Distribution and Regularities of Placing Clinic Raw Material in the Far East of Russia

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Abstract. Shows the distribution and patterns of placement of gemstone raw materials deposits of Primorsky Krai. Mineragenic zoning of the territory was carried out. The taxonomic units of different hierarchical levels are taken as the basis. The province is taken as the largest unit. The selected Far Eastern province includes the Sikhote-Alin sub-province and the Primorsk region, including the Upper-Bureya, Upper-Anyuy, Bikin, Dalnerechenskaya, Ussuri and Coastal mineragenic zones. The characteristic of ore regions with known deposits and promising manifestations of noble opal, sapphire, zircon, chrysolite, agate and garnet, which constitute the mineral and raw material base of colored stones of the Russian Federation, is given.

1. Introduction
On the territory of the Russian Federation (RF), many jewelry, jewelry and ornamental stones are known [1], but they are placed extremely unevenly: the leading place is occupied by the Urals, Eastern and Southern Siberia, and the Far East [2]. Over the years, the systematization of deposits was carried out, the patterns of their location were studied, and individual stone-colored regions were distinguished. For the period from 1965 to 2004, the territory of the Russian Federation was divided into a series of gemstone taxa [3, 4, 5]. The tectonic, formational and other features are the basis of the layouts. However, it was not without drawbacks: regional and local levels of mineralization of colored stones were often mixed, the basic metallogenic principles of zoning were not taken into account. In addition, due to the reduction of funding for geological exploration, many facilities were closed, research was not completed.

2. Purpose of the study
The purpose of our research was to conduct mineragenic zoning of the territory of the Russian Federation on colored stones on the principles of metallogenic analysis laid down by Yu. A. Bilibin, V. M. Crater et al. And in view of the above. This allows you to assess the resource potential of the regions for further exploration. When performing zoning, taxonomic units of different hierarchical levels are taken as the basis. The province is taken as the largest subdivision of objects of gemstone flowers, followed by a subprovince (region), mineragenic zone, ore region, ore field [6].

As a result of mineragenic zoning, we identified 9 stone-colored provinces [7, 8]: Eastern European, Caucasian, Timan-Ural, Eastern Siberian, South Siberian, Mongol-Okhotsk, Far Eastern, North-Eastern, Kamchatka-Sakhalin. They consist of 23 sub-provinces and stone-colored areas:
Karelo-Kola, Voronezh, Baltic-Dnieper, North-Caucasian, Timan, North-Ural, Middle-Ural, South-Ural, Taimyr, Olenek-Anabar, Mid-Siberian, Aldan-Ural Stanovaya, Yeniseysko-Altau, Sayan, Baikal, Mongolo-Okhotsk, Hanka-Bureya, Sikkote-Alinskaya, Primorskaya, Kolymo-Indigirskaya, Verkhoyano-Adychansk, Koryak-Kamchatka, Sakhalin[9,10].

In mineragenic terms, the administrative Far Eastern Federal District includes the East Siberian, Mongolo-Okhotsk, Northeastern, Kamchatka-Sakhalin and Far Eastern stone-colored provinces. In this article we will look at the latter. The primary task of the work performed should be considered the refinement of the mineragenic zoning scheme of the Far Eastern region, developed in the early 1980s, and in subsequent additions that did not receive proper development.

3. Research results and discussion
The Far Eastern stone-colored province located in the southern part of the Russian Far East, has a pronounced linear shape, elongated in the northeast direction, geographically coinciding with the Sikhote-Alin ridge. Administratively, it is located in the Primorsky and Khabarovsk Territories. Geologically, the province is confined to the Sikhote-Alin folded system of the Amur folded region of Mesozoic age. The province has known manifestations and deposits of many colored stones, including beryl, topaz, rhodonite, jasper, agate, chrysolite, sapphire, zircon, andradite.

The structure of the Far Eastern province includes the Sikhote-Alin sub-province and the Primorsk seaside stone region. The first one includes the Upper Burea, Upper Anyui, Bikin, Dalnerechensk and Ussuri mineragenic zones; Primorsky region — Coastal mineragenic zone (Table 1).

Table 1. Mineragenic zoning of the Far Eastern province.

| Sub-province, region | Mineragenic zone | Ore district | Basic colored stones | Natal place |
|----------------------|------------------|--------------|----------------------|-------------|
| Sikhote-Alinskaya    | Verkhne-Bureinskaya | Etmatinsky   | Beryl, Topaz         | Etmata, Merekskoe (beryl), Hunho (topaz) |
|                      | Verkhne-Anyuiskaya | East Amur    | Rhodonite, beryl, jasper, chrysolite | Anyuiskoye (beryl) |
|                      |                   | Sovgavan-Terney |                        | Vostretsovskoe, Snail, Podgelbanochnoe (chrysolite) |
| Bikin                | Rainbow Alchansky | Noble opal, carnelian, agate, chrysolite, amethyst | Rainbow (noble opal), marching, burnt, noisy etc. (agate) |
|                      | Nezametinskyy Festival | Saphire, zircon, Rhodonite, agate reflux | Imperceptible (saphire, zircon), Festival (rhodonite), Key Four (agate-reflux) |
| Dalnerechenskaya     | Ussuri, Sinerechensky | Amethyst, garnet andradite | Sinerechenskoye (andradite) |
|                      | Coastal           | Marble onyx, danburite, chrysolite | Dalnegorsk (danburite, skarn) Malaza (noble opal) |
Sikhote-Alin subprovince occupies the western slope of the Sikhote-Alin range, stretching from the submeridional direction from the southern Primorye (near the town of Nahodka) to the mouth of the Amur River in the north of the Khabarovsky Territory.

Verkhne-Bureinskaia mineragenic zone is located in the eastern spurs of the Bureinsky Range, in the upper reaches of the Ussuri River. The zone includes the Etmatinisky ore region with the Mereksky, the Pravo-Bureinsky and the Etmatinisky manifestations of beryl and the manifestations of the Tofoho of Hoonho. Etmatinisky beryl manifestation is associated with microcline beryl-topaz translucent granite pegmatites. Hunho topaz manifestation — with apogranite quartz-topaz-muscovite greisens with topaz.

Upper-Anyuiisk mineragenic zone is located in the northern part of Sikhote-Alin. The zone includes the East Amur and Sovgavan-Terneisky ore regions. On the area of the East Amur ore region, elongated in a submeridional direction from the Kabuli River (tributary, Khor) in the south to the middle course of the river. Tummin in the north, are manifestations of rhodonite, beryl, jasper. Among them, rhodonite is of primary importance. Sovgavan-Terneisky ore district, located on the headwaters of the Samarga River in the south to the outskirts of Sovetskaya Gavan, specialized in chrysolite. Within the ore region, there are three manifestations (Vostretsovskoye, Ulitka (Kultukha) and Podgelbanhoe), in which more than half of the predicted resources of chrysolite of the Far Eastern Province and 2% of all-Russian are concentrated. Chrysolite mineralization is genetically associated with manifestations of basic magmatism, confined to subalkaline nodule-containing basalts and eruptive breccias. In the future, these manifestations may have industrial significance.

Bikin mineragenic zone also extended in a submeridional direction. Located on the western slope of the Sikhote-Alin, stretching from the Ussuri River in the south to the Choir River in the north. The zone includes the Raduzhny and Alchansky ore districts. The zone is specialized in noble opal, carnelian, agate, chrysolite. Amethyst of Bikin manifestation and corundum are of secondary importance. The main color stone is noble opal from the Raduzhnye deposit. Raduzhny field is located in the upper Alchan River,opal is contained in the andesite-basalts of the Upper Cretaceous, which filled the tectonic depression. The deposit belongs to the hydrothermal (postvolcanic) genetic class associated with the areas of the young Meso-Cenozoic volcanism. It is represented by mineralized fracture zones in effusive and tuffs of primary and secondary compositions. Noble opal is similar to Mexican fire opal.

In Primorye, there are about 20 occurrences of agate, chalcedony, carnelian. In Alchansky ore district, agate is found in almost all tributaries of the upstream. Alchan. Agate-chalcedonic mineralization of the Agate marching deposits, Noisy, Deevskoye and Goreloye is associated with Late Cretaceous andesite-basalt. Agates in most cases are found in almond-stone lavas of the main composition. Agates of the Noisy and Goreloye deposits are contained in the crushing zones of lavas mainly of medium composition. The most valuable are eluvial and deluvial placers of all types of agate-chalcedonic raw materials. Examples of this type are the Goreloye and Pokhodnoye deposits.

The color of agate is light brown, blueish-gray, brown etc.

Dalnerechensk mineragenic zone occupies a significant territory in Sikhote-Alin. It extends from the headwaters of the Ussuri River in the south to the middle reaches of the Bikin in the north. The zone includes the Nezamatinsky and festival ore regions. In the area of the zone there are deposits and manifestations of sapphire, zircon, agate-refloating, rhodonite, jasper, collection garnet — andradite. Sapphire and zircon of the Nezamatinsky complex zircon-sapphire-gold-bearing deposit are of primary importance. The Nezamatinsky ore region is located in the basin of the Kedrovka and the Black River (streams Unnoticeable, Rocky, Animal). Administratively — in Krasnoarmeysk district of Primorsky Krai.

The Nezamatinskoe gold deposit was discovered in the early 1930s. During its operation in the Kedrovka River basin, corundums and zircons of gem quality were installed. According to the Federal State Unitary Enterprise "Centerkvarts" [4], single diamonds were also found within the ore field. At the present time, it is a primary and placer gold deposit with noble corundum and zircon [11, 12, 13]. The Kedrovka placer is confined to mid-Upper Quaternary deposits. The total length of the industrial
part is 5.5 km, the width is up to 500–500 m. The alluvium thickness is on average 14 m. Sapphire and zircon are concentrated together with gold in the part of the sandy-pebble sediments. Carpentry — sandstones and aleurite-clay shales of Middle Upper Paleozoic age.

Corundum — rounded crystals and their fragments ranging in size from 2–5 mm to 30 mm (5–7 mm prevail). The color is purple-blue, grayish blue, blue, blue, greenish blue, blue-green, green, yellowish-green, grayish-green, purple, brown, greenish-brown, pearl gray. The color is often zonal, spotted. There are transparent, translucent and opaque [14]. Nezametinskoe corundum deposit belongs to the magmatic class. Alluvial corundums are genetically related to granitoids of Mesozoic age [15]. The estimated resources of sapphire in category P1 + P2 are 20,400 thousand carats [16].

In the Festival Ore Region, the main importance belongs to the rhodonite of the same-name deposit, which is localized in the metamorphosed manganese-silicate deposits among the quartzite — and jasper-green-shale strata. Rhodonite light pink color with a purple tinge and black dendritic pattern. Ore bodies form lizovoobraznye separation, veins and nests.

The agate overflow deposit, The Fourth Key is localized in the endocontact by granite intrusion of late cretaceous age with tuff sandstones of the lower cretaceous. Agate-contained in quartz-agatone-bearing veins in granites and granite-gneisses.

**Ussuri mineragenic zone** is located in the southwestern and western parts of the subprovince, stretching along a narrow strip along the Blue Range and along the Ussuri River from Vladivostok to Dalnegorsk. The zone includes Sinerechensky and Ussuri ore districts. Amethyst, agate, carnelian, beryl, tourmaline, corundum, petrified wood, and garnet-andradite are known here.

The Sinerechensky ore region is located on the western slope of the Sikhote-Alin range, in the middle reaches of the Blue Key, a right tributary of the Pavlovka River [17]. Primary importance belongs to Andradite. The ore region is represented by the Blue River with Zakharovskoye, Nadezhdinskoye, Kavalerovskoye, Sinerechenskoye and other manifestations. Garnet skarns occur in the form of veins with bulges and pinchings. There are numerous cavities up to 1 m³ in volume, with pomegranate druses on the walls and quartz between them. In large cavities, in addition to well-formed small crystals of rock crystal, amethyst is contained. The origin of the tectono-karst cavities. The mineral composition of ore bodies varies from substantially garnet to actinolite-garnet with epidote and magnetite. Among the minerals, garnet-gross-andradite and andratis garnet predominates. The size of crystals is from 1 to 6 cm. The color of pomegranate is greenish-brown, brown, yellowish; less often black and red. In the bulge veins, garnet composes monomineral accumulations (lenses) up to 40–50 m long, with a power of 5–7 m. Andradite is contained in the form of aggregates and forms druses with a base area from 3 cm² to 1.5 m². The crystals reach 5×5 cm. Stocks of collection raw materials are 15 tons in category C2.

**Primorsky stone gem area** is located on the eastern slope of Sikhote-Alin, along the coast of the Sea of Japan. From the Sikhote-Alin sub-province, it is separated by the Central Sikhote-Alin fault, which the Sikhote-Alin megazon is divided into West Sikhote-Alin, East Sikhote-Alin and Coastal tectonic zones [18, 19].

**Coastal mineragenic zone** extends from the suburbs of Partizansk in the south to n. Terney in the north. It is the eastern part of the East Sikhote-Alin tectonic zone. Its peculiarity is the outcrops of the Paleozoic and Lower Mesozoic complexes from under the formations of the volcanic belt. The zone is specialized in marble onyx, danburite, chrysolite. Of minor importance are rhodonite, agate, petrified wood, obsidian, chaledony and opal. The zone includes Dalnegorsky and South-Primorsky ore regions.

Dalnegorsky ore region with the same borosilicate deposit is located in the basin of the Ore River (Tetyukhe. Ore district has an area of about 70 km², includes a number of polymetallic deposits (Nikolaevskoe, Second Soviet, Partizanske, Svetly branch, Malyshevskoe, Smirnovskoe and others.) Two hundred different minerals. The main ore minerals are sphalerite, galena, stannite, cassiterite. Among the minerals there is danburite suitable for cutting, which is contained in association with quartz and andradite. Gemstone raw materials, except for danburite, belong to the hedenbergite-wollastonite skarn, which for unusual textures can be called a unique ornamental stone. The total
thickness of the skarns from the Dalnegorsk deposit exceeds 500 m. Endogenous manifestations of agate are associated with Pliocene formations of the andesite-basal formation.

In the South Primorsky ore region there are the Sergeevskoe manifestation of agate and the manifestations of the noble opal Malaza, confined to the dacitoliparite formation of late Cretaceous age. Agates are localized in the rhyolite integument, where the inner part of spherulites is performed. Color is white, yellow, bluish-gray etc.

4. Conclusion
Currently, the Far Eastern Province is one of the most promising gem-colored provinces of Russia. The industrial significance of a province is determined by the location within its borders of deposits and promising manifestations of noble opal, sapphire, zircon, chrysolite, agate and garnet. The province contains the only deposits of noble opal Raduzhnoe and jewellery sapphire in Russia — Nezametninskoe. The latter concentrates significant resources of the country's sapphires. The province has a fairly high potential of beryl and topaz. There are prospects for increasing the mineral resource base of semi-precious stones and collection minerals, particularly, due to numerous ore objects with collection mineralogical material of museum level, including galena, sphalerite, calcite, danburite, hedenbergite-wollastonite skarn etc. A positive factor is the location of the province in the economically developed part of the Far Eastern region with favorable geographical conditions. Prospects for the province are significantly enhanced by the discovery of single diamond grains within the Nezametninsky ore district. Further study and development of the province will contribute to the development of the productive forces of the southern part of the Far Eastern region.

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