Geology, geochemistry and gold-ore potential assessment within Akimov ore-bearing zone (the Altai Territory)

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Abstract. The article considers the geological setting of ore-bearing zone. Geochemical zoning of secondary dispersion haloes within Akimov ore-bearing zone was analyzed. Based on analytical data, distribution of gold mineralization trace-elements was examined. Geochemical associations were identified, analyzed and geometrized. The structure of abnormal geochemical field associated with gold-silver mineralization was determined. Three promising areas for exploration activities were identified.

1. Introduction

Akimov ore-bearing zone is located in the north-western part of Gorny Altai (the Altai Mountains). It is an administrative subdivision of Kurinsky and Krasnshchekovsky regions of the Altai Territory (Siberian Federal District of the Russian Federation) (figure 1).

The study area is within the transition zone between the Pre-Altai plain and the Altai Mountains and is comprised of gently-rugged, hillocky foothill and low-hill terrains that rise between 50-120 m at an absolute elevation of 400-430 m. The climate is extreme continental, average precipitation being not more than 450-500 mm. Hydrographic network of the area is poorly-developed. The Charysh river is the main water artery. The river Loktevka runs through the center of the ore-bearing zone, the river Poperechnaya and the river Kukuyka (right affluents of the Charysh river) run in the West and East, respectively.

According to metallogenic zoning, the study area is confined to the western part of North Altai gold belt characterized by intensive Middle Devonian volcanism [1].

Regionally, Akimov ore-bearing zone located within Novofirsovsky area is confined to Charysh block, close to its border with Ore Altai block and within the depression superimposed on Cambrian-Silurian structures and composed of Lower Devonian carbonate-terrigenous deposits (Kamyshenskaia D1km and Baragashskaia D1br formations), volcanic and igneous-sedimentary deposits of Middle and Upper Devonian (Kukuiskaia formation D2-3kk) which are intruded by subvolcanic bodies of diorite porphyry, rhyodacite, and rhyolites of Middle Devonian Kukuisky complex (figure 1) [2]. Spatially, gold-silver mineralization is associated with volcanic deposits of Kukuisky complex.

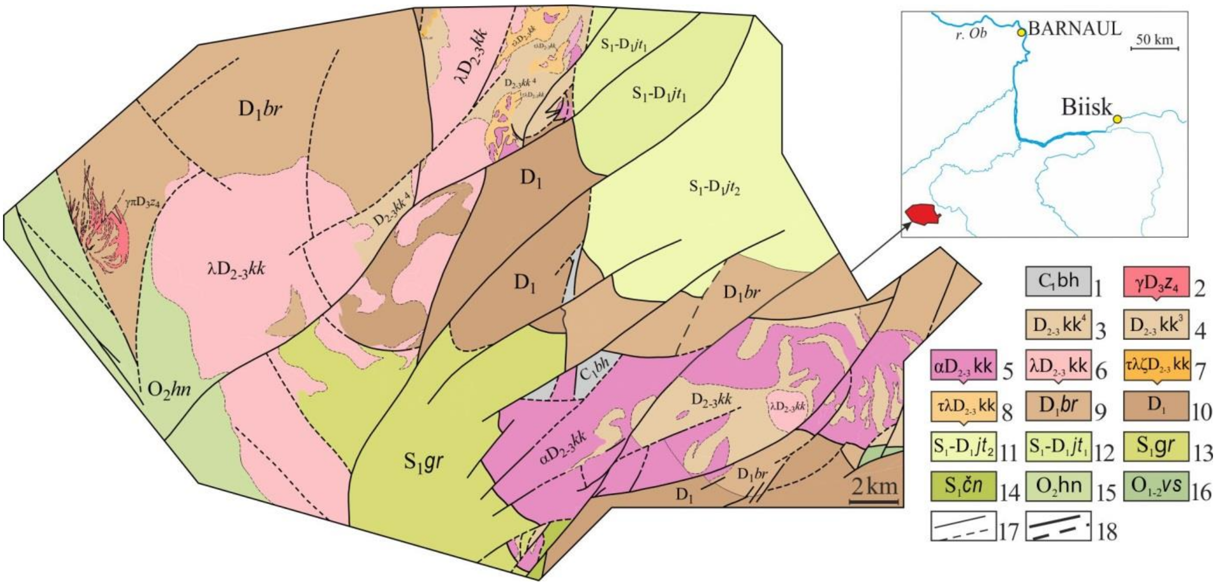


Figure 1. Geological map of the Akimov promising ore area (after Timkin V, 2009)

1 – Bukhtarminskaia Formation: limestones, siltstones, sandstones; 2 – Zmeinogorsky magmatic complex gabbro-granite-leykogranit; 3 – Kukuiskaia Formation, four member: tuff-sandstones and silty sandstone; 4 – third member: siltstones and claystones; 5-8 – Kukuiskii magmatic complex rhyolite-dacite-andesite; 9 – Baragashskaia Formation: sandstones and siltstones; 10 – Undifferentiated Lower Devonian: polymictic sandstones, gritstones, conglomerates and siltstones; 11-12 – arkose and polymictic sandstone, siltstones; 13 – Gromotukhinskaia Formation: siltstones, clayey sandstones, limestones; 14 – Chinetinskaia Formation: clayey sandstones, siltstones, sandstones; 15 – Khankharinskaia Formation: siltstones, calcareous sandstones, gritstones and conglomerate; 16 – Voskresenskaia Formation: calcareous sandstones, siltstones, quartz sandstones; 17 – measured (inferred) geological boundary; 18 – measured (inferred) fault

Structurally, rectilinear elements of the relief that correspond to the fault pattern are basically observed within the study area. NE and NW linear structures are extensionally and quantitatively identified (figure 1). The rings and arcs of the relief are well-defined within the volcanic and metasomatic formations [3].

According to [4], metasomatic formations identified within the zone are classified as metasomatites "deposited throughout progressive stage of magmatic-hydrothermal systems development" and "plutonic metasomatites of the regressive stage" within the linear zones. The vertical zoning with uprise alteration of hydrothermal column of propylites (epidot-calcite and albite-chlorite-calcite facies), argillizated rocks (kaolinite-smectite and kaolinite-quartz facies), and secondary quartzites was identified in the metasomatites. The centers of hydrothermal activity and location of gold-silver mineralization are controlled by the linear metasomatites of progressive stage.

2. Research technique

The present study is based on the lithochemical surveys in scale 1:50 000 along the secondary dispersion haloes and 1:200 000 along dispersion trains carried out by JSC "Gorno-Altaiskaya Ekspeditsiya" in 2006-2009. To estimate a gold-bearing potential of the study area, a total of 2 000 samples were processed (figure 2). The samples were collected at depth between 0.2-0.6 m. Then, the samples were dried and sieved.

All collected samples were sent to the laboratory Stewart Geochemical and Assay, LLC., Moscow, where semiquantative spectral analysis and gold assays (subsample 30g) followed by atomic absorption test were carried out.

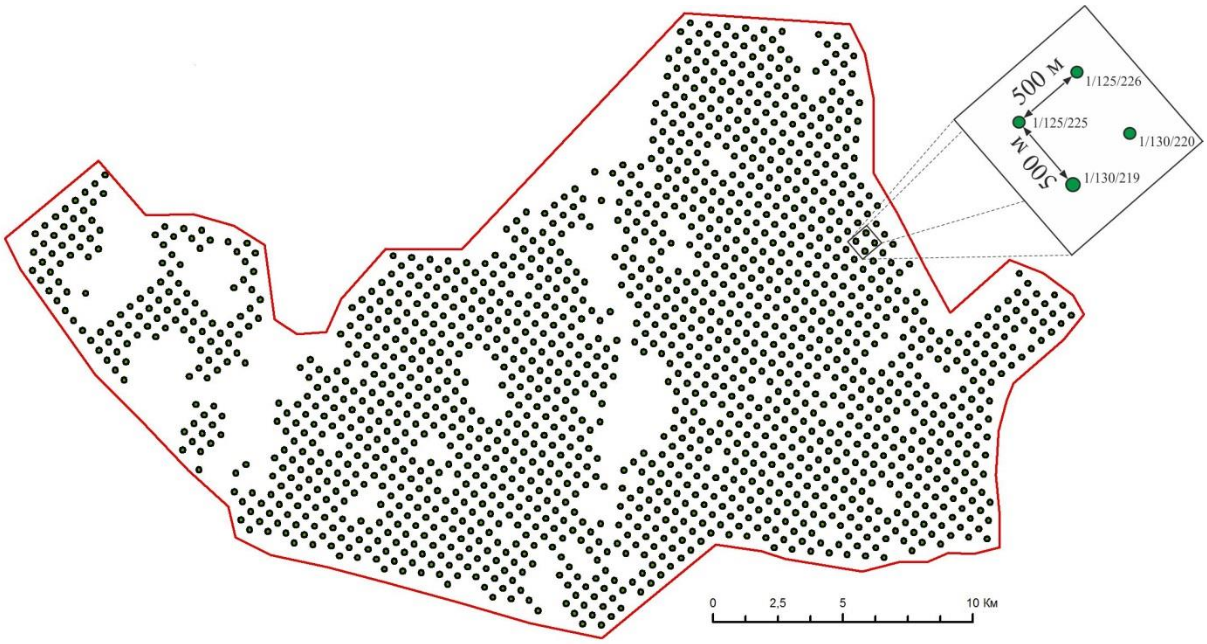


Figure 2. Map showing location of the sample points

Geochemical data were processed using software program Statistica 12, while geometrization was performed by ArcGis and Surfer in accordance with generally accepted methods and techniques [5, 6, 7, 8, 9, 10, 11].

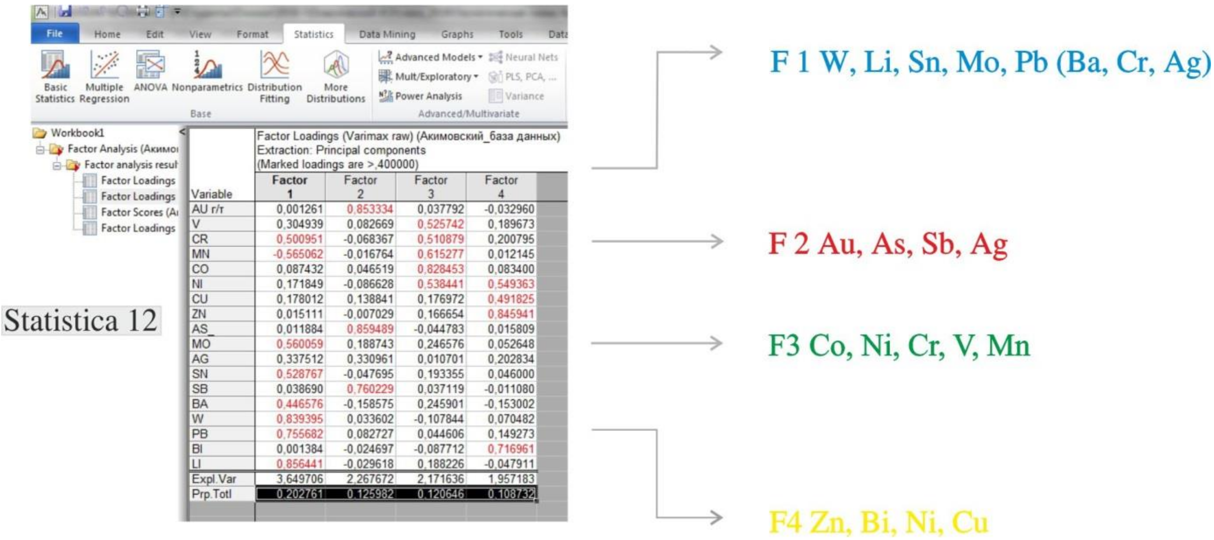
3. Research results

As a result, background and minimum abnormal concentrations of gold and trace-elements in secondary dispersion haloes were identified. In addition, geochemical associations were revealed and association zoning within the study area was outlined. The location of gold-silver mineralization within the abnormal geochemical field was determined. The geochemical criteria for gold-silver mineralization prospecting within Akimov ore-bearing zone were proposed.

The background and minimum abnormal concentrations of elements were calculated according to standard methodology developed by A.P. Solovov [12]. Since element distribution within the study area does not conform to the normal law (A/SA>3 and E/SE>3), the log-normal distribution model was used to calculate background and abnormal values.

In order to identify the resistant associations of elements and determine their location for further analysis of geochemical field structure, factor analysis was used to combine groups of correlated variables [13, 14].

Within the secondary geochemical haloes of the study area, 4 factors were defined (figure 3). They are interpreted on the basis of elemental composition, spatial distribution of factors, and geological environments. Thus, factor 1 (W,Sn,Li) corresponds to Kurino-Akimov volcano-tectonical structure, i.e. paleo caldera.



Factor Loadings (Varimax raw) (Акимовский_база данных)
Extraction: Principal components
(Marked loadings are >,400000)

Variable	Factor 1	Factor 2	Factor 3	Factor 4
AU г/т	0,001261	0,853334	0,037792	-0,032960
V	0,304939	0,082669	0,525742	0,189673
CR	0,500951	-0,068367	0,510879	0,200795
MN	-0,565062	-0,016764	0,615277	0,012145
CO	0,087432	0,046519	0,828453	0,083400
NI	0,171849	-0,086628	0,538441	0,549363
CU	0,178012	0,138841	0,176972	0,491825
ZN	0,015111	-0,007029	0,166654	0,845941
AS_	0,011884	0,859489	-0,044783	0,015809
MO	0,560059	0,188743	0,246576	0,052648
AG	0,337512	0,330961	0,010701	0,202834
SN	0,528767	-0,047695	0,193355	0,046000
SB	0,038690	0,760229	0,037119	-0,011080
BA	0,446576	-0,158575	0,245901	-0,153002
W	0,839395	0,033602	-0,107844	0,070482
PB	0,755682	0,082727	0,044606	0,149273
BI	0,001384	-0,024697	-0,087712	0,716961
LI	0,856441	-0,029618	0,188226	-0,047911
Expl.Var	3,649706	2,267672	2,171636	1,957183
Prp.Totl	0,202761	0,125982	0,120646	0,108732

Figure 3. Matrix of factor loadings area

Factor 2 unites elements (Co,Ni,Cr,V) commonly accumulated in the frontal enrichment zones, which is a characteristic feature of all hydrothermal deposit types and can be used for delineation of abnormal geochemical fields of various ranks. In other words, it can be applied for ranking oregenetic geochemical fields. Factor 3 relates to gold-ore mineralization itself (Au,As,Sb), while the elements included in factor 4 (Ag,Mo,Sn,Pb) can be associated with sulphide mineralization within the flanks of ore bodies and supraore space where gold grade decreases.

The analysis of geochemical associations distribution allows identifying 3 abnormal zones of sulphide mineralization (figure 4).

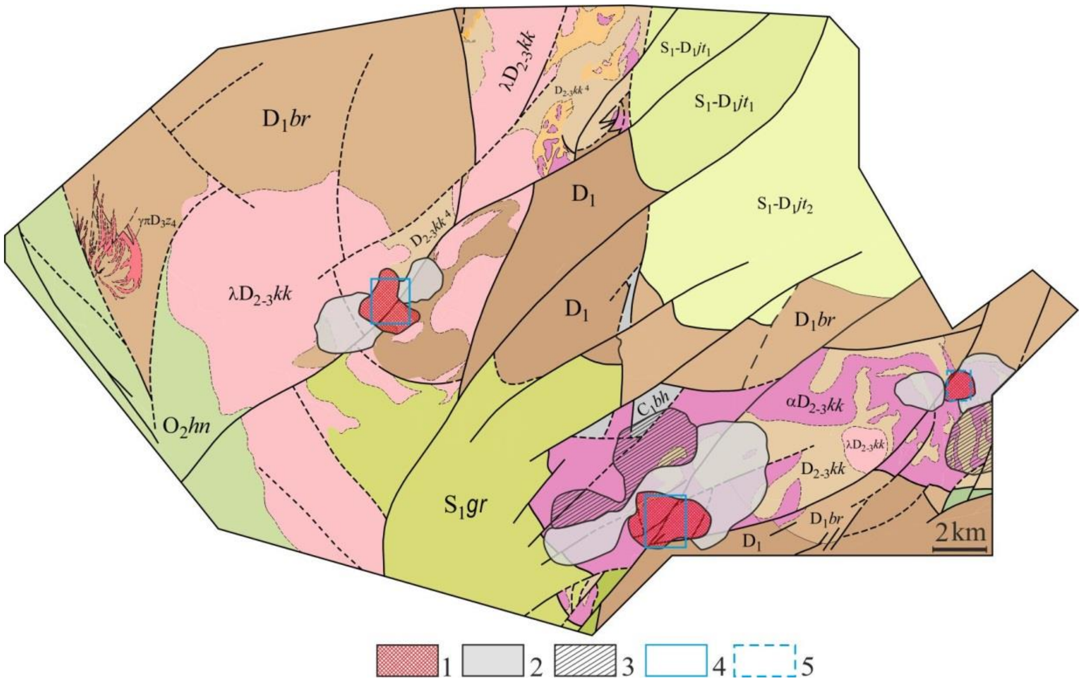


Figure 4. Geochemical zoning model of perspective area; 1 – central concentration zone (Au,As,Sb,Ag); 2 – intermediate concentration zone (Co,Ni,Cr,V,Mn); 3 – high value area (Cu,Zn,Bi,Ni); 4 – promising areas (first stage); 5 – promising areas (second stage)

Based on the character of association correlation, it is possible to conclude about different degree of ordering of abnormal geochemical field structures within the identified zones. As known [2], the degree of ordering reflects the intensity of hydrothermal mineralization. The concentric zonal abnormal geochemical fields with ore elements in their central parts are the most well-ordered structures [4]. Such a geochemical zoning was identified in the southern part of the study area.
Previously, based on the geological survey results, 4 promising zones, 3 of which are well-correlated with the identified geochemical anomalies, were determined. This fact proves the validity of the obtained results.

4. Conclusion
Thus, the highest gold concentrations are confined to the zones of co-occurrence of several diachronous mineral associations. The presence of ore controlling structures contributes to numerous relocation of gold and its concentration within the geochemical barriers.
Based on the analysis of geochemical data including statistical calculations, chemical element mapping, and factor analysis, it has become possible to develop a geochemical model of Akimov promising ore-bearing zone and identify 3 areas for further exploration: 2 promising areas of first stage and 1 promising area of the second stage.

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