

Rare-earth element distribution patterns in metasomatites of Eastern Kazakhstan gold -ore deposits

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Abstract. The article describes the distribution patterns of rare-earth elements in metasomatites of Eastern Kazakhstan gold-ore deposits. The results demonstrated that the formation of all metasomatites is associated in the rebalancing process of rare-earth elements. The investigation established the vertical differentiation of rare-earth elements in beresites accompanying gold-ore mineralization of various structural and morphological types. Three types of distribution of rare-earth elements in wallrock beresites have been identified.

1. Introduction

Conventionally, the distribution characteristics of rare-earth elements have been extensively discussed and are used as geochemical indicators of substance source and geodynamic genesis conditions of magmatic systems. However, the information on the behavior of rare-earth elements within ore-metasomatic formations of gold -ore deposits in black-shale thicknesses is considerably limited.

Most Eastern Kazakhstan gold-ore deposits are concentrated within Eastern Kalbin metallogenic zone of Zaysan fold system. Within this zone, 18 gold-ore deposits were revealed in 2nd-order cross structures. Ore deposits are united into three structural and morphological groups: 1) ore quartz-veined and stockwork types in terrigenous, volcanogenic and carbonate thicknesses and gabbro-plagiogranite thicknesses; 2) mineralized sulphide zones in Carbonaceous terrigenous thicknesses; 3) combined type, including quartz veins, stockworks, gold-pyrite-arsenopyrite deposits in various terrigenous and volcanogenic thicknesses and intrusions. It is assumed that various structure and morphological mineralization types are located in extensive unified complex ore-metasomatic layered horizons [1]. Furthermore, the bottom section of these layered horizons predominantly embraces impregnated mineralization within black-shale thicknesses and intrusion massifs; in the middle section the gold mineralization is primarily associated with vein-disseminated morphological type occurring in black-shale thicknesses and mottled-structured dikes; in the top section the gold mineralization is primarily associated with the veined morphological type. The following metasomatic process types have been detected in the ore fields: albite-amphibolitic, quartz-feldspathic, propylite and listvenite-beresite [2].

The REE distribution located in Carboniferous black-shale rock thicknesses was investigated within the metasomatites of Baladzhai, Kyzyl and Espinsk gold-ore areas. The Baladzhai ore area embraces impregnated, vein-impregnated and vein mineralization types not only in the mafic intrusions but also in the exocontact of terrigenous thicknesses, whereas major gold reserves are



concentrated within impregnated ores of beresitized gabbroids. In the Kyzyl ore area, the major gold reserves are concentrated in Bakyrchik deposit that is confined to superimposed near NW fracture systems having formed the Kyzyl thrust [3]. The main deposit ore bodies are comprised of veinlet-impregnated gold-pyrite-arsenopyrite associations within mylonitized and beresitized Carboniferous terrigenous rocks.

The Espe ore area is characterized by the development of predominate quartz-veined deposits within Carboniferous molassoid formation. Such gold-bearing quartz veins are in the cross-cutting position with host rocks and demonstrate variable thickness and accompanying beresitization.

2. Investigation methods

Analytical analysis employed the following methods: mass spectrometry with inductively coupled plasma (conducted in the Chemical Analysis Center, Tomsk) and instrumental neutron activation analysis (conducted in the Nuclear Geochemical Laboratory, Department of Geoecology and Geochemistry, Tomsk Polytechnic University). Graphic representation of the results involved normalization chondrite [4] and unaltered rocks.

3. Results and discussion

All mineragenic types of Baladzhal deposit metasomatic formations are characterized by the predominance of light lanthanides overlying heavy ones (figure 1). Integrally, the distribution trends of rare-earth elements in metasomatites reflect the distribution patterns of elements in replacement gabbro. In this case, the maximal total concentration of rare-earth elements (REE) contains quartz-feldspathic metasomatites (from 221 to 242 g/t) and minimal concentration of beresites (from 88 to 78 g/t). The cerium anomalies in metasomatites are not pronounced, preassuming the involvement of magmatogene fluids during their formation. The regular REE concentration reduction level was determined as from alkali quartz-feldspar to late listvenite-beresites, which, in its turn, indicated a well-defined flow of REE during the hydrothermal process.

The REE distribution was investigated in the top section of the 9th ore body of the Bakyrchik deposit located in Kyzyl ore area. The analytical samples were selected from underground and surface mine openings, as well as core samples from bore holes. The vertical sampling range was 120 meters and ore body a-dipping more than 250 meters. Samples of unaltered hosted silty - sandstones were selected at 8 to 10km from the ore area in blocks uncontaminated during the hydrothermal processes.

The data analysis demonstrated that the REE concentration in beresites varies from 70 to 122 g/t, whereas, the maximum enriched concentration was determined in beresites of the upper horizons. Light lanthanides dominated over heavy and intermediate lanthanides, while intermediate lanthanides dominated over the heavy ones within all horizons. Europium anomaly within all horizons is slightly negative, and its magnitude increases along the ore body uprising angle. This indicates the fact that the relative oxidation of metalliferous fluid is due to its interaction with host rock pore solutions.

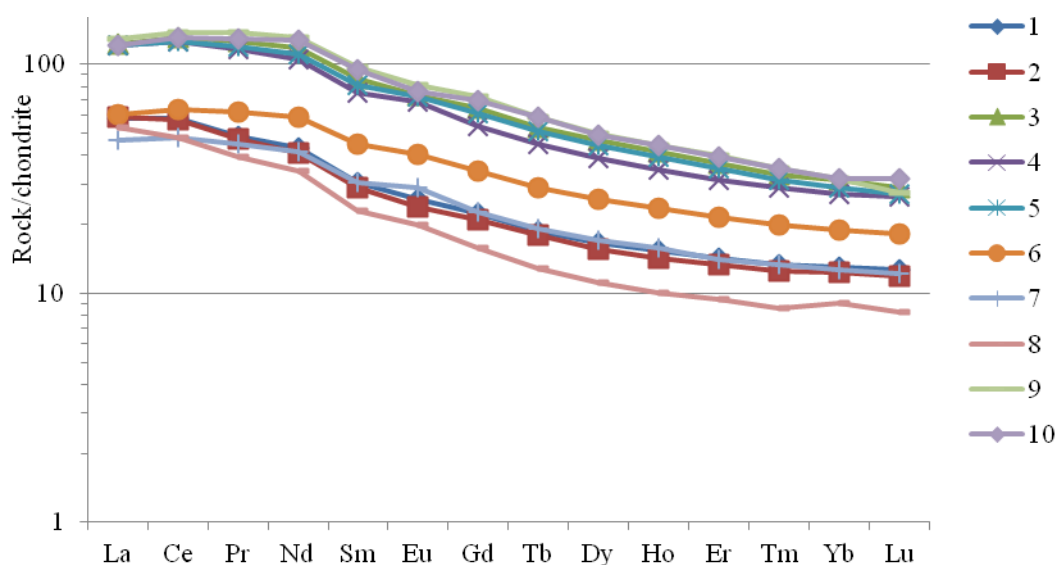


Figure 1. REE distribution in apogabbro metasomatites: 1 and 2 albite-amphibolitic metasomatites; 3 – 5 apogabbro quartz-feldspathic metasomatites; 6 apogabbro propylites; 7 and 8 apogabbro beresites; 9 and 10 unweathered gabbro.

The relation of REE content in beresites to that of unaltered rocks allows identifying the areas of relative element input / loss. For example, the REE normalization to unaltered silty sandstone revealed (figure 2) the relative loss of all REE at horizon +254 meters, partial loss at horizon +288 meters and fixation of all elements at horizon +405 meters. Such a partial REE differentiation in an ore body may be governed by the gravitational factor, while insignificant concentration variations of lanthanides within different horizons indicate a rather significant process uprising, which, in its turn, formed the deposit ore bodies.

The lateral and vertical REE distribution in beresites was investigated within the Espinsk ore area. The investigation of lateral REE distribution patterns in Sevrero beresite veins (horizon +60 m) showed that the minimum element concentration was detected in fore-set of the metasomatic horizon, while maximum concentration was found in the back of the horizon, which proves the fact that REE input into beresites during the metasomatic process. Moreover, there is a regular concentration exchange of light, intermediate and heavy lanthanides, i.e. maximum concentrations are identified in the back zone, and the minimum concentrations in the fore-set zone. The ratio of light, intermediate and heavy lanthanides confirms the REE differentiation in the metasomatic horizon: fraction of maximal light lanthanides in the fore-set horizon, while heavy lanthanides - in the back. Such a REE distribution could be the result of only a potassium metasomatism [5].

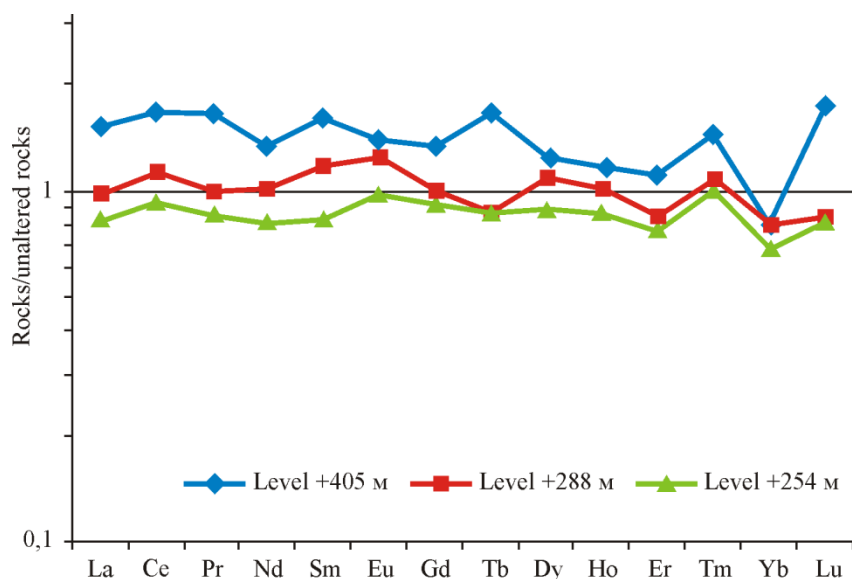


Figure 2. REE distribution in beresites of Bakyrchik deposit-9th ore body

The vertical REE distribution was investigated in beresites accompanying the Severo vein in three horizons: +60, +180 and +240 m. The investigation showed that the total REE concentration in beresites increased along the vein uprising. Furthermore, the concentration of light lanthanides in beresites uprises, while the content of intermediate and heavy elements slightly reduces. The ratio of total concentrations of light, intermediate and heavy rare-earth elements in beresites uprises in the veins, notably, while the most contrasting is the ratio of light and heavy lanthanides. The normalization of lanthanide concentrations to unaltered rocks showed that the lanthanides are fixated in all horizons.

The beresites in all studied ore areas have very close distribution parameters, which is probably conditioned by a uniform origin of fluids (figure 3)

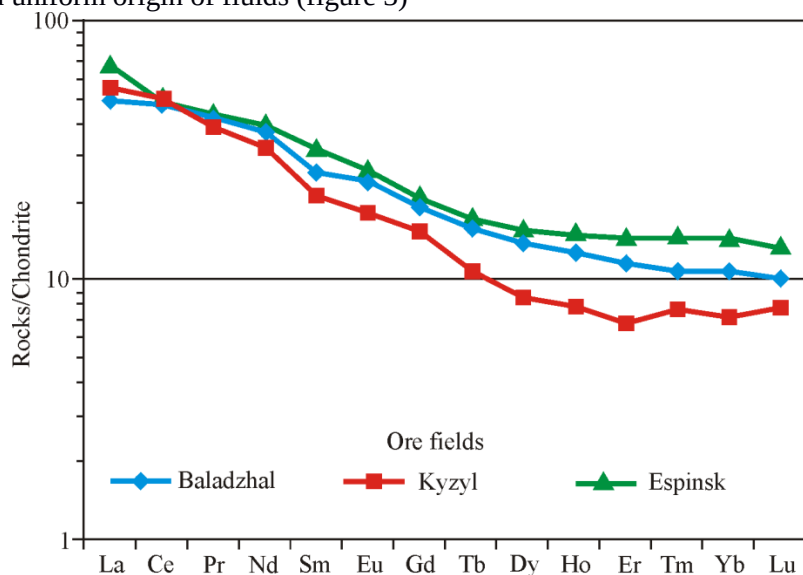


Figure 3. Distribution curves of average REE concentration in beresites of Baladzhai, Bakyrchik and Espinsk ore areas

The distribution pattern of noncoherent elements could be the uniform feature of hydrothermal fluid origin. Thus, the distribution pattern of Y, Zr, La, Sm and Nb in beresites within the studied targets is indicative of their uniform origin. The distribution of K and Rb could be correlated to the main magmatic trend [6], which with [7] could be regarded as indirect evidence of the fluid origin magmagenic of formed the beresites with associated gold mineralization.

Conclusions

1. All metasomatite types in Eastern Kazakhstan gold-ore areas were formed as a result of the redistribution of rare-earth element concentrations.
2. All metasomatite types are characterized by a uniform feature of REE distribution, i.e. the predominance of light lanthanides over intermediate and heavy lanthanides.
3. Near-vein lateral zoning is governed by the maximum fraction of light lanthanides in the fore-set of the metasomatic horizon, while heavy lanthanides are vividly observed in the back sections of the metasomatic horizon.
4. There is an axial distribution zoning for rare-earth elements within these deposits, i.e. maximal fraction of light lanthanides within the upper sections of ore bodies, and heavy lanthanides - in the bottom sections.
5. There are three types of lanthanide distribution in the beresites of the Eastern Kazakhstan gold -ore areas: 1) loss of all lanthanides at formation stage of impregnated ores; 2) redistribution in black-shale thicknesses at formation stage of vein-disseminated ores; 3) fixation in black-shale thicknesses at formation stage of vein bodies.
6. Beresites of investigated gold-ore areas have a uniform origin, whereas it is the magmagenic source that formed these fluids.

Acknowledgement

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References

- [1] Korobeynikov A and Maslennikov V 1994 Regularities of formation and location of noble metal deposits in black-shale rock masses of Northeastern Kazakhstan, Tomsk TSU p. 337
- [2] Ananyev Yu 2010 *Exploration and protection of mineral resources* **11** 3
- [3] Antonov Yu 2010 *Geology and protection of mineral resources* **35** (2) 15
- [4] Evensen N, Hamilton P and O'Nions R 1978 *Geochim. et Cosmochim. Acta* **42** (8) 1199
- [5] Balashov Yu 1976 *Geochemistry of rare-earth elements* Moscow Science p 267
- [6] Shaw D 1968 *Geochim. et Cosmochim. Acta* **32** (6) 573
- [7] Bortnikov N, Gamyagin G, Vikenteva O, Prokofev V, Alpatov V and Bakharev A *Geology of ore fields* **49** (2) 99