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Wallrock alterations in the porphyry copper deposits of the Panagyurishte ore district and formation-facial belonging of the metasomatites

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The Panagyurishte ore district in Bulgaria includes three significant porphyry copper (-gold) deposits (Medet, Elatsite and Assarel), and several small ones (Vlaikov Vruh, Tsar Asen, Petelovo and others). The porphyry copper deposits in the district were objects of intensive investigations during the last decades and numerous studies provide data about these hydrothermal systems and their mineral composition (Strashimirov et al., 2000).

The aim of the present paper is to summarize and determine correctly the hydrothermal alteration of the host rock according to the two most preferable genetic classifications: 1) the classification given by Meyer and Hemley (1967), which is used in the USA, Australia, Japan, New Zealand, UK, Spain, France, Italy, etc., and 2) the classification on a formation-facial basis given by Жариков, Омельяненко (1978), which is used in the East and Central European countries, Sweden, China, etc.

The equilibrium mineral associations according the classification of hydrothermal alteration of the host rocks offered by Meyer, Hemley (1967) and developed by Бин, Титли (1980), Heald et al. (1987), Pirjano (1992) were studied (Kanazirski, 1998). Determination of the equilibrium mineral associations in the porphyry copper deposits of the Panagyurishte ore district is done using physico-chemical analysis of mineral parageneses (Коржинский, 1957). Formation-facial analysis (Жариков, Омельяненко, 1978; Жариков, 1982) and studies of the alterated rocks based on theory for the metasomatic zonality (Коржинский, 1969) were used for determination of formation-facial classification of the metasomatites offered by Жариков, Омельяненко (1978). Experimental modelling of the metasomatic zonality was realized for the metasomatic column in the Asaral deposit (Каназирски et al., 1996).

On a physico-chemical basis (physico-chemical analysis of mineral parageneses, thermodynamic modelling, experimental modeling and facial analysis) the theoretical foundation have been analyzed and unifying characteristics of the two genetic classifications have been deduced (Kanazirski, 1992; Каназирски, 1994; Каназирски et al., 1996). It was particularity interesting to trace genetic analogues in the two classifications on a crystallochemical basis in their structural and energy aspect (Kanazirski, 1998).

Wallrock alterations in the Medet deposits. The wallrock alterations in the *Medet* deposit have been studied by Ушев et al., (1962). The authors established mineral specific alteration zones, which can be combined into two main types: K-silicate alteration (metasomatic K-feldspar and biotite, quartz and apatite) and propylitic alteration (chlorite, epidote and carbonate). Sericitic alteration has a limited distribution mainly around the zone of K-silicate alteration. The most likely pre-ore metasomatites in this deposit is the formation of quartz-feldspar metasomatites according to the classification of Жариков, Омельяненко (1978).

Wallrock alterations in the Elatsite deposits. The main types of hydrothermal alterations are K-silicate (and/or K-silicate-sericitic), propyilitic and sericitic alteration (Table 1).

According to the classification of Жариков, Омельяненко (1978). pre-ore metasomatites in

Table 1
Wallrock alterations and mineral assemblages in the Elatsite deposit

Type of wallrock alteration	Mineral paragenesis
Propilitic	Ep + Act + Ab + Bi + Q + Ca Ep + Chl+ Ab + Bi + Q
K-silicate	Ksp + Bi + Q + Il + Ab+ Ca Ksp + Chl + Q+ Il+ Ab
K-silicate-sericitic	Chl + Ab + Q + Il + Py Chl + Q + Il + Py
Sericitic	Il + Q+ Py

Minerals: Ab — albite, Act - actinolite, Bi - biotite, Ca - calcite, Chl —chlorite, Ep — epidote, Hem — hematite, Il — illite, Ksp — K-feldspar, Pyr — pyrite, Q — quartz

Table 2
Wallrock alterations and mineral assemblages in the shallow parts of the Asarel deposit

Type of wallrock alteration	Mineral paragenesis
Propylitic	Ep + Chl + Ab + Ksp + Il + Q + Pyr Chl + Ab + Ksp + Il + Q + Pyr Chl + Ab + Il + Q + Pyr
Propylitic-argillic	Chl + Kl + Ab +Il + Q + Pyr ± Ep ± Ksp Kl + Ab +Il + Q + Pyr
Propylitic-sericitic	Chl +Il + Q + Pyr
Sericitic	Il + Q + Pyr
Sericitic–advanced argillic	Il+ Q + Pyr + Prl Il + Q + Pyr + Kl
Advanced argillic (acid-chloride sub-type)	Prl + Q + Pyr Kl + Q + Pyr
Advanced argillic (acid sulphate sub-type)	Alu + Q ± Prl ± Pyr ± Hem Alu + Q ± Kl ± Pyr ± Hem

Minerals: Q — quartz, Ab — albite, Chl —chlorite, Ksp — K-feldspar, Il — illite, Pyr — pyrite, Ep — epidote, Prl — pyrophyllite, Alu — alunite, Kl —kaolinite, Hem — hematite

the Elatsite deposit can be determined as sericitic facies of the quartz-sericite formation.

Wallrock alterations in the Asarel deposits. Studies in the upper levels in the Asarel deposit established following pre-ore hydrothermal alterations developed over the subvolcanic-hipabissal bodies, volcanites and Paleozoic granitoides: propylitic, propylitic-argillic, propylitic-sericitic, sericitic, sericitic-advanced argillic and advanced argillic — acid chlorine and acid-sulphate subtypes (Каназирски, 1994; 1996; Kanazirski, 2000) The typical mineral parageneses for the different types are shown in Table 2.

The wallrock alteration products in the Asarel deposit can be referred to the quartz-sericite metasomatic formation and the secondary quartzite metasomatic formation.

Table 3 presents the modernized results from the analysis of wallrock alterations and of formation-facial belonging of the metasomatites in porphyry copper deposits of the Panaguyrishte region, according to the two most preferable genetic classifications. Based on the studies for hydrothermal alterations in the largest type of hydrothermal systems of the Panaguyrishte region could be divided — dominantly magmatic, magmatic-meteoric and dominantly meteoric systems (Table 4).

The porphyry style of wallrock alterations from the studied deposits is presented by K-silicate and propylitic alterations as an early stage of the hydrothermal-metasomatic processes. The outer parts of the deposits are generally affected by propylitic alteration developed proxi-

Table 3
Wallrock alterations and metasomatic formations and facies in porphyry copper deposits and in ore manifestation of the Panaguyrishte region

Deposit	Type of wallrock alteration	**Formation**, *facies*
Medet	K-silicate, Propylitic (Sericitic - limited distribution)	**Quartz-feldspar metasomatites**
Elatsite	K-silicate, Propylitic K-silicate-sericitic Sericitic	***Quartz-sericite metasomatites*** ***Sericitic***
Vlaikov Vruh	K-silicate, Propylitic Sericitic	***Sericitic***
Kominsko chukarche	K-silicate-sericitic, Propylitic	
Karlievo	Sericitic K-silicate-sericitic, Propylitic Sericitic	***Sericitic*** ***Sericitic***
Asarel	K-silicate-sericitic, Propylitic Propylitic-argillic, Propylitic-sericitic, Sericitic, Sericitic- advanced argillic Advanced argillic (acid-chlorine, acid-sulphate)	**Quartz-sericite metasomatites** *Sericitic* **Secondary quartzites** *Kaolinite-pyrophyllite* *Quartz-alunite*
Tsar Asen	K-silicate, Propylitic Sericitic, Advanced argillic (acid-chlorine, acid-sulphate)	**Quartz-sericite metasomatites** *Sericitic* **Secondary quartzites** *Quartz-alunite*
Petelovo	K-silicate, Propylitic, Sericitic, Sericitic-advanced argillic, Advanced argillic (acid-chlorine, acid-sulphate)	**Secondary quartzites** *Quartz-alunite*

Table 4
Type hydrothermal systems and styles of wallrock alteration in porphyry copper deposits and in ore manifestation of the Panaguyrishte region

Hydrothermal system	Style of wallrock alteration	Deposit
Dominantly magmatic	Porphyry (K-silicate, Propylitic)	Medet
Magmatic-meteoric	Porphyry (K-silicate, Propylitic) Epithermal (Sericitic)	Elatsite, Vlaikov Vruh, Kominsko chukarche Karlievo
Dominantly meteoric	Porphyry (K-silicate, Propylitic) Epithermal (Sericitic, Advanced argillic)	Asarel Tsar Asen Petelovo

mally to a K-silicate zone (Medet deposit), a sericitic zone (Elatsite deposit), or a sericite-advanced argillic zone (Asarel deposit).

The zone of K-silicate alteration in the Elatsite deposit is replaced at the upper levels by a zone of sericitic alteration, where the main sulphide mineralisation is developed. Sericitic and advanced argillic assemblages (acid-chloride and acid-sulphate sub-types) are developed at the upper levels and are representatives of an epithermal style of alteration (e.g. Asarel). This type of alteration overprints the K-silicate and propylitic alterations as the second stage of wallrock alterations.

Apart from differences of the erosion level, the differences in the types of the wallrock alterations are mainly due to variable proportions between fluids derived from a magmatic source and fluids of meteoric origin. However, more data have to be collected to apply precise modelling of the development of these systems.

It is assumed that in Medet deposit only limited participation of meteoric waters in the initial stages occurred (Strashimirov et al., 2002) In contrast, the shallower volcanic level of the Asarel system facilitated intensive re-working of the host rocks and was a more open environment for the incursion of meteoric water. Therefore, processes developed closer to the surface and an intensive influence of meteoric waters can explain the close spatial relationships between porphyry copper and high-sulfidation epithermal styles of mineralization that are characteristic, in particular, for the Asarel deposit and, in general, for the Panaguyrishte region and the Balkan — Carpathian belt. It is possible that the epithermal overprint on the porphyry copper system is caused the syn-hydrothermal deformation of the paleosurface by strong erosion and/or gravitational collapse of volcanic structures, as suggested for other systems by Sillitoe (1995).

We think that the Central Srednogorie zone with its different deposit types deserves further investigations, because it is one of a few areas where the relationships between epithermal and porphyry systems can be explored. Upcoming projects could include isotope and quantitative fluid and mineral analyses, to resolve processes and the sources of fluids in these porphyry copper systems, but also to understand the connection among the different deposits.

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