TEMPORAL RELATIONSHIP BETWEEN VOLCANISM AND THE HYDROTHERMAL SYSTEM IN THE REGION OF CHELOPECH HIGH-SULPHIDATION CU-AU DEPOSIT: CONSTRAINTS FROM GEOCHRONOLOGICAL AND MINERALOGICAL DATA

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Introduction

The Chelopech high-sulphidation Cu-Au deposit is situated about 65 km east of the town of Sofia in the northern part of Panagyurishte ore region in the Central Srednogorie magmatic zone, Bulgaria. It is one of the major Cu-Au mines in Europe with a production (since 1954) of 11.5 Mt with 1.0 % Cu, 3.0 g/t Au and remaining resources of 31 Mt with 1.39 % Cu, 3.5 g/t Au (Strashimirov et al., 2002). Based on its economic importance, this deposit is object of various investigations concerning the genesis, the timing of the volcanic and hydrothermal events and the relationships with the local porphyry deposits.

In the present study we made an attempt to identify the temporal relationship between the magmatic products of the Late Cretaceous Chelopech volcanic complex that hosts the deposit and the hydrothermal alterations to constrain the minimum age of the economic important hydrothermal processes. For this purpose we combine field observations with new geochronological and mineralogical data.

Geological setting

The Chelopech deposit is hosted in the Upper Cretaceous volcanic complex, located within the Central Srednogorie magmatic zone that belongs to the Apuseni-Banat-Timok-Srednogorie belt, extending from Romania through Serbia to Bulgaria. The Chelopech volcanic complex transgressively overlies high-grade metamorphic basement composed of gneisses, schists and amphibolites and low-grade metamorphic phyllites and schists of Lower Paleozoic age (Popov et al., 2000). The genesis of the deposit is related to intermediate Late Cretaceous volcanism with calc-alkaline to high-K calc-alkaline affinity, emplaced in a possible island-arc setting. The products of this volcanism are dominantly of andesitic to trachydacitic composition (Stoykov et al., 2002). This complex is covered transgressively by Turonian sandstone, deposited in a freshwater or coastal environment (Stoykov et al., 2003). Stoykov et al. (2002) distinguished three units of the volcanic complex: (1) dome-like bodies, (2) lava to agglomerate flows, and (3) the Vozdol lava breccias and volcanics or a neck (Fig.1).

Part of the volcanics (second unit) have been intensively altered to an advanced argillic style and host the epithermal Cu-Au mineralization of the deposit. This volcanic and sedimentary succession is covered transgressively by the reddish argillaceous limestone of Mirkovo Formation and a terrigenous flysch sequence of Chugovo Formation (Moev and Antonov, 1978).

The Chelopech deposit includes more than 20 ore bodies. The geometry of the hydrothermal system is tightly linked to various breccia types. Textural relationships indicate multiple breccia events of different origin – phreatomagmatic and magmatic hydrothermal injection breccias (Moritz et al., 2001; Chambefort et al., 2002). The morphology of the ore bodies is variable, with disseminated, massive, banded and vein-type ore. The vertical development of economic ore is known down to a depth of 600 m below the recent surface and is open downward.

Hydrothermal alteration and ore assemblages

Three main alteration zones are developed in the volcanic complex lateral with distance to the ore bodies: (1) quartz-kaolinite-dickite zone with pyrite, alunite, aluminium-phosphate-sulphate (APS) minerals, anatase, including “vuggy” silica and massive silica localities, spatially followed by (2) quartz-sericite alteration zone, and external (3) propylitic zone of alteration mainly exposed on the surface. Two deep drill-holes reveal that the advanced argillic alteration is developed in the volcanic rocks down to a depth of more than 2000 m. A vertical variation of the mineral composition is observed with development of diaspore, pyrophyllite and zunyite at depth (Simova et al., 2001).

Volcanic clasts from different type of alterations could be found in breccias of the third volcanic complex unit and in the Vozdol sandstones, the latter dated by Stoykov et al (2004, in press), and Stoykov and Pavlishina (2003) as Turonian in age. Moutafchiev and Chipchakova have also reported in 1969 the presence of ore clasts and andesitic clasts in propylitic, sericitic and secondary quartzite alteration among the volcano-sedimentary breccias, but the age of this complex was considered as Senonian. If we know the proper age of the complex including these altered volcanic xenoliths and if we could make a link to the distinct mineralising stage, we could estimate a minimum age of this mineralising event.

Three successive stages of the ore-mineralizing process have been recognized (Petrunov, 1994, 1995): (1) Fe-S, with disseminated and massive pyrite of banded texture (considered to be of hydrothermal sedimentary origin); (2) Cu-As-S with enargite and tennantite and (3) Pb-Zn-S. The predominant minerals are pyrite, enargite, tennantite, chalcopyrite, bornite and barite. A large number of subordinate and rare

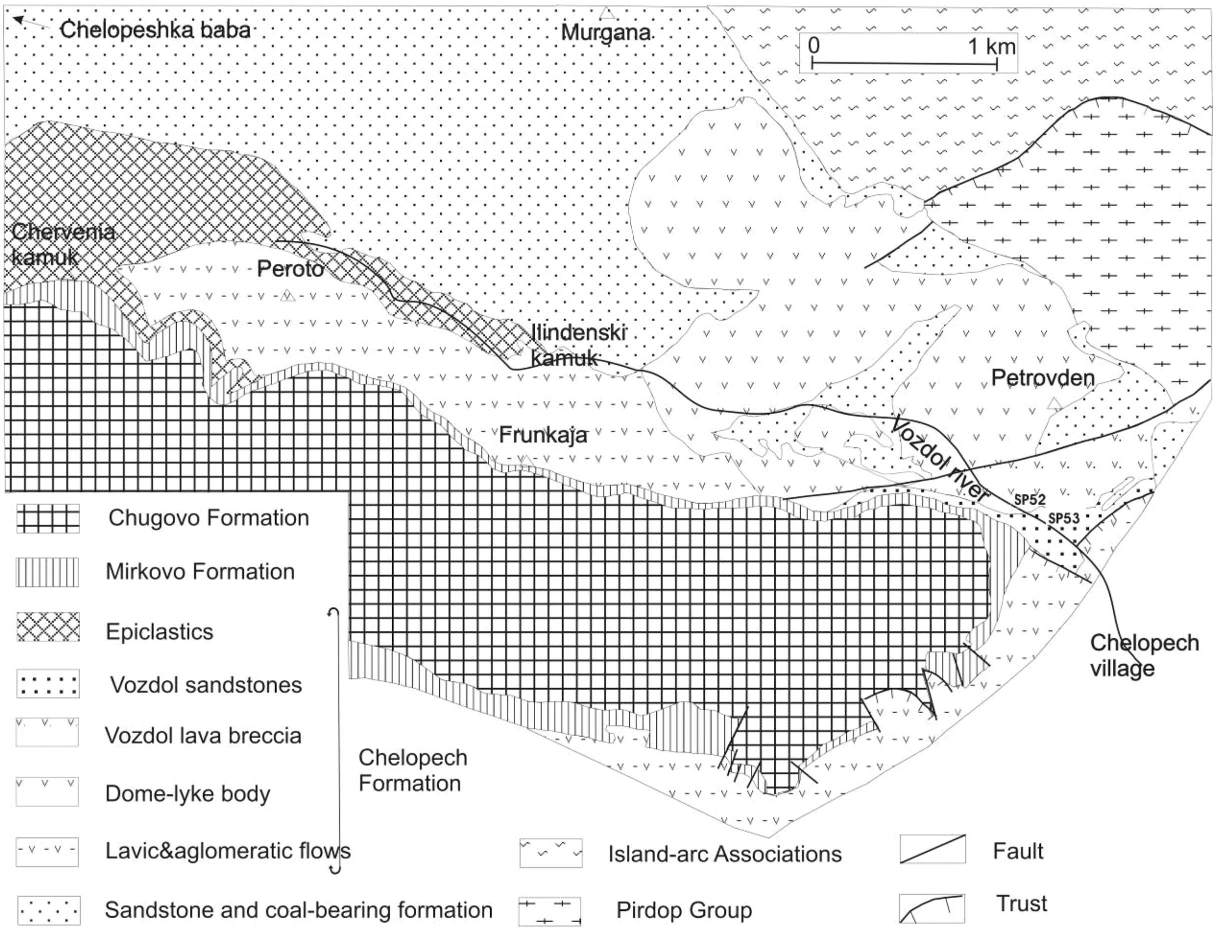

Fig. 1. Geological map of Chelopech region, after Moev and Antonov (1978) with revision of Stoykov et al. (2002).

minerals are present in the Cu-As-S main economic ore stage, including sulphides, sulphosalts, tellurides, selenides and native metals.

Mineral compositions and characteristics of the altered volcanic xenoliths

Two types of altered volcanic fragments have been found within the volcanic breccias of the third volcanic unit and in the Vozdol sandstones.

The first one (SP52) (Fig.1) is strongly altered in advanced argillic style. This clast is found in the Vozdol volcanic breccias and has an obliterated primary texture, which embarrasses us to recognize the type of the initial volcanic rock. The only evidence referring this clast to the first phase of the Chelopech volcano may be the presence of resorbed quartz crystals, which is typical for the dome-like bodies of andesitic, latitic to trachydacitic chemistry (Stoykov et al., 2002). The mineral alteration assemblage of this fragment contains abundant fine-grained quartz, dickite, kaolinite, barite, pyrite and ± aluminium phosphate-sulphate minerals and anatase. This assemblage is typical for the upper parts of the hydrothermal system in Chelopech deposit and is also present in one of the outcrops, known as ore body 1.

The second clast (SP53) is affected by propylitic alteration and is located in the Vozdol sandstone. The texture of this rock is porphyric, mainly with plagioclase porphyries with irregular form, amphibole and biotite. Amphibole and biotite phenocrysts are completely replaced by sericite whereas the plagioclase is replaced by sericite and quartz in thin veinlets. Fine-grained quartz, pyrite, sericite and carbonate replace the groundmass of the rock. This hydrothermal assemblage is typical for the propylitic alteration in the deposit and could be accepted as a part of this zone.

Discussion and conclusions

The recent study of Stoykov et al (2004, in press) using U-Pb zircon data demonstrate that the magmatic activity of the Chelopech region started with the intrusion of the dome-like bodies at 92.2 ± 0.3 Ma. The products of the second and the third units followed closely one after the other and they are undistinguishable within their uncertainties: U-Pb analyses of zircons yield an intrusion age of 91.3 ± 0.3 Ma. The high-sulphidation epithermal Cu-Au mineralization is hosted by the volcanites of the second unit. U-Pb analyses of zircons from andesite of this unit (Chambefort et al., 2003; Moritz et al., 2003), which is overprinted by alteration and mineralization yield an age of 91.45 ± 0.15 Ma. Consequently we could consider this date as the maximum age of the economic important mineralisation in the Chelopech deposit.

The minimum age of the deposit could be roughly estimated. The third unit of the volcanic complex in the Chelopech region – the Vozdol volcanic breccias are intercalated and covered by the Vozdol sandstone, which has a Turonian age based on new pollen stratigraphic investigation (Stoykov and Pavlishina, 2003). Thus, there is a contemporaneity in the extrusion of the third unit volcanites and the sedimentation of the sandstones in the Turonian. Since the Vozdol sandstones are not affected by any alteration we could assume that the hydrothermal activity in the region has been finished before the sandstone deposition starts, and probably before the extrusion of the third unit. The altered volcanic xenoliths, which have been found in the sandstones and in the Vozdol volcanic breccias are comparable in mineral composition to the zoned hydrothermal alteration which includes the Cu-Au mineralization of the Chelopech deposit. This argument also confirms that hydrothermal activity in the region of the deposit terminated before the formation of the third phase of the Chelopech volcano and the Vozdol sandstone. Thus, we could constrain the minimum age of the deposit with the formation of the Vozdol breccias and volcanites at 91.3 ± 0.3 Ma.

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