

Au-Ag-Te-Se deposits

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Au-Ag-Te-Se mineralization in the Potashnya gold deposit, Kocherov tectonic zone, Ukrainian Shield

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Abstract. Bismuth tellurides are widely abundant in most Precambrian orogenic gold deposits of the Ukrainian Shield. The recently discovered Potashnya gold deposit of the Volyn' Megablock, however, is conspicuous because it is typified by a Au-Ag-Te-Se type of mineralization and the practical absence of Bi tellurides. This unusual mineralogical signature gives the deposit additional interest. Telluride formation occurs as the result of an unusual 'telluric metasomatism', not observed anywhere else in the Ukrainian Shield deposits. Phases including weissite (Cu_{2-x}Te), hessite (Ag_2Te), altaite (PbTe), frobergite (FeTe_2), melonite (NiTe_2), tellurobismuthite (Bi_2Te_3) and bohdanowiczite (AgBiSe_2) and unnamed Au_3TiTe_2 have been found.

Key words: Au-Ag-Te-Se mineralization, Bi-tellurides, Ukrainian shield, Potashnya gold deposit

Introduction

Most Precambrian orogenic gold deposits of the Ukrainian Shield show the persistent presence of bismuth tellurides (Bondarenko et. al., 2004). Hedleyite is predominant, with lesser amounts of pilsenite. As a result, the first identification, in the Precambrian Potashnya deposit, of a Au-Ag-Te-Se type of mineralization, in which Bi-tellurides are virtually absent has attracted not only mineralogical interest to this deposit, but also raised practical interest in connection with the estimation of possible economic prospects in the area, and in particular, the possible presence of richer ore bodies at depth.

Geological setting

The Potashnya deposit is situated in the western part of the sub-meridional Kocherov

regional tectonic zone, which strikes almost parallel to the geographical meridian and which is spatially confined to the southeastern flank of Korosten rapakivi granite pluton (Fig. 1).

Metamorphic rocks of Teterev Group ($\text{PR}_{1\text{tt}}$) and anatectic formations of the Zhitomir Complex ($\text{PR}_{1\text{zt}}$) comprise the main geological structure of the zone. Metamorphic rocks are commonly found as small relict bodies among granitoids and migmatites, and are mostly represented by rocks of the Kocherov suite ($\text{PR}_{1\text{kc}}$). The latter includes dominant crystalline schists, biotite and biotite-amphibolite gneisses with thin layers of calciphyres and marbles.

Rocks of the Kocherov suite are regionally metamorphosed at the middle to upper amphibolite facies. Gold mineralization is commonly found at the exocontact zones of the apical part of granite massifs, which are characterised by the widespread presence of

various types of migmatite. Available isotope data (Shcherbak et. al., 1978) indicate an interval of 1900-2100 Ma for formation of these massifs. The area surrounding the Potashnya gold deposit is characterized by the presence of dense networks of plicated (folded) and disjunctive (faulted) dislocations, which form extensive fault zones with predominantly orthogonal and diagonal directional systems. These systems define the margins of the Au-Ag-Te-Se mineralization.

Gold-silver mineralization is mostly found in quartz veinlets within amphibolite plagiogneisses. The most unaltered varieties of host rock have the following mineralogical composition (in vol.%): plagioclase (30-55), amphibole (30-35), quartz (10-15), microcline, epidote (2-3), quartz (10-15). Newly formed barium feldspar was found in a selvage of quartz veinlet (hyalophane; 2.84-7.88 wt.% BaO) (Fig. 2a), in association with W-bearing rutile (up to 4 wt.% WO₃) and carbonate (Fig. 2b).

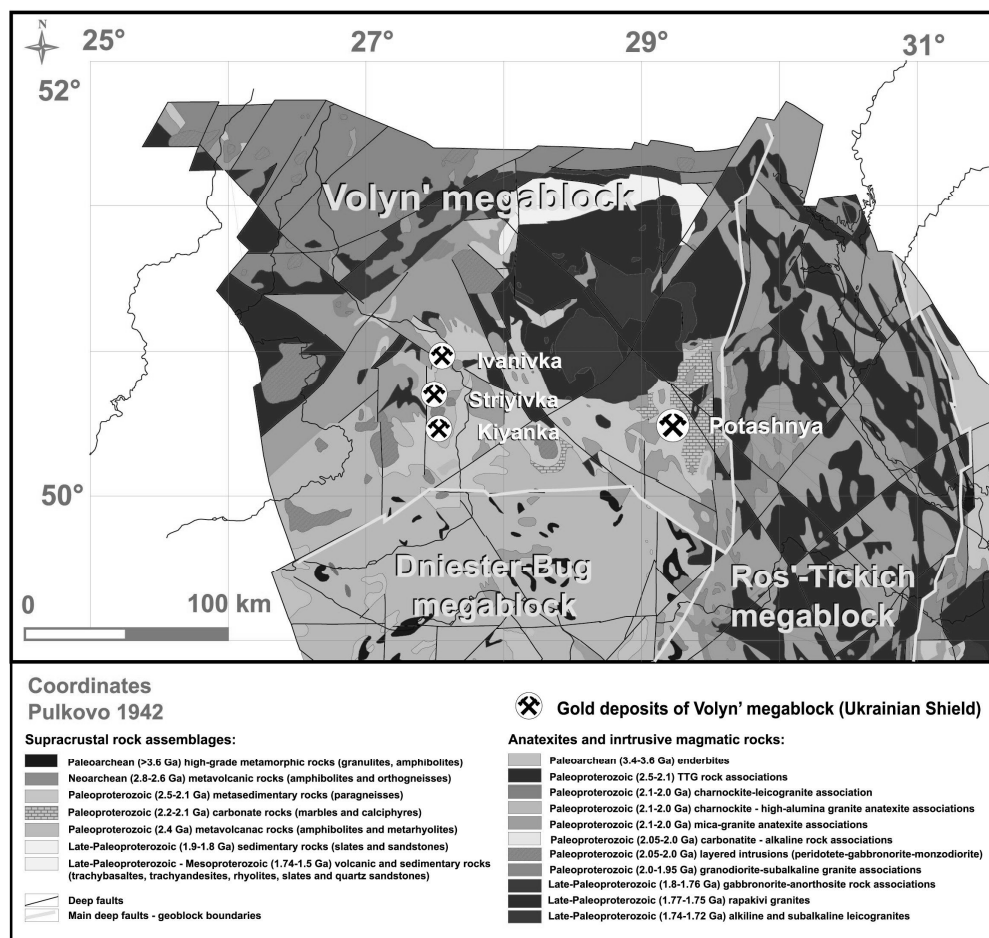


Fig. 1. Geological map of North-Western part of the Ukrainian Shield

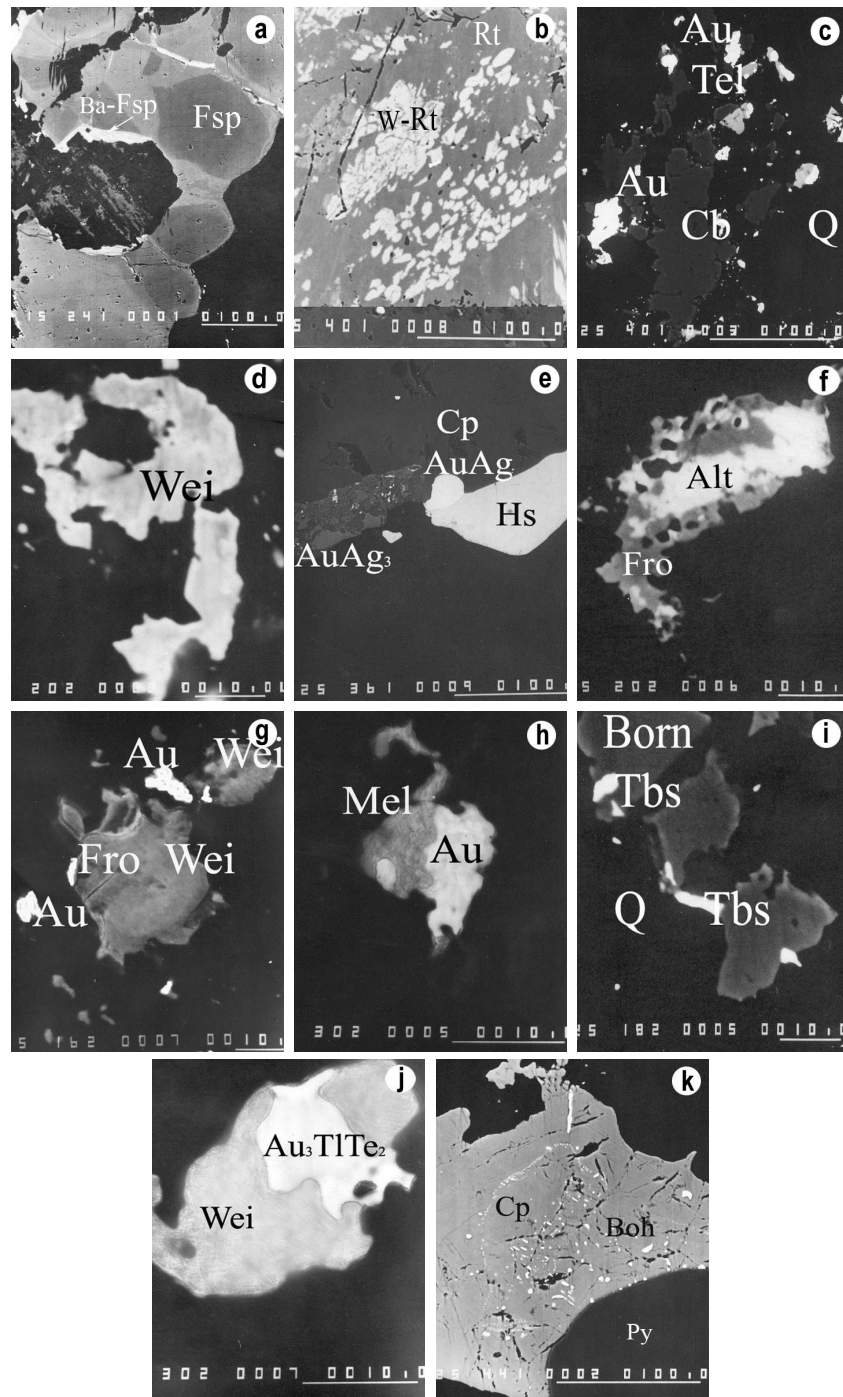


Table 1. Chemical compositions of tellurides from the Potashnya deposit (wt.%)

Analysis	Au	Ag	Cu	Bi	Te	S	Sb	Pb	Fe	Ni	Co	Σ
1	1.61	0.19	42.67	0.09	53.75	0.10	0.27	0.22	0.21	0.00	0.00	99.11
2	0.00	0.14	43.48	0.17	55.69	0.02	0.23	0.00	0.18	0.00	0.01	99.92
3	0.45	0.24	44.03	0.00	55.00	0.00	0.23	0.00	0.00	0.00	0.00	99.95
4	0.12	0.00	42.95	0.36	54.68	0.16	0.00	0.08	0.12	0.02	0.00	98.49
5	1.23	60.09	0.13	0.09	37.20	0.11	0.15	0.21	0.34	0.00	0.08	99.63
6	0.00	61.46	0.12	0.04	36.86	0.06	0.18	0.12	0.46	0.00	0.00	99.30
7	0.68	0.00	3.59	0.23	78.41	0.81	0.37	0.18	14.96	0.35	0.12	99.70
8	0.00	0.00	0.09	0.00	82.39	0.00	0.32	0.58	15.09	0.75	0.22	99.44
9	0.14	0.31	0.56	0.08	80.96	0.08	0.03	0.15	14.05	0.16	1.87	98.39
10	1.01	0.00	0.04	0.13	80.38	0.02	0.48	0.17	0.32	17.33	0.04	99.92
11	0.12	0.00	0.02	0.22	38.20	0.00	0.15	60.91	0.19	0.01	0.00	99.82
12	0.00	0.00	0.17	52.10	44.62	0.43	0.13	0.72	0.63	0.00	0.18	98.98

Key to analyses: 1 – weissite: an allotriomorphic grain in intergrowths with native gold and altaite; 2 – weissite: elongated grain in quartz; 3 – fine segregations of weissite in association with native gold and tellurides; 4 – weissite: one phase of a polymineral aggregate consisting of frobergite-melonite-hessite; 5 – elongated grain in intergrowths with electrum at the margin of chalcopyrite-bornite aggregate; 6 – hessite: rounded inclusion in chalcopyrite; 7 – frobergite: intergrowths with tellurides of copper, gold and thallium; 8 – frobergite: fringe surrounding a grain of altaite; 9 – frobergite: fine lens-shaped inclusion in weissite; 10 – melonite: allotriomorphic grain in association with native gold; 11 – altaite intergrown with frobergite; 12 – tellurobismuthite: veinlet segregations in association with chalcopyrite

Ore mineralogy

The ore mineralization that accompanies gold is characterized by a rather wide range of mineral species, from sulphides through native elements to tellurides and selenides. Gold itself is characterized by a wide range in chemical composition, with a continuous series between Au and Ag. Compositions approximating to Au_3Ag , Au_2Ag , AuAg and AuAg_3 are common.

Tellurides are spatially associated with gold and form fine-dispersed impregnations (Fig. 2c), as well as ‘simple’ single grains in the selvages of quartz veins. Formation of the tellurides occurred as a result of an unusual

‘telluric metasomatism’ event and resulted in the practically synchronous crystallization of numerous microphases.

Our observations indicating the possible formation of Cu-, Fe-, and Ni-tellurides after earlier sulfides are as follows: the predominant occurrence of weissite and frobergite directly near to the Cu-Fe-sulfides, the presence of their intergrowths with aggregates of bornite-chalcocite, and lastly the presence of relic microinclusions of bornite within weissite. The hessite is spatially confined to Ag-bearing bornite, in which Ag contents reaching 0.6-0.9 wt. %.

Weissite (Cu_{2-x}Te) is the most widespread

Fig. 2. Back scattered electron images showing mineral assemblages. a, b – newly-formed Ba-feldspar in association with W-bearing rutile; c – fine impregnations of tellurides in gold; d – xenomorphic aggregates of weissite; e – hessite intergrown with Au-Ag minerals in chalcopyrite matrix; f – altaite replaced by frobergite – elongated lens-shaped inclusions of frobergite in weissite; h – melonite intergrown with native gold; i – tellurobismuthite as inclusions in secondary sulphides (aggregates of bornite and chalcocite); j – mineral Au_3TlTe_2 at the border of weissite; k – bohdanowiczite in association with gold and hessite

telluride in the mineralized zones. The mineral is commonly found as a component of polymineral aggregates and forms intergrowths with tellurides of lead, iron and native gold. The coarsest xenomorphic aggregates (Fig. 2d) consisting mainly of weissite reach up to 40-80 μm in size.

Hessite (Ag_2Te) is the second most abundant telluride phase and is found both as fine inclusions in the chalcopyrite matrix as well as intergrown member with other tellurides and gold-silver minerals (Fig. 2e). Depending on the composition of the mineral associated with hessite, different type of admixtures were found - such as Au, Ag, Cu and Fe (Table 1, analyses 5 and 6).

Altaite (PbTe) is present in minor amounts and is frequently replaced by frobergite (Fig. 2f).

Frohbergite (FeTe_2) occurs as elongated lens-shaped inclusions in weissite (Fig. 2g) or as thin corrosion fringes around the altaite grains (Fig. 2f). The largest frobergite grains do not exceed 30 μm in size. Microprobe investigations of frobergite show significant amounts of Co (0.12-1.87 %), Ni (0.16-0.75 %), Pb (0.15-0.58 %), Cu (0.09-3.59 %) and other elements (Table 1, analysis 7-9). The abundance of the chalcophile elements might be explained by the presence of various mechanical inclusions and intergrown grains, but the presence of the iron group of elements more likely indicates extensive solid solution. Nekrasov (1991) mentioned the existence of high chemical affinity between the iron group elements and Te_2 . In this case we are clearly dealing with extensive solid solution between FeTe_2 , CoTe_2 and NiTe_2 .

Melonite (NiTe_2) was found as discrete grains and as intergrowths with native gold (Fig. 2h).

Tellurobismuthite (Bi_2Te_3) is a rather rare mineral in the deposit and was identified as inclusions within secondary sulphides (aggregates of bornite and chalcocite) (Fig. 2i).

Unnamed Au_3TiTe_2 was found as a separate phase at the border of weissite (Fig. 2j). According to microprobe analysis, the composition of this phase is (in wt.%): Au –

55.68, Te – 22.18, Ti – 18.21 with some admixtures of Cu – 1.32, Bi – 0.20, S – 0.29, Sb – 0.17. Much earlier, a similar unnamed species has been reported from the Mayske gold deposit, Ukrainian Shield (Bondarenko et al., 1993; Nechaev et al., 2000).

Bohdanowiczite (AgBiSe_2). This is the first finding of a selenide in the Ukrainian Shield.

The mineral occurs as the product of solid solution disintegration in chalcopyrite, in association with gold and hessite (Fig. 2k). Microprobe analysis gives (in wt.%): 21.43 Ag, 41.67 Bi, 31.30 Se, 1.10 Cu and 1.02 Fe.

Discussion

The discovery of Au-Ag-Te-Se mineralization in the Potashnya ore deposit has drawn not only mineralogical interest to this occurrence, but shows the considerable economic prospects of this region of Ukrainian Shield in the search for new gold resources. First of all, the Kocherov structure is located within the least eroded Volyn' Megablock of the Ukrainian Shield and the presence of near-surface Au-Ag-Te-Se mineralisation may indicate the possible existence of rich ore bodies at depth within the deposit. In the metallogenic scheme, it may be expected that a near-surface Au-Ag-Te-Se ore changes into a Au-As or Au-quartz type with depth, reflecting vertical zonality of gold distribution (as mentioned by Groves, 2002).

References

- Bondarenko, S.N., Grinchenko, O., Siomka, V. 2004. Typomorphic features of telluride and native gold in Proterozoic Au-deposits of the Ukrainian Shield. In: N.J. Cook, C.L. Ciobanu (Eds.), *Au-Ag Telluride Deposits of the Golden Quadrilateral, South Apuseni Mts., Romania*. IAGOD Guidebook Series, **12**, 214-216.
- Bondarenko, S.N., Nechaev, S.V., Syrodoev, N.F. 1993. Telluride mineral associations in Mayske ore deposit. *Geol. Journal*, **5**. (in Russian).
- Groves, D.I. 2002. The nature, global distribution and critical exploration characteristics of orogenic gold deposits, with emphasis on Archean examples. Abstracts, Int. Symposium,

- Metallogeny of Precambrian Shields*, Ky'iv, 13-26 September 2002, p. 59.
- Nechaev S.V., Cook, N.J. 2000. A natural occurrence of Au_3TiTe_2 from the Maiskoe Au-deposit, Ukraine. *Neues Jahrbuch für Mineralogie Monatshefte*, 12, 557-562.
- Nekrasov, I.Y. 1991. *Geochemistry, Mineralogy and Genesis of Ore Deposits*. Moscow, Nauka, 302 p. (in Russian).
- Shcherbak, N.P., Zlobenko, V.G. 1978. *Catalogue of Isotopic Data on Rocks of Ukrainian Shield*. Naukova Dumka, Kiev, 223 p. (in Russian).