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Research Article

DETERMINATION OF DEPOSIT TYPES OF SOME MINERALIZATIONS IN THE BASHTAVAK AREA IN THE KURAMA MOUNTAINS

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ABSTRACT
The Kurama mountain range is one of the western parts of the Tien Shan, located in the northeastern part of Uzbekistan. It is distinguished by its richness in various minerals. Ancient mining structures have been found in the region, indicating that mining operations were carried out in the Middle Ages, and information about the region is provided in numerous ancient manuscripts of historians.

INTRODUCTION
Favorable geological and structural positions, the presence of the Arabuloq and Kulyuksoy gold-silver ore deposits and the adjacent areas of the Kichkina lead-silver deposit, the Shamirsay and Sardob polymetallic deposits, the Abdulakan lead-silver ore deposit, copper and copper-bismuth deposits, as well as the proximity of certain ore deposits of the Southern Block (Shkolnoe gold-bearing, Kanzhal lead-silver and Oltintopkan polymetallic ore deposits), served as the basis for conducting exploration work in the Bashtavak area in 1984-90. The results of which are presented in this report (Abdurazzakov 1990).
The geological structure of the Bashtavak mineral deposit located in the Almalyk ore field and the prospect of its connection with vein rocks through a comprehensive study of the rocks distributed in it are among the urgent tasks of developing scientific research work on the creation of a mineral raw material base. Currently, geological mapping and geological assessment of various scales have been carried out in the Bashtavak area by exploration expeditions under the State Geological Committee from the 1950s to 2010 [Rasulov, 2023].
The geological structure of the Bashtavak area is dominated by rocks formed during the period of Caledonian (O_3-D_1) and Hercynian
(S_1-S_{2-3}) orogeny. Shales formed in the Upper Ordovician - Lower Silurian (O_3-S_1) period in the region are overlain by intrusive and effusive igneous rocks of the Akcha and Nadak formations of the Carboniferous period. In addition, Quaternary deposits are also partially distributed in the region. They consist of alluvial and prolluvial deposits of the slope loess, Sokh, Tashkent, Golodnosteppe-Syr Darya complex: loess, stones, sandstones, gravels and sandy soil [Olmaliq, 2008].
During the general geological exploration work, a 1:2,000 scale geological-structural map of the Bashtavak region was compiled (Figure 1), and several gold mining zones and copper ore deposits were discovered [Rasulov, 2023].

MATERIALS AND METHODS
In the course of exploration work, previously established data on the geological structure of the site were generally confirmed, and information on the extremely complex tectonic structure of the site was supplemented to a certain extent. It is characterized by large faults such as the Bashtavak and Kaskanasoy faults and numerous small tectonic faults covering them. The main tectonic structure of a continuous nature is the Bashtavak fault, which runs in the sub-latitudinal direction in the northern part of the area. The slope

of the fault to the south is steep (75-80°). The fault in the area passes mainly along the contact section of biotite granites with silicic shales and lower Devonian tuffs. The fault is characterized by strong fragmentation, limonitization and lightening of rocks and is accompanied by quartz veins and a zone of silicification. The thickness of the fault is from 20 to 80 m, the thickness of the surrounding zone of

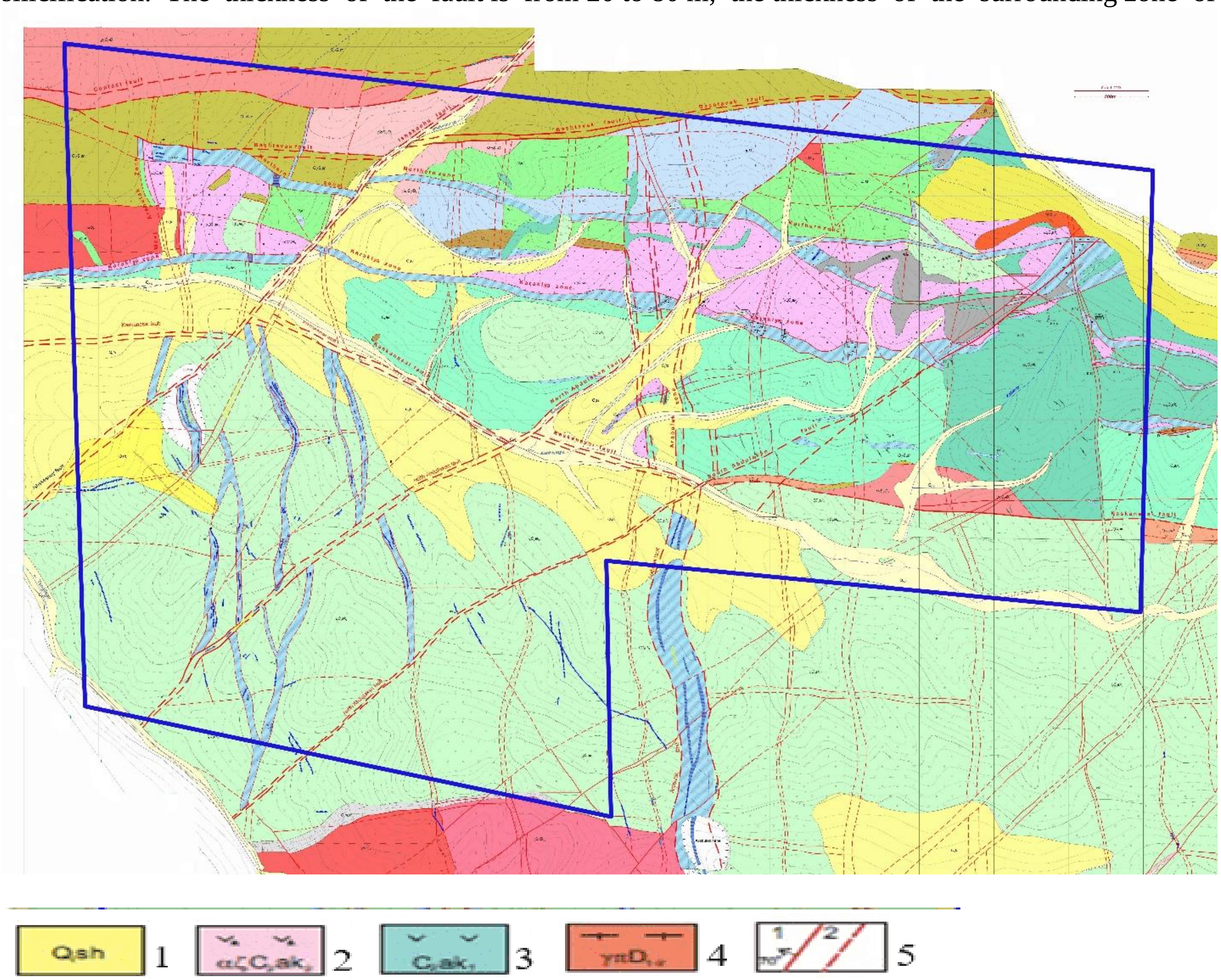

Figure 1. Schematic geological map of the Bashtavak area. 1-modern Quaternary deposits, 2-upper Akcha complex dacites and rhyodacites, 3-lower Akcha andesite-dacites, 4-biotite quartz porphyries and granite-porphyries, 5-earth faults

influence is from 200 to 300 m. The amplitude of the fault displacement is 3-4 m thick, represented by mylonite rocks. The Kaskanasoy fault can be traced from Sardobsoy to the junction with the Bashtavak fault, and was identified by trenches and exploratory drill holes in the central part of the area. The angle of dip to the north is 70-80°. The fault in the area passes through dacite tuffs and is represented by crushed rocks and quartz veins. The Northern fault is a feather structure of the Bashtavak fault. It has a latitudinal strike with a steep dip in the northern and southern directions with a thickness of 10 to 30 m. The Ishakashchui fault has a north-eastern strike and dips to the north-west, and is represented by a crushing zone and quartz veins. The Karakiyinsky fault is exposed by exploration and mapping boreholes at depth. The fault runs mainly along Karakiyasay, has a latitudinal direction and cuts the contact of dacite porphyries with granodiorite porphyries of the Karakiyinsky type. The fault thickness is from 10 m to 20 m, at the contact the rock is completely crushed. Within the area, smaller faults filled with quartz veins are widely developed, which are the feathers of larger tectonic structures *(*Abdurazzakov, 1990*)*.

RESUTLS AND DISCUSSION

Intermediate-sulfidation (IS) epithermal mineralisation of the Bashtavak Silver- Gold Project can be classified as Epithermal which can be assigned to depths of emplacement typical of dilatational structure control.

Epithermal deposits are responsible for 8% gold (Frimmel, 2008), 17% silver (Singer, 1995), and a certain amount of base metals production globally, being the important source of precious metals for Mexico, the United States, Canada, Chile, Peru, Papua New Guinea, and Japan. Lindgren (1922, 1933) first defined epithermal deposits as precious metal and base metal accumulations formed by ascending hydrothermal water at relatively shallow depths (≤900 m) and low temperature (50–200 °C), typically hosted in volcanic and adjacent rocks. By now there is a consensus that epithermal deposits formed at a depth less than ∼1.5 km and generally at a temperature between 150 and 300 °C (e.g., Hedenquist *et al.*, 2000; Simmons *et al.*, 2005). Epithermal ore deposition occurs where focused, rapidly ascending fluids sharply change composition within several hundred of meters of the surface (boiling). This process favors precipitation of bisulfide complexed metals such as gold. Boiling and its concomitant phase separation and rapid cooling also result in associated features such as deposition of bladed calcite, colloform quartz, and adularia, as well as the generation of steam-heated waters that create advanced argillic and argillic alteration blankets. Moreover, sharp depressurization following hydraulic fracturing or brecciation focuses the flow of vigorously boiling fluid (Hedenquist *et al.*, 2000).

Among three types of epithermal deposits, i.e., HS, IS and LS type, IS deposits were most recently distinguished from their low sulfidation (LS) siblings (John, 1999; Hedenquist *et al.*, 2000; Sillitoe and Hedenquist, 2003), with subsequent attention worldwide (e.g., Gemmell, 2004; Shamanian *et al.*, 2004; Gantumur *et al.*, 2005; Koděra *et al.*, 2005; Camprubí and Albinson, 2007; Downes, 2007; Kouzmanov *et al.*, 2009; Velador, 2010; Yilmaz *et al.*, 2010; Mehrabi and Siani, 2012; Gamarra *et al.*, 2013; Nie *et al.*, 2015; Márquez-Zavalía and Heinrich, 2016; Manning and Hofstra, 2017; Wang *et al.*, 2018). Due to different naming tradition, IS deposits in the Cordillera have been termed "Cordilleran polymetallic \base metal deposits" (Sawkins, 1972; Einaudi, 1982; Hemley and Hunt, 1992; Bendezú and Fontboté, 2002), "polymetallic\base metal epithermal deposits" (Bendezú *et al.*, 2008; Baumgartner *et al.*, 2008), and "carbonate-base metal Au deposits" in the circum-Pacific region (e.g., Leach and Corbett, 1994; Corbett and Leach, 1998). In this review, we use the name intermediate sulfidation epithermal deposits to keep the consistence with High sulfidation (HS) and LS and hence to facilitate their direct comparison. IS deposits generally have lower Au grade than LS veins. However, what makes IS deposits important in exploration is their potential for significant Ag and base metal contents and their close relations with PCDs, porphyry molybdenum deposits (PMDs), and HS deposits. Compared with HS and LS deposits, the understanding of IS deposits is relatively lagging. This review summarizes the current knowledge of key features of IS deposits, including spatiotemporal distributions, ore and gangue mineralogy, ore and deposit morphology, magmatic affinity, tectonic and structure control, metal transporting and depositing mechanisms, factors controlling its occurrence, and relationships with porphyry-HS deposits and LS deposits. An empirical subclassification scheme of IS deposits is proposed based on distinctive tectonic settings and associated stress states within which they formed. A tectonicmagmatic control on subtypes of IS are proposed. This classification may facilitate the investigation and exploration of IS and related deposits.

The term 'sulfidation' was first used in epithermal classification (high sulfidation deposit characterized by oxidized sulfur valence (SO_4 2−, n=+6) and low sulfidation deposit characterized by reduced sulfur (H_2S, n=−2)) by Hedenquist (1987). In this contribution, the sulfidation terminology refers to sulfidation state of the principal sulfide minerals, but also includes a range of characteristics that are typical, but not necessarily exclusive, to one type of deposit. Sulfidation state of sulfide minerals is a function of fs2 and temperature

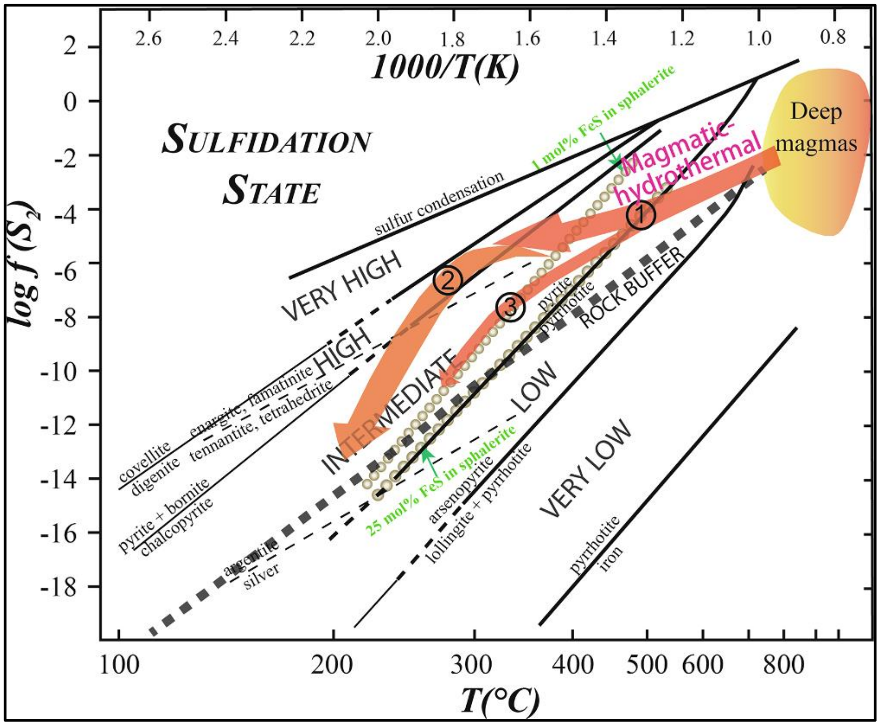

Figure 1: Log*f*(S2)-T (°C) diagram showing the variety of sulfide assemblages in porphyry and epithermal deposits that reflect sulfidation state. I. Trajectories ① and ② are those described for porphyry copper deposits and intermediate-sulfidation precious-base metal veins associated with porphyries, respectively; based on Einaudi *et al.* (2003). Trajectory ③ is a speculative path that could explain the sulfidation evolution deduced for the La Guitarra deposit and other similar epithermal deposits (e.g., Bacis, Guanajuato, Tayoltita, Maguaríchic, Pachuca–Real del Monte) in México (Camprubí and Albinson, 2007). Adapted after Einaudi *et al.* (2003) and CamprubÍ and Albinson (2007).

(1000/T, Fig. 2; Einaudi *et al.,* 2003). By definition (Einaudi *et al.,* 2003), intermediate sulfidation is stable with respect to chalcopyrite-pyrite-argentite as well as tennantite and tetrahedrite. This practical description based on mineralogy is more useful than determining a range of fluid inclusion homogenization temperatures and corresponding sulfur fugacities from measuring the FeS in sphalerite and Ag contents of electrum (Barton and Toulmin, 1964, 1966; Barton and Skinner, 1979). The term "intermediate-sulfidation epithermal deposits" has been used for nearly two decades. John *et al.* (1999) classified LS deposits of northern Nevada as type 1 LS (associated with a western andesite arc) (Table 1) and type 2 LS (related to bimodal magmatism) based on several distinct geological facts. They noticed that type 1 LS formed from moderate temperature, low to moderate salinity fluids with relatively high oxygen and sulfur fugacities, which are the median between HS and type 2 LS. The resulting deposits generally have higher base metal and silver contents and higher Ag/Au than type 2 LS, and their sulfide mineral association is transitional between HS and type 2 LS. Type 1 LS was proposed to be called IS deposits by Hedenquist et al. (2000) (Table 1). Sillitoe and Hedenquist (2003) refined the terminology for epithermal deposits and noted that HS and IS form in the same tectonic setting as porphyry, and they can be related, which is distinctly different from extensional setting of LS deposits (Table 1). The epithermal classification HS, IS, and LS is currently the most accepted scheme (e.g., Shamanian *et al.,* 2004; Downes, 2007; Kouzmanov *et al.,* 2009; Velador, 2010; İmer *et al.,* 2016; Xie et al., 2017) despite the presence of other classification schemes (Simmons *et al.,* 2005). Later, Camprubí and Albinson (2007) proposed a IS-LS transition type based on a summary of

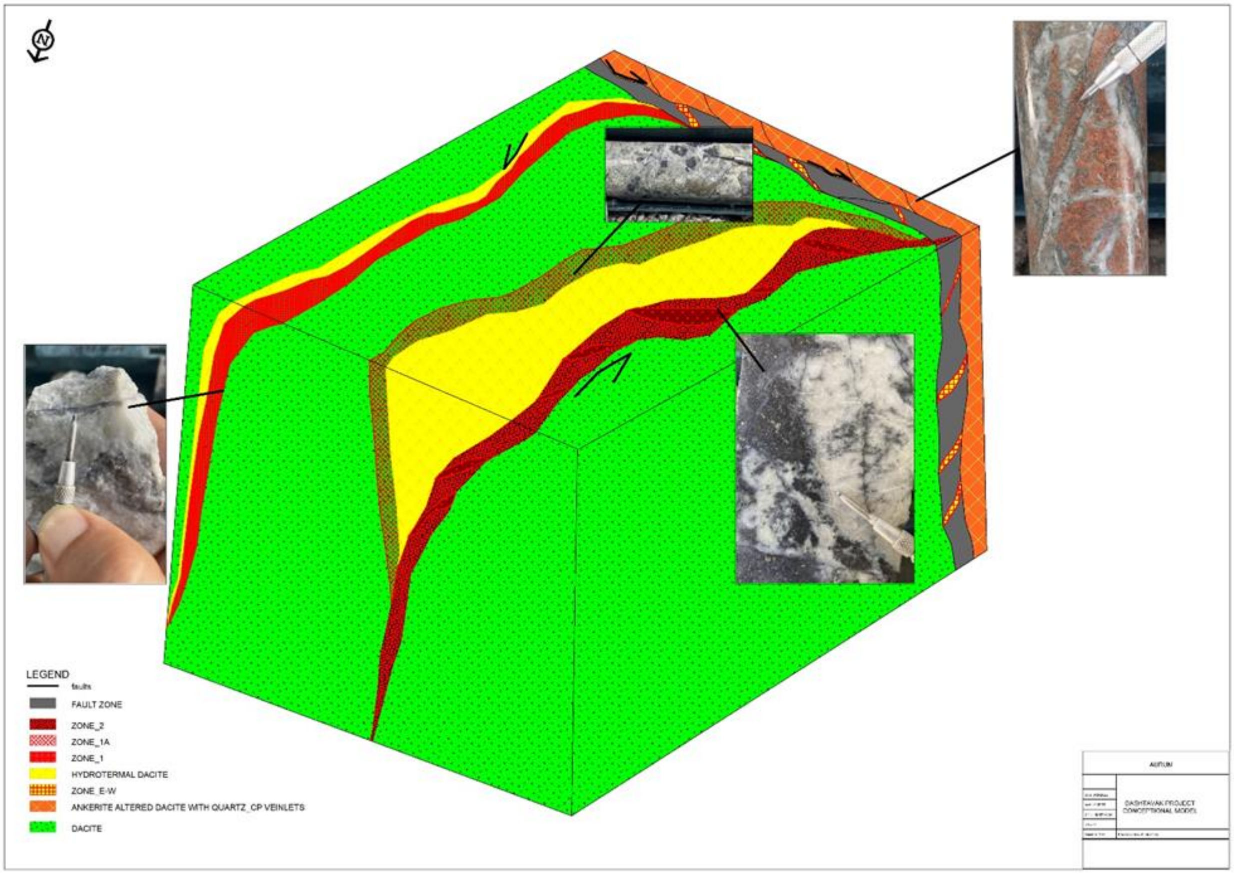

Figure 3. Bashtavak Project Zone 1-2-1A and E-W conceptional section

35 of epithermal deposits in Mexico, noting an atypical epithermal style with upper LS precious metal and roots of IS polymetallic base metal mineralization (Table 1). Key terms used in this review are clarified here (mainly based on Sillitoe and Hedenquist, 2003). HS deposits: a kind of epithermal deposits characterized by high content sulfides (10–90 vol%), pyrite – enargite – luzonite – famatinite – covellite as major ore minerals, quartz – sulfate (e.g., barite) as main gangue minerals (carbonate absent), and quartz – alunite – pyrophyllite – dickite as main proximal alteration minerals. Lithocap: blankets of alunite, kaolinite, and vuggy quartz formed from acid leaching of condensation of a low-density magmatic vapor and meteoric water, also known as acid altered lithocap or advanced argillic lithocap. The lithocap usually predates the HS mineralization and could act as host rock for it (Sillitoe and Hedenquist, 2003). LS deposits (associated with subalkaline magma in this review): a kind of epithermal deposits featured by low sulfides content (typically< 2 vol%), minor pyrite – arsenopyrite ± pyrrhotite ± sphalerite ± galena ± chalcopyrite ± tetrahedrite/tennantite as ore minerals, chalcedony – quartz ± carbonate ± fluorite as primary gangue minerals, illite/smectite – adularia as key proximal alteration minerals. IS deposits: a sort of epithermal deposits featured by intermediate sulfides content (5–20 vol%), pyrite – sphalerite – galena – chalcopyrite – tetrahedrite/tennantite as chief ore minerals, quartz – manganiferous carbonate ± adularia ± manganiferous silicate ± barite as gangue minerals, illite as proximal alteration minerals. IS-LS deposits, an atypical epithermal style with upper LS Au-Ag and roots of IS polymetallic mineralization (Zn-Pb-Cu), largely located in Mexico (Camprubí and Albinson, 2007).

The Bashtavak 2nd Zone deposit is characterized by its sulfide content, mineral assemblage of pyrite-sphalerite-galena-chalcopyrite, Ag-sulphosalt content, illite, Fe-Mn carbonate alteration, and the presence of barite gang minerals. According to Sillitoe and Hedenquist (2003), it is an intermediate-sulfidation epithermal mineralization. However, according to Leach and Corbett (1994) and Corbett and Leach (1998), it is classified as a carbonate base metal deposit.

Figure 4. Bashtavak Alteration zones; ankerite- rhodochrosite- siderite-illite respectively.

CONCLUSION

Currently, geological exploration is underway in the southern part of the Almalyk ore field, i.e., in the Bashtavak area, adjacent areas. In this article, we have tried to identify some types of mineralization in the Bashtavak area. This will be useful in identifying other types of mineralization in the area and identifying promising areas. The presence of a number of criteria that should be considered during geological exploration in the field can also facilitate and accelerate the work.

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