Volcanic Belts and Gold-Silver Epithermal Deposits of Northeast Russia

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Abstract: Gold–silver mineralization in Northeast Asia is controlled by 9-th volcanic belts of different ages that are superimposed on cratonic, passive continental-margin, island-arc, and oceanic terranes. The brief overview of volcanic belts in Northeast Asia presented in this communication shows that the mineralogy of the epithermal gold-silver deposits in these belts depends on the metallogeny and composition of rocks in structures of the basement and, probably, the Precambrian basement

Keywords: volcanic belts, gold, silver, deposits, genetic features

1 Introduction

Gold-silver mineralization in Northeast Asia is controlled by volcanic belts of different ages that are superimposed on cratonic, passive continental-margin, island-arc, and oceanic terranes (Fig. 1). According to the concept of accretion tectonics, the study region represented a dynamically evolving active Mesozoic-Cenozoic continental margin. This is reflected in eight NW- to SW-oriented postaccretionary volcanic belts. Among them, six were developed parallel to the present-day position of the Kuril-Kamchatka deep-water trench (Fig. 1). These are the Late Jurassic-Early Cretaceous Uda-Murgal (UMVB), Late Cretaceous-Paleogene Okhotsk-Chukot (OCVB), Late Cretaceous-Paleogene East Sikhote-Alin (ESVB), Eocene-Oligocene Koryak-West Kamchatka (KWKVB), Oligocene-Quaternary Central Kamchatka (CKVB), and Pliocene-Quaternary East Kamchatka (EKVB) belts.The Uyanda-Yasachen (UYaVB) and Oloi (OVB) belts developed parallel to the northern continental margin in Jurassic times. The successive post Early Cretaceous rejuvenation of volcanic belts corresponded to the shift of the volcanic arc-trench system toward the Pacific Ocean. In addition to the volcanic belts mentioned above, the pre-accretionary

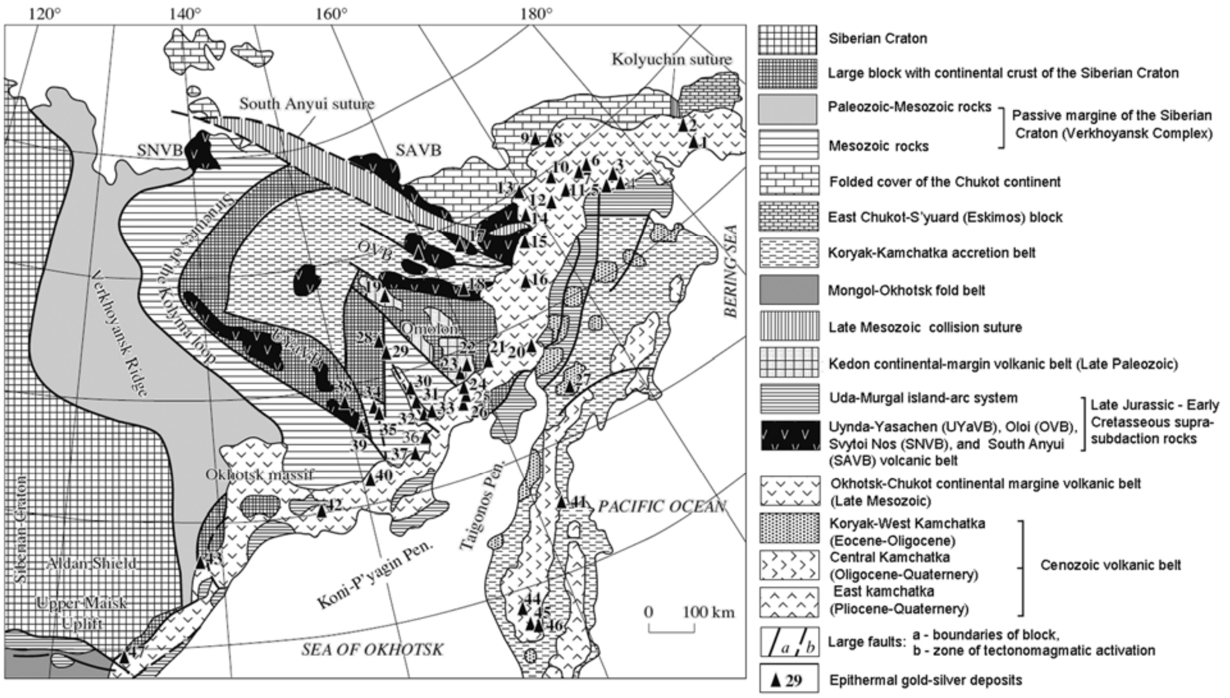

Figure 1. Volcanic belts and gold-silver deposits in Northeast Russia. Tectonic scheme is modified after (Sokolov et al., 1999). (1) Pepenveem, (2) Korrida, (3) Valunistoe, (4) Tenkerei, (5) Zhil'noe, (6) Televeem, (7) Proval'nye Ozera, (8) Sopka Rudnaya, (9) Promezhutochnoe, (10) Enmyvaam, (11) Arykvaam, (12) Kaenmyvaam, (13) Dvoynoy, (14) Kupol, (15) Gornostaevy, (16) Irguny, (17) Klen, (18) Vesenny, (19) Ol'cha, (20) Sergeev, (21) Kegali, (22) Birkachan, (23) Kubaka, (24-26) Evensk group: (24) Oroch, (25) Irbychan, (26) Sopka Kvartsevaya, (27) Ametist, (28) Rogovik, (29) Gromada, (30) Lunnoe, (31) Arylakh, (32) Dukat, (33) Gol'tsovy, (34) Pechal'noe, (35) Vetvisty, (36) Dzhul'eta, (37) Nyavlenga, (38) Kunarev, (39) Shirokoe, (40) Karamken, (41) Ozernov, (42) Burgagylkan, (43) Khakanzha, (44) Aginsk, (45) Baran'ev, (46) Ogancha, (47) Avlayakan.

Late Paleozoic Kedon marginal volcanic belt (KVB) is also known in the Omolon cratonic terrane (Fig.1).

The volcanic belts and auxiliary perivolcanic zones of tectonomagmatic activity in the study region together form one of the world's largest metallogenic provinces with polychronous and compositionally diverse volcanoplutonic associated mineralization.

2 Geology and Metallogeny of the Volcanic Belts

The Kedon marginal volcanic belt formed on the continental crust in the Middle Paleozoic during a period of 30-35 Ma (Egorov and Sherstobitov, 2000). Relicts of this volcanic belt are retained as fragments in the Omolon cratonic terraine. The belt is composed of differentiated subaerial red-colored volcanic rocks coupled with compositionally similar subvolcanic and hypabyssal intrusions. The volcanic rocks belong to the calc-alkaline series. There are two types of epithermal volcanic mineralization in the Kedon volcanic belt. Gold mineralization (Au/Ag=1:1-1:5) is developed in the Kubaka, Birkachan, and Elochka deposits. Whereas the gold-silver mineralization (Au/Ag=1:10-1:50) is developed in the Sedoi, Yunyi and Ol'cha deposits. The large Kubaka and Birkachan deposits are characterized by a low content of sulfides (<0.1 and 0.1-0.5%, respectively). The ores are mainly composed of gold, electrum, and pyrite. The predominance of pyrite and hematite in the ore suggests that the mineralization can be assigned to the ore complex of Precambrian ferruginous quartzites and amphibolites (Sidorov, 1987) that are widespread in the basement of the Kedon volcanic belt (Fig. 2).

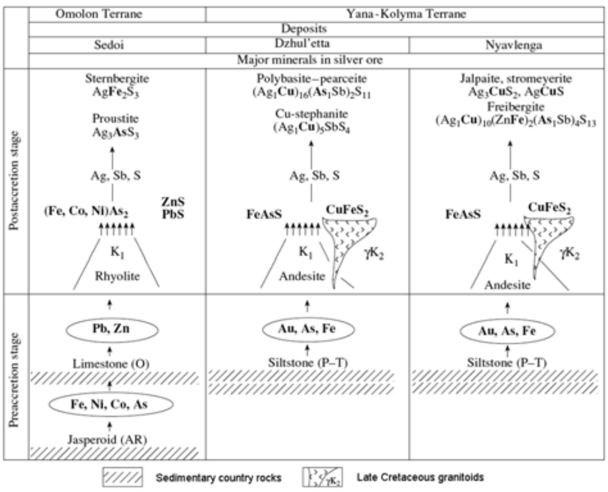

Figure 2. Mobilization and redistribution of material in rocks lying at the base of volcanic structures.

The Uyanda-Yasachen volcanic belt, was mainly formed a NW-oriented series of conjugated Late Jurassic-Neocomian grabens (Fig.1). The structures of this belt are superimposed on continental uplifts (Kolyma and Omulev). In the first case, sediments were accumulated in marine conditions. In the second case, the initial subaqueous sedimentation gave way to the subaerial setting at the final stage. Metallogenic specialization of the Uyanda-Yasachen volcanic belt can be related to the development of carbonate-rich stratiform base metal deposits in the Paleozoic basement (Shpikerman, 1998). Faults zones developed as auxiliary elements of the Uyanda-Yasachen belt in the western Verkhoyansk region incorporate large epithermal silver-base metal deposits (Prognoz and Mangazei) and numerous gold-silver occurrences of the N'yutak district (Konstantinov et al., 2003).

The Oloi volcanic belt is controlled by an Early Cretaceous island-arc system sandwiched between the South Anyui and Omolon terranes (Fig. 1). The NW-oriented Oloi belt extends over more than 600 km and reaches the Svyatoi Nos Cape. Its width is as great as 200 km in the central sector. Numerous porphyry Cu-Mo and epithermal gold-silver deposits in this belt are related to magmatism of the paleoisland arc. Based on the geological setting and isotope data, the mineralization is attributed to the terminal Late Jurassic (Shpikerman, 1998). The Oloi belt is characterized by an abundance of sulfides, hematite, and minerals of Co and Pt, probably owing to the ophiolitic composition of the substrate and the presence of fragments of the Precambrian crust with ferruginous quartzites (Volkov et al., 2006).

The Uda-Murgal volcanic belt represents the basement of the Okhotsk sector of the OCVB. This belt is controlled by the continental margin and boundaries of the Okhotsk paleoisland arc (Parfenov, 1984). The paleoisland arc is exposed on basins of the Uda River, the Koni-P'yangin and Taigonos peninsulas, and basins of the Penzhina and Anadyr rivers (Fig. 1). The field of epithermal Au-Ag and porphyry Cu-Mo deposits coincides with the front of the OCVB superimposed upon the terrigenous-volcanic complex of the continental-margin arc.

The Okhotsk-Chukot volcanic belt formed over 25 Ma (middle Albian-Cenomanian) (Belyi, 1994) at the boundary between the continental Verkhoyansk-Chukot and Koryak-Kamchatka terranes (Fig.1). This giant belt is 3000 km long is composed of subaerial volcanic rocks. Relative to the oceanic margin, the Okhotsk-Chukot belt is divided into the inner, outer, and perivolcanic zones. The intricate structure of terranes of the basement and the Okhotsk-Chukot belt produced a diversity of epithermal deposit types. The inner zone of the belt mainly accommodates porphyry Cu-Mo deposits. The outer and perivolcanic zones include gold-silver and silver-tin ore deposits. The gold-silver subtype is more widespread in the outer zone (Karamken, Valunisty, Kupol, and Dvoinoi). Deposits of the silver subtype (Dukat, Lunnyi, Arylakh, Golcovy and others) are confined to the volcanic rift located between the Yana-Kolyma and Omolon terranes of the Okhotsk-Chukot belt (Fig. 1).

The Koryak-West Kamchatka volcanic belt extends along the western coast of the Kamchatka Peninsula and walls of the Penzhina depression (Fig. 1). The volcanic sequence is 3500 m thick (Petrenko, 1999). The northern part includes the Ichigin-Uineivayam ore district with the large Ametist deposit and numerous gold-silver and tin occurrences associated with paleovolcanic edifices of the andesite-dacite-rhyolite formation.

The Paleogene Central Kamchatka volcanic belt is controlled by the Main Kamchatka deep fault zone over nearly 1800 km (Fig. 1). In contrast to the volcanic belts described above, the Central Kamchatka belt is dominated by andesites and basaltic andesites. This feature reflects the presence of a mafic basement in the belt and governs the metallogenic specialization of the Central Kamchatka belt - absence of tin and silver occurrences and abundance of near-surface gold-silver-telluride mineralization.

The East Kamchatka volcanic belt adjoins the present-day Kuril-Kamchatka trench and extends parallel to the southeastern coast of Kamchatka from its southern tip to the Aleut island-arc (Fig. 1). The belt was initiated in Pliocene time and active volcanism is continues to the present day. This belt contains the Kumroch gold-silver deposit.

In addition to the volcanic belts mentioned above, some tectonomagmatic zones branching off from volcanic depressions of the OCVB also contain the epithermal gold-silver deposits. In the Khurchan-Orotukan zone, the epithermal Pechal'noe (Au-Ag) and Vetvistoe (Ag-base metal) deposits occur in Jurassic terrigenous sequences beneath remnants of Late Cretaceous volcanic rocks.

3 Discussion

Figure 1 shows that volcanic belts of different ages are juxtaposed in some districts. For example, a significant part of the Okhotsk-Chukot belt overlaps the Uda-Murgal belt. Volcanic depressions of the former belt and auxiliary tectonomagmatic activation zones are also superimposed upon the Kedon volcanic belt. These districts include several multistage gold-silver deposits (Dzhul'eta, Nyavlenga, and others). The Kubaka and Birkachan deposits include Paleozoic and Mesozoic gold-silver mineralizations. However, the metallogeny of the majority of such ore districts is poorly studied.

Even the brief overview of volcanic belts in Northeast Asia presented in this communication shows that the mineralogy of the epithermal gold-silver deposits in these belts depends on the metallogeny and composition of rocks in structures of the basement and, probably, the Precambrian basement (Fig. 2).

The porphyry Cu-Mo and massive sulfide ore districts, as well as regional zones of disseminated sulfides, include deposits of gold-silver and silver subtypes. Basic-ultrabasic rock complexes host deposits of the gold-silver-telluride subtype; ferruginous quartzites incorporate deposits of the gold subtype; and tin ore districts include the gold-silver deposits (Sidorov and Volkov, 2004).

The epithermal Au-Ag and Ag-bearing base-metal deposits are localized in the young volcanic structures. Furthermore, it was established that the model isotopic age of lead in galena from the Mesozoic deposits corresponds to the age of the basement: that is Ordovician at the Sedoi occurrence and the Neoproterozoic in the Pravaya Vizual'naya area (Shpikerman, 1998).

4 Conclusion

The volcanic belts and zones described in the present paper are poorly studied. Therefore, not only small and medium bonanza deposits, but also large epithermal gold-silver deposits may be discovered in Northeast Russia, as shown by the recent discovery of the large Kupol and Svetly deposits.

The potential for epithermal stockwork mineralization, which can be developed by the method of open pit mining and heap leaching, deserves attention in the study region.

Acknowledgements

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