



Spheroidal and radiating aggregates of Mn-pyroxenoids in the Olympias polymetallic sulphide ore deposit, E. Chalkidiki peninsula, North Greece

Сфероидални и радиални агрегати от Мп-пироксеноиди от полиметално сулфидно находище Олимпиа, И. Халкидики, Северна Гърция

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Introduction

A variety of manganese silicates of the $RSiO_3$ type (pyroxenoids) are common constituents of the Mn silicate-carbonate rocks, metamorphosed from greenschist to the granulite facies (Takahashi, Hariya, 1995). Besides, the manganiferous pyroxenoids rhodonite and its polymorph pyroxmangite occur as important and abundant primary Mn minerals in various types of ore deposits, such as hydrothermal polymetallic vein-type, skarn-type and metamorphosed Mn ores (e.g. Winter et al., 1981; Abrecht, 1988; Mohapatra, Nayak, 2005). In this investigation the presence of spheroidal forms of Mn-pyroxenoids found within the Olympias polymetallic sulphide deposit, E. Chalkidiki peninsula, North Greece, is studied for the first time.

Geology and mineralogy

The Olympias sulphide ore deposit is hosted in marbles of the polymetamorphic Kerdylia formation of the Serbomacedonian massif. The deposit is generally stratabound (manto) but disseminated, cavity- and fracture-filling forms are also present. There exists a close relationship between marbles and mineralization and the ore textures confirm a successive replacement of the marbles. The ore mineralogy includes mainly pyrite, galena, sphalerite and arsenopyrite. The principal gangue minerals are calcite, quartz, rhodochrosite and minor Mn-pyroxenoids. Characteristic spheroidal forms (diameter 1–5 cm) of light-pink to brownish-pink color were locally found in the Olympias deposit. They occur as isolated or in

three-dimensional clusters of many spherules. Macroscopically, as well as under the microscope the spherules are consisting of an intimate intergrowth of radiating long prismatic to fibrous crystals of Mn-pyroxenoids in a matrix of pink carbonates, calcite and quartz. Rhodochrosite usually forms complex intergrowths with quartz at the expense of Mn-pyroxenoids. Traces of ore minerals are also found dispersed within the spheroidal forms. The origin of the Olympias ore is subject to controversy. Nicolaou and Kokonis (1980), Kalogeropoulos et al. (1989) have suggested that the ore mineralization is epigenetic and genetically related to the contact metamorphism and hydrothermal activity of the 29.6 Ma Stratoni granodiorite and the associated pegmatite – aplite formations. Nebel et al. (1991) suggested a premetamorphic syngenetic origin for the Olympias ore which was subsequently regionally metamorphosed and later reworked by Tertiary hydrothermal activity related to igneous rocks in the broader area.

Mineral chemistry

Chemical compositions of co-existing Mn-pyroxenoids and carbonates in the Olympias ore deposit were determined by EPMA using a CAMEBAX instrument. Molecular components in the studied Mn-pyroxenoids were as follows: $MnSiO_3$ – 82 to 90%, $CaSiO_3$ – 2 to 9%, $FeSiO_3$ – 3 to 12%, and $(Mg+Ni)SiO_3$ – 1 to 5%. The Mn-pyroxenoids mostly fall in the Mn-Ca-(Fe+Mg+Ni) ternary diagram into the field of rhodonite and the less into the field of pyroxmangite. The pink carbonate phase is a Mn-Mg-Fe-Ca solid solution rich in rho-

dochrosite component (72–84 mol.%) with significant calcite (9–25 mol.%) and minor but variable magnesite (1–5 mol.%) and siderite (1–4 mol.%) end members.

Discussion and conclusions

Radial structures and concentric banding are common features in most colloform minerals and the dominant factor controlling the formation is a relatively high degree of supersaturation, resulting in high rates of nucleation and crystallization (Roedder, 1968). However, the structure of the studied Mn-pyroxenoids can be explained in the view of Ramdohr (1969) who stated that radial growth of crystals, particularly in an open space, derives from a more or less uniform supply of material, from all directions, acting in conjunction with a preferred growth direction in the crystal to promote a spherical or globular growth.

Mineral reactions in Mn silicate and carbonate associations were interpreted to be of decarbonation type (e.g. Dasgupta et al., 1993) depending on the CO₂ activity and the bulk element composition of the mineralizing fluids. Mutual boundaries of the associated minerals show that rhodochrosite and quartz were formed as younger phases and include

corroded crystals of Mn-pyroxenoids in teethlike forms. These replacement textures can be expressed by the reverse reaction to that proposed by Abrecht (1988), i.e. $\text{MnSiO}_3 + \text{CO}_3 = \text{MnCO}_3 + \text{SiO}_2$, in a CO₂-saturated environment and dropping temperature. Natural Mn-pyroxenoids invariably contain Ca, Fe and Mg substituting for Mn, and the amount of these substitutions (especially that of Ca) play an important role for the determination of structural type.

Besides, natural assemblages and experimental data (e.g. Abrecht, 1988; Takahashi, Hariya, 1995; Mohapatra, Nayak, 2005) suggest that the relative stability of the Mn-pyroxenoids is a function of P and T as well as of the chemistry, especially of the Ca/Ca+Mn ratio and the CO₂ content of the fluid phase. Thus, rhodonite structure is stabilized with respect to pyroxmangite by Ca, whereas Fe and Mg increase the stability of pyroxmangite with respect to rhodonite. According to Maresch and Mottana (1976) pyroxmangite is the high-P, low-T (below 400° C) phase. Therefore, we suggest that rhodonite was first formed, followed by pyroxmangite during dropping temperature and increasing concentration of Fe and Mg in the mineralizing fluids. Rhodochrosite and quartz originated by a “carbonatization” process in CO₂-saturated environment and further dropping temperature.

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