The Urals Platinum Polygon – New Data

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During one hundred years the Solovyova mountain's dunites of the Nizhny-Tagil massif enclosing numerous original deposits and platinum ore manifestations leave to be a standard polygon of the world's imporpance while characterizing platinum mineralization of the Urals (Urals-Alyaska) type. However inspite evident success in studying mineralization of this type connected first of all with the names of L.Dupark, N.K.Vysotsky, A.N.Zavaritsky, A.G. Betekhtin, a number of principal problems of geochemistry and mineralogy of platinum metals in dunites of zonal complexes, chromite-platinum concentrations genesis demanded further all-sided researches at a modern device level for creating a genetic modal of the Urals type ore formation and the development of scientific criteria of their prospecting and forecasting. Investigations of the last decades in the Urals and other regions were based mainly on the materials of platinum placers scince for the last 50 years in dunites of the Urals Platinum Belt proper it was not revealed a single new original platinum exposure, commensurable on scales with classic objects found here at the end of the XIXth - the beginning of the XXth centuries: the deposits of Krutoi Log, Avrorinskoye, Gospodskaya Shakhta and others. The situation changed only in the last years when on a base of the elaborated by us criteria of concentrated platinum mineralization in dunites were opened two new platinum-ore zones in the massif of the Solovyova mountain possibly having industrial importance as well. Numerous collections gathered on new ore manifestations (Dunitovoye and Syrkovskoye) in combination with additional researches carried out at the well-known worked-out deposits (Gospodskaya Shakhta, Krivoi Log, Alexandrovskoye) provided a basis for comparable characteristic (on a modern level) of chromite-platinum mineralization of the Urals type.

It is necessary to note the over-whelming part of the Solovyova mountain's dunites presents itself high-temperature blastomilonites with mezogranular porphyrolath and mosaic-lath microstructures that stress manifestations of vertical zonality in dunite body. Among that most intensively deformed dunites with mosaic microstructures one can notice the areas of heterogeneous stucture caused by presence of numerous thin (1-5-10 mm) stripes enriched with chrome-spinellids and also chromite schlieren-veins of segregated origin bearing the traces of plastic deformation as well. Geochemical platinum distribution in these dunites is being controlled by composition parameters and by the position in dunite bodies' section. In dunites of western, northern and eastern parts of the Solovyova mountain's massif, practically is not touched by epigenetic processes of chromite-platinum ore formation (ordinary background dunites) platinum compositions are connected by direct dependence with olivine (dunite) ferruginousness and by indirect one - with chrome-spinellid quantity (chrome content in dunites). While rising ferruginousness from 6-7 to 10-12 mol.% platinum content increases from 5-10 to 50-70 mg/t and does not grow further. In parallel chrome content in dunites decreases from 2-1,5 to 0,5-0,3 mass.%. In banded chromite-bearing dunites and segregational schlieren platinum content is also quite low - from 5 to 10 and up to 100 mg/t.

Among the main mass of the considered background dunites with regular variations of geochemic field on platinum at a number of areas for the first time were determined pair (negative and positive) geochemical anomalies and estimated their parameters. It becomes more evident that all high chromite-platinum concentrations of the Solovyova mountain are conjugated with zones and nodes of fragile deformations and negative geochemical anomalies on platinum. Negative platinum anomalies have complicated morphology, heterogeneous spotted character and composed with dunites with cataclastic microstructures. Their sizes on the data of quarry and borehole studying vary on width from 30-50 m to 100 m and more. On dip they are traced at the depth to more than 100 m. For dunites in limits of negative anomalies it is characteristic sharp (5-50 times) of platinum amounts in comparison with background ones (up to traces less than 1 mg/t and contents - 5-15 mg/t) with substantial decrease of olivine ferruginousness to 6-7,5 mol.%. On the data obtained on sampling in the limits of these anomalies 75-85% of samples are found to be empty and contain less than about 10 mg/t of platinum while "drops out" as a rule correspond to its usual back-ground contents in 30-

50 mg/t (data on 5 boreholes along the perimeter of Alexandrovsky quarry ore bodies (166 samples). Similar results are also obtained for a sloping borehole of 120, 5 m depth that overlaps the contour of the biggest Gosshakhta ore body on the Solovyova mountain.

The established for the first time megazonality of platiniferous dunite bodies - ordinery background dunite - negative geochemical anomaly -positive geochemical anomaly (chromite - platinum ore body) - is supplemented with a complicated structure of positive geochemical anomalies with contrast particularities of structural-morphological and mineralogo-geochemical characteristics of different ore bodies. The late one determines the necessity and possibility of distinguishing in volume of the Urals type of two subtypes of chromite-platinum mineralization - chromite subtype and dunite subtype.

Comparative characteristic of two distinguished ore subtypes is given on the base of the detailed study of their typical representatives: Gosshakhta deposit - chromite subtype, Dunitovoye deposit - dunite subtype.

Gosshakhta deposit was opened in 1909 and had been exploiting for more than 30 years to the depth of about 150 m. Platinum mineralization content differed by exclusive richness at the extremely uneven distribution - from 50 to 450 g/t and even to 10 kg/t. On approximate estimation a quantity of the producted platinum made up more than 400 kg. The deposit tube-column-like ore body is from 3 to 5-7m in diameter, East-South-East pitch at an angle of 60-70^0 complex inner stucture of the ore body was determined by a system of subparallel and interlayering veins, lenses and spray-like fusiform chrome-spinellid isolations with numerous apophysis, dispersing in all sides. For ores are quite typical nest-stria sideronitic, looped and brecciated textures. Nest, loop and vein chrome-spinellid as a rule is middle and coarse-grained, broken-down. On its composition it correlates to high-chromous (Cr/Cr+Al=0,84-0,82) mostly magnesial (Mg/Mg+Fe^{2+} =0,77-0,67) kinds (Fig.1). Ore silicate cement is presented by olivine, serpentine, chlorites, micas and also by carbonates. Olivine ferruginousness varies considerably from 3,7 to 7 mol.%. Olivine microinclusions in chrome-spinellid fix lower ferruginousness - 2,5-3,5 mol.%. Middle CaO content in olivine makes up 0,2 mas.% - lower than in olivine of negative geochemic aeureoles - 0,25 mas.%.

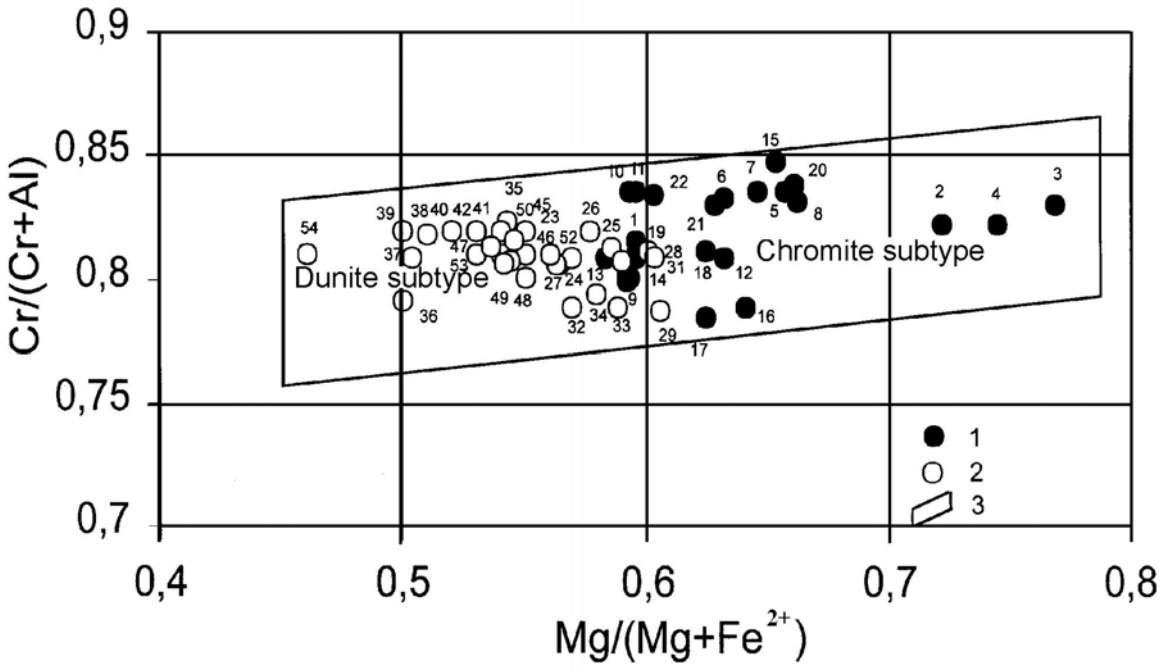

Figure 1. *Types of ore-formaing chrome spinels of the m. Solovyova (Nizhny-Tagil massif) chromite-platinum ore deposit. 1 – chrome spinels with platinum inclusions of Gosshakta deposits (an. 1-22); 2 – chrome spinels with platinum inclusions from Dunitovoye deposits (an. 23-54); 3 – general field boundaries of ore-forming chrome spinels with platinum inclusions from the analysis of 100 samples from five deposits of the m. Solovyova..*

Platinum in Gosshakhta deposit mineralization is presented in the form of impregnation of scattered grains, nest-like accumulations and veins to 1 mm thickness and of 3-5 cm length. Granulametric analysis of 100 grains extracted from chromite-platinum ore samples showed that 60% of them are of 400 microns in diameter, 20% - from 100 to 400 microns and merely 20% of them are less than 100 microns. Thus for mineralization of this deposit coarse platinum is the most typical with the presence of native platinum as well. Platinum extractions as often as not cement the ore-forming chrome-spinellid and are seldom included into silicate ore cement. They as a rule have xenomorphic angular, hackly and whimsical-branchy form. In broken-down and chloratized grains of chrome-spinellid postdeformational veins and platinum extractions intersect not only cataclasis cracks but also veins of chlorite cementing them. On correlation of the main components and optical properties platinum is refered to two mineral kinds - isoferroplatinum absolutely predominant and sharlpy subordinated - tetraferroplatinum. For both of the minerals are typical higher iridium contents (2,85 and 3,86 mass.% accordingly). Iridium tetraferroplatinum forms independent grains and grows in the shape of thin (about 100 microns) rims over iridium isoferroplatinum. In paragenesis with them are present osmirid, iridosmin and laurite in the form of needle and laminated crystalls, located in marginal parts of the platinum grains. For ferroplatinum solid solutions is typical relatively even distribution of all mineral-forming components, including iridium, copper and nickel. Typochemism of the Gosshakhta depost (isoferroplatinum) consists in stably higher iridium content at the extreme low impuritive quantaties of copper and especially - nickel - 0,56 and 0,24 mas.% accordingly (Fig.2).

The Dunitovoye deposit was revealed in 1997 in near-frontal part of big negative geochemical anomaly on platinum locating in North-North-East part of the Solovyevogorsk dunite quarry. Platinum mineralization zone of thickness to 1-1,5 m is traced on strike for 300 m. Platinum ore content is from 1-5 g/t to 50 g/t. Zone's strike is North-North-West of $300\text{-}330^0$, the dip is steep to subvertical to South-West and North-East at an angles of $60\text{-}80^0$. On dip it is traced up to the depth of 30-40 m. It is of complex inner structure which is determined by alteration of lens-like isometric and branchy pinches of thickness to 2-2,5 m and swells - conductors of 0,1 m thickness, creating a picture of lenticular beads, that are being repeated on the zone's dip. It is saturated with chromite-bearing pegmatoid dunites and contignous of small thickness short veins of chrome-spinellid which are distant from each other for 5-10-20 cm. Lens-shaped-streakly banded and limbate textures are typical of ores. Veins and spot-srip-like chrome-spinellid isolations as well as pegmatoid chromite-bearing dunites enclosing them always have traces of frail deformations and dissected by numerous thin (0,1-1 mm) carbonate serpentine-brucite-carbonate veins stressing cataclasis and brecciation of platinum mineralization zone. Ore chrome-spinellid is thin-mid-grained strongly broken-down. At a diagram "chrome presence-magnesia presence" (Fig.1) ore-forming chrome-spinellids of the Dunitovoye deposit from a compact field in the left part of series relating to moderately chromous ($Cr/Cr+Al$ = 0,77-0,82) and considerably less magnesial contents ($Mg/Mg+Fe^{2+}$ = 0,60-0,50). In them there are monomineral and polymineral inclusions of size from 5-10 to 100 microns and more presented by olivine chlorite, phlogopite, diopside and other minerals. Ore silicate cement is presented by serpentinite, carbonate, chlorite, micas. Fresh olivine in ore and rim cement is not preserved; olivine of microinclusions in chrome-spinellid has ferrogeniousness of 4,4 mol.%. Ferruginousness of olivine of ore-enclosing pegmatoid dunites is of 6,5-7,7 mol.%. For dunites of negative geochemical aureole olivine's ferruginousness is from 6 to 8 mol.%, back-ground dunites in the platinum mineralization zone have their ferruginousness of 8-9,5 mol.%.

Platinum in ores is present in the form of small and thin disperse grains and also (seldom) of their nest-like accumulations of 2x4 mm size.Granulometric platinum analysis on the base on 400 grains studying showed that 83% of them refer to the class of less than 400 mcm at that two third of them are of less than 100 mcm coarse - that is they have flotational largeness. Thus for the Dunitovoye deposit mineralization small and thin platinum is the mist typical. The platinum idiomorphic crystalline grains are enclosed in broken - down chrome-spinellids where they are located near chlorite - serpentine isolations and in thin cracks of cataclasis often intersecting and cementing them without any traces of further deformations. On their content and optical properties majority of grains correlates with tetraferroplatinum with with low iridium content (2,10 mas.%) high copper (4,60 mas.%) and nickel (2,26 mas.%) contents. In tetraferroplatinum are present idiomorphic crystalline ingrowths of iridosmine, native osmium and laurite of size from 30-50 to 100-200 microns. One can meet single small grains of low iridium isoferroplatinum and

the crystalline growths of zonal structure which central part is composed with low-iridium isoferroplatinum and periphery - with tetraferroplatinum. In platinum crystalline grains it is determined even distribution of all the main components including copper and nickel. However contents of the last ones sharply change from grain to grain even in the boundaries of one sample.

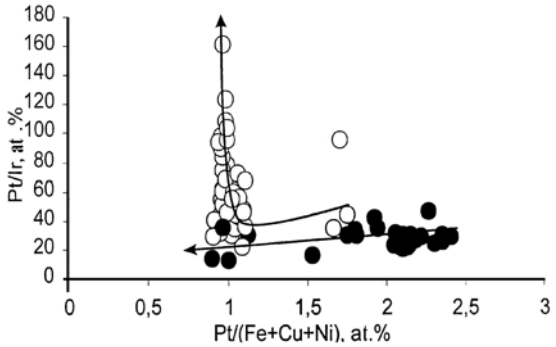

Figure 2. *Evolution of composition of platinum minerals sduring the formation of chromite-platinum ores of the Urals type. Black circles are isoferroplatinum and tetraferroplatinum depostis of Gosshakta (26 an.). Unfilled circles are tetraferroplatinum and isoferroplatinum of Dunitovoye deposit (51 an.).*

Evolution of platinum composition during ore formation of the deposits of the Gosshakhta and Dunitovoye and mineralization of the Urals type on the whole is shown in fig.2. It is clearly seen the composition discretency of ferroplatinum and tetraferroplatinym at the chromite and dunite mineralization subtypes with the presence of more general (iridium) trend connected with lowering refractory platinoid compositions and raising ferrum and nonferrous metals compositions - copper in the first turn. It is necessary to note wider in general variations of iridium, copper, nickel and ferrum compositions in platinum minerals of Dunitovoye deposit that testifies to a big heterogenity of mineralization processes of dunite subtype in comparison with the mineralization of chromite one. For chromite-platinum mineralization of both subtypees it is characteristic the presence of variable fluid-containing minerals both in chrome-spinellids and in platinum that is the proof of an important role of volatile components in processes of platinum metal concentration and chromite-platinum mineralization. Thus ferroplatinum mineralization of the Urals type are epigenetic postdeformational fluid-metamophogenic formations and comit their origin to processes of pair (nagative and positive) platinum anomaly formation. The appearance of these anomalies occurred under the determinative influence of polycomponent mantle -crust fluids which composition evolved into the side of CO_2 enrichment and was accompanied by sharp rise of ore-forming system oxidation state. As the source of ore substance in this process were both dunites themselves and deep fluids as well. The results obtained testify to wider than it was supposed before development of high-ferrugineous and cupreous platinum in the Urals type mineralization. Substantially isoferroplatinum composition of modern valley and buried ancient placers reflects merely sharp different placer-forming capacity of chromite (isoferroplatinum) and dunite (tetraferroplatinum) subtypes of the Urals type of mineralization.