Paragonite in hydrothermally altered rocks from the Asarel porphyry copper deposit, Central Srednogorie

Парагонит в хидротермално променените скали от меднопорфирното находище Асарел, Централно Средногорие

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Introduction

The sodium mica paragonite – $NaAl_2[AlSi_3O_{10}](OH)_2$ is generally undistinguishable from muscovite and talc in thin sections because of similar optical characteristics. It is described on the Bulgarian territory only in metapelites from Sakar (Machev, 2007). Paraginitic and paragonite-containing hydrothermal alterations, even though being more unusual, are described in different hydrothermal systems as well as in porphyry copper deposits (Zaraysky, 1989; Jiang, Peacor, 1993; Grabezhev et al., 1995).

The Asarel porphyry copper deposit is located in Panagyurishte ore region, part of the Upper Cretaceous Apuseni–Banat–Timok–Srednogorie magmatic and metallogenic belt. The Asarel magmatic center represents a volcano-plutonic edifice emplaced in Paleozoic metamorphic and plutonic basement. The following volcanic rocks are distinguished: andesites to latites; basaltic andesites; andesites to dacites. The volcanics are intruded by comagmatic porphyritic bodies of quartz-diorite, quartz-monzonite to granodiorite porphyry and granite porphyry (Nedialkov et al., 2007). Propylitic, argillic, sericitic and advanced argillic alteration types are described in the deposit.

Characteristic of paragonite and paragonitic rocks

A new alteration type was established during this study with leading mineral the Na mica – paragonite. The quantity of paragonite varies from 13 to 36% in the different samples. The mineral association includes kaolinite, sericite, quartz, pyrite, sometimes alunite, svanbergite, pyrophyllite and diaspore. This alteration type is relatively rare and occurs in depth in single samples from 3 drillholes from SW part of the deposit. The paragonitic rocks look like the sericitic rocks and it is difficult to discriminate them. In some cases sericite-paragonite mixture together with pyrite form over highly altered silicated rocks. Some features of mixed sericite-paragonite-advanced argillic alteration type are established also. Its place in the metasomatic zoning in Asarel deposit is still unknown.

The Na mica occurs in a fine mixture with sericite and two mica types cannot be distinguish in thin sections. The presence of paragonite in the studied samples was detected by X-ray diffraction. Wide range of chemical composition of white micas was documented by microprobe analyses. Muscovite type characterizes with presence of Na from 0.20 to 0.34 *apfu*, while Na/(Na+K) fluctuates in most cases from 0.22 to 0.30, being rarely 0.42–0.44. The last values are close to the mixed Na–K mica, where Na is 0.38–0.41 *apfu* and Na/(Na+K) is 0.47–0.50. The sodium mica paragonite has stable Na concentration of 0.55–0.58 *apfu* while Na/(Na+K) varies between 0.67–0.68 and 0.77–0.78, depending from the K content. Typical admixtures in all micas are mainly Mg and Fe, rarely Ca, Mn, Ti.

Paragonitic altered rocks are characterized with depletion of the most petrogenic elements. Na_2O and K_2O are depleted about 50% in compare to unaltered rocks, but their quantities are enough to determine the alteration type (Na_2O varies from 1.69 to 2.13%). MORB normalized multi-element patterns show week depletion of LILE, HFSE (Th, U, Nb, Ta), Y, HREE and comparatively inert behaviour of the rest elements. Chondrite-normalised REE patterns show depletion of HREE while LREE are relatively immobile. There are raised concentrations of Cu and Mo also.

Discussion and conclusions

According to Fleet (2003) there is a miscibility gap in the system muscovite–paragonite between 0.38 and 0.78 Na/(Na+K). This maybe a result of lack of enough data, especially for metasomatic rocks, because Jiang and Peacor (1993) described metastable K–Na mica ($Mu_{47}Pa_{52}Ma_1$) in hydrothermally altered metabasites and Grabezhev et al. (1995) reported a paragonite with Na/(Na+K)=0.64. New data from Asarel deposit show a number of intermediate compositions, which may change the concept for this system.

Zaraysky (1989) obtained experimental chorite–paragonite–quartz association by interaction of acid Na-bearing fluid with granodiorite (pH=4; 1.0 *m*NaCl + 1.5×10^{-4} *m*HCl; T=300 °C). He also mentioned that paragonitic metasomatites are rare as wall-rock alteration but the presence of paragonite component in muscovite (sericite) is a typical feature. Grabezhev et al. (1995) described 3-mica association in porphyry copper deposit formed at 320–380 ºC.

The coexisting mineral association of quartz, paragonite, sericite, kaolinite and pyrophyllite can be represented in 5-component system K_2O–Na_2O–Al_2O_3–SiO_2–H_2O on the diagrams with coordinates *m*KCl/*m*HCl and *m*NaCl/*m*HCl at 300 and 200 °C and excess of quartz (Ivanov, 1984). Paragonite and sericite are probably in equilibrium with kaolinite and/or pyrophyllite at about 300 °C.

It may be conclude that the paragonitic altered rocks are formed by acid Na-bearing hydrothermal fluids with temperatures at about 300 °C. On the other hand there are coexisting K-, K-Na and Na-micas, which probably is due to the local disequilibrium. The assumption is that the paragonitic rocks are analogous to the sericitic type altered rocks in case of local increasing the activity of Na^+ in the solutions. With the formation of paragonite, activity of Na^+ decreases and mixed K-Na and K-micas may form.

The sodium metasomatism is more uncommon in porphyry copper systems. The data from Asarel do not support the hypothesis of Grabezhev et al. (1995) for evolution of fluids from initial sodium to mixed and potassium to the end of the hydrothermal process and to the higher levels of the system. Seedorff et al. (2005) mentioned that Na-Ca alteration with albite is widespread beneath the potassium alteration and fingerlike projections of Na-alteration extend up through the center of the system. Such projections may get to the higher levels of sericitic alteration and may form altered rocks with paragonite instead of albite. Paragonite-containing mineral associations are obtained during geochemical modeling of reaction of a magmatic fluid with granite from the Butte porphyry copper deposit (Reed et al., 2013) which may form in certain moment in certain part of the system. It may turn out that sodium alteration is more widespread in the porphyry copper deposits but there are many unclear points for its role in ore formation.

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