developed. However, they occur in small amounts. Cuprite, limonite, malachite and azurite were formed in the oxidation process, which is not developed in depth.

Conclusion

Skarn occurrences lie in a metamorphosed series consisting of metamorphosed basic rocks, amphibole schists and amphibolites, chlorite-amphibole-mica schists and metamorphosed sediments (marbles and cipolines). At the contact between basic rocks and marbles ascending alterations have developed characterized by skarn formation.

It can be said that in the Isar occurrence various mineral compositions have been found whose minerals built the complex paragenetic relationships. Based on their evolution, several types of minerals and paragenesis could be distinguished.

Minerals of intramagmatic paragenesis formed in gabbroic rocks (pyrite, pyrrhotite, rutile, ilmenite, magnetite, sphen, petlandite and lineite);

Minerals of the skarn paragenesis (pyrite, hematite, martite, mushketovite, chalcopyrite, molybdenite, bornite, sphaleite, galena, amphibole, garnet, pyroxene, epidote, rutile, calcite and quartz);

Minerals formed in cementation processes (coveline and chalcocite);

Minerals of the oxidation phase (cuprite, malachite, azurite and limonite).

As said before, the paramagnetic relationships in the Isar are fairly complex. This relationship in the development of individual minerals and mineral assemblages underwent a complex genetic mineralization process in which individual minerals were deposited partly in silicate and partly in carbonate medium, and mostly in mixed silicate-carbonate medium.

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