Indicators for colloidal origin of the auriferous colloform-banded macro-texture in the Khan Krum Au-Ag deposit, SE Bulgaria

Показатели за колоиден произход на златоносната коломорфно-ивичеста макротекстура в Au-Ag находище Хан Крум, ЮИ България

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Introduction

The detailed studies of colloform textures by Grigor'ev (1965), Lebedev (1967), Roedder (1968), etc., have revealed that these textures could form either via crystallization from true solutions or via crystallization and re-crystallization from gels. Additionally, it is well known that the crystallization and diagenesis of gels erase their colloidal stage. Thus, when the colloform textures have been formed by a primary precipitation of opal or chalcedony it is very difficult to decipher their origin due to the crystallization of opal and chalcedony into the more stable quartz (Herdianita et al., 2000). In these cases only some textural and morphological features of the metacolloidal minerals testify to their colloidal origin.

The colloform-banded textures in the Khan Krum deposit (known also as Ada Tepe deposit), Eastern Rhodope Mountain, SE Bulgaria, are observed in high-angle veins of open-space filling along predominantly east-west oriented faults located in the hanging wall of the regional Tokachka detachment fault. They are presented by a colloform-banded macro-texture and by a millimetre-to-submilimetre-wide banding, and are associated spatially with massive and banded textures. The hand specimens of colloform-banded macro-texture are composed mainly of quartz and adularia sized up to 20–30 μm, adularia being commonly in the range from 30 to 50 vol.% (Marinova, 2009). Marchev et al. (2004) have suggested a colloidal origin of gold-rich millimetre-wide bands due to the presence of opal and dendritic gold. According to optical observations of electum-rich millimetre-to-submilimetre-wide bands in hand specimens, taken on the summit of the Ada Tepe ridge, it is determined that they contain mainly apparently isotropic silica, microcrystalline adularia, and electrum of high grades. The micro Raman spectroscopy measurements of apparently isotropic silica displayed only peaks of α-quartz. No evidence was obtained from the micro Raman spectroscopy study for low-crystalline and non-crystalline silica phases (see Marinova, Titorenkova, this issue). In this way, for deciphering of the origin of the colloform-banded texture in the Khan Krum deposit have remained only textural and morphological features.

The objective of this study was to identify textural and morphological signs for colloidal origin of the colloform-banded macro-texture in the Khan Krum deposit.

Material and methods

About 100 hand specimens of colloform-banded macro-texture, taken from 10 high-angle veins, cropping out mainly on the summit of the Ada Tepe ridge, were collected in 2007 and 2008 for textural analysis. Thirty thin sections and polished thin sections, as well as 20 polished sections, and 15 unpolished sections were prepared for study. The study was carried out by a stereomicroscope, a conventional polarizing optical microscope in transmitted and in reflected light, and a Philips-515 SEM in secondary electrons at a voltage of 25 kV and magnifications ranging from 100 to 10 000. For identifying the silica phases, powder samples of colloform-banded specimens were investigated using the X-Ray diffraction method by a Dron-3M diffractometer, operating at λ=0.17 903 nm (cobalt radiation), 35 kV, 25 mA and with an iron filter for the range from 8 to 70° 2θ.

Results and discussion

Visually, it is observed that the macro-bands differ significantly in texture one from another: there are as massive bands as well as bands with a finer inner banding due to the alternation of differently coloured bands. The substantial differences in the texture of bands are evidence for their formation from individual hydro-

thermal pulses one after another. At the same time, the numerous recorded X-Ray diffractograms of different bands revealed presence only of quartz and potassium feldspar of varying amounts, confirmed by a petrographic study (Marinova, 2009). The observed variation in the quartz-to-adularia ratio, colour of quartz, and the texture of individual bands are reason for the striped appearance of the colloform-banded veins. As observed in the field and under the stereo- and optical microscope, the high-angle veins are formed via mineral filling of open space, and crystal growth from the contacts of veins toward their central part. Thus, the missing comb texture along the walls and band boundaries, combined with the presence of a random-grain fabric of quartz and adularia within the bands, of a finer periodic banding in some macro-bands, and of obscured boundaries indicate that the macro-bands can hardly be formed from true solutions rather speaks in favour of crystallization from a silicate gel. Quartz and adularia in most quartz-adularia macro-band show a differentiation one from another in almost monomineral spots that could be explained with re-crystallization characteristic of the crystallization from gels (Chuhrov, 1955; Lebedev, 1967). In the studied specimens of auriferous colloform-banded macro-texture, everywhere there are voids that look like oval primary millimetre-scaled pores, centimetre-scaled empties, and cracks of exfoliation, all they lined with sub-millimetre-long quartz-adularia druses, deciphered as pores, empties and cracks of syneresis, respectively. Widely distributed is feathery quartz, abundant of fluid inclusions sized below 1 μm that occur as oriented trails in sections of the quartz crystals. This suggests the formation of feathery quartz via re-crystallization of a fibrous precursor, most likely chalcedony.

Electrum appears only as dispersed micron-sized grains irregularly distributed in each band, and in varying content from one to another macro-band.

On the basis of performed textural analysis the following indicators for colloidal origin of the colloform-banded macro-texture are specified: (1) obscured boundaries of bands; (2) a finer inner banding; (3) a strongly prevailing random-grain fabric of quartz and adularia; (4) pores and cracks of syneresis lined with comb quartz and adularia; (5) re-crystallization of quartz and adularia.

Conclusions

1. The colloform-banded macro-texture points to the economically important portion of the Khan Krum deposit and is less distributed than the other associated macro-textures such as the banded and massive ones. It is formed via episodic reopening of a high-angle vein and repeated income of fluid, probably resulted from intermittent fault dilation, each macro-band being deposited from an individual hydrothermal pulse. **2**. It is supposed that the proposed earlier by the author intense boiling of fluids during the formation of the colloform-banded macro-texture has led to the formation of relatively water-rich colloidal solutions, later coagulated in a water-rich gel. Finally, fine-grained, relatively equigranular quartz and adularia (with grains up to 20-30 μm in size) have crystallized from the gel. The gel was abounding in micro-pores of syneresis lined with comparatively coarse (about 200–300 μm long) comb quartz and adularia, deposited from true solutions, already passed through the silicate gel like through a semi-permeable membrane. We believe that the paleohydrothermal system was closed or partly closed during the colloform-banded macro-texture formation. **3**. The colloform-banded macro-texture is characterized with both full crystallization and considerable re-crystallization of quartz and adularia. **4.** The degree of boiling of fluids has been not sufficient for voluminous deposition of electrum.

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References

Chuhrov, F. 1955. *Colloids in the Earth Crust*. Moscow, Izd. AN SSSR, 671 p. (in Russian).

Herdianita, N. R., P. R. L. Browne, K. A. Rodgers, K. A. Campbell. 2000. Mineralogical and textural changes accompanying ageing of silica sinter. – *Mineral. Deposita*, *35*, 48–62.

Grigor'ev, D. P. 1965. *Ontogeny of Minerals*. Israel Program for Scientific Translations Ltd, Jerusalem.

Lebedev, L. 1967. *Metacolloids in Endogenic Deposits.* New York, Plenum Press.

Marchev, P., B. Singer, D. Jelev, S. Hasson, R. Moritz, N. Bonev. 2004. The Ada Tepe deposit: a sediment-hosted, detachment fault-controled, low-sulfidation gold deposit in the Eastern Rhodopes, SE Bulgaria. – *Schweiz. Mineral. und Petrogr. Mitt.*, *84*, 59–78.

Marinova, I. 2009. Preliminary data on auriferous colloform-banded textures from high-angle veins in the low-sulfidation Khan Krum gold deposit, SE Bulgaria. – In: *Proceedings of National conference "Geosciences 2009"*. Sofia, BGS, 105–106.

Marinova, I., R. Titorenkova. 2011. Indications for colloidal origin of the bonanza of electrum millimitre-to-submillimetre-wide colloform-banded texture in the Au-Ag Khan Krum deposit, SE Bulgaria. – In: *Proceedings of National conference "Geosciences 2011"*. Sofia, BGS (in this issue).

Roedder, E. 1968. The noncolloidal origin of "colloform" textures in sphalerite ores. – *Econ. Geol.*, *63*, 451–471.