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Placer Minerals of the Russian Arctic Shelf.

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THEME 10: Metallogenetic Provinces in the Circum-Arctic Region

Summary: Placer concentrations of tin, gold, diamonds, amber and other minerals form an important part in the mineral resource potential of the Russian Arctic shelves. These concentrations occur within the nine major zones which include 20 smaller regions differing in the type of placer minerals. Of primary interest are the gold and tin placers. More than 30 gold placers have been discovered at the Bol'shevik Island (Severnaya Zemlya) and on the northern Taymyr Peninsula. Placer concentrations of tin minerals are traced from the Malyi and Bol'shoi Lyakhov Islands (New Siberian Islands) to the mainland. The Lyakhov region is unique in the scope of tin resources; 13 placers of cassiterite were reported both from onshore and offshore.

The East Siberian-Chukchi bimetal zone includes the major Chaun tin-bearing region and the Val'karai region is known for a combination of tin placers in the Cape Billings area and a unique placer gold occurrence at Ryveem.

Placer concentrations of titanium, iron and rare earth elements, as well as placer shows of diamonds occur around the periphery of the White and Barents Seas.

The coastal areas of West and East Siberia are considered to be prospective in respect of amber placers; in some areas there are significant accumulations of fossil ivory.

The Cenozoic paleoenvironments on the Arctic continental margin were on the whole quite favorable for the formation and conservation of sizable placer concentrations of valuable minerals. Long duration (since Eocene to Recent) and low sedimentation rates along with relatively stable tectonic environments, multiple alternations of transgressive and regressive cycles facilitated the formation of major and unique placers with polygenetic productive horizons.

VNIIOkeangeologia has developed and currently operates the data base which contains characteristics of 500 placer concentrations located in the Arctic; they are classified according to their dimension and mineralogy.

GENERAL DESCRIPTION AND REGIONAL DISTRIBUTION

The shelves of the Arctic seas within the Russian Federation extend from the Kola to the Chukchi Peninsula for a distance of more than 8000 km. The geology of the margins represents the alternation of ancient pre-Cambrian massifs with Paleozoic-Mesozoic fold and activation zones with vast gentle depressions (littoral lowlands) involving Mesozoic-Cenozoic sedimentary complexes. The latter form offshore a thick cover within marginal-continental basins. Different mineral resources; coal, oil, gas and condensate, phosphorites are accumulated in the sedimentary cover, with placers of different minerals in its upper part.

Minerogenic zoning has allowed, as applied to placers, to discern several taxonomic units. A large unit, a *placer zone,* is linear or ring-wise in plan with the area of several ten thousands km^2. *Placer areas* involved in the zone are slightly elongated (or close to isometric) with an area of several thousands of km^2 (locally up to 10000-15000 km^2). Local units, *placer clusters* (100-1000 km^2, locally up to 2000-3000 km^2), contain certain placers or, more often, their groups. Smaller areas of placer mineralization located within the areas and zones present a poorly studied unit. Placer clusters and smaller areas are monomineralic, while placer areas can be either monomineralic or containing two or three kinds of minerals.

Principles and procedures of minerogenic zoning of shelf areas were developed, in case of placers, in the All Russia Research Institute for Geology and Mineral Resources of the World Ocean (VNIIOkeangeologia; 1980-1985) as a basis for compiling different-scale maps, estimating mineral resources and developing data base.

Nine placer zones with different minerals are located along the shelf zone of the Russian Arctic (Fig.1). These zones are: Severnaya Zemlya and Kara gold-bearing, East Laptev tin-bearing, East Siberian-Chukchi and Chukchi-Anadyr bimetal (tin and gold), South Laptev gold- and diamond-bearing, and three zones in the western sector of the Arctic, specialized for diamonds, minerals of titanium, iron, zirconium and rare earth elements (IVANOVA et al. 1998). Of primary interest are the gold and tin placers.

Gold placers

Along the shoreline of the Taimyr Peninsula, on Severnaya Zemlya and the adjacent shelf, there are the following gold-bearing areas (GRAMBERG & USHAKOV 2000): Bolshevik Island, Chelyuskin and North Taimyr included into the Taimyr-Severnaya Zemlya gold-bearing province (Severnaya Zemlya and Kara placer zones). Clusters with placer minerals are prominent within these areas. There are formations including alluvial Pleistocene-Holocene near-surface placers (dominating on Bolshevik Island) and those containing littoral or polygenetic productive beds ranging in age from Oligocene to Holocene. The latter are most common in clusters of the Chelyuskin area where gold placers occur in vast paleodepressions (Fig. 2). Gold-bearing beds of high thickness and length are buried beneath the cover of soft sediments 5-10 to 50-60 m thick. The underlying waste mantle and Mesozoic conglomerates are also gold-bearing. The near-surface Pleistocene gold-bearing horizons are extended along the seafloor.

An unique Ryveem cluster of the Valkarai area near the East Siberian Sea shoreline is characterized by a combination of two types of gold placers (alluvial placers normal to the

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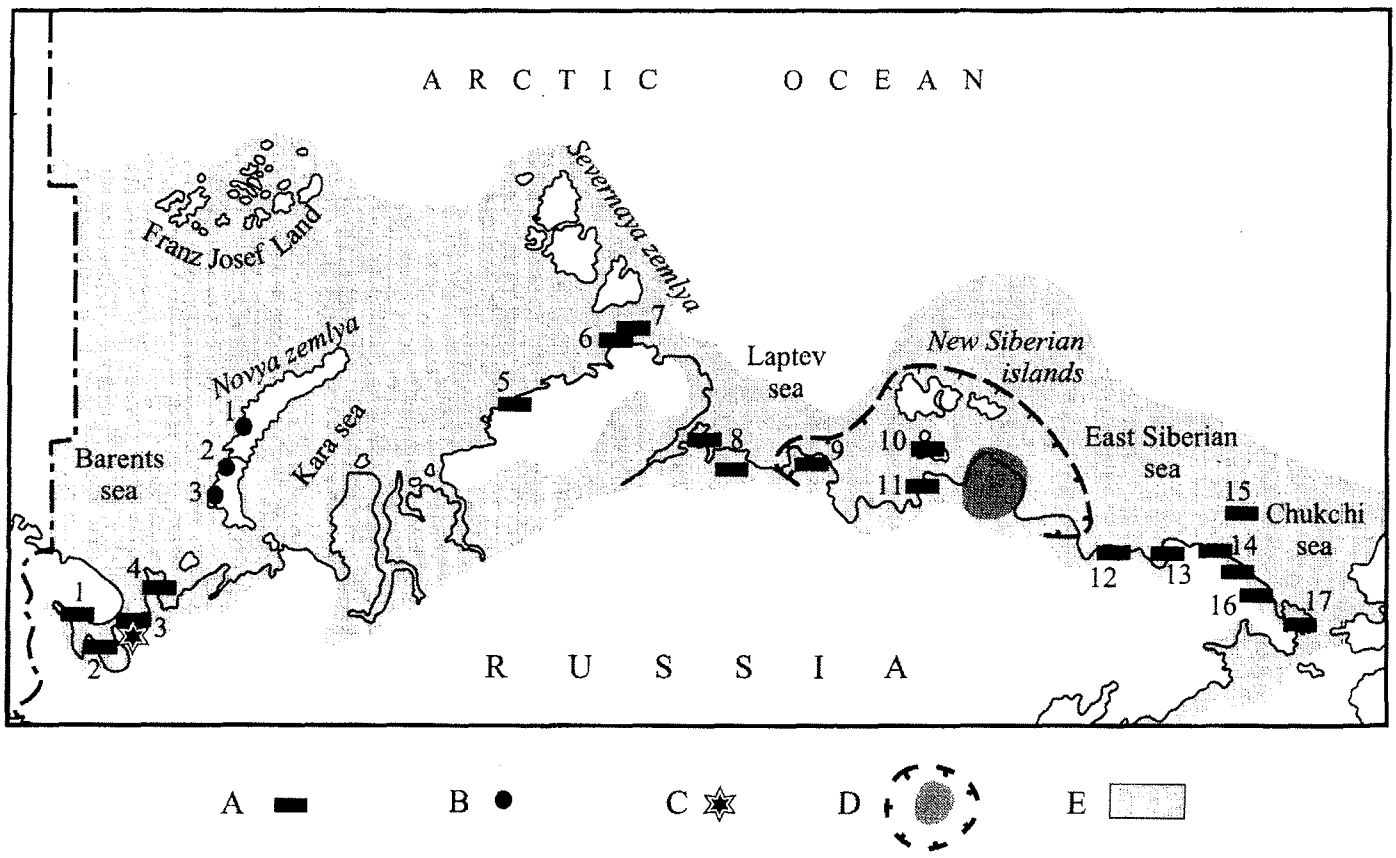

Fig. 1: Distribution of placers and some other deposits in Russian Arctic.
A: placer areas, 1-4: minerals of Ti, Fe, Zr, REE and diamonds, 1: Tersk - Kandalaksha, 2: Onega, 3: Kuloi, 4: Kanin - Timan; 5-9: gold, 5: North Taimyr, 6: Chelyuskin, 7: Bol'shevik Island; 8-9: gold and diamonds, 8: Anabar - Khatanga, 9: Ust' Lena; 10-13: tin, 10: Lyakhov, 11: Chokurdakh - Svyatoi Nos, 12: Prikolym-Rauchuan, 13: Chaun; 14: tin and gold - Valkarai; 15-16: gold, 15: Wrangel Island, 16: Amguem-Vankarem; 17: gold and tin - East Chukchi.
B - Novaya Zemlya deposits, 1 & 3: manganese, 1: Sul'meneva, 3: Rogachev - Tainin; 2: polymetals - Bezymyannyi and Pavlov. C: onshore diamond deposits in Arkhangel'sk region. D: area of fossil ivory accumulations. E: shelf zone

present shoreline and littoral placers striking concordant with ancient and recent beaches). The gold placers are of a very wide age range (Eocene to Holocene) there, being commonly buried beneath the cover of loose deposits up to 40-50 m thick. Gold dispersion haloes occur in Pleistocene-Holocene sediments at the seafloor of the De Long Strait (northern flank of Ryveem Cluster). The placers are associated with primary sources (ore showings) and ancient (late Cretaceous - Danian) waste mantle. Similar features in distribution and formation of placers are most likely typical of the Chelyuskin gold-bearing area, where discovery of large formations is expected. Wrangel Island shows certain prospects for placer gold, but geological exploration at the territory of its national reserve is prohibited. Deep-seated gold placers are typical of littoral lowlands in the Amguem-Vankarem area.

Tin placers

Tin placers are associated with the East Arctic margins of the Eurasian continent and with the adjacent shelf. The East Laptev placer zone involving two areas extends along the boundary between the Laptev and East Siberian seas (DOROFEEV et al. 1999). The Lyakhov placer area (Bolshoi and Malyi Lyakhov Islands of New Siberian Islands, in Eterikan Strait) is unique in its scope of tin reserves. Thirteen placer formations are known there, three of them are large and two are medium in size. Productive polygenetic horizons of great thickness vary in age from Eocene-Oligocene to Holocene and are commonly buried (Fig. 3). Three placer formations lie on the seafloor. A submarine Chokurdakh cassiterite placer (Van'kina Bay in Laptev Sea) with a thick Miocene-Holocene productive bed is located in the same Chokurdakh-Svyatoi Nos area.

The Chaun area is the second largest tin-bearing district. It stretches along the shoreline and on the seafloor of the Chaun Bay and is part of the East Siberian-Chukchi placer zone. Five mainly submarine placers with the Miocene-Holocene productive horizons have been discovered there. Small cassiterite placers and gold placer shows are known further east near Ichatka and Billings Capes (Prikolym-Rauchuan area). Shows of placer gold and cassiterite are common in the East Chukchi area, easternmost part of the region.

Diamond placers

The shoreline and littoral zones of the Arctic seas show real prospects for placer diamonds. Within the Kola-Belomorsk-Tyman zone, placer shows of diamonds and dispersion haloes of associated minerals are closely related to primary sources. These sources are diamond-bearing kimberlite bodies in the

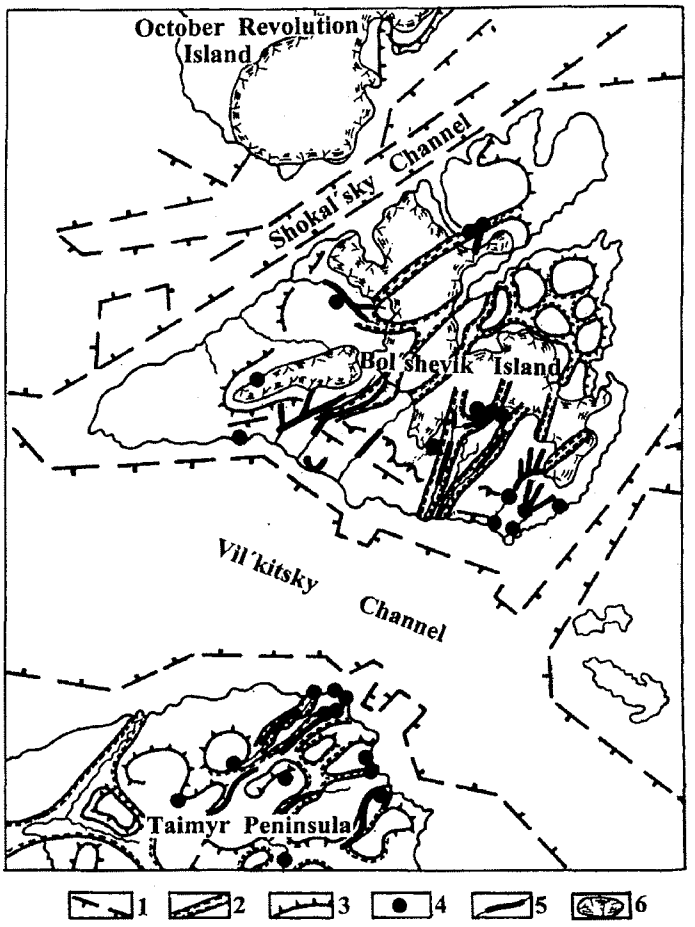

Fig. 2: Gold placers of Bol'shevik Island. 1: tectonic scarps along Mesozoic-Cenozoic riftogenic structures; 2: graben valleys; 3: abrasion scarps; 4: showings of gold; 5: gold placers

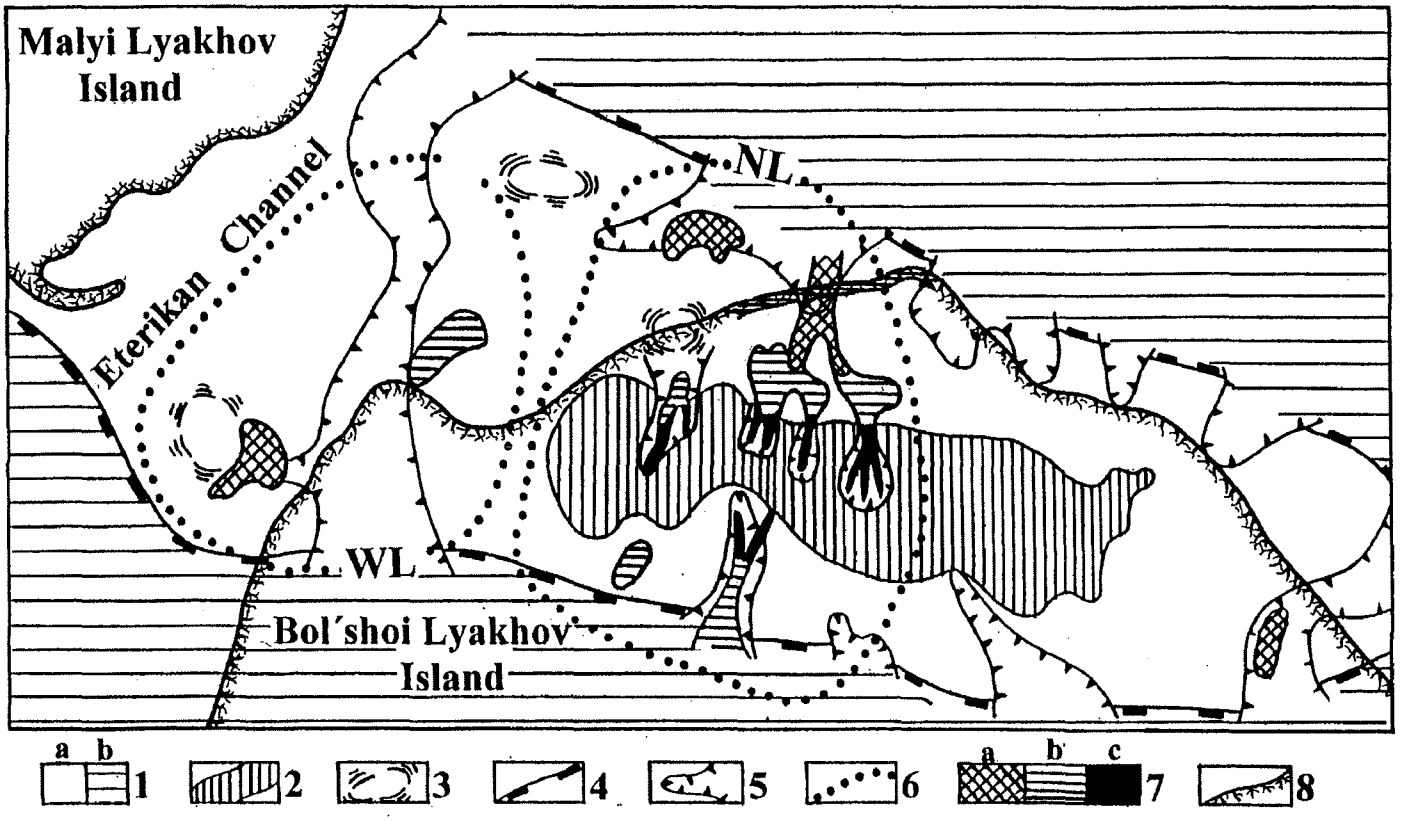

Fig. 3: Tin placers of Bol'shoi Lyakhov Island. 1a: uplifted blocks of ancient denudation relief, 1b: ancient compensated basins; 2: remnant highs; 3: local low-amplitude uplifts; 4: structural-tectonic scarps of arched-blocky uplifts; 5: erosion-tectonic depressions; 6: boundaries of placer clusters: NL: North Lyakhov, WL: West Lyakhov; 7a: polygenic placers, 7b: littoral placers, 7c: alluvial placers; 8: shore line.

Tersk-Kandalaksha, Onega and Kuloi areas, and intermediate collectors (sedimentary Silurian, Devonian and probably Lower Triassic and Jurassic beds) in the Kanin-Timan area. Diamond crystals and satellite minerals associate with gold in Pleistocene-Holocene sediments (beaches, alluvium) of the Anabar-Khatanga and Ust' Lena placer areas (South Laptev zone). Jurassic and Cretaceous conglomerates are the main sources of the mineralization. Accumulations of titanium, zirconium and iron (occasionally REE) minerals are observed on beaches in every area of the Kola-Belomorsk-Tyman zone.

Amber placers

Placer shows of amber are very common along the shoreline of Russian Arctic seas from the Kola Peninsula to the Lower Indigirka River. The West-Arctic Region of the Baltic-Dnieper subprovince of the Eurasian amber-bearing province, known by its unique amber deposits near the city of Kaliningrad, is considered as the most prospective in terms of high-quality amber.

Fossil ivory accumulations

The coasts and islands of the Laptev and East Siberian Seas form part of the vast area of fossil ivory accumulations (SMIRNOV 1998). Russia is a monopolist for this kind of mineral raw material. At the close of the XIX century, production of mammoth tusks in Russia was one-third of the ivory world trade. The world-wide prohibition for production of ivory is causing a rebirth of interest in fossil ivory. Sizeable industrial accumulations of fossil ivory are known in northern Yakutia and New Siberian Islands (recent beaches, drainage areas, terraces and river beds). These areas are unique in mass burial and conservation of fossil ivory in permafrost by loess and glacial late Pleistocene sediments. Subsequent processes of fluvial erosion and thermoabrasion were responsible for continuing exposure of fossil ivory accumulations fairly classified as placer deposits.

PLACER FORMING CONDITIONS

The study of placers on Russian Arctic shelves, conducted over the last 30 years made it possible to infer the main regularities in their distribution and formation.

Closely associated with structural framework of the region is the main feature of lateral distribution of the placers, their restriction to transition zones located in the marginal parts of sedimentary basins along orogenic structures of the continental frame and also along the periphery of insular structures. The transition zones are characterized by accumulative and denudation-accumulative relief, by morphostructures of moderate downwarpings and uplifts (total effect of neotectonic movements varies from +200 m up to -200m) and by the Cenozoic sedimentary cover of several meters up to 100-150 m thick.

The presence of source ore formations (both primary and intermediate collectors) is a prerequisite for placer formation. Concentrations of minerals in placers are controlled by distribution and nature of traps. They involve the recent and ancient depressions, levelling planes, river valleys, beach and terrace systems, and foot of slopes. The shore and the adjacent shelf are known to have been an area for multiple alternations of transgressive and regressive cycles during the Cenozoic. This is reflected in the vertical section of the sequences, in the structural-formational complexes. The regular alternation of marine and continental facies has been responsible for polygenetic composition of productive horizons which is the striking feature of shelf placer formation. Temporal periodicity, i.e. the existence of epochs most favorable for placer formation is closely related to sedimentological stages. So, the highest productivity belongs to the ancient (Eocene-Oligocene-Miocene) epochs and commonly following denudation and crust formation. The young Pleistocene-Holocene epochs in the Arctic regions are characterized by polar type of lithogenesis with the formation of permafrost strata and glaciers, by ice-coverage of offshore zones and by relatively weak lithodynamic activity.

The intrinsic feature of the Arctic placers, related to the recent position of the shoreline, is the occurrence of most formations and potential placers on the seafloor. The distribution of a great number of minerogenic taxa (both placer and primary) in high latitudes is approximated by natural, geographic conditions. North of 69° 20', there are the Taimyr-Severnaya Zemlya gold-bearing province, East Laptev tin-bearing zone, cassiterite placers in the Chaun Bay, Billings and Ryveyem tin- and gold-bearing clusters, and Wrangel Island promising for gold.

The presence of placer metals within the Arctic shelves is distinguished by a great number of large and unique formations. The share of occurrences of gigantic placers (against total number of formations) is abnormally high, about 10 % and 13 % for gold and tin placers, respectively. It is of interest that similar (and much more contrast in terms of percentage) regularities are also typical of the Arctic hydrocarbon deposits. This common feature of different mineral types can probably be explained by their similar structural position and evolution of sedimentary basins. The crucial role was most likely played by the duration of deposit emplacement of the occurrences under relatively stable subplatform environments and permanent downwarping. These long-lived occurrences have productive horizons of great thickness and wide age range.

THE RESOURCE POTENTIAL OF THE RUSSIAN ARCTIC SHELVES

Since 1981 VNIIOkeangeologia has been engaged in monitoring of minerogenic zonation and assessment of placer potential of the Russian offshore areas, with development of the geological surveys and exploration. The results are presented on the map at a scale of 1:2,500,000 (latest version is of 1996). An information system of the offshore placer formations was developed in VNIIOkeangeologia in 1997. The geological data base „Placer formations of the Russian offshore" intends to assess the placer potential based on all the mineral resources involved. Today the base holds data on 300 different-rank placer formations located in the Arctic, with more detailed information on commercially important mineral resources (gold, tin, diamonds, minerals of iron, titanium, zirconium). It

should be noted in conclusion that the resources of placer minerals are only part of the total mineral-raw potential of the Russian Arctic shelf zones. Along with large oil- and gas-bearing areas discovered onshore and offshore, sizable accumulations of ore minerals (manganese and polymetals on Novaya Zemlya and diamond fields along the White Sea shoreline; Fig.1) have been discovered and studied for the last decade. These discoveries permit us to consider the Arctic offshore areas as the most diverse and sizable in terms of mineral resources.

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