Magmatic Stratiform Chrome-Bearing Complexes of the Central Uraline Belt: Tectonics, Metamorphism, Platinum Mineralization

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The Central Uralian (Saranovsky) Belt of stratiform chromite-bearing complex is situated in the Western Urals in the boundaries of the axis part of Central-Urals uplift on the strip of development of pre-Cambrian riftogenic formations. On the base of finds of the Saranovsky type chromite ore fragments in conglomerates of Serebryansk series of Early Vendian it is supposed Late Riphean-Vendian age of formation of chromite-bearing ultramafites of this Belt that corresponds to the time of manifestation here of the main stage of epicontinental riftogenesis as a system of riftogenic paleograbens and regional riftogenic faults.

Saranovsky chromite-bearing complex proper which is the biggest and well - studied object of the Central Uralian Belt is related to the regional riftogenic fault`s zone separating terrigenic and volcanogeno- terrigenic deposits of Upper Riphean (Fedotovskaya suite) from carbonate-terrigenic Vendian deposits (Vilvenskaya suite). Detailed geologic-structural researches showed that Saranovsky stratiform chromite-bearing complex of 6 x 0.2-0.4 km length traced for the depth to 500-700 m presents itself a system of tectonic blocks of lens-clino- and plate-shaped form. Contacts of separate blocks (lenses, plates) with enclosing slated series have a character of zones of crushing, brecciation and schist formation from 5-10 to 30-50 m thickness and more. The degree of tectonic dislocation of the complex increases from North to South where it transforms into sharply decreased on thickness lens-like block, having a store structure with numerous "blind" chromite-bearing bodies – Intermediate area, Ziminskoye deposit, South-Saranovskoye deposit. It is exposed a typical massif`s pinching on the North and South flanges and with depth. It is clearly expressed delensing of chromite-bearing complex with the blocks turning on flanges in opposite directions that is fixed in the North by vertical and steep (75-80°) western and in the South – gentle (40-50°) north-eastern dip of chromite layers. Typical to Saranovsky chrome-bearing complex numerous blocks and mosaic character of inner structure of mafite-ultramafite bodies is explained by a great number of steeply dipping and gentle rupture dislocation, the shifts on which usually have a big amplitude and a character of faults and overfaults in combination with displacements. Besides, huge thrusted dislocations were revealed with amplitude of dislocation commensurable with the observed thickness of chromite-bearing complex - that is - evaluated in many hundred meters. It is principally important that such structural elements are mapped in the massif of lens-like form with the enough researched simple enough surface of contact zones of gabbro-ultrabasite body with enclosing slated series with the absence on the researched interval (to 500-700 m from the surface) of some wedge-like blocks of slates dividing it, and corresponding tectonic peaks and small xenoliths of chromite-bearing ultramafite in the frame's slates. All these in combination with the mapped thick zones of different tectonites in mafite-ultramafite body contacts, testifies to the formation of leading structural elements not at the place massif's modern occurrence, but considerably deeper and up to getting by it complete boudinage-lens-like form. It is possible to make a conclusion that Saranovsky stratiform chromite-bearing massif presents itself a huge boudinated tectonic block, and had been stripped and lost its initial form, which dislocation amplitude on vertical can reach many kilometers.

The stratiform chromite-bearing complex's profile is presented mainly by serpentinites for which on the base of pseudomorphic stucture study is being established apodunite and apoharzburgite nature. In the complex's eastern part are present green-stoned changed gabbro that makes it possible to relate it on the whole, to gabbro-ultrabasite association. On the main petrochemical and geochemical parameters a complex of rocks and ores can be related to the products of differentiation of basaltoid (with picritoid incline) magma. This can be proved by higher ferruginousness and presence of titanium of chromite-bearing ultramafites, higher ferruginousness and aluminiferousness of accessory and ore-forming chrome-spinellids. In less destroyed chromite-bearing parts of the profile it is established a clear primary differentiation in connection of dunites and bronzite dunites with the profile's bottom (lying side). Dunites and bronzite

dunites are changed by chromite-bearing dunite-harzburgites with numerous layer-like bodies of chromite ores of thickness changing from 0,1-1,0-4,0 m to 6,0-14,0 m and higher - by harzburgites, pyroxenites and at last - by gabbro. It is established a regular rising in this direction of orthopyroxene, ferruginousness of serpentinites (from 13 to 18%), titanium bioxide contents (from 0,10 to 0,20-0,35 mass.%) and so on. The revealed gradiency of the profile on iron, titanium, alumina and other elements including platinum group metals, regular change of composition of ore-forming and accessory chrome-spinellid composition allow to make a conclusion that stratiform chromite-bearing body of Saranovsky complex initially had more smooth, most possibly - subhorizontal occurrence that was desturbed by later successive deformations.

Into a general stucture of the complex considered are also included numerous dykes of the main content, that are related to the age groups. To the earliest deformational ones are refered dykes of alkaline diabases and picrite-diabases which do not come out of the contours limits of separate blocks and are sheared by their tectonic boundaries. They are often present near chromite-ore layers and directly contact with them, being usually heavily metamorphosed and turned into green chlorite slates, the so called “locks”. On their composition alkaline diabases are comagmatic to trachibasalts of volcanogenic complex, known among Late Riphean-Vendian deposits and composing graben structures (Schegrovitsky complex of Early Vendian). Later group is formed by weakly changed dykes of gabbro-dolerites and dolerites that intersect both ore-bearing blocks of Saranovsky stratiform complex and slated series of its frame. They are known among Early Paleozoic deposits and comparable with calcareous-alkaline basalts of tholeiite series. So one can make a conclusion that the earliest deformations of the ore-bearing stratiform complex took place in Vendian (Late Vendian), but before Early Paleozoic stage. With Paleozoic (Lower-Middle-Paleozoic) history of the complex are connected processes of platform activation, intrusion of thick and long dykes of gabbrodolerites and formation of near-dyke aureoles of metamorphism of chromite ores (cataclasis, milonitization, antigoritization, carbonatization, chloritization and so on). The materials obtained substantiate the views on structural-substantial complexes of the Central Uralian Belt as of polygenic and polychronic ore-bearing formations, including substantial associations of the Middle-Late Riphean epicontinental riftogenesis stage, the stage of the Vendian (Vendian-Cambrian) transformations of paleoriftogenic structures and the stage of the Late Early-Middle-Paleozoic platform activization.

Accordingly in the formations of the Saranovsky stratiform chromite-bearing mafite-ultramafite complex are present three different types of platinum-metal mineralization, Ru-Os-Ir-type of Saranovsky proper in stratiform chromite ores; Pd-Pt-Au type of the Churolsky-Saraninsky in ore-bearing dykes of gabbrodolerites and Au-Pd-Pt Maldinsky type in near-dyke metasomatites on chromite-bearing ultramafites.

The main particularities of platinoid distribution in researched sections of stratificated chromite-bearing profiles consist in one-type geochemical specialization of ultramafites and chromite ores for refractory platinum metals (ruthrnium, osmium, iridium) and regular change of their compositions both in ores and in minerals proper. It is established relative enrichment of lower and middle parts of the profile with osmium, iridium and ruthenium and on the contrary, of upper parts - with palladium, rhodium and platinum. Both in ultramafites and in chromite ores the share of refractory platinum metals makes up 60-90% of the sum of all platinoids. A sum total of Os, Pt and Ir contents in chromite ores varies from 0,2 to 2,0 g/t, their maximum concentration being related to near-contact parts and deformation zones inside the late ones - that is - to those areas where metamorphism processes are displayed mostly. In all parts of stratificated chromite-bearing profile occurres platinoid mineralization presented by sulphides and sulpho-arsenides of refractory platinum metals: laurite, osmium laurite, erlichmanite, irarsite and others. These minerals form thin idiomorphic inclusions of size from 5-10 to 50-80 mcm in chrome-spinellids and silicate cement of ores. It is revealed conjugation of laurite composition and osmium, ruthenium and iridium distribution in chromite ores. Maximum enrichment with osmium and iridium characterizes laurites of low and middle parts of the profile. Laurites of the chromite-bearing profile’s parts are enriched with ruthenium and there arsenicum is present. It is established a genetic connection of minerals proper of platinum metals with sulphides and sulphoarsenides of nickel, iron, cobalt, copper, millerite, bravoite polydimite, hizlewoodite, heredorfite and others. It is of importance to stress that mineral inclusions of platimun metals that are present in broken-down and metamorphosed chromite ores with talc-chlorite-carbonate cement, possess morphostructural features of metaformations and do not bear the traces of fragile deformations and resorbtion. The relationship of concentrating

platinum metal Ru-Os-Ir mineralization of the Saranovsky type to the areas of strong metamorphism of chromite ores, paragenesis with metamorphogenic sulphides and sulphoarsenides of nickel, iron, cobalt make it possible to consider it as a product of metamorphogenic - hydrothermal transformations of stratiform chrome-bearing dunite-harzburgite series of transport stage.

Gold-platinum-palladium Saraninsky type of mineralization is found in thick dykes of metagabbrodolerites of Saranovsky complex containing impregnated cobalt-nickel-copper mineralization. Ore specialization is determined by palladium, platinum and gold at extreme low compositions of the rest of platinum metals. A sum total content of palladium, platinum and gold makes up about 1,0 g/t, silver content - 1,0-2,0 g/t. The main feature of noble metal distribution in ore bodies in close connection with the areas of maximum concentrations of non-ferrous metal sulphides. Flotoconcentrates extracted from ores with high concentrations of copper, nickel, cobalt and sulphur contain palladium - to 32, platinum - to 10 and gold - to 9 g/t. Platinum-bearing mineralization proper is presented by stibiotellurides of palladium and platinum, borovskites including their mercury kinds as well as tellurides and bitellurides of palladium and platinum antimonial kotulskite, bismuth merenskiite. Palladium gold is present. Noble metal minerals form idiomorphic crystalline grains of 10x10 - 30x30 microns in pyrrhotite, chalcopyrite, pentlandite.

Palladium mineral typochemism is determined by constant impurities of nickel, iron, mercury but in most degree - by bismuth, antimony and arsenic impurities on composition of which these minerals are sharply isolated from analogical ones from metamorphogenic - hydrothermal Uralian platinum metal (Kachkanar, Baronka, Volkovka) mineralization.

Geological position of gold-palladium mineralization of the Maldinsky type in the limits of Saranovsky stratiform chromite-bearing complex is determined by its connection with aureole zone of deformations and metamophism in exo-contact (700x50 m) dyke of weakly changed gabbrodolerites - Churolsko-Saraninsky type of mineralization.

Schistosed and carbonatized antigorite serpentinites on chromite-bearing dunite-harzburgites and the enclosing metamorphosed chromite-olivine rocks of the Vostochnoye ore manifestation contain higher and high quantities of palladium, platinum and gold reaching in sum total of 2 g/t and more. Flotational concentrates from these ores contain 100-195 g/t of palladium, 23-33 g/t of platinum and 3-9 g/t of gold. In concentrates are found variable proper minerals of palladium, platinum and gold with charateristic impurities of mercury, arsenic and copper - ateneite, palladoarsenite, potarite arsenious and others. Besides usual palladium gold it is also met porpezite containing to 12,5 mass.% of palladium, 5,7mass.% of mercury and 1,6 mass.% of copper. Native melts and intermetallides of the Maldinsky type form in ores one-two-phased crystalline grains of size from 5x5 mcm to 30x50 - 70 microns, located in aggregates with sulphides of nickel, iron, copper as well as with chrome-spinellids, chlorite and serpentine. For the first time established genetical connection of gold-palladium mineralization of the Maldinsky type with gold-platinum-palladium-bearing gabbrodolerites of the Middle Paleozoic age while analysing ore formation factors testifies to the priority of structural-magmatic control of contact-metasomatic mineralization of this type. Comparison of the data obtained on platinum mineralization of stratiform chromite-bearing Urals complexes with available data on laminated riftogenic complexes of the adjacent areas reveals evident features of similarity with the objects of Karelia, in the first turn - with the Burakovsky, Khautovaara massifs and others.