European Current Research on Fluid Inclusions (ECROFI-XXI)
Montanuniversität Leoben, Austria, 9–11 August, 2011. Abstracts, p. 124

Characteristics of the ore fluids during magnesite metasomatism in the Satka Ore Field (Veitsch type, Urals, Russia)

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Of crucial importance in studying the "sparry magnesite problem [Aharon, 1988]" are the thermodynamic conditions of formation this type of deposis. The investigation of fluid inclusions in magnesites and host rocks along with other geochemical methods allows to specify the parameters of the replacement mechanisms. We investigated some features of fluid inclusions in the stratiform Satka ore group (coarse-grained "Veitsch Type" magnesite deposits) from the Southern Urals magnesite province in Russia. 90 % of the Russian periclase production comes from the Satka ore field.

The study of the chemical composition of the fluid inclusion (crush-leach analysis) showed an evaporitic trend for the magnesites in the Na/Br-Cl/Br diabram for the Satka deposits and for other sparry magnesite deposits of Southern Urals province. The host limestones in this plot are in the area of sea water Krupenin Prochaska, 2005. This method is very useful in the case of very fine size of fluid inclusions in host rocks. A series of special structural features like pseudomorphs after sulphates, tepee-structures and angle-shaped coarse-grained white dolomite, sometimes with chert in fine-grained grey dolostones are developed in the magnesite-bearing horizon of the Satka formation (Mezoproterozoic age) indicating pre-evaporitic conditions during sedimentation. Buried evaporitic brines in this sequence may be the original source of magnesium for the metasomatic fluids. It proposes to use a seepage reflux model for magnesite precipitation, similar to the proposed formation of the sparry magnesites of Austria Prochaska, 2000.

Microcryometric and microthermometric study of fluid inclusions in the magnesites and adjacent metasomatic minerals are very important for understanding of the physico-chemical conditions of metasomatic process. Nests and clusters of dolomites and quartz can be found in the magnesites. It seems that the studied mineralizations were formed at one single stage of metasomatism. At preliminary stage about 130 inclusions were studied. The inclusions of the magnesites and of the dolomite/quartz clusters are more of less the same (>15 % NaCl. with ice melting temperature from -10C to -28C) and temperatures of homogenization varies from 120C to 400C.

The inclusions were studied with successive microcriometric and heating study of every inclusion. We used a THMSC-600, «Linkam» equipment which allows to measure temperatures of phase transitions from -196C to +600C. We used samples from the quartz nests from a dolomite collaps-breccia in a distance of 8-10 m laterally from magnesite body contact. Quartz precipitated in the collaps-breccia as secretions (fine-bended agate-like filling of the nest) and is a perfect mineral for keeping primary inclusions in comparison with carbonates [Goldstein, Reynolds, 1988]. These thin lays were formed during high alkaline magnesium metasomatism in external parts of magnesite bodies.

The majority of the studied inclusions are of primary or primary-secondary type. They occur as gas-liquid 2-phase vacuoles the different forms like orbicular and negative crystals in the size of 5-15 microns. The majority of the considered inclusions contain a saline solution and the gas phase amounts 10-25 %, higher filling rates are rare. Only in four cases we found 3-phase inclusions with liquid CO_2. In three cases we found 3-phase inclusions with a solid phase in the vacuoles which turned out to be halite.

The salt content of the solutions was defined by the temperature of eutectic fusion [Borisenko,

1977]. Concentration of salts in inclusions was estimated on temperature of last ice melting for the salt system $CaCl_2$ Goronovsky et al., 1987. The salinity of the liquid phase is calculated as $CaCl_2$ as the temperature of fusion of ice is in most cases below the eutectic point of NaCl (-212C). For the overwhelming majority of inclusions a salinity of 28-32 % $CaCl_2$ is calculated, only 11 inclusions (with mainly secondary inclusions) have a salinity of 5-8 % $CaCl_2$ (see 1). Prevailing temperatures of liquid-vapor homogenization of inclusions are in the range from 85 to 235C, (median 149C). Temperature calculations based on cation exchange thermometers (Na/Li) indicate a formation temperature of the magnesites of ~ 130°C which confirms the average temperatures of homogenization of the fluid inclusions. In one sample 3 inclusions with liquid-vapor homogenization in an interval 386-440C were obtained. For the sample having high-temperature inclusions, the presence $MgCl_2$ and KCl is supposed. This means, that the original brines had elevated temperatures and contained chlorides of magnesium and potassium. We assume, that the fluids from the quartz –dolomite nests in the outer zone of the magnesite bodies contain a fractionated residual fluid from which the major amounts of magnesium has already been fixed in the areas of the magnesite precipitation. Therefore the prevalence of $CaCl_2$ in the brines of this external zone is quite naturally.

The calculation of the fluid pressure has shown comparable results in an interval between 590-664 bar. If to admit, that the fluid during Mg-metasomatism was under lithostatic pressure the calculated pressure of a fluid phase corresponds to a depth of about 20 km. This depth corresponds to the overall thickness of the magnesite-bearing horizon of the Satka Formation and the overlying Bakal Formation. Then a large break in sedimentation with a pronounced unconformity, connected with the formation of the Mashak riftogenic structure (volcano-terrigenous graben) to the east of Satka ore field follows. The riftogenic event was accompanied with crustal extension, regional development of a diabasic formation and the penetrating of granitoids, including Berdyaush rapakivy granite in the northern periphery of the Satka ore field (1371.3 ± 26 Ma, Sm–Nd method Ronkin et al., 2007). The homogenization temperatures of the fluid inclusions, obtained in the present research, mismatch temperatures of heating of country rocks as a result of immersing into depths of 15-20 km, and it is probable that additional heating of the fluids from an additional heating source occurred with the Berdyaush rapakivy pluton being the heat-source. The results obtained well fit into the concept of Mg-metasomatism as a result of riftogenic heating of buried evaporitic brines in the permeable dolomitic collaps-breccias of Satka Formation Krupenin Prochaska, 2005.

Researches are carried out at partial financial support of the grant of the RFBR 09-05-00694a.

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