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Geophysical Study of Ada Tepe Occurrence in Eastern Rhodopes

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Abstract: *The low sulfidation epithermal gold occurrence Ada Tepe is located on the north-eastern border of the Momchilgrad depression in Eastern Rhodopes. The use of gravity, aeromagnetic, gamma-ray spectrometric data on 1:50000 scale and electric and magnetic data on 1:10000 scale allows more detailed determination of the Ada Tepe occurrence geological structure to be obtained. The south-north, east-west, north-west and east-northeast oriented faults and their knots, as well as the areas of intensive hydrothermal alterations were marked according to geophysical data. The main geophysical anomalies related to the gold-silver-bearing mineralization in Ada Tepe occurrence were separated. Based of the outlined geological, geophysical and geochemical criteria three areas were distinguished favorable for epithermal mineralization prospecting.*

Key Words**:** *Gamma-ray Spectrometry Electric profiling, VLF profiling, Radiogeochemical specialization, Hydrothermal alteration, Fault, Gold-silver-bearing Mineralization.*

INTRODUCTION

The gold-bearing potential of Ada Tepe occurrence was established in 1994-1995 during the new East Rhodope`s geological mapping and was accompanied with metallogenic-prognostic evaluation of the studied areas. The consecutively performed geological, geophysical and geochemical works gave opportunity to be revealed detailed new data about its structure and mineralization.

The low sulphidation epithermal gold occurrence Ada Tepe is located on the north-eastern border of Momchilgrad depression. The region consists of hydrothermaly altered modified metamorphic rocks and Paleogene sediments, which are cut by intensive normal-slip and reverse-slip faults caused by thrusting.

The region of investigation is covered by gravity, aeromagnetic and gamma-ray spectrometry studies on 1:50 000 scale. Magnetic studies, apparent resistivity and radiowave VLF profiling on 1:10 000 scale were also carried out in the occurrence area.

REGIONAL POSITION OF THE ADA TEPE OCCURRENCE ACCORDING TO GEOPHYSICAL DATA

A south-north oriented structure in the area situated east of Ada Tepe Peak is characterized by well expressed

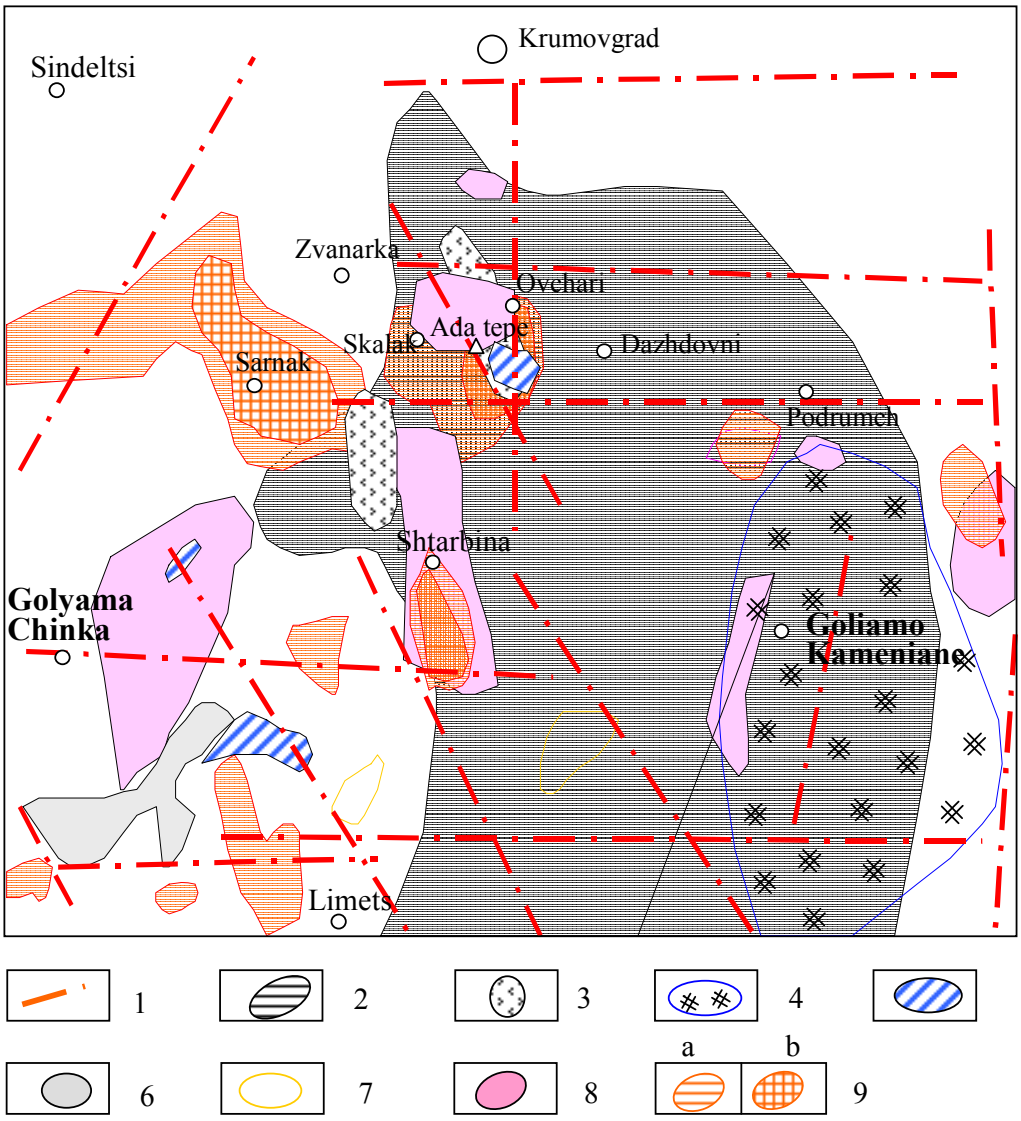

Fig. 1. Regional setting of the "Ada Tepe" occurrence, according to geophysical data: 1–Fault zones, according to gravity data; 2–Regional Goliamo Kameniane gravity maximum related to high density "ophiolite" rocks" 3–Local gravity maximum, related to high density rocks uplifting; 4–Serpentinized body, according to 2D magnetic inversion; 5–Apparent resistivity maximum, related to silica alterations; 6–Induced polarization anomalies, associated with graphite in the metamorphic rocks; 7–Increased uranium abundance, according to gamma-ray spectrometry data; 8–Anomalies of radio geochemical specialization (K-RGS) of the rocks related to potassium enriched alterations; 9–Anomalies of the ratio F = U.K/Th related to quartz-adular alterations: a) intensive, b)more intensive.

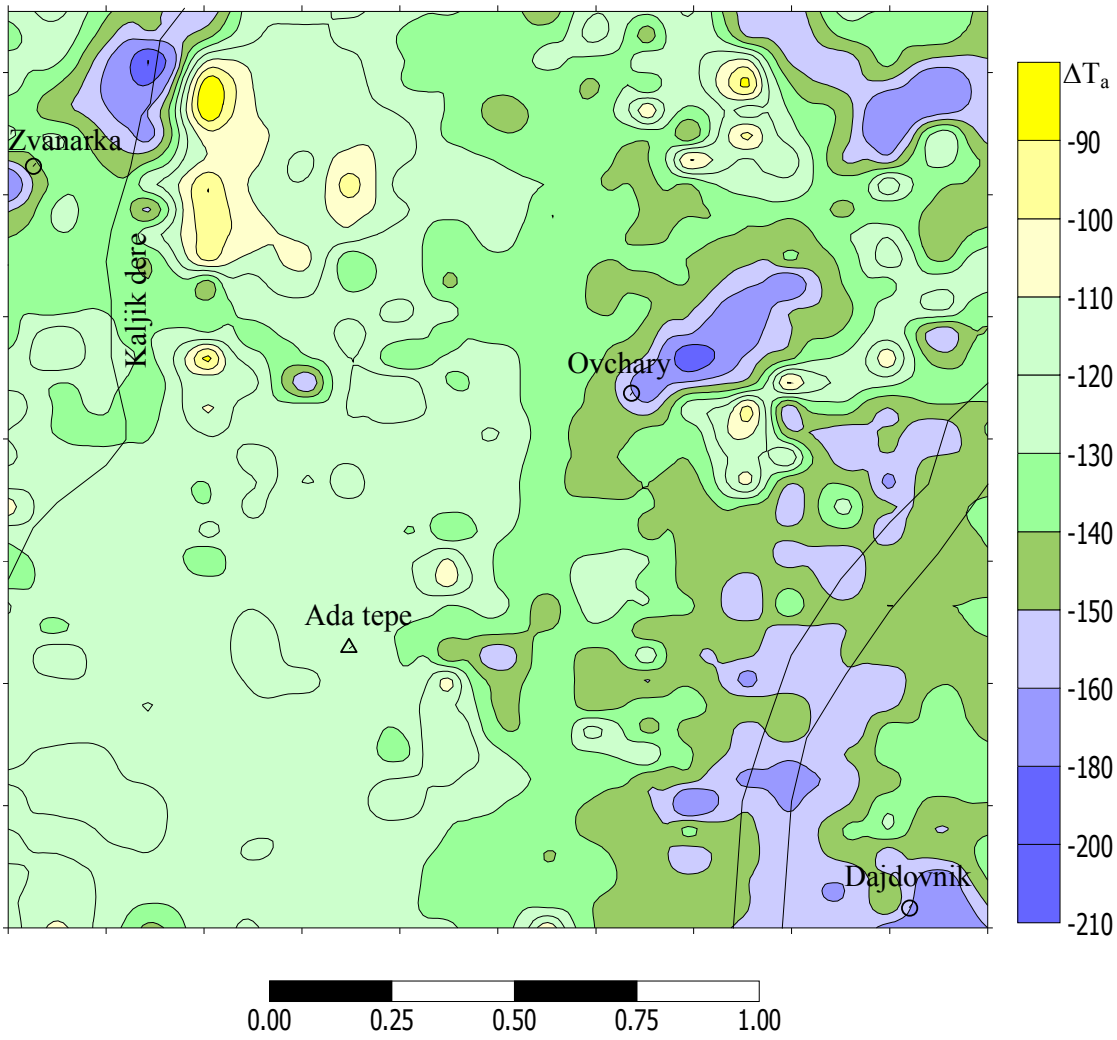

Fig. 2. Total magnetic anomalous field ΔT_a map of the "Ada Tepe" occurrence.

gravity and magnetic gradients along the line Ladovo – Ovtchari – Krumovgrad (Fig. 1, 2). This structure is marked distinctively on the apparent resistivity map of electrical profiling data (Fig. 3) where it separates areas of different resistivity values. According to the geophysical data, the structure represents a fault bundle that probably had played essential part in the area`s tectonic evolution and the location of the gold-bearing mineralization.

Another typical element of the gravity field in the discussed area is the linear anomaly marked between Podrumche village in the east and Skalak village in the west. The gravity gradient is a result of an east-west orientated boundary between the metamorphic rocks of Strajetzco-Belorechka lithotectonic unit and the Paleogene sediments.

According to the geophysical and geochemical data these two structures form a tectonic knot in the area of Ada Tepe Peak and the village of Ovtchari where northwest and east-northeast orientated structures are included. One

of them is located near Ada Tepe Peak and follows northwestern direction.

The statistical analyses of the aero gamma-ray spectrometric data on 1:50 000 scale allow construction of maps of the parameter F = U.K/Th and the radiogeochemical specialization of the rocks based on potassium and thorium contents (Portnov, 1987). A well expressed maximum of the parameter F and a break in the correlation between these radioactive elements (K, Th) were detected. They are due to the determined increase of potassium and decrease of thorium contents in the occurrence area. These anomalies are often directly related to the process of potassium metasomatism of the rocks and are considered favorable for epithermal mineralization prospecting. Similar anomalies were also registered in the areas around Shtarbina, Skalak, Podrumtche villages as well as in the region of the Sarnak deposit. This is the reason to presume that in the indicated areas can be expected with considerable degree of authenticity the presence of hydrothermal alternations that in these parts of Eastern Rhodopes are in close relation to the gold-silver-bearing mineralization.

All areas mentioned above are in the periphery of the intensive gravity and magnetic maxima of Goliamo Kameniane, which are predetermined probably by the presence of ophiolite rocks slabs – high density slab of orthoamphibolites, unaltered ultramafites, schists with garnet, etc., as well as high magnetization slab of serpentinites. These slabs might tolerate a screening effect on the movement of the ore-bearing solutions and their presence has been presumably a beneficial precondition of the gold-bearing ore localization.

Additional attention deserves the fact that within the limits of the complicated tectonic knot, determined from geophysical data, intensive hydrothermal alterations were established in quartz-sericite-adular facies and monoquartz facies, as well as the best expressed gold anomalies from the soil sampling data were observed.

RESEARCH OF THE GEOLOGICAL STRUCTURE OF ADA TEPE OCCURRENCE BASED ON DETAILED GEOPHYSICAL DATA

In order to obtain a more detailed picture of the geological structure of Ada Tepe occurrence area, detailed geophysical studies were performed. They include apparent resistivity four-electrode profiling, very low frequency (VLF) profiling and magnetic research over a 100 by 25 m network. The PSDV-1 receiver constructed in Sofia University of Mining and Geology was used for the acquisition of the VLF data (Lozenski and Tzvetkov, 1971). Readings for vertical H_z and horizontal H_y magnetic components were taken along the lines stepwise at 12,5 m intervals (6, 25 m over line 17). The source frequency is equal to 16 kHz.

Based on the graphs of the apparent resistivity and radiowave frequency 16 kHz magnetic components, as well as on the composed magnetic (Fig. 2) and electrical (Fig. 3) maps on 1:10 000 scale the main lithological boundaries and faults were outlined**.** Since the terrain is quite covered by Paleogene sediments **(**Goranov and Atanasov, 1992) the geophysical data essentially facilitates the tracing of the east-western, north-southern and north-western orientated structures. Figure 4 illustrates the constructed geophysical

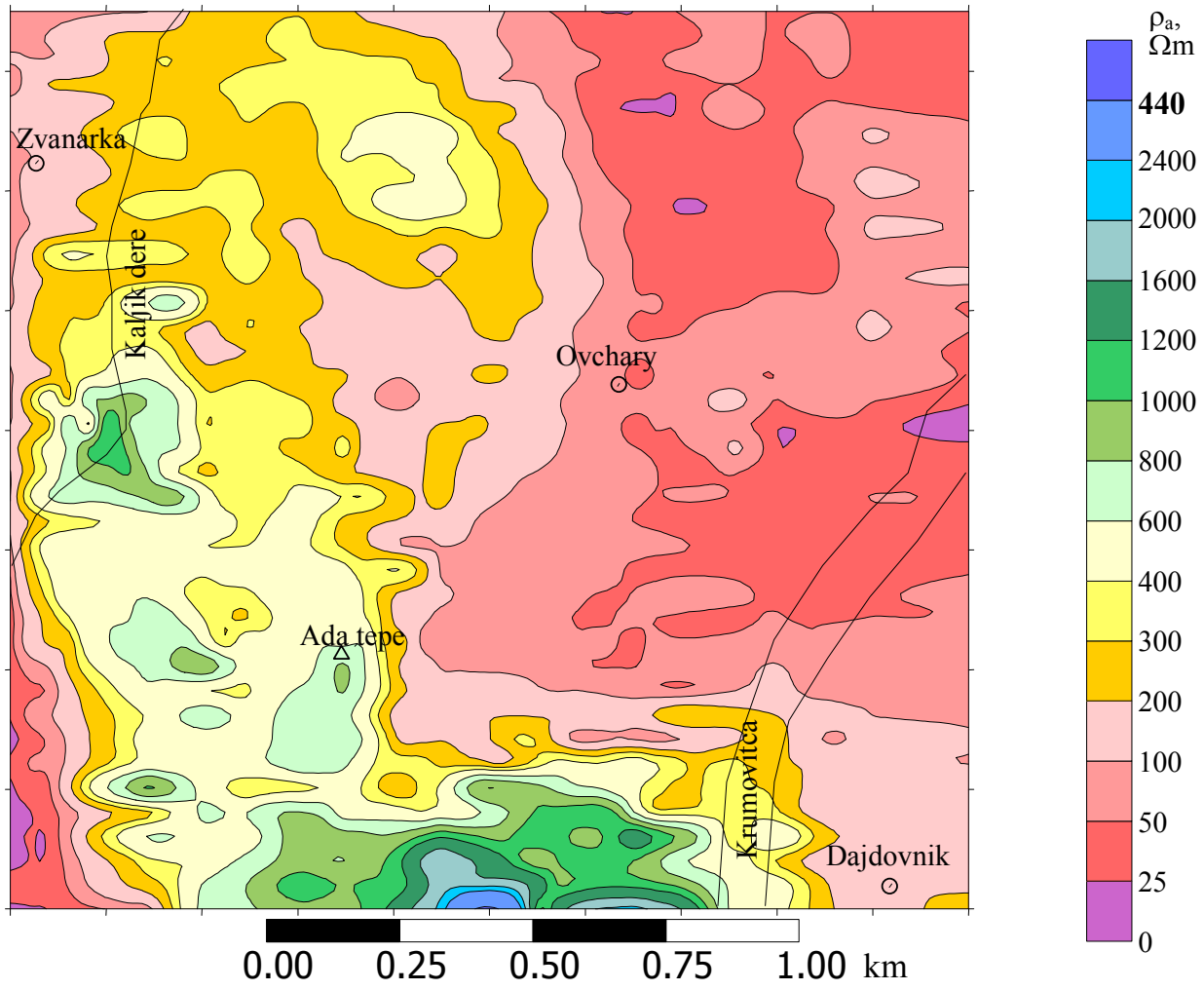

Fig. 3. Apparent resistivity map of the "Ada tepe" occurrence

profiles and geological section with results presented along line 17 that also passes trough Ada Tepe Peak. The exact location of line 17 is shown in Figure 5. The Karous-Hjelt filter is applied to the VLF data (Karous and Hjelt, 1983) and the filtered data are given in Figure 4(b).

According to the resistivity and VLF profiling data east-western orientated faults of quartz veins and disseminated sulphide mineralization filling were marked. The typical corelatation of the profiles for these conductive zone anomalies are shown in Fig. 5. In some occasions in such zones intensive pyritizations with contents of pyrite from 1-2 to 10 % is observed. The subequatorial conductivity zones, determined using electrical profiling

methods, cross the rock formation of three different complexes - allochthonous, autochthonous and neoautochthonous. On the constructed 2-D currrent density pseudosections by the radiowave VLF method data these structures are outlined clearly as shallow vertical conductivity zones (Fig. 4). They have best expression at depth under 20 m from the Earth's surface.

The areas of intensive hydrothermal alterations in quartz-adular-sericite and monoquartz facies are characterized by anomalies of increased electrical resistivity. Such areas having length about 200 m and width from 2 –3 m up to 15 – 20 m were registered near Ada Tepe Peak and to the south of the Ovtchari village. In these areas the apperent resistivity of the electrical profiling frequently has values in the interval between 600 and 1200 Ωm.

Figure 5 shows a map of the geological, geophysical and geochemical criteria for metallogenic evaluation (A. Tzvetkov, D. Tzvetanov, Y. Gergelcheva, 1997 – unpublished data) and is presenting all geophysical anomalies asociated with the occurrence "Ada Tepe":

1. Anomalies of increased values (over 2-3%) of potassium radiogeochemical specialization of the rocks and of the ratio F = U.K/Th (over 1,5%) according to the gamma-ray spectrometric data marking areas of potassium metasomatism of the rocks and representing hydrothermal alterations as adularization, argillization, seritization etc.;
2. Local gravity maxima associated with local uplifting of the metamorphic basement covered with Paleogene sediments, which also create favorable conditions for the localization of the gold-bearing mineralizations;
3. East-western, south-northern and north-western oriented faults, marked by characteristic gravity, magnetic and electrical anomalies as well as the junctions of the faults where are established the most intensive geochemical gold anomalies and metasomatic alterations of the rocks of Ada Tepe occurrence;
4. Electrical resistivity maxima associated with intensive silicification in the areas with hydrothermal alterations in quartz-sericite-adular and monoquartz facies.
5. Conductive zones with east-western orientation marked by the electrical resistivity and VLF electromagnetic data that cross the rocks of autochthonous, allochthonous and neoautochthonous structures. In these zones are located quartz veins and disseminated sulphide mineralization.

Based on the outlined geological, geophysical and geochemical criteria are distinguished (Fig. 5) three areas in the boundaries of Ada Tepe occurrence favorable for gold-silver-bearing mineralization searching.

CONCLUSION

The interpretation results from gravity, magnetic, gamma-ray spectromety and electrical data show the high effectiveness of geophysical methods in obtaining important information about the structure of Ada Tepe epithermal occurrence and its gold perspective.

East-west and south-north oriented faults were marked using electrical, gravity and magnetic data. These structures form a complicated tectonic knot in the area of Ada Tepe Peak and the village of Ovchari, where northwestern and east-northeastern orientated structures are included. Within its limits, related to intensive

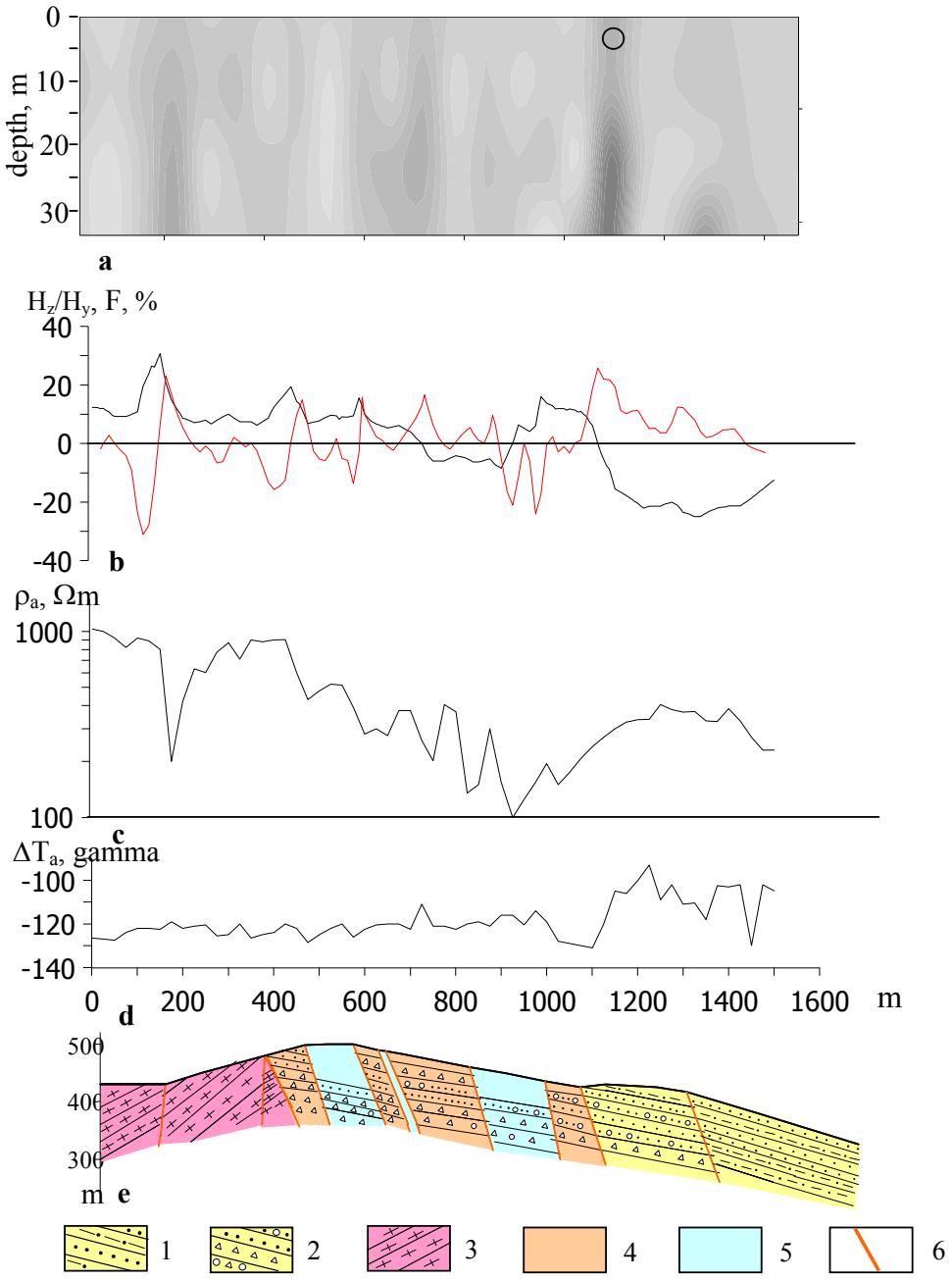

Fig. 4. Geophysical profiles and geological section over "Ada Tepe" occurrence a) VLF current density pseudo-section; b) VLF horizontal H_y, vertical H_z magnetic field and filtered data F, c) apparent resistivity ρ_a, based on the symmetric four-electrode profiling; d) anomalous magnetic total field ΔT_a; e) geological section. 1–Sandstones, argillites, limestones; 2–Breccia, breccia conglomerates, sandstones; 3–Metagranites; 4–Sericite-adular alterations; 5–Silica alterations; 6–Faults. 0 – pipeline

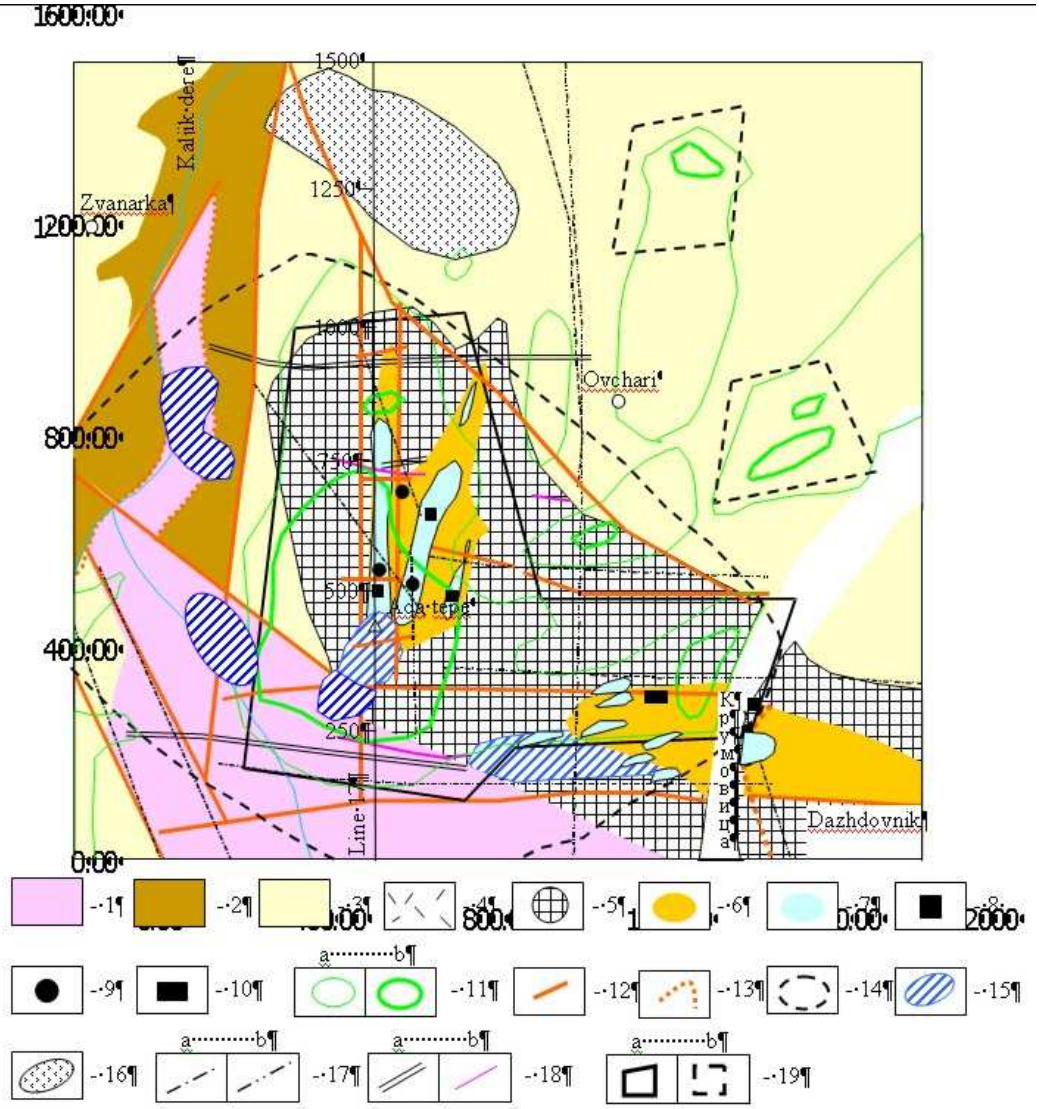

Fig. 5 Map of the geological, geophysical and geochemical criteria, related to the gold- silver-bearing mineralization of the ”Ada Tepe” occurrence
Lithological criteria: 1 – Metagranites; 2 – Biotite and hornblend-biotite gneisses, amphybolites; 3 – Paleogene sediments; 4 – Rhyolite tuffs; *Mineralogic and geochemical criteria*: 5 –Argillic alterations; 6 - Quartz-sericite-adular alterations; 7 – Silica alterations; 8 – Chalcopyrite and pyrrhotite; 9 – Gold; 10 – Pyrite; 11 – Gold anomalies from the soil sampling data a: a) > 0,02 ppm b) > 0,1 ppm; *Structural criteria*: 12 – Faults; 13 – Thrust faults; *Geophysical criteria*: 14 - Area of increased radochemical specialization, according to gamma-ray spectrometric data; 15 - Apparent resistivity maximum, related to silica alterations; 16 - Gravity maximum, associated with local uplifting of the high density “ophiolite” rocks; 17 – Faults, marked by: a) apparent resistivity data. b) magnetic data; 18 –Quartz-sulphide veins, according to: a) apparent resistivity data, b) VLF EM data; 19 –Area favorable for gold-silver-bearing mineralizations searching: a) well expressed, b) supposed

hydrothermal alterations in argillite and monoquartz facies, anomalies of increased potassium geochemical specialization were established according to gamma-ray spectrometry data and electrical profiling resistivity maxima. Geophysical anomalies coincide with the best-expressed gold anomalies from soil sampling data in the area of investigation.

According to the electrical profiling and VLF data the east-western faults with quartz veins and disseminated sulfide mineralization were marked.

The main geophysical anomalies related to low sulphidation epithermal gold Ada Tepe occurrence were outlined. Based on the established lithologic, metallogenic, geophysical and geochemical criteria areas favorable for gold-bearing mineralizations prospecting were distinguished.

The obtained results represent sufficient evidence to prove the essential role of the geophysical investigations in Eastern Rhodopes for their Au-Ag-polymetallic potential and mineralizations prospects.

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