19. Oleynikov B.V., Kopylova A.G., Korobeynikov A.F., Kolpakova N.A. Osmium in native iron of continental basite // Otechestvennaya geologiya. – 1998. – № 6. – P. 58–63.
20. Korobeynikov A.F. Fractionation of gold in magmatic melt at its crystallization // Reports of the Academy of Sciences of the USSR. – 1981. – V. 259. – № 5. – P. 1200–1204.
21. Almukhamedov A.I., Medvedev A.Ya. Geochemistry of sulphur in processes of magma evolution. – Moscow: Nauka, 1982. – 148 p.
22. Gorbachev N.S. Fluid-magmatic interaction in sulphide-silicate systems. – Moscow: Nauka, 1989. – 127 p.
23. Korobeynikov A.F. Platinum metals in golden-ore deposits of folded structures of Siberia and Northeast Kazakhstan // Geokhimiya. – 1998. – № 10. – P. 1009–1020.
24. Korobeynikov A.F. Complex gold-platinoid-rare-metal deposits – reserve of the XXI century // Bulleting of the Tomsk Polytechnic University. – 2001. – V. 304. – № 1. – P. 169–182.
25. Korobeynikov A.F. Conditions of gold concentration in Paleozoic orogens. – Novosibirsk: Institute of Geology and Gas of the Siberian Branch of the Academy of Sciences of the USSR, 1987. – 177 p.
26. Korobeynikov A.F. Features of behavior of gold at areal and local metasomatosis of granitoid intrusions of the Sayano-Altaiskaya folded area // Geokhimiya. – 1977. – № 2. – P. 288–297.
27. Korobeynikov A.F. Ore-metasomatic zoning on gold deposits // Geology of ore deposits. – 1983. – № 1. – P. 96–99.
28. Khe In. Regional, intermediate and local zoning of Au, Mo, W, Sn-mineralization on the example of areas of Russia and China // Izvestiya vuzov. Geologiya i razvedka. – 1998. – № 1. – P. 154–155.
29. Korobeynikov A.F. Criteria of connection of gold mineralization with magmatism and metasomatism in the Sayano-Altaiskaya folded area // Criteria of forecast evaluation of endogenic mineralization of the Altai-Sayanskaya area. – Novosibirsk: Nauka, 1982. – P. 89–93.
30. Korobeynikov A.F., Tchernyaeva E.I. Behavior of gold at formation of zonal dyke bodies of gabbro-diabases // Reports of the Academy of Sciences of the USSR. – 1987. – V. 292. – № 3. – P. 680–684.

Received on 01.06.2007

UDC 553.493.6:528.7 (571.15)

COSMOSTRUCTURAL MODEL OF THE KALGUTINSKIY RARE-METAL DEPOSIT AREA (MOUNTAINOUS ALTAI)

A.A. Potseluev, Yu.S. Ananyev, I.Yu. Annikova*, A.G. Vladimirov*, A.N. Vasilevskiy**, L.V. Vitte**

Tomsk Polytechnic University
E-mail: poan@ign.tpu.ru
*Institute of Geology and Mineralogy of the Siberian Branch of the Russian Academy of Sciences, Novosibirsk
E-mail: ira99@uiggm.nsc.ru
** Institute of Oil-and-Gas Geology and Geophysics of the Siberian Branch of the Russian Academy of Sciences, Novosibirsk
E-mail: kontorovichAE@uiggm.nsc.ru

Cosmostructures of the Kalgutinskiy rare-metal deposit area (Mountainous Altai) have been studied on the materials of multispectral space survey Landsat ETM+ and radar-tracking survey SRTM. The area is localized inside of the large ring structure of a complex construction, characterized by the long multistage (multipulse) development. Immersing of the root (focus) part of the structure from the north – northwest to the east – southeast is established. Position of the ring structure is controlled by the crossing knot of fracture zones of northwest, northeast and northeast – sublatitudinal directions. The Kalgutinskiy granite massif and the deposit itself are located in the internal belt of the structure in the ring 15,2 km in diameter. The perspective of ore-bearing ability of the southeast part of the area is highly evaluated in connection with development of small ring structures of the second type.

Introduction

Research of conditions of deposit formation, revealing of sources of matter and energy and reasons of ore deposition are the most important problems of minerageny. Their solution is the base of forecast-prospecting models and underlies genetic constructions. A connection with large structures of the earth's crust which find their reflection in materials of regional geological, geophysical and space researches is established for many large and huge deposits of gold, uranium, polymetals, diamonds and other minerals [1, 2].

Last few years a new data on features of geological structure, petrology of magmatic formations and material composition of ores of the Kalgutinskiy deposit has been obtained allowing asserting about a significant energetic and material influence of the mantle source on the Kalgutinskiy fluid-magmatic system. Application of multispectral space surveys, possessing significant visibility, high information content at corresponding spatial resolution, allow obtaining new data about regional geological structures and abyssal composition of the deposit area. A number of new structures that have not been allocated before during ground geological and geophysical researches appear.

Research technique

Materials of multispectral space survey using the system Landsat ETM+ (table 1) are used in the work. Al-titude of the orbit is 705 km, inclination 98,2°. Channels 1–3 give information in a visible range of the spectrum, channel 4 is in the infrared, 5–7 – in near and far thermal area, channel 8 (PAN channel) – gives

information in a wide range of visible and near IR areas. Spatial resolution (linear pixel size) varies through the channels from 15 up to 60 m. In addition, a digital model of the relief is created according to radar-tracking survey using the radar SRTM (Shuttle radar topographic mission).

Table 1. *General characteristics of radiometer ETM+ (Landsat 7) [3, 4]. The swath 185 km. Frequency of the survey is 16 days*

Channels	Spectral range, mkm	Spatial resolution, m
1	0,450...0,515	30
2	0,525...0,605	30
3	0,630...0,690	30
4	0,75...0,90	30
5	1,55...1,75	30
6	10,40...12,50	60
7	2,09...2,35	30
8	0,52...0,90	15

Processing, decoding, analysis of cosmomaterials and modeling of geological and ore systems are carried out according to methodical recommendations and approaches [3, 4]. The basic scheme of works consisted of:

- formation of the initial data array;
- processing and decoding of initial raster images with use of classification algorithms, improvement procedures, complex of methods of filtration and image oversampling;
- creation and processing of a synthesized image of multispectral pictures. Recalibration of initial images with low spatial resolution into images of higher resolution using a pixel matrix PAN;
- creation of derivative raster images using «map algebra»;
- correlation analysis of a synthesized image;
- processing and decoding of a thermal channel;
- processing and analysis of a digital model of the relief;
- combined analysis of raster images and digital model of the relief, decoding using 3D-visualization, creation and interpretation of anaglyphic images.

Interpretation of the obtained data has been carried out with use of materials on the geological structure of the area and the obtained by the authors results of isotope, geochemical and mineralogical researches of magmatic and hydrothermal-metasomatic formations of the Kalgutinskoy ore field.

Geological structure

The considered area is a component of the marginal-continental volcanic belt of the Mountainous Altai which generated on the sialitic block the Altai-Mongolia microcontinent. Two structural floors of Early-Paleozoic and Middle-Paleozoic age are allocated in its structure (Fig. 1). Terrigenous deposits of the Gornoaltaiskaya series are attributed to the first ($Є_3$-O), red-color sedimental-volcanogenic deposits and subvolcanic formations of the Aksaiskaya series – to the second (D_{1-2}). The latter in the area of the Kalgutinskiy deposit carry out the same volcanic-tectonic depression with an intrusive file of the same name in the center.

On the modern erosive surface the Kalgutinskiy massif has the form of the latitudinal-focused dissymetric oval. The total area of outflow amounts to nearby 70 км^2, Fig. 1. Contacts of granitoids with containing rocks have an intrusive character. Composing the massif granitoids are attributed to the L-type and their formation is connected with the Late-Paleozoic Early-Mesozoic stage of intraplatform tectonothermal activization [5, 6]. Features of this period are defined by the display of Siberian Permo-Triassic superplume on the Siberian platform and in its folded frame, for the final stage of which a local display of mantle ore-bearing magmatism is characteristic [7].

Two intrusive rhythms (complexes) are allocated in formation of the Kalgutinsky rare-metal-granite file. The early rhythm (Kalgutinskiy complex itself), composing more than 90 % of the massif total area, is represented by biotitic porphiyraceous granites of the general phase, binary-mica and muskovitic leucogranites of additional intrusion phases, and veins of aplites and aplitopegmatites of the final phase. According to the latest isotope-geochronological researches the age of biotitic porphyraceous granites is estimated in 218...216 million years [5, 8]. Introduction of the dyke belt of apatite- and fluorobearing granite-porphyres, elvanes and ongonites, including ultra-rare-metal ones that got their own name «kalgutites» based on mineral structure specifying crystallization of apatite instead of a topaz, is connetcted with a late rhythm (East-Kalgutinskiy complex) [9]. The absolute age of rocks of the late rhythm is 205...201 million years [8].

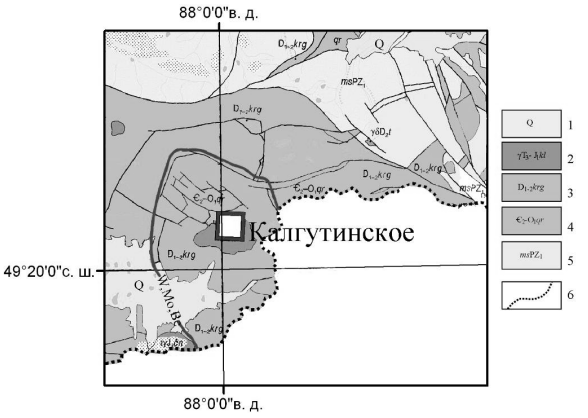

Fig. 1. *The scheme of geological structure of the Kalgutinskiy deposit area: 1) quaternary sediments, 2) Kalgutinskiy granite-leucogranitic complex, 3) Kargonskaya formation of volcanites mainly of sour composition and Aksakayskiy subvolcanic complex of trachiandesite-diceite-riolitic composition, 4) Gornoaltaiskaya series of rhythmically-interstratified multicoloured sandstones, aleurolites, clay shales, 5) Kokurskiy metapelite-green-shale complex, 6) frontier; Калгутинское – Kalgutinskoe; с.ш. – north latitude; в.д. – east longitude*

Mineralization of the Kalgutinskiy deposit is represented by a series of steeply deeping tungstate-molybde-

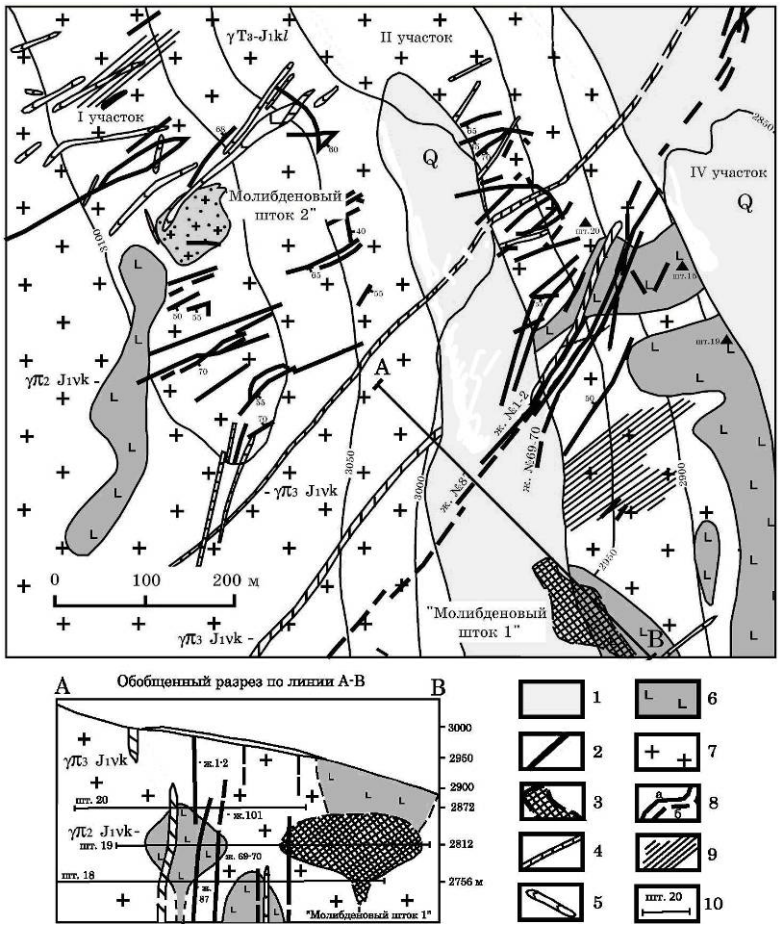

Fig. 2. *The schematic geological map of the Kalgutinskiy deposit (made according to N.I. Timofeev and B.G. Sementsov with author's additions): 1) quaternary alluvial-delluvial deposits; 2) ore-bearing quartz veins; 3) independent greisens formation with rich molybdenum mineralization «Molybdenum stock 1»; 4) dykes of changed «kalgutites» ($\gamma\pi T_3$–J_1vk); 5) microgranite-porphyries ($\gamma\pi T_3$–J_1vk); 6) albitized granite-porphyries; 7) porphyraceous biotitic granites (γT_3–J_1kl); 8) geological boundaries: authentic, prospective; 9) zones of splitting; 10) projections of adits and their numbers; участок – site; молибденовый шток – molybdenum stock; обобщенный разрез по линии А-В – generalized cut along the line A-B*

nite-quartz veins with chalcopyrite, bismuthine, beryl and stock-like mainly molybdenite-quartz bodies, Fig. 2. The length of veins ranges from first tens up to 1000 m at capacities seldom exceeding 1 m. Vertical amplitude of mineralization is more than 500 m. Quartz-ore veins, as a rule, are accompanied by greisen margins with capacity of up to 0,5 m. Isolated parts of greisens are marked in the form of linear zones, swells and column-like bodies of the «Mo-stock» type. According to field observation [10] it is established that the latest dykes of «kalgutites» have complex character of interaction with ore veins and greisen bodies – they are both intraore and postore which points to a close time of formation of dykes and main industrial mineralization.

The deposit ores are complex in geochemical and in economic aspect. Alongside with typical useful components of greisens mineralization (Be, W, Mo), Cu and Bi have an industrial value. High contents of elements of various geochemical groups (litho-, chalco- and siderophile) – Nb, Ta, Ba, U, Li, Rb, Cs, La, Lu, Au, Ag, Pt, Pd, Os, Rh, Cd, Sb, As, Pb, Zn, Cr, Mn [11] are marked in the ores. Mineral composition of ores is characterized by a significant variety – more than 50 hypogenic ores and veined minerals are known. Native elements: gold, bismuth, copper, carbon (graphite) can be found alongside with the widespread oxides, sulphides and sulphosalts. H_2O, CO_2, CO, H_2, as well as marginal and non-marginal (C_2H_2, C_2H_4) hydrocarbons are present in the composition of gas-liquid intrusions in quartz of ore-bearing formations. The content of H_2O и CO_2 increases with depth, but the content of CO, H_2 and hydrocarbons in the structure of the fluid decreases. Formation of mineralization occurred in contrast conditions of oxidation of primarily restored abyssal metal-bearing fluid [12, 13].

Two stages and five phases, within the limits of which few impulses of introduction of magmatic melts and hydrothermal-metasomatic ore-formation naturally inerconectively occur, are shown in the evolution of the Kalgutinskiy fluid-magmatic system.

The first pre-ore stage is paragenetically connected with porphyraceous biotitic granites of the general intrusive phase and includes one tourmaline-wolframite-quartz stage.

The second stage, the main stage of ore formation, combines two substages. The first substage includes the stage of formation of autonomous greisens mineralization of the «Mo-stock» type, apparently, paragenetically connected with Kalgutinskiy granite-leucogranitic complex. The second main substage of ore-formation consistently combines formations of rare-metal-hubnerite-quartz, sulphosalt-sulphide-quartz and the final carbonate-quartz stages of mineral-formation. Formations of the sulphide-sulphosalt-quartz stage are mainly telescoped in earlier structures with formation of complex in structure sulphide-sulphosalt-rare-metal-hubnerit-quartz veins. Introduction and becoming of the East-Kalgutinskiy dyke complex occurred within the limits of this substage.

The carried out researches allow considering geological formations of the deposit as products of development of a uniform evolving fluid-magmatic system. The evidence of it is Affinity of absolute age, geochemical characteristic of geological formations and analysis of their correlation connections of their geochemical spectra can serve as evidence [5, 8, 12, etc.]. During the process of the fluid-magmatic system development the influence of abyssal fluid increases and reaches the maximum during formation of mineral associations of the main sulohie-sulphosalt-quartz stage of mineral-formation.

The revealed mineralogical-geochemical features specify the defining influence of abyssal (mantle) processes at formation of the Kalgutinskiy ore-magmatic system.

Basic results

The carried out examination of materials of space survey Landsat ETM+ and the analysis of a digital model of the relief (Fig. 3, 4) allow drawing a conclusion that large structures of the linear and ring form are widely developed in the area of the Kalgutinskiy deposit.

The technique of cosmogeological mapping implies performance of the remote data interpretation in the conventional ruler of scales: from fine to large. It enables to establish an accessory of fine, non-distant lineaments to larger structures, and to reveal laws and prominent features of structure of large objects, to decipher their age interrelations and as a whole to define a trend of geological development of the area and its separate parts.

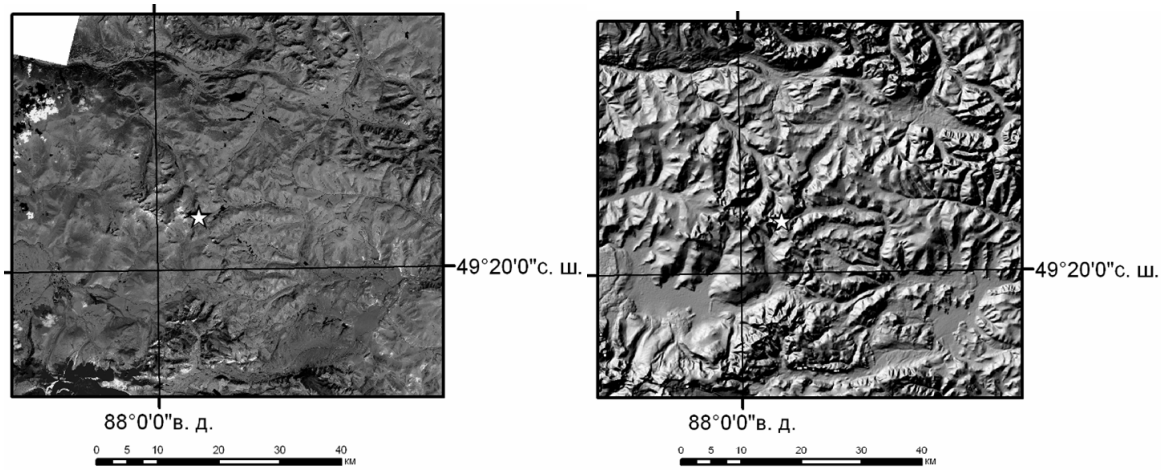

Fig. 3. *The composite of the remote basis based on materials of space survey Landsat ETM + (at the left) and digital model of the relief based on materials SRTM (on the right). Position of the Kalgutinskiy deposit is hereinafter shown by an asterisk*

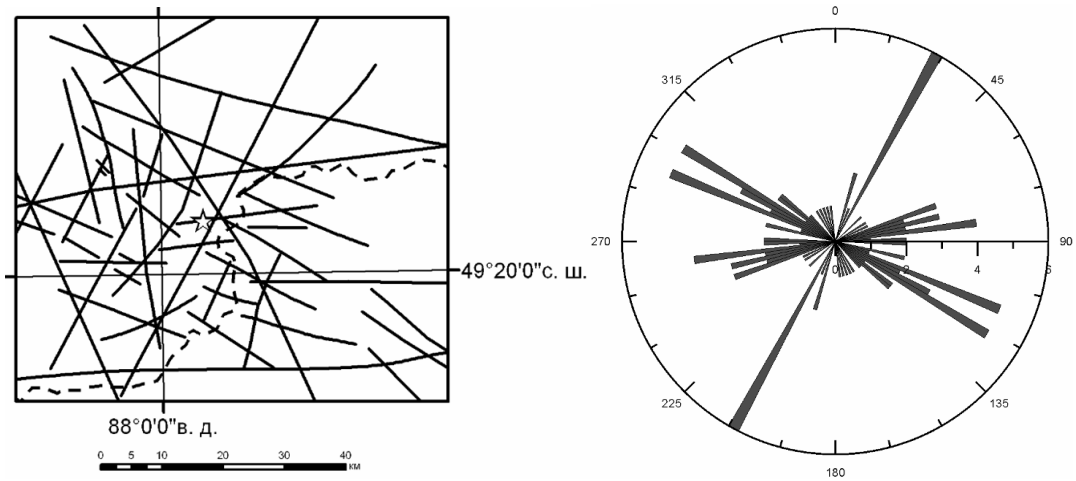

Fig. 4. *The scheme of lineaments of the Kalgutinskiy deposit area and their rose-diagram. The frontier is hereinafter shown by a dashed line*

Linear structures of the area are distinctly shown by the following attributes: rectilinear sites of the relief elements, rectilinear fragments of boundaries between blocks of a various relief texture, linear boundaries of vegetative cover variety, landscape heterogeneities of linear morphology, rectilinear sites of boundaries between geological bodies et al.

More than 40 lineaments of various length and direction interpreted as explosive infringements have been decoded in the area (Fig. 4). Alongside with the prevailing structures with the length of 5 up to 30 km, creating the structure of a «broken plate» in the center of the area, large linear zones that cross the whole area and fall outside the limits of the studied area are allocated. Structures of northwest (nearby 330°), northeast (30) and north-east-sublatitudinal (nearby 80) directions are attributed to them. The Kalgutinskiy deposit is located in the knot of their intersection.

The analysis of orientation of the revealed structures shows that lineaments of northeast (30°), sublatitudinal (80...90°) and northwest strike quantitatively prevail (Fig. 4).

20 ring structures (RS) and their arch fragments were decoded and edited in the area (Fig. 5). Attributes of RC allocation are:

- ring and arch boundaries between blocks with a various structure of the relief;
- ring and arch boundaries between decoded geological bodies;
- boundaries of landscape non-uniformities arch and ring morphology.

With the purpose of the RS analysis the module for GIS ARCVIEW allowing defining their sizes and coordinates of centroids has been created, (Fig. 5). Diameter of RC changes in a significant limit from 5 up to 50 km. In the northeast corner of the area a fragment of RS of greater size is allocated, but its main part is located outside the studied area. By sizes, features of spatial position, and interrelation all RS can be divided into two groups.

The first group is the basic RS, covering all the area of the Kalgutinskiy deposit in which RS of the smaller size are naturally enclosed (telescoped). From a greater structure to a smaller there is a natural localization of the area in the center which the Kalgutinskiy massif is situated (Fig. 6). At obvious telescoping, these structures are characterized by the expressed eccentricity – their centroids are displaced in the west – northwest direction.

Six small RS (diameter no more than 15...20 km), allocated by 2–3 rings, are attributed to the second group. They do not find visible connection with the Kalgutinskiy massif, situated on periphery of the area, but their main part is concentrated in southern – southeast part of the area.

An important characteristic of RS is the position of its centroid and depth of focus deposition, with which the formation of RS is connected. According to representations [3, 14] visible diameter of structures on the surface is 2...4 times larger than the depth of the focus. The average value is accepted (3) and the depth of formation of RS of the first group is calculated (table 2). The depth of their formation is consecutively decreases from RC of a greater to a smaller size from 15,8 up to 5,1 km. Considering that development of the process took place on ascending, and position of centroids corresponds to the focus area, consecutive connection of centroids reveals the trajectory (a projection onto the horizontal plane) of pulse developments of endogenic system (Fig. 6). The trajectory specifies that as a whole at rise of the center to the surface it was displaced from the east – southeast to the west – northwest. But on separate sites the trajectory «was controlled» by structures of sublatitudinal or northwest direction.

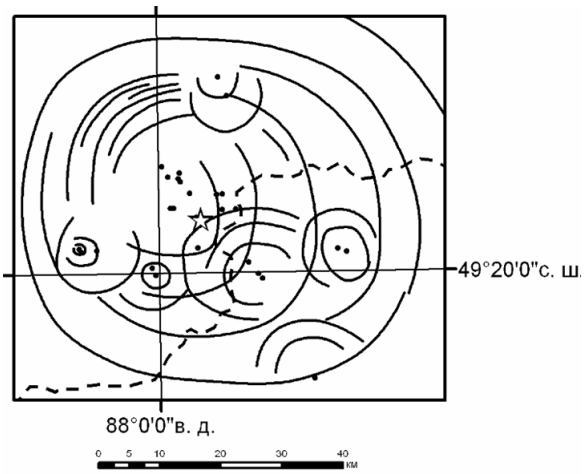

Fig. 5. *Ring structures and their centroids (black dots) of the Kalgutinskiy deposit area*

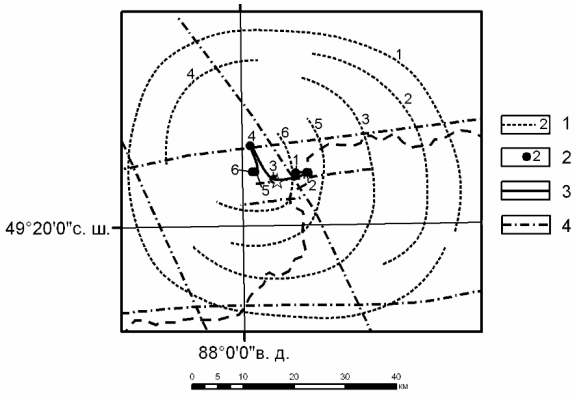

Fig. 6. *Cosmostructural model of the Kalgutinskiy deposit area: 1) basic ring structures and their numbers, 2) centroids of ring structures and their number, 3) projection onto the day time surface of the trajectory of change of focus position of the Kalgutinskiy ore-magmatic system, 4) basic lineaments of the area*

Table 2. *Key parameters of ring structures (Fig. 6)*

№	Diameter, km	Depth of deposition, km
1	47,4	15,8
2	45,4	15,1
3	38,4	12,8
4	32,8	10,9
5	26,6	8,9
6	15,2	5,1

Discussion of results

The area of the Kalgutinskiy deposit is localized inside of the large isometric ring structure which size is estimated at least in 50 km. The structure is dated to the crossing knot of three fracture zones of northwest (nearby 330°), northeast (30°) and northeast – sublatitudinal (nearby 80°) directions. The area is characterized by the telescoped eccentric character of ring disposition of the basic structure with the developed autonomous local structures (the second group), mainly concentrated in the southeast part of the area. The Kalgutinskiy deposit itself is located in the internal part of the basic ring structure.

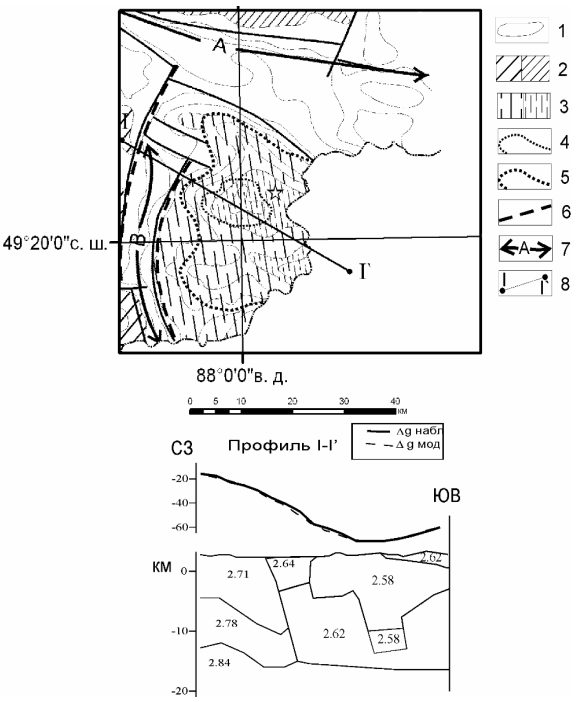

Fig. 7. *The scheme of zonation of local gravitational anomalies of the southern part of Mountainous Altai (made by A.N. Vasilevskiy, L.V. Vitte, I.Yu. Annikova, A.G. Vladimirov on the basis of gravimetric survey, scale 1:200 000): 1) isolines gravitational field intensity; 2, 3) anomalies of gravity (frequency of shading is the intensity of anomalies): relative maxima (2), minima (3); 4) contour of outcropping of the Kalgutinskiy pluton; 5) contours of the buried massif according to modeling; 6) abyssal fractures; 7) gravitational steps (A, B); 8) design profile*

Character of disposition of centroids of rings of the basic ring structure allows restoring the character and the trajectory of movement of the focus, forming given structures. Probably, it was a series of consistently generated focuses which had genetic or paragenetic connections and simultaneously developed for a long time. With the rise of the focus to the surface it was displaced from the east – southeast to the west – northwest. In other words, the structure of controlling the development of the Kalgutinskiy ore-magmatic system submerges from the west – northwest to the east – southeast. Such conclusion is proved to be true by the results of geological-geophysical modeling with use of the data of gravimetry [15]. Their analysis shows the presence in the central part of the intrusive massif of a deep lying «leg» in width of 1...2 km, submerging to the southeast at an angle of 45...60° (Fig. 7).

Ring structures are allocated in all the areas and on deposits of various structure and genesis. The smaller the size of RS the more its material structure is homogeneous. Large RS include in their borders formations (complexes) of various structure, genesis and age. According to increase in size of RS the sphere of the ore control is also increases. Here the analogy with hierarchy of mineralization in the range from an ore body to a province is traced.

As a rule, the majority of researchers specify to a great shock-explosive character of RS. From the set of all representations on the nature of the shock-explosive forming RS phenomena, it is possible to allocate two points of view regarding their genesis – cosmogenic (astroblems) and endogenic (geoblems).

Supporters of the cosmogenic concept consider that a shock-explosive influence of a falling space body is an initial impulse of RS development. This influence covered the earth's crust and penetrated the mantle which led to activization of endogenic geological processes and as consequence to formation of various minerals.

Natural geological and mineragenetic character of development of Mountainous Altai, the telescoped construction unequivocally specify on the endogenic nature of ring structures of Kalgutinskiy deposit area.

Supporters of the endogenic concept consider that an original cause of RS formation are the abyssal explosions of huge capacity caused by an impulsive rise of fluids (accompanied by introduction of portions of abyssal melts and/or leading to fusion rocks of the earth's crust) to the terrestrial surface owing to degasification of the earth's core [16], or other endogenic processes.

The following facts can be attributed to the features of display of explosive processes in development of the Kalgutinskiy system:

- presence on the deposit of explosive breccias composing isometric pipelike bodies («Mo-stock 2») named after G.E. Dashkevich [17] as «tubes of explosion». A certain coordination of regional and local structural factors is marked – the vertical axis of the body is declined under the angle of 70° to the southeast. Breccia bodies of the flattened arched form are known;
- The spherical form in the plan and on the cut of bodies «Mo-stock 1 and 2» (Fig. 2). Their morphology specifies that they were formed in sites of the space subjected to the sharp (explosion-like) influence accompanied by destruction of rocks in the isometric volume, on the form of which heterogeneity of the geological substratum has not essentially influenced. In other words, if formation of pipelike bodies can be connected with long process in the zone of crossing of differently oriented explosive infringements, then the spherical bodies were formed impulsive and dynamically practically equivalent in all directions.

There are different points of view regarding the nature of endogenic explosions, and thus the most important question is their power source [18]. It is represented that at formation of the Kalgutinskiy ore-magmatic system two basic mechanisms could be realized – interaction of gases of various structure and electric discharges of high capacity.

Research of fluid inclusions of ore-bearing quartzes of the deposit has shown the presence of a high quantity of explosive gases at their structure (table 3). First of all it includes carbonic oxide, hydrogen and various hydrocarbons. Their concentration varies in different bodies but the common thing is that with the depth their content increases and the content of waters considerably decreases [19]. That means a «dry» mainly hydrogen-hydrocarbonic fluid has poured into the area of ore-formation.

Table 3. *Average contents of basic gases in quartz of the Kalgutinskiy deposit, mg/kg*

Ore bodies		H_2O	CO_2	CO	H_2	ΣУВ	Total
Ж. 87	Horizon 20	1280	80	15	<2	32	1400
	Horizon 18	970	71	27	2	40	1110
	All vein	1030	72	17,5	<2	36	1150
Ж. 69–70	Horizon 19	1300	43	4,7	<2	13	1360
	Horizon 18	1000	43	9,3	<2	20	1080
	All vein	1150	43	7	<2	16	1220
Stock1	Horizon 19	1650	75	10	<2	24	1760
	Horizon 18	1420	77	10	<2	31	1540
	All stock	1500	76	10	<2	28	1630
Stock 2, surface		880	85	43	6	54	1070

Note. $\Sigma УВ = CH_4+C_2H_2+C_2H_{4,6}+C_3H_8+C_4H_{10}+C_5H_{12}+C_6H_{14}$

Occurrence of oxygen in the system (containing rocks, exposed to acid leaching or «protoning» could be the source) led to oxidation of the fluid. These reactions were accompanied by significant allocation of energy (table 4). Appearing in the system water played a role of the catalyst capable to accelerate interaction of substances in one thousand and more time [14]. Such explosions led to occurrence of compression chambers and then zones of crushing and fracturing.

Table 4. *Thermal effect of reactions, characteristic for explosive gas mixes [14, 20]*

Gas	Equation of the process	Thermal effect, kJ/g·mole
Hydrogen	$2H_2+O_2=2H_2O$	573
Methane	$CH_4+2O_2=CO_2+2H_2O$	892
Acetylene	$2C_2H_2+5O_2=4CO_2+2H_2O$	2604
Ethane	$2C_2H_6+7O_2=4CO_2+6H_2O$	3123
Propane	$C_3H_8+5O_2=3CO_2+4H_2O$	2221
Butane	$2C_4H_{10}+13O_2=8CO_2+10H_2O$	5761
Carbon monoxide	$2CO+O_2=2CO_2$	556

It is obvious that this mechanism could be realized at the final hydrothermal ore-forming stage of the system development, on a small depth and was accompanied by formation on the surface of rounded morphostructures of a small diameter. Formation of stock-like ore bodies is, probably, connected to these phenomena in the beginning of the hydrothermal stage.

The possibility of an electric (electrokinetic) mechanism of explosive processes of a big capacity with formation of structures of the central type is described in the A.A. Vorobev's work [21]. It is shown that display and accumulation of free electric charges, formation of volumetric charges and display of discharges of the storm type is possible in terrestrial bowels. At a significant list of the reasons of this process occurrence the most probable reason is the contact electrization of various in electroconductivity bodies, especially in fracture zones, as well as on the sites of significant gradients of temperatures, pressure or concentration of chemical elements. Presence of zones of various and increased electroconductivity on various depths in the crust and the mantle and their connection with hypocenters of earthquakes is shown in the work of O.A. Stepanov 18].

The electric mechanism of explosive processes could be the main one at the initial (tectonic-magmatic) stage of development of the Kalgutinskiy system and its display at movement of metal-bearing hydrogen – hydrocarbonic fluids into the area of the ore deposition is rather probable.

Basic conclusions

It is established:

- the area of the Kalgutinskiy deposit is localized inside of a large ring structure of a complex construction. The size of the structure amounts to at least 50 km. The telescoped eccentric character of the structure points to a long multi-staged (multipulse) character of its development. Immersing of the root (focus) part of the structure is established from the west – northwest to the east – southeast;
- position of the ring structure is controlled by the joint of crossing of three fracture zones of northwest (nearby 330°), northeast (30°) and northeast – sublatitudinal (nearby 80°) directions;
- the Kalgutinskiy massif and the deposit itself are located in the internal belt of the structure in the ring with the diameter of 15,2 km;
- within the limits of the ore area it is possible to allocate a number of perspective sites connected with development of small ring structures of the second type.

Authors are grateful to F.A. Letnikov for the constructive criticism and useful advice. The work has been executed at financial support of the Russian fund of basic researches (projects 05-05-64356 and 06-05-65137).

REFERENCES

1. Pertsov A.V., Galperov G.V., Antipov V.S. et al. Cosmostructural criteria of localization of ore giants //Otechestvennaya geologiya. – 1999. – № 6. – P. 17–21.
2. Thomson I.N., Polyakova O.P. Features of localization, construction and structure of large and unique deposits of color and precious metals //Otechestvennaya geologiya. – 1994. – № 11–12. – P. 24–30.
3. Space methods of geological researches / Edited by A.V. Pertsov. – Saint Petersburg: Publishing house of Saint Petersburg map reproduction plant of Russian Geological Research Institute, 2000. – 316 p.
4. Potseluev A.A., Ananyev Yu.S., Zhitkov V.G. et al. Remote methods of geological researches, forecast and search of minerals (on the example of the Rudniy Altai). – Tomsk: STT, 2007. – 232 p.
5. Borisenko A.S., Sotnikov V.I., Izokh A.E. et al. Permo-Triassic mineralization of Asia and its connection with display of plume magmatism //Geologiya i geophisika. – 2006. – V. 47. – № 1. – P. 166–182.
6. Distanov E.G., Borisenko A.S., Obolenskiy A.A., et al. Features of metalogeny of the polyacretion Altai-Sayanskaya oregenous area //Geologiya i geophisika. – 2006. – V. 47. – № 12. – P. 1257–1276.
7. Dobretsov N.L. Mantle plumes and their role in formation of anorogenic granitoids // Geologiya i geophisika. – 2003. – V. 44. – № 12. – P. 1243–1261
8. Annikova I.Yu., Vladimirov A.G., Vystavnoy S.A. et al. U-Pb, Ar^{39}/Ar^{40} dating и Sm-Nd, Pb-Pb isotope research of the Kalgutinskiy molybdenum-tungstic ore-magmatic system, Southern Altai // Petrologiya. – 2006. – V. 14. – № 1. – P. 90–108.
9. Dergachev V.B. New species of ongonites // Reports of the Academy of Sciences of the USSR. – 1988. – V. 302. – № 1. – P. 188–191.
10. Annikova I.Yu, Dergachev V.B., Terekhov B.H. On interrelation of rare-metal granites, ongonites and mineralization in the Kalgutinskiy massif (Mountainous Altai) // Geological construction and minerals of the western part of the Altai-Sayanskaya folded area. Thesis of reports of the scientific-practical conference – Kemerovo-Novokuznetsk, 1999. – P. 220–222.
11. Potseluev A.A., Kotegov V.I., Rikhvanov L.P. et al. Precious metals in the Kalgutinskiy rare-metal deposit (Mountainous Altai) // Bulletin of the Tomsk Polytechnic University. – 2004. – V. 307. – № 5. – P. 36–42.
12. Potseluev A.A., Babkin D.I., Kotegov V.I. The Kalgutinskiy complex deposit, Mountainous Altai: mineralogical and geochemical characteristics and fluid regime of ore formation // Geology of ore deposits. – 2006. – V. 48. – № 5. – P. 384–401 [in Russian].
13. Potseluev A.A., Kotegov V.I., Akimtsev V.A. Graphites of the Kalgutinskiy rare-metal greisens deposit (Mountainous Altai) // Reports of the Russian Academy of Sciencea. 2004. – V. 399. – № 2. – P. 241–244.
14. Explosive ring structures of shields and platforms / V.I. Vaganov, P.F. Ivankin, P.N. Kropotkin et al. – Moscow: Nedra, 1985. – 200 p.
15. Annikova I.Yu, Vladimirov A.G., Vystavnoy S.A. et al. Geologic-geophysical model of formation of the Kalgutinskiy ore-magmatic system (Southern Altai) // Bulletin of the Tomsk Polytechnic University. – 2004. – V. 307. – № 4. – P. 38–42.
16. Letnikov F.A. Supeabyssal fluid systems of the Earth and problems of oregenesis // Geology of ore deposits. – 2001. – V. 43. – № 4. – P. 291–307.
17. Dashkevich G.E., Mortsev N.K., Borovikov A.A. Explosive breccias on the Kalgutinskiy eksplozivnye deposit (Mountainous Altai) // Petrology, geochemistry and ore contentof intrusive complexes of the south of Siberia. – Novosibirsk: Publishing house of Institute of Geology and Gas and Mineralogy of the Siberian Branch of the Russian Academy of Sciences, 1991. – P. 44–49.
18. Stepanov O.A. The explosive mechanism of formation of structures of the central type // Sovietskaya geologiya. – 1989. – № 12. – P. 95–104.
19. Potseluev A.A., Babkin D.I., Kotegov V.I. Composition and laws of distribution of gases in quartzes of the Kalgutinskiy rare-metal deposit // Bulletin of the Tomsk Polytechnic University. – 2005. – V. 308. – № 2. – P. 36–43.
20. Goronovskiy I.T., Nazarenko Yu.P., Nekryach E.F. Brief directory in chemistry. – Kiev: Naukova dumka, 1974. – 991 p.
21. Vorobyev A.A. On the possibility of electric discharges in bowels of the Earth // Geologiya i geophysika. – 1970. – № 12. – P. 3–13.

Received on 20.11.2006