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GEOLOGY

Ore-Magmatic Systems with Noble Metals in the Northern Marginal Sector of the Argun Superterrane

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The Argun Superterrane [9] or Kerulen–Argun–Mamyn ensialic composite massif [4] represents the Lower Precambrian crystalline basement of the Amur geoblock (figure). The superterrane is characterized by the primary mantle–core heterogeneity, increased mobility, and intense tectonothermal reworking under the influence of multiple processes of destruction and granitization. These processes are probably related to the confinement of the terrane between two polycyclic fold–thrust systems (the South Mongol or Dasinanlin–Selemdzha system in the south and the Mongol–Okhotsk system in the north). The superterrane is separated from the Mongol–Okhotsk system by the Uldza, West Aginsk, East Aginsk, Prishilka, South Tukuringra, and other tectonic zones that are segments of the united marginal suture of the Late Proterozoic or probably an earlier time [4]. According to [9], the superterrane was separated from the southern margin of the Siberian continent in the post-Cambrian time as the result of dextral strike-slip faulting in the course of the opening of the Mongol–Okhotsk oceanic basin. Several gold deposits (Olimpiada, Sovetskoe, Zun-Kholba, Sukhoi Log, and others) have been discovered at the margin of the Siberian Platform [3, 8]. The Argun Superterrane is composed of lithostructural complexes of the ancient (Archean–Proterozoic) protolith and the deformed Phanerozoic (Cambrian–Carboniferous) sedimentary cover.

The Transbaikal and upper Amur regions are characterized by the development of large gold ore nodes and districts (Lyubava, Balei, Kara, and Gonzha), as well as smaller ore deposits and occurrences, in a relatively narrow (approximately 100 km wide) zone adjoining the Mongol–Okhotsk suture (figure). Their formation is related to the activity of magmatic systems that appeared in the Late Mesozoic under the influence of tectonomagmatic activation.

It is expedient to define essential elements of the respective ore-magmatic systems (OMS) in order to understand regularities in the distribution of noble metal deposits in the ore nodes and districts mentioned above. The Lyubava OMS is confined to the periphery of a large Precambrian salient mainly located in Mongolia. The northern framing of the salient incorporates the relatively isometric Kyra nidal-domal structure (NDS) with the Khamara–Tyra granitoid massif at the center [5]. The western and eastern boundaries of the NDS are defined by the Altan–Kyra–Byrtsa and Onon linear volcanotectonic depressions filled with Late Jurassic–Early Cretaceous effusive–pyroclastic and terrigenous sediments. According to Tauson et al. [10], volcanic rocks of the Early Cretaceous Byrtsa, Ulacha, and Doronino formations (basaltic andesites, trachybasalts, trachyandesites, xenoclastic lavas, and rhyolites) pertain to the latite series. Granitoids of the Khamara–Tyra massif and associated bodies in the Kyra NDS belong to the Early–Middle Jurassic Kyra intrusive complex that includes rocks of phase I (quartz diorites and granodiorites) and phase II (granites).

The Lyubava ore node, the best studied structure studied best in the Lyubava OMS, incorporates the Nikolaevka, Bol'shaya Fedorovka, Bayan-Zurga, and other deposits at the periphery and the Khaverga and Lyubava deposits at the center. The deposits are confined to a near-latitudinal deep fault expressed at the surface as an intensely fractured zone. The fault zone encloses the plate-shaped Kyra granitoid body and Late Jurassic minor intrusions, as well as dikes of andesites, diorite porphyres, spessartites, plagiogranite porphyres, granite porphyres, felsites, and quartz porphyres. The granitoid bodies include differently oriented auriferous veins among sandstones, siltstones, and shales of the Early Triassic Khapcheranga Group. The noble metal mineralization is divided into the feldspar–quartz (molybdenite–chalcopyrite–arsenopyrite, biotite–scheelite, and wolframite–albite–quartz associ-

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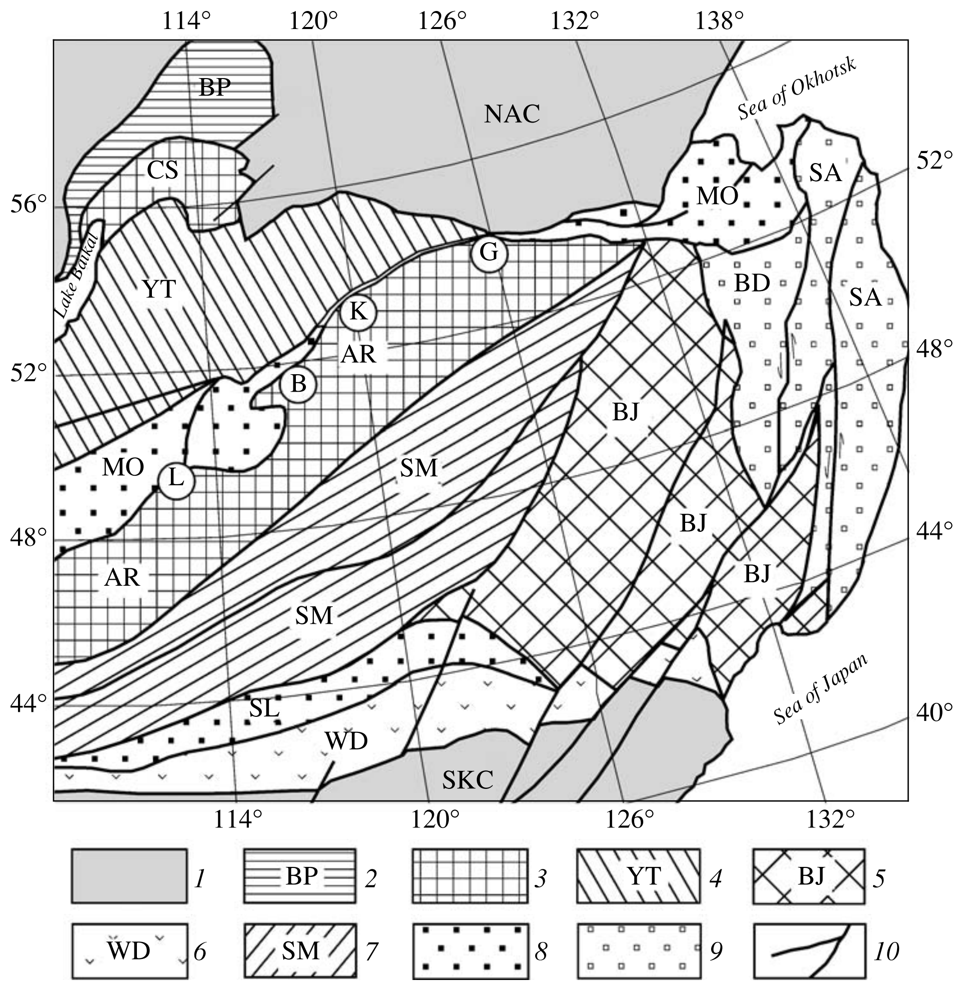

Location of noble metal nodes and districts in the marginal sector of the Argun Superterrane in the tectonic scheme of the Amur geoblock (modified after [4, 9]). (*1*) Cratons (ancient platforms): (NAC) North Asian, (SKC) Sino-Korean; (*2*) subsided margin of the craton: (BP) Baikal–Patom fold–thrust belt; (*3–9*) orogenic belts (superterranes) of different ages: (*3*) Late Riphean, (*4*) Late Precambrian–Early Ordovician, (*5*) Early Paleozoic, (*6*) Silurian, (*7*) Late Paleozoic, (*8*) Late Paleozoic–Early Mesozoic (*9*) Late Jurassic–Early Mesozoic; (*10*) faults. Superterranes: (AR) Argun, (CS) Circum-Siberian, (YT) Yenisei–Transbaikal, (BJ) Bureya–Janmusin, (WD) Wundurmiao, (SM) South Mongol, (MO) Mongol–Okhotsk, (SL) Solonker, (BD) Badzhal, (SA) Sikhote-Alin. Gold ore districts and nodes (letters in circles): (L) Lyubava, (B) Balei, (K) Kara, (G) Gonzha.

ations), tourmaline–quartz–sulfide (pyrite–arsenopyrite, quartz–base metal, and quartz–tourmaline associations), gold–quartz–chalcopyrite–boulangerite–bismuthite (productive association), quartz–sulfosalt–antimonite (antimonite, proustite, and pyrargyrite), and quartz–carbonate stages [12].

The major tectonic structure in the Balei gold ore district is represented by a large polychronous NDS known as the Borshchevochnyi swell [4]. The Borshchevochnyi swell and adjacent areas incorporate Late Riphean metamorphic rocks (crystalline schists, marbles, quartzites, and amphibolites) and different-age intrusive complexes that evolved in the Late Riphean, Paleozoic, and Middle–Late Jurassic. The Phanerozoic intrusive complexes accommodate occurrences of Au, Mo, W, Pb, Zn, Hg, and F. The north-northwestern and south-southeastern framings of the Borshchevochnyi swell incorporate Lower Cretaceous linear riftogenic depressions filled with terrigenous effusive–pyroclastic sediments that are overlapped by nonlithified Pliocene–Quaternary sediments in some places [5]. The Dain depression, which is located at the south-southeastern boundary of the Borshchevochnyi swell, is filled with volcanosedimentary rocks of the Late Jurassic Unda–Dain and Middle–Late Jurassic Shadoron groups. The depression also includes numerous sill- and stock-shaped bodies and variegated dikes that are comagmatic relative to volcanic rocks.

Gold mineralization in the Dain limb of the NDS is represented by the gold–scheelite–quartz (Kazakov), gold–rare metal (Sredniie- Golgotai and Andryushkino), gold–base metal (Sosnovka, Maisk, Kosachikha, and others), and gold–silver (Balei and Taseevka) deposits [1]. The northwestern limb of the NDS assigned to the

Shilka fault and Shilka depression includes ore occurrences of the Aprelevkovo–Peshkovo ore-placer node with manifestations of the porphyry gold–copper (Talovka–Zimov'e field) and stockwork gold–sulfide–quartz (Pogromnoe deposit) mineralization.

Geological positions of the Balei OMS and ore node are governed by the southwestern widest segment of the Borshchevochnyi swell, on the one hand, and the Balei depression (effusive–pyroclastic and terrigenous rocks of the Shadoron and Unda–Dain groups), on the other hand. The Balei ore node is marked by the greatest number of gold deposits of the vein, porphyry, and even skarn types. Tungsten and fluorite occurrences are also abundant. The gold–silver mineralization is concentrated in the depression and its northern flank [1] adjoining the Balei swell. In general, the distribution of noble metal mineralization in the ore district is controlled by deep faults developed near the boundaries of rigid Precambrian and Paleozoic rock blocks. Geophysical, in particular, gravimetric, data [6] provide insight into the deep structure of the OMS and tectonomagmatic constraints of mineralization therein. These data indicate that the Balei ore field is located at the center of a decompression zone that corresponds to a large long-lived magmatic source. The Balei ore node is underlain by a lopolith-type body of Middle–Late Jurassic granitoid massifs of the Borshchevochnyi and Amudzhikan–Shakhtama complexes. The lopolith center located beneath the Balei ore field represents a depression filled with polychronous, Late Riphean, and Paleozoic–Mesozoic (Ordovician–Jurassic) granitoids of the Borshchevochnyi NDS. The lopolith is approximately 40 km wide (based on the contour line of –2 mGal) and 4–5 km deep. The depression bottom/conduit boundary is located at a depth of 10–12 km from the present-day surface. According to this model, conduits for the transport of cryptovolcanic agents and circulation of ore-bearing fluids, which provided the formation of unique (in grade and scale) deposits, were located beneath the Balei depression bottom. This model is consistent with the mechanism proposed in [1].

In the Kara OMS, ore deposits are confined to the Ust'-Kara NDS at the northeastern edge of the Shilka arch [5]. In addition to multiphase granitoids (Amudzhikan–Shakhtama complex) of the Middle–Late Jurassic Kara–Chacha massif, Archean, Late Riphean, and probably Ordovician gneissic granodiorites are exposed in the Ust'-Kara NDS core. The Ust'-Kara NDS is surrounded by linear volcanotectonic depressions filled with effusive–pyroclastic rocks of the Middle–Late Jurassic Nyukzha Formation, Late Jurassic Unda–Dain Group, and Early Cretaceous Kuta terrigenous sequence. The northern NDS area with the Kara ore node is characterized by the abundance of Late Mesozoic magmatic rocks, subvolcanic bodies, various dikes, aureoles of metasomatism (feldspathization, propylitization, silicification, and so on), and numerous gold ore occurrences. The Kara–Chacha massif incorporates several phases of the intrusion of granitoid rocks that are sometimes considered facies varieties of a single rock complex. The rock complex includes megaphyric granites and granodiorites (phase III), porphyric and equigranular biotite–hornfels granodiorites (phase II), and quartz monzonites and diorites (phase I). Subvolcanic bodies and dikes of igneous rocks are developed in the Ust'-Kara ore node as diverse porphyry rocks, lamprophyres, and basaltic andesites. Many researchers believe that the molybdenum (Bogocha and Ivanovo ore occurrences) and gold (Dmitrievsk, Pil'nensk, Sul'fidnoe, and Amurskaya Daika) mineralizations are genetically associated with the dike series. The mineralization is concentrated in veins, vein-stringer and stringer-disseminated zones, and stockwork lodes. They formed at the quartz–tourmaline–sulfide (quartz–tourmaline–pyrite association), quartz–actinolite–magnetite–rare metal (actinolite–hematite–magnetite, quartz–scheelite, gold–tetradymite–bismuthinite association), quartz–sulfide (pyrite–chalcopyrite and quartz–arsenopyrite associations), and quartz–carbonate–base metal stages. The southwestern Ushumun gold deposit is also characterized by multiphase mineralizations (pyrite–pyrrhotite, quartz–molybdenite, quartz–bismuthinite–telluride, quartz–tourmaline–sulfide, and zeolite–fluorite–quartz–carbonate associations). Many of these associations are typical of the Srednii Golgotai and Andryushkino deposits in the Balei ore node.

Geological positions of gold deposits in the Gonzha ore district [2] are governed by their confinement to the Late Mesozoic volcanoplutonic framing of the Precambrian Gonzha swell. The ore district and swell make up a large (100 × 130 km), relatively isometric NDS outlined by the regional gravity minimum. The Gonzha swell is a long-lived (400–500 Ma) intrusive dome with a granite core. The dome arch shows a thin (<1 km) relict of ancient crystalline complexes. The deep fabric of the NDS is characterized by decompression that reaches a maximum at a depth of 20–30 km. According to the DSS data, the decompression interval corresponds to the "seismic transparency" zone that intrudes the upper mantle [7]. The metamorphic framing of the Gonzha swell includes exposures of granitoid massifs of the Late Jurassic–Early Cretaceous Magdagacha, Early Cretaceous Verkhneamursk, and Early Cretaceous Burinda complexes. The outer and inner contact zones of granitoid intrusions are well outlined by gravity anomalies. Junctions of the contact zones with the subvolcanic and extrusive-effusive rocks of local volcanoplutonic depressions are marked by aureoles of different types of metasomatism (feldspathization, tourmalinization, propylitization, silicification, and argillization). The metasomatic rocks incorporate nearly all gold deposits (Pioner, Pokrov, Borgulikan, Burinda, and others) and largest gold ore occurrences assigned to the gold–silver, gold–quart, gold–rare metal, porphyry gold–copper, and other types of mineralization. Occurrences of molybdenum, copper, and base metals are also known in the study region.

Data presented above demonstrate that ore-magmatic systems with noble metals at the Argun Superterrane margin are characterized by the following common features: assignment to the periphery of large salients of the crystalline basement; confinement to the long-lived NDS that are defined in geophysical fields; and confinement to junctions of subvolcanic granitoid bodies with Late Mesozoic volcanotectonic depressions. Members of the NDS demonstrate similar patterns of metasomatic alterations and comparable assemblages of ore-bearing mineral associations. This fact makes it possible to consider the characteristics of noble metal nodes as an essential prospecting guide that can be used to outline sectors for the revision and exploration in insufficiently studied ore-placer districts.

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