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

**I. Marinova**

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**Abstract**

Representative replacement textures from the electrum-bearing, layer-like pervasive silicification of sedimentary breccias and breccio-conglomerates in the epithermal, low sulfidation, of adularia-sericite type Khan Krum gold deposit are presented.

**Key words:** quartz textures, electrum-bearing layer-like pervasive silicification of sediments

**Introduction.** Khan Krum gold deposit is located in the vicinity of Ada Tepe Peak (height of 492.4 m), Eastern Rhodope Mt, SE Bulgaria. The peak is the highest point of a ridge of N-S elongation and a size of 1.5/0.8 km (Fig. 1, a). The deposit is hosted within the northern periphery of the NNE-trending Kessebir Gneiss Dome [1], covered from north by the colluvial-proluvial-alluvial polymict breccias and breccio-conglomerates of Shavar Formation, which is of a Maastrichtian-Paleocene age [2] (Fig. 1, b). The breccias and breccio-conglomerates are block-, boulder-, and gravel-sized, poorly sorted and consolidated. The clasts prevail over the matrix which is psammitic-aleurolitic in size, and heterolithic in composition [2]. The boundary between the underlying metamorphic rocks of the dome and the Shavar Formation is traced by the regional, low-angle Tokachka Detachment Fault [3]. The gold mineralization is epithermal, low sulfidation, of an adularia-sericite type [4–7], and is around 35 Ma of age [7]. The style of mineralization includes ore bodies of two types entirely developed above Tokachka Fault: a massive, tabular (layer-like) body within the sediments of Shavar Formation, and an open-space filling along E-W-trending high-angle listric faults [5–7]. The layer-like body is most outcropped on the southwestern slope of the ridge, known as Stenata (The Wall) outcrop (Fig. 1, a). It includes dispersed, micron-sized electrum, marcasite and goethite pseudomorphs after pyrite [4, 8]. It is accompanied by quartz-adularia metasomatites (± sericite, ± kaolinite) [4]. A geological cross-section and a 3D-image of Khan Krum gold deposit are shown in [7], and alteration and ore mineralization are described in [4–8].

The aim of the present work is to describe representative textures of the layer-like body in Stenata outcrop in order to evaluate the deposition conditions of the electrum.

**Sampling.** The layer-like body was sampled in 2004 in Stenata outcrop by vertical channel samples downwards and upwards Tokachka Fault plane covering about a 5-metre interval (Fig. 1 c, d, e). Hand specimens of Balkan Mineral and Mining from trenching are also used.

**Results and discussion.** The layer-like body in Stenata outcrop is well-marked in the field massive body of sugary appearance, whose lower boundary is Tokachka Fault plane (Fig. 1, c, d, e). Due to a supergene alteration, the layer-like body is yellow ochre-, brown ochre- and rusty-coloured by widespread X-ray amorphous iron ochres, goethite and hematite (Fig. 1, c, d, e) [8]. The layer-like body is formed through intensive pervasive silicification of gravel breccias and breccio-conglomerates of Shavar Formation, as the shape and the textures of replaced clastic rocks are preserved at many places. According to our powder diffraction and optical data commonly the quartz quantity in the pervasive silicification is about 98–99 wt%, adularia and kaolinite do not exceed 1–2 wt%. One can also observe opaline silica and adularia in quantities comparable to this of quartz in limited volumes.

The following genetic textures of the layer-like pervasive silicification were recognized in outcrops, hand specimens and in thin sections: 1) replacement textures; 2) open-space filling textures and, 3) brecciation textures. In the present paper the first group of textures is described. We understand under the term "ore textures" features of physical appearance, determined by the shape, size and the spatial interrelations of the constituent mineral aggregates different in mineral composition or in structure [9]. The names of textures are mainly accepted from [10,12–14].

Replacement textures. In the layer-like pervasive silicification massive, gridwork, platy and lattice replacement textures were recognized. The massive texture is widespread, because the layer-like silicification consists mainly of massive, microcrystalline quartz – clear, milky and pale gray, rarely milky pink in colour, deposited through the replacement of clastic sediments (Fig. 1, 2). The massive, microcrystalline

Fig. 1. Khan Krum gold deposit: a) view from east of the ridge with Ada Tepe Peak hosting Khan Krum gold deposit. Photo of Balkan Mineral and Mining; b) geological scheme of Rhodope Mt (after J. Nikolov, 1980, modified): *1* – Neogene sediments, *2* – Late Eocene-Early Miocene volcanic rocks, *3* – Maastrichtian-Paleocene sediments and pyroclastics, *4* – Late Cretaceous-Tertiary granites, *5* – Mesozoic metavolcano-metasedimentary rocks, *6* – high grade metamorphic basement; c) Tokachka Detachment Fault in Stenata outcrop along the fault strike. Small arrows show the fault plane. Pervasively silicified breccias crop out in the upper plate, hydrothermally altered metamorphic rocks of fine schistosity – in the lower plate; d) intensive pervasive silicification in the upper plate of Tokachka Fault. Wooden lath for scale, length of 35 cm; e) upper plate of Tokachka Fault – pervasively silicified breccias, fractured by high-angle sub-parallel faults. Intensive supergene iron ochres and goethite in all field photos →

Fig. 2. Polished hand specimens from the layer-like pervasive silicification. The hand specimens are supergene coloured by iron ochres and contain dispersed, micron-sized electrum: a) a massive texture – milky, microcrystalline quartz is replaced breccio-conglomerates with clasts around 2-3 cm in diameter; the clasts touch one another; b) a massive texture – milky, microcrystalline quartz is replaced breccio-conglomerates with clasts around 0.5 cm in diameter; the clasts touch one another; c) a massive texture – milky, microcrystalline quartz is replaced semi-rounded clasts, sub-parallel arranged and included in psammitic-aleurolitic matrix →

quartz is sized from above 1 $\mu$m up to 200 $\mu$m, commonly around 20–50 $\mu$m and it changes the size within micron distances and forms micro-grained masses, and randomly, bundle-likely and orthogonally oriented one to another crystals (Fig. 3). Quartz reveals unusual pleochroism under parallel nicols, namely pale brown along $N_p$ and colourless along $N_g$ (Fig. 3, d).

In outcrops and hand specimens of massive quartz the shape of former breccias and breccio-conglomerates is preserved. Commonly, one can observe intensively silicified angular and semi-rounded clasts of various size, not exceeding few centimetres which touch one another (Fig. 2, a, b). The matrix is silicified as well but is observable only at isolated places. In other cases former rounded clasts now completely built up of milky, microcrystalline quartz are sub-parallel arranged and are included in a matrix of silicified rounded psammitic and aleurolitic clasts as the matrix prevails over the clasts (Fig. 2, c). Varied quantitative relations of the clasts and the matrix are observed between these two end cases.

One can clearly distinguish in transmitted light preserved shapes of silicified former psammitic rock clasts as quartz had inherited the textures of the replaced rocks (schistose or massive) (Fig. 3, a, b). Quartz is being more coarse-grained in the pore space and commonly its c-axis is oriented perpendicular to the clast walls (Fig. 3, a). More rarely it forms bundle-like aggregates that delineate the clasts (Fig. 3, b).

At micron distances and comparatively often quartz shows grid-work texture (orthogonal, reticulate after some authors). At this texture quartz crystals of various size are oriented one to another at angles of about 90°, thus forming orthogonal systems of crystals [10] (Fig. 3, c, d). As it is seen in secondary scattered electrons quartz crystals grow up nearly perpendicular onto the walls of neighbouring crystals (Fig. 3, e, f). The presence of grid-work texture is an indication for a high speed of nucleation and/or for a high activity of $SiO_2$ [10].

One could often observe in the massive microcrystalline quartz a macro- or a micro-sized replacement textures of a platy mineral. They are represented by thin plates, which reach few millimetres in diameter, built up of microcrystalline quartz. A platy texture of parallel plates was recognized (Fig. 3, g), but more often – a lattice texture, when the plates cross one another under various angles, thus forming multi-angular cavities (Fig. 3, h). These textures are seen in many epithermal gold deposits. They are explained through a deposition of quartz on calcite plates followed by a dissolution of calcite as peculiar cavities have left [11–14]. Calcite is not preserved in our samples due to a dissolution, but an alternation of platy calcite and quartz is documented in Khan Krum deposit [7]. The platy and the lattice textures have not been observed so far underneath Tokachka Fault [7]. They point to boiling of fluids [12–14], started from above the fault [7], where the hydrothermal fluids had flooded the sediments being more permeable than the underlying metamorphic rocks.

**Conclusions.** 1) Representative replacement textures of the layer-like pervasive

← Fig. 3. Replacement microtextures from the layer-like pervasive silicification: a-d in transmitted light: a) angular psammitic clasts are replaced by massive, microcrystalline quartz inherited the schistosity of the source rock; in the pore space more coarse quartz is deposited with c-axis perpendicular to the clast walls, +N; b) bundle-like quartz surrounds semi-rounded clast, replaced by equal-grained, microcrystalline quartz, +N; c) a grid-work texture, +N; d) same field, //N: near to 90 °C angle between the dark cuts and the pleochroism in quartz; e-g in back scattered electrons: e) orthogonally arranged quartz crystals, scale bar 100 $\mu$m; f) detail of e - growth of a quartz crystal on a prismatic wall of a neighbouring quartz crystal, scale bar 100 $\mu$m; g) a platy texture of dissolution of calcite within the massive quartz, scale bar 10 $\mu$m; h) a lattice texture of dissolution of platy calcite within the massive quartz in reflected light silicification in Stenata outcrop are: (i) massive; (ii) grid-work; (iii) platy and (iv) lattice ones. These textures are widespread in the epithermal, low sulfidation gold deposits worldwide. 2) The massive replacement texture is most widespread in Stenata outcrop. It is formed by massive microcrystalline quartz, traces of kaolinite and adularia and by dispersed micro-sized electrum, marcasite and goethite pseudomorphs after pyrite. 3) The massive and the grid-work textures point that the layer-like pervasive silicification in Stenata outcrop is deposited by highly supersaturated of silica hydrothermal solutions. 4) The platy and the lattice textures are indicative of boiling of fluids.

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*Academician Ivan Kostov Central Laboratory of Mineralogy and Crystallography*
*Bulgarian Academy of Sciences*
*Acad. G. Bonchev Str., Bl. 107*
*1113 Sofia, Bulgaria*
*e-mail*: marinova@clmc.bas.bg