

# Metasomatic alteration associated with the formation of subvolcanic rocks of the Abagatuysky complex (Nerchinsk ore region, Eastern Transbaikalia)

I O Kremer, P A Tishin

Department of Geology and Geography, Tomsk State University, Lenin Avenue 36,  
Tomsk, 634050, Russia

E-mail: [stilcev@yandex.ru](mailto:stilcev@yandex.ru)

**Abstract.** Within the northeastern edge of the Borschovochny pluton, located in Eastern Transbaikalia, a complex of small intrusions is localized, represented by the subvolcanic bodies of the Early Cretaceous Abagatuysky andesite-dacite complex. These intrusions, along with significant dynamometamorphic (tectonic) transformations, produced the development of metasomatic alteration, united in three large rock associations — propylites, beresites, and argillisites. These metasomatic associations successively replace each other as they move away from the center of heat exposure of intrusions. In addition, each of these groups of metasomatites has its own unique internal mineral zonality, and the most productive of them, on the subject of gold ore mineralization, is the beresite association.

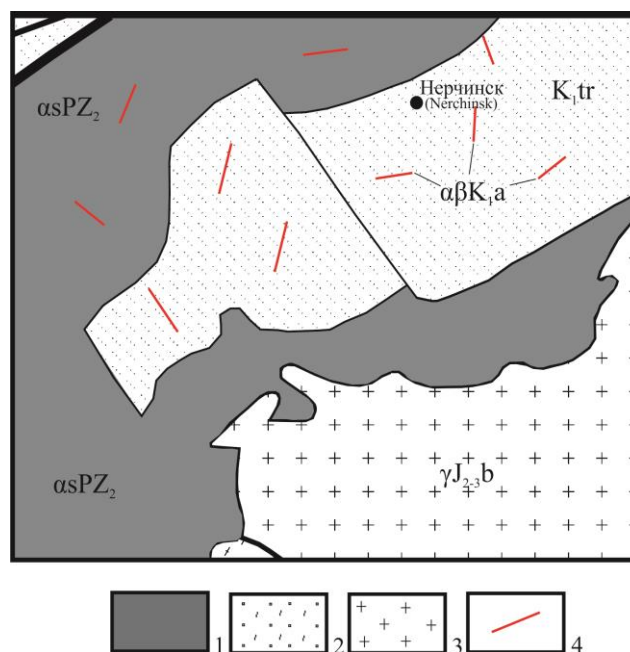
## 1. Introduction

Eastern Transbaikalia has a complex geological structure, where many different age complexes of different compositions and origins are combined. Another page in the history of this region is large-scale Mesozoic tectonic-magmatic events associated with the collision of the Siberian Craton and the Argun microcontinent [1-3]. The result of these events was an intense occurrence of granitization and the development of large-scale volcanic processes.

One of their examples, similar to the Mesozoic activation in Eastern Transbaikalia, is the territory of the Nerchinsk ore district (figure 1). In this area, localized in the northeastern part of the large Borschovochny granitic pluton, there are multiple subvolcanic bodies of andesitic-dacite composition, attributed by the researchers [4] to the Early Cretaceous Abagatuysky complex [5]. These subvolcanic bodies (dikes, sills) are located among the dynamometamorphic rocks of the Paleozoic aginko-borschovochny complex and in the Late Mesozoic rift depressions made by the Jurassic (Shadron series) and the Cretaceous (Turginsk suite) framing the Borschovochny pluton from the north-eastern part.

Intense exhibition of subvolcanic magmatism contributed to the large-scale development of metasomatic processes responsible for the distribution of gold mineralization. These metasomatic alterations do not always showing themselves in contrast, and their distribution is often obscured by tectonic recrystallization. Nevertheless, within the limits of the studied area, three main types of metasomatic formations are revealed: propylites, beresites, and argillisites.





**Figure 1.** Map of the position of subvolcanic bodies framed by Borschovochny granitic pluton  
 Abbreviations: 1 - aginsko-borschovochny complex, 2 - Late Mesozoic rift depressions (Shadoron series and Turginsk suite), 3 – granitoids Borschovochny pluton, 4 – dikes Abagatuysky complex

## 2. Propylites

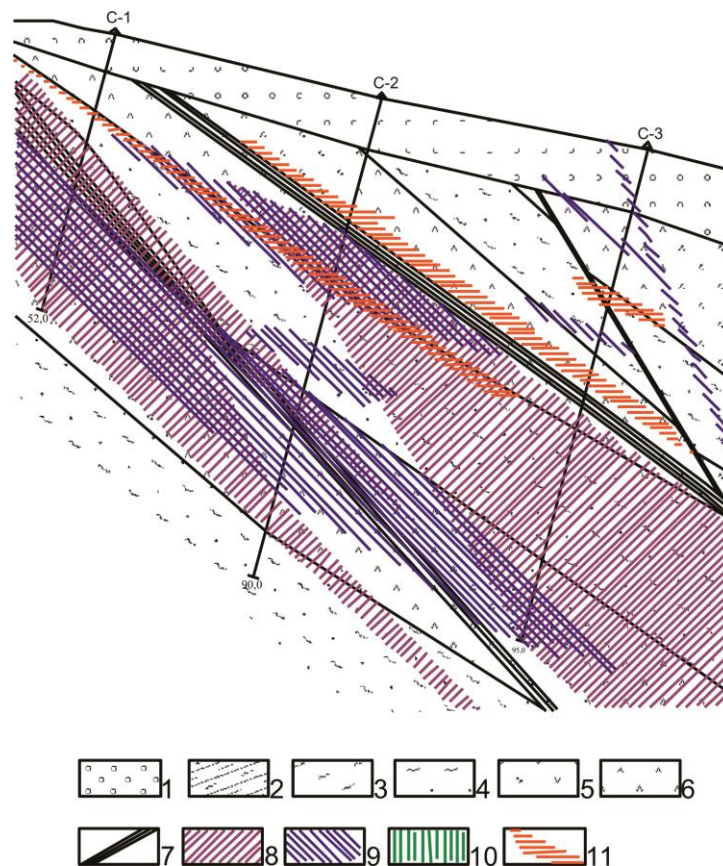
Metasomatism of the propylitic series is spatially and genetically associated with alterations of andesitic and dacitic magmatism, encompassing both exocontact regions and directly magmatic bodies. Structural control of propylitization is carried out both by shallow faults controlling magmatism and by later compensatory syncinematic faults (figure 2).

In the microscope, propylites are recorded by the development along the system schistosity and metamorphic banding of epidote and hematite, as well as by a stable association of calcite and chlorite, evenly distributed in the matrix of the rock.

The spatial position of these associations allows us to distinguish three main zones of propylitic columns. As a rule, the rear zones are represented by epidote + hematite + albite ± calcite ± chlorite with quartz and sericite-muscovite relicts. For intermediate zones, hematite + albite + chlorite ± calcite is characteristic. The frontal zones are composed of the association of albite and calcite chlorite with full or partial preservation of the original minerals.

The morphology of the metasomatic zonality is determined by the structural control of chemical processes. For propylites developing along andesites and dacites, a symmetric zoning is characteristic, in which the rear zones are localized in the axial parts of metasomatic columns and wedging along the strike (figure 2). In the case when the formation of propylites is controlled by later tectonic disturbances, the zonality becomes asymmetric with the rear zones to the fracture bodies, and the frontal ones to their hanging or downward layers, depending on the position of the nearest magmatic body.

The gold productivity of propylitic metasomatism is not significant. Most likely, propylitization contributed to the preparation of ore collectors for metal accumulation, as evidenced by the close spatial relationship of metasomatites of this series with the most productive beresitic columns.



**Figure 2.** Mineralogical-petrographic section showing the spatial relationship and zonation of metamorphic formations of the propilitic and beresitic series

Abbreviations: 1 - deluvial layer and near-surface oxidation zone; 2 - 4 rocks of metasedimentary non-stratified associations: high carbon (2), quartz-sericite (3) and albite-chlorite schists (4); 5-6 subvolcanic bodies of metaandesites (5) and metadacites (6); 7 - faults; 8 - 10 fields of distribution of the main propilitic zones: frontal (8); intermediate (9) and rear (10); 11 - areas of influence of metasomatic processes of the beresitic profile, undifferentiated.

### 3. Beresites

Metasomatism of the beresitic series is distinguished by dual structural control and at least two phases of manifestation. The earliest beresites form along the contacts of andesites (figure 2). These transformations are expressed in the sericitization and muscovitization of volcanic rocks and their nearest framing. Subsequently, the beresite associations are complicated by the later chlorite-calcite-albite paragenesis. The intensity of these occurrences, clearly controlled by the degree of dislocation of rocks.

Occurrence of beresite metasomatites is the earliest and is determined by the interaction of cooling magma and magmatogenic solutions with metamorphogenic fluids; as a result, chemical transformations of rocks are comparable with the usual postmagmatic alteration and differ mainly in the degree of recrystallization. As a rule, the scale of primary beresitization is insignificant and rarely exceeds 5 meters, and the rocks themselves are not of interest from the point of view of ore productivity. In this respect, the second phase beresites play a more important role.

The spatial position of the second phase beresites, as in the description of propylites, is considered in close connection with the position of the subvolcanic magmatism and tectonic setting. When analyzing the geological sections, this made it possible to establish the coincidence of the beresites to the zones of the main (figure 2) compensating for the northeastern oblique-slip that intersect the subvolcanic bodies of andesites.

The study of the core sampled allowed dividing the internal structure of the beresite formations into two frontal and rear zones, between which the correlation of metasomatic zones is established. In this case, from the front to the rear, the following zones are distinguished: quartz-chlorite-sericite → calcite-ankerite-sericite → quartz-ankerite-sericite → quartz-calcite.

In practice, diagnostics of the frontal zones is impossible, due to the non-contrast occurrence and similarity of the mineral composition of metasomatites with deformed meta-andesites, quartz-sericite crystalloids and their propylized varieties. At the macro- and meso-levels, the main diagnostic sign of the quartz-chlorite-sericite zone may be chloritization of mica schists with a stable association of marcasite and pyrite.

More complete metasomatic processing is observed in the intermediate (calcite-ankerite-sericite) zone. As a rule, the rocks here are completely changed, but the newly formed minerals are characterized by an extremely low degree of crystallization. The most intensive grain growth is established for calcite and sericite, which gives the rocks a porphyroblastic appearance. In this case, calcite forms weakly extended grains (up to 0.8 mm) without clear boundaries. Their orientation according to fracturing emphasizes the structural control of beresitization by secondary compensatory violations (figure 2). The increase in the quantitative role of sericite and ankerite that is established underlines the gradual transition to the quartz-ankerite-sericite zone.

In the rear zone (calcite-quartz), as a rule, their exhibitions are characterized by low thickness, not more than 1 meter. Reliable diagnostics of these beresites under a microscope is carried out by increasing the density of quartz veinlets, with a thickness of 1 cm, and scattered exhibitions of chalcedony silicification. As a rule, these rocks are characterized by the most complete processing and a high degree of crystallization, which is expressed in an intensive increase in the size of calcite grains, reaching 3 mm. Calcite-quartz beresites have a banded and/or spotty appearance, due to the separation of silica in the carbonate matrix. At the same time, quartz grains are composed of a chalcedony aggregate, depending on the size of the monomineralic isolation.

The gold ore productivity of beresites is associated with the inner regions of the intermediate and outer fragments of the rear zones and is determined by the stability of the ankerite-sericite mineral paragenesis, the dissolution of which is accompanied by the removal of the useful component.

#### **4. Argillisites**

Argillisites are located at the maximum distance from the centers of magmatic activity, therefore, the effect of subvolcanic formations on the processes of argillisation is minimal and was carried out according to the residual principle. However, the nature of the distribution of these metasomatites has its own characteristics. The metasomatism of the argillisite series is distinguished by dual structural control and at least two exhibitions. Most often argillisites are found in the oxidation zones of ores and ore aureoles in the zone of exposure to groundwater. The most intensively argillization occurs in the mineralized zones and in the development sites of the earliest gold-bearing metasomatics. At the same time, low-temperature metasomatites often become brittle tectonic zones and are expressed in the appearance of kaolinite, ferrous carbonate and iron hydroxides against the background of the general disintegration of the original rocks. Such structural lithological control indicates that this form of argillisite metasomatism is caused by the interaction of rocks and ores with ground and surface waters.

Another form of argillization is “shadow” metasomatites, which develop along quartz-sericite and carbonaceous schists. Here, the rocks retain their integrity, and the mineral associations of argillisites are evenly dispersed over the primary rock, or they develop along the veins and fractures. Among the main metasomatic minerals are quartz, kaolinite, siderite, chlorite (delesit), calcite.

#### **5. Conclusion**

Thus, when studying the metasomatic alteration associated with the intrusion of the subvolcanic bodies of the Abagatuysky complex, the following conclusions can be made:

(1) The change in the nature of metasomatism has been established, as the distance from the source of intrusion of the sills and dikes of the Abagatuysky complex. In the zone of contact of subvolcanic

bodies, the distribution of the most high-temperature metasomatic alteration is established - propylites, as they move away from the insertion centers, they are replaced by beresites, and argillites are located in the most distant parts. (2) For each type of metasomatite, metasomatic zonality was established, confirmed by characteristic mineral paragenesis. (3) The most productive, in terms of the distribution of the gold component, are the metasomatites of the beresite series.

### Acknowledgements

This work was conducted as a government task of the Ministry of Science and Higher Education of the Russian Federation, Project Number 5.9338.2017/P220. The examinations of samples were performed on the equipment of Analytic Center of Natural Systems Geochemistry of Tomsk State University.

### References

- [1] Mazukabzov A M Sklyarov E V Donskaya T V Gladkochub D P Fedorovsky V S 2011 *Metamorphic core complexes of the Transbaikalia: Review* Geodynamics & Tectonophysics (Russian geodynamics & tectonophysics) Vol **2** p 95-125
- [2] Sklyarov E V Mazukabzov A M Melnikov A I 1997 *Cordilleran-Type Metamorphic-Core Complexes* [in Russian] Izd. SO RAN Novosibirsk p 197
- [3] Parfenov L M Popeko L I Tomurtogoo O 1999 Problems of tectonics of the Mongol–Okhotsk orogenic belt. *Geology of the Pacific Ocean* **18(5)** p 24-43
- [4] Rutshtein, I G 2013 *Geology of ore-bearing structures dynamometamorphic of the East Transbaikalia* [in Russian] Izd. Geokart-Geos Moscow p 154
- [5] Kremer I O Tishin P A 2017 Geochemical characteristics of the Late mesozoic subvolcanic rocks of the northern frame of the Borschovochny ridge (Eastern Transbaikalia) *Proc. 17th International multidisciplinary scientific geoconference SGEM 2017* Albena, Bulgaria Vol 17 Geology Mineral Processing., p 183-190