Доклади на Българската академия на науките
Comptes rendus de l'Académie bulgare des Sciences

Tome 59, No 11, 2006

GEOLOGIE
Minéralogie

BRECCIATION TEXTURES FROM THE ELECTRUM-BEARING, LAYER-LIKE PERVASIVE SILICIFICATION IN THE LOW SULFIDATION KHAN KRUM GOLD DEPOSIT, SE BULGARIA

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(*Submitted by Corresponding Member I. Velinov on July 27, 2006*)

Abstract

Representative brecciation textures from the electrum-bearing, layer-like, massive pervasive silicification of breccias and breccio-conglomerates in the epithermal, low sulfidation, of adularia-sericite type Khan Krum gold deposit (SE Bulgaria) are presented.

Key words: brecciation textures, electrum-bearing layer-like pervasive silicification of clastic sediments

Introduction. During the study of the electrum-bearing, layer-like, massive pervasive silicification in Stenata (The Wall) outcrop of Khan Krum gold deposit three genetic groups of textures were divided: 1) replacement textures; 2) open-space filling textures and 3) brecciation textures. The first two groups of textures reflect the way of precipitation of the hydrothermal minerals built up the layer-like, pervasive silicification and they are described in 1,2. The third group describes the fractures which host hydrothermal minerals and have played important role throughout the evolution of Khan Krum gold deposit. The authors of [3,4] report for intensive, multiple brecciation and silicification in Khan Krum gold deposit (Ada tepe) but a systematic description of brecciation textures, their origin and role in the deposit evolution is absent till now. This requires a study to be carried out on the brecciation textures, which is a subject of the present work.

Khan Krum gold deposit is located in Eastern Rhodope Mt, SE Bulgaria. It is epithermal, low sulfidation, of an adularia-sericite type. The deposit is hosted in the breccias and breccio-conglomerates of Shavar Formation (Maastrichtian-Paleocene), is related to Tokachka Detachment Fault, and it is around 35 Ma of age [3–6]. The reserves are 6.15 Mt of ore at 4.6 g/t gold for 910000 ounces of gold at 1.0 g/t cutoff grade [5]. The location, geological setting of the region and of the deposit, hydrothermal alteration and ore minerals, sequence of precipitation of minerals, stiles of mineralization are given in [1–8].

Sampling. The layer-like, pervasive silicification (massive microcrystalline quartz) in Stenata outcrop was sampled in 2004 by vertical channel samples downwards and upwards Tokachka Fault plane covering about a 5-metre interval. The sampling sites are documented by photographs in [1]. Hand specimens of Balkan Mineral and Mining from trenching are also used.

Results and discussion. Brecciation textures are widespread in Stenata outcrop and are observable at macro- and microscale. In hand specimens, polished and thin sections we recognized the *stockwork*, *breccious*, *veinlet* and *jigsaw-fit puzzle textures* among the brecciation textures described in the geological literature.

The most often observed texture of brecciation in Stenata outcrop appears the *stockwork* one – everywhere the massive, microcrystalline quartz is cross-cut by short stockwork, hair-like joints randomly oriented (Fig. 1; Fig. 2, a, b). Depending on the rheological properties of the silicified rocks the stockwork jointing is manifested to a different degree. It is well expressed in the massive quartz replaced clasts of breccias and breccio-conglomerates (Fig. 1, a, b, d), whereas it is unclear in the matrix (Fig. 1, c).

The stockwork joints are opened and most often are filled by crustiform, banded quartz (Fig. 2, c, d), more rarely by opal partially crystallized in microcrystalline quartz (Fig. 2, e, f) and by banded quartz with adularia (± electrum) (Fig. 1, d).

On the other hand, stockwork joints of quartz filling cross-cut not only the massive quartz but also the later adularia (Fig. 1, d), opal (Fig. 2, g, h) and the joints filled by banded electrum-adularia-quartz (Fig. a-d). At places stockwork quartz joints contain dispersed micron-sized opaque minerals: pyrite (transformed into goethite) (Fig. 3, e, f) and electrum (Fig. 3, g, h).

Postmineral stockwork joints without any filling are also observed. They cross-cut the massive silicification and displace the electrum-rich veinlets (Fig. 1, d; Fig. 4, a, b).

The stockwork joints displace also earlier straight-linear veinlets of 2–5 mm thickness, filled by brecciated and floured microcrystalline quartz. Milky, banded quartz is deposited along the veinlet boundaries. These veinlets form the *veinlet texture* (Fig. 1, b).

Fig. 1. Polished hand specimens from the electrum-bearing, layer-like pervasive silicification in Stenata outcrop (a, b, c are supergene coloured by iron ochres): a) stockwork and jigsaw-fit puzzle textures: milky microcrystalline quartz, replaced breccio-conglomerates is brecciated by stockwork joints. Some joints follow boundaries of gravel clasts and are filled by milky quartz; b) a veinlet and later jigsaw-fit puzzle textures of hydrothermally brecciated massive, microcrystalline quartz replaced gravel breccio-conglomerates. Milky crustiform quartz is grown up on the walls of veinlets, whose central parts are filled by brecciated and floured quartz coloured by iron ochres; c) a stockwork texture: the stockwork joints are clear in the brittle milky quartz, replaced breccio-conglomerates and are unclear in the matrix due to its lower competency; d) multiple brecciated hand specimen. The brecciated massive quartz is cemented by massive adularia (ad). Adularia is observed also in electrum-rich quartz-adularia bands, filling stockwork joints (outlined with yellow colour for clearness). Both adularia and quartz (massive and banded) are cross-cut by stockwork quartz joints. At last postmineral joints without filling are formed and they displaced electrum-rich adularia-quartz bands

Fig. 2. Brecciation microtextures of the layer-like pervasive silicification: a-b – in reflected light; c-h – in transmitted light: a) stockwork joints filled by quartz cross-cut the massive pervasive silicification, +N; b) same field, //N; c) a quartz veinlet cross-cuts finer massive quartz. The veinlet boundaries are healed (fluidofracturing), +N; d) same field, //N; e) a veinlet filled by partially crystallized opal cross-cuts massive microcrystalline quartz. In the middle a late joint without any filling passes, +N; f) same field, //N; g) a veinlet filled by microcrystalline quartz cross-partially crystallized opal (in the upper and lower quarters of the photo), +N; h) same field, //N. Black spots of goethite ⟶

At places the stockwork jointing passes into dense network, thus forming the *breccious texture*, represented by angular clasts of massive quartz cemented by adularia and quartz (Fig. 1, d; Fig. 4, c, d).

A big part of the numerous stockwork joints follow the boundaries of clasts and form the *jigsaw-fit puzzle texture* as the size of clasts varies from few centimetres to few millimetres and to few tens of millimetres. The confining joints are partly filled by crustiform quartz thus outlining the outer contour of the clasts. The jigsaw-fit puzzle texture is also observable in transmitted light, where the interstices of next psammitic clasts of the matrix are filled by crustiform quartz (Fig. 1, a, b; Fig. 4, e, f).

The presented observations showed that the most characteristic fracture structures in the layer-like pervasive silicification in Stenata outcrop are the joints and veinlets. The variety of their morphology and size shows different intensity of brittle deformation, and the cross-cutting relationships – multiple episodes of jointing and brecciation, infilling of the newly formed structures with ore-bearing solutions and a postmineral jointing without hydrothermal infilling. Due to the multiple episodes of jointing and brecciation one could propose a multiple deposition of electrum favoured the high gold grade of Khan Krum gold deposit, proved by the prospecting of Balkan Mineral and Mining.

A peculiar feature of infilling quartz, adularia and opal is the absence of sharp boundaries with the ground on which they had grown up, thus sealing the fractures and healing them, which is clear in transmitted light (Fig. 2, 3, 4). This feature suggests the formation of stockwork joints and veinlets in a fluidized medium, known as fluidofracturing. Frequent fluidofracturing is likely a consequence of repeated overpressured conditions of fluids in depth after which a rapid pressure drop follows [8,9].

The analysis fulfilled of replacement textures [1], of open-space filling textures [2], and of brecciation textures (present paper) and the published data allow us to interpret the structural and the mineral evolution of Stenata outcrop in the following way. Replacement of breccias and breccio-conglomerates of Schavar Formation above Tokachka Detachment Fault by a layer-like, pervasive silicification has created a low permeable barrier for the next portions of hydrothermal solutions. Overpressure of fluids formed beneath the barrier have released repeatedly through multiple episodes of fluidofracturing of the layer-like pervasive silicification. Newly formed open structures are filled by banded quartz, quartz + adularia, adularia, pyrite, electrum. Multiple fluidofracturing have protracted the fractures and they have reached the paleosurface.

Fig. 3. Brecciation microtextures of the layer-like pervasive silicification (in reflected light): a) electrum-rich (yellow grains) quartz-adularia bands cross-cut massive quartz and are also cross-cut by joint filled by quartz, +N; b) same field, //N. Quartz is clear and adularia is milky. Spots of supergene iron ochres; c) quartz-adularia bands with electrum clots (light yellow grains) in massive quartz are cross-cut by quartz joint, +N; d) same field, //N. Brown iron ochres and green spots of polished powder (Cr_2O_3); e) a quartz joint containing pyrite transformed into goethite (gray metallic colour) cross-cuts massive quartz, +N; f) same field, //N. Brown iron ochres; g) a quartz joint containing two electrum grains (pointed by arrows) cross-cuts massive quartz, +N; h) same field, //N. Green spots of polished powder (Cr_2O_3)

Fig. 4. Brecciation microtextures of the layer-like pervasive silicification: a-d – in reflected light; e-f – in transmitted light: a) banded quartz containing electrum (white grains) cross-cuts massive quartz. Open zigzag joint (only epoxy resin filling) cross-cuts both massive and banded quartz, +N; b) same field, //N. Brown iron ochres; c) a breccious texture of massive quartz; cemented by quartz, which is healed the joints, +N; d) same field, //N; e) a jigsaw-fit puzzle texture: crustiform quartz is filled the space between four psammitic clasts, +N; f) same field, //N. Black spots of goethite

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The rapid pressure and temperature drops that followed caused the solutions to boil and to supersaturate in respect to opaline silica and to electrum and they have deposited banded opaline silica and bonanza electrum ores and silica sinter on the paleosurface.

In a wider sense, the Stenata outcrop is one of the examples of self-organized geological system due to its spontaneous tendency to equilibrium [11,12].

Conclusion. 1. Representative brecciation textures of the layer-like pervasive silicification in Stenata outcrop are: (i) stockwork, (ii) breccious, (iii) veinlet and (iv) jigsaw-fit puzzle ones.

2. The main synmineral and postmineral structures of the layer-like pervasive silicification are stockwork joints and veinlets.

3. The main mineral, infilling the synmineral fractures and cementing the hydrothermal breccias is quartz, to a less extent – adularia and opal.

4. The healing of joints and veinlets showed that the brecciation textures were formed in a fluidized, extensional medium.

5. The analysis of brecciation textures revealed multiple jointing and brecciation of the layer-like pervasive silicification in Stenata outcrop, which corresponded to multiple electrum precipitation, favoured the high gold grade of Khan Krum gold deposit.

Acknowledgement. The author thanks to Balkan Mineral and Mining for the provided possibility to sample Khan Krum deposit and for the given hand specimens.

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