Petrophysical zoning elements of Chertovo Koryto gold-ore deposit (Patom Upland, Eastern Siberia)

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Abstract. The paper considers magnetic susceptibility (χ) and electrode potentials (EP) of rocks in the Chertovo Koryto deposit. Carbon-bearing substance is found in all the studied samples, but in some cases, this substance supplies EP (-150 ÷ -400 mV). In these samples χ rarely exceeds $40 \cdot 10^{-5}$ SI units, while, in other samples χ is 8-10 (up to 30) times higher. Less intensive EP (-20 ÷ -240 mV) is furnished due to the sulfides in this deposit. Rocks with polarized carbon-bearing substance do not contain magnetic pyrrhotine and are negative linear EP anomalies. Rocks in which carbon-bearing substance is associated with pyrrhotine are revealed as magnetic anomalies. The adjacent rocks determine petrophysical zoning of the Chertovo Koryto deposit. The combination of negative linear EP anomalies and magnetic anomalies is a potential indicator and can define the multi-stage formation of the deposit itself.

1. Introduction

Central Patom Upland hosts Bodaibo ore-placer area where gold-mineralization has been explored completely. Today this area embraces precious metal reserves of thousands of tons including the unique Sukhoi Log deposit. There is the underexplored Tonodsk ore-placer area in the northern Patom Upland. Being currently placed under production, Chertovo Koryto deposit, containing more than 100-ton reserves, confirms the gold mineralization potential of this area (figure 1). The deposit is located in carboniferous shales of Kevaktinsk ore zone where numerous gold placers, the ore bodies of which, are still to be detected.

Efficiency of the magnetic survey in Chertovo Koryto deposit [3] makes it possible to apply geophysical methods in prospecting similar deposits.

The article presents data on the ore occurrences in the Chertovo Koryto deposit via natural electric and magnetic fields. Investigating the matter within this deposit makes it possible to identify the petrophysical zoning of the deposit and explain the structure and disposition of its geophysical anomalies.

2. Geological structure

The extended ores in the Chertovo Koryto deposit are located in Low-Proterozoic terrigeneous-sediment formations of Mikhailovsk suite, which, in its turn, includes carbon-bearing substance content of up to 2%. Metasandstones and metasiltstones account for up to 90 % of the host rocks and according to transformation grade are referred to as initial alterations of albite-epidote facies regional metamorphism [2].

The gently sloping structure, hosting the ore deposit, is confined to the innermost part of the sublateral Mikhailovsk syncline; while eastward to high-angle fault interarea which could have been an ore conduit. These displacements trending west -south-west plunge at the angles of 15-20° and 60°, respectively.

Basic ore deposit minerals are pyrite, pyrrhotine, arsenic pyrite, while galena, sphalerite, chalcopyrite are of smaller proportions. The ground mass of sulfides formed as inclusions and veinlets are concentrated in aposhale metasomatites, the rear zones of which are associated with the beresite formation. Gold is associated with sulfides and occurs often in quartz.

3. Research methods

The natural electric field (EF) of Kevaktinsk ore zone, including Chertovo Koryto deposit, was surveyed on the scale of 1:10000 during 1978-1980 under the guidance of M.M.Bazhenov. In 2006 magnetic survey with proton magnetometers was carried out, applying the above-mentioned survey grid (figure 1).

To understand and explain the relationship between magnetic field (ΔT) and EF anomalies, 139 core samples from exploratory wells № 301-308 and 190-199 were selected study the physical properties (figure 1). The electrode potential (EP) and magnetic susceptibility (χ) was also studied. EP measurements were conducted in sulfides and carbon-bearing substance to a copper unpolarized electrode. All the samples contained carbon-bearing substance. Visible sulfide grains suitable for EF observations were found in 23 samples.

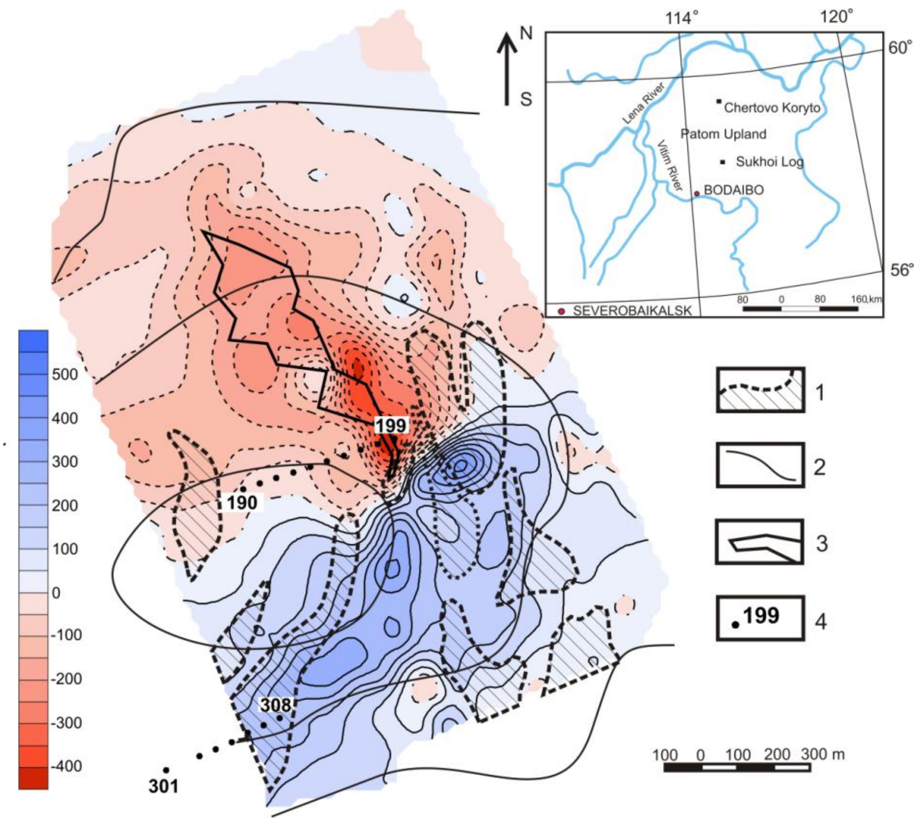

Figure 1. Scheme of magnetic anomaly field (ΔT, nT) in Chertovo Koryto deposit: 1 – anomalies of natural electric field (-300 ÷ -850 mV); 2 – contours; 3 – ore body outcropping (C_{Au}>1g/ton); 4 – wells.

4. Research results

With reference to carbon-bearing substance EP was detected only in 42 samples from 301-307 wells. Their values vary within -150 ÷ -400 mV. χ values of these samples seldom exceed $40 \cdot 10^{-5}$ SI units (figure 2 A, B). In the remaining samples, containing unpolarized carbon-bearing substance, χ is 8-10 (up to 30) times higher.

The most intensive EP was detected in pyrite comparable to other sulfides. Their values range from -100 to -245 mV (figure 2, D). Pyrrhotine and arsenic pyrite occurrences furnish EP values within -20 ÷ -100 mV range.

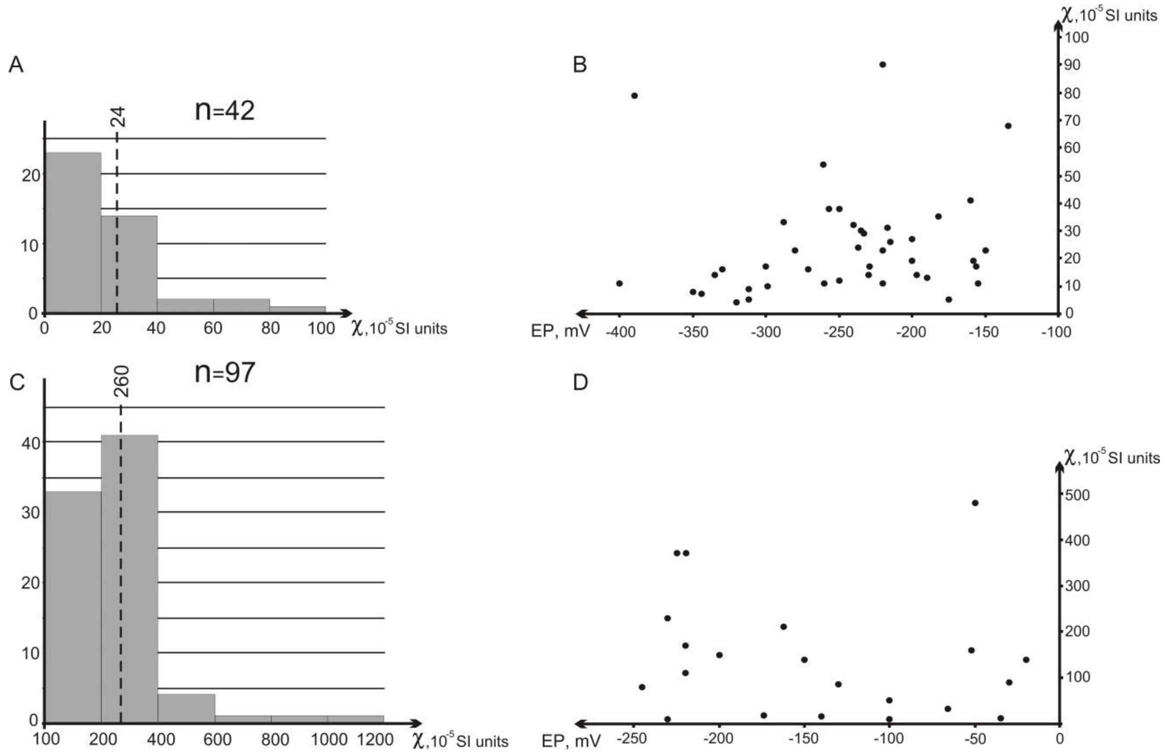

Figure 2. χ and EP measurement results in samples with polarized (A, B), unpolarized (C) carbon-bearing substance and visible sulfides (D). Sample number and average χ values in this selection (dotted line) are indicated at the top of the bar charts.

5. Discussion

The χ value of Chertovo Koryto deposit rocks is directly associated with the concentration of pyrrhotine - the only ferromagnetic ore mineral. It is obvious that it is observed in samples with polarized carbon-bearing substance and, vice versa- in samples where carbon-bearing substance does not produce EP.

Intensive magnetic anomaly is evident on the surface of pyrrhotine concentrations. Pyrite, arsenic pyrite and other sulfides are distributed comparatively the same as pyrrhotine within this deposit. Sulfide concentration is rather high in commercial gold deposit zones, however, polarized carbon-bearing substance is absent (samples from 190-199 wells) and, consequently, there are no negative EP anomalies.

Petrophysical measurements of 1-2meter-interval cores (301-307 wells) indicate the fact that there are cases of alternating non-magnetic samples with lenses of polarized carbon-bearing substance and magnetic samples with unpolarized carbon-bearing substance. This could explain the fact why linear negative EP anomalies in the southern and eastern parts of the deposit are adjacent to magnetic anomalies.

Thus, a distinctive petrophysical zoning can be observed in this deposit, which involves areal isolation, and contiguous two carbon-containing rock types: 1) rocks with intensive EP to carbon-bearing substance and low χ value; and 2) rocks with zero EP to carbon-bearing substance and high χ value. The same tendency can be traced in EF and ΔT anomalies. Although they are contiguous, their epicenters are not coincident (figure 1).

The main source of above-described regularities could be the multi-stage formation of the Chertovo Koryto deposit itself. Apparently, polarized carbon-bearing substance was formed during the pre-ore stage. Later, during the ore stage beresitization occurred due to the intensive hydrothermal solubility in ore-hosting thicknesses. Carboniferous minerals with dielectric properties are typical of this process, overlapping the polarized carbon-bearing substance and disintegrating the aggregates at the micro-level. As a result, beresitization responses to a conductivity loss and further becomes depolarized. In this case, commercial gold mineralization zone are more intensively subjected to these processes. The southern and eastern field areas were less affected and carbon-bearing substance was preserved retaining its electrochemical activity. This can also be observed in Blagodatnoe gold-ore deposit located within Kordinsk suite carboniferous shales (Yenisei Ridge) [1].

6. Conclusion

Petrophysical zoning of Chertovo Koryto deposit is apparently due to its multi-stage formation. The combination of linear negative EP anomalies and magnetic anomalies is a significant indication of ore grade mineralization similar to the ore types of Chertovo Koryto deposit and this fact can be applied in mineral exploration.

References

[1] Kolmakov Yu V 2014 Blagodatnoe gold-sulfide deposit (Yenisei Ridge, Russia): the nature of geophysical anomalies and the succession and causes of formation of petrophysical zoning. *Russian Geology and Geophysics* **55** (11) 1321–32

[2] Kucherenko I V, Gavrilov R Yu, Martynenko V G and Verkhozin AV 2009 Strukturno-dinamicheskaya model zolotorudnykh mestorozhdeniy obrazovannykh v neslantsevom i chernoslantsevom substrate -Mestorozhdenie Chertovo Koryto. *Bulletin of the Tomsk Polytechnic University* **314** (1) 23–38

[3] Sokolov S V, Kolmakov Yu V and Gusev E V. 2011 Tektonicheskaya obuslovlennost raspredeleniya sulfidnoj mineralizatsii i magnitnoj anisotropii porod na zolotorudnom mestorozhdenii Chertovo Koryto *Subsurface prospecting and protection* **12** 19–26