GEOCHEMICAL INVESTIGATION OF BASIC VOLCANITE-HOSTED AUTOCHTHONOUS LATERITIC BAUXITE OCCURRENCE IN MURATBAGI (ISPARTA-TURKEY)

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Autochthonous bauxite occurrence is situated at the top of the Islikayatepe volcanite, located northwest of Muratbagi village (Sarkikaraagac-Isparta). There are three different bauxite levels in the profile and each level has basic volcanite, partly weathered volcanite (saprolite) and bauxite. A total thickness of profile is 167 meters. Lateritic bauxites contains average 39.98 % Al_2O_3, 25.22 % Fe_2O_3, 5.60 % TiO_2, 14.19 % SiO_2, 82.66 ppm Ni, 65 ppm Sc, 111 ppm Y. Average rare earth elements (REE) of bauxites are 194.1 ppm. Light rare earth element (LREE; La-Sm) is 144 ppm, and heavy rare earth element (HREE; Gd-Lu) is 46.1 ppm. Chondrite-normalized REE values for the bauxites are $(La/Lu)_N$ = 5.23, $(Gd/Yb)_N$= 3.72, $(La/Sm)_N$= 2.02, $(La/Yb)_N$= 1.52, Eu/Eu* = 1.04 and Ce/Ce* = 0.73; basalt-normalized REE values for the bauxites are $(La/Lu)_N$= 1.35, $(Gd/Yb)_N$= 2.01, $(La/Sm)_N$= 1.11, $(La/Yb)_N$= 1.52, Eu/Eu* = 0.97, Ce/Ce* = 0.72. HREE has strongly positive correlation with Fe_2O_3, Cu, Y. While Al_2O_3 is showing strongly positive correlation with CaO, Cr_2O_3, Th, Zr, Sc and strongly negative correlation with Na_2O, K_2O, MnO, Ni, Zn, Fe_2O_3 has strongly positive correlation with TiO_2, P_2O_5, Cu, V, Y, HREE and has strongly negative correlation with MgO, Pb, U, Ce. In factor analysis was realized to the bauxites, the first two factors that eigen values over 1, correspond with 68 % of total variation. Two significant groups are determined in cluster analysis such as «Main component group» and «Trace element group» of basic volcanite-hosted lateritic bauxite.

PLATINUM MINERALIZATION IN THE NIZHNY TAGIL AND KACHKANAR ULTRAMAFIC COMPLEXES, URALS, RUSSIA: A GENETIC MODEL

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We present a model to account for the PGE-(Pt) enrichment of the Uralian type Complexes and for the specificity of the PGM composition. This model takes into consideration the systematic association of the PGE mineralization with chromitite concentration (with the definition of a *CR factor*) and the specific textures of the PGE mineralized chromitite. It is largely inspired by the comparison with the mode of emplacement of the chromite pods in ophiolite complexes.

The Nizhny Tagil Complex is composed of a dunite core with a rim of wehrlite and pyroxenite. The dunite unit, which has a uniform mineral composition (olivine $Fo_{89.8-92.1}$, av. 0.25 wt% CaO, Fig. 1), represents an accumulation of olivine and minor chromite from a mafic magma in an open-system magma chamber. After solidification of the dunite, differentiation began with the formation of the wehrlite (olivine $Fo_{77.9-88.8}$) and pyroxenite, corresponding to the closure of the magmatic system. Two main types of chromitite occurrence are observed in the dunite body: small (100 × 5 cm) scattered schlieren of chromite crystals within the ultramafic unit and much larger (up to 100 × 5 m) concentrations. The chromite composition in both types is similar and uniform $[Cr/(Cr+Al+Fe^{3+})$ = 66.02,

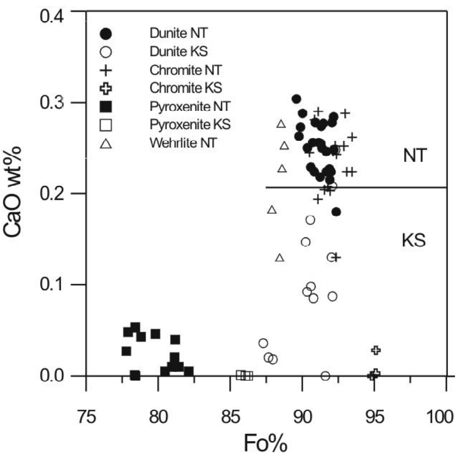

Fig. 1. Plot of CaO versus Fo content in olivine from the Nizhny Tagil (NT) and Kachkanar (KS) Complexes.

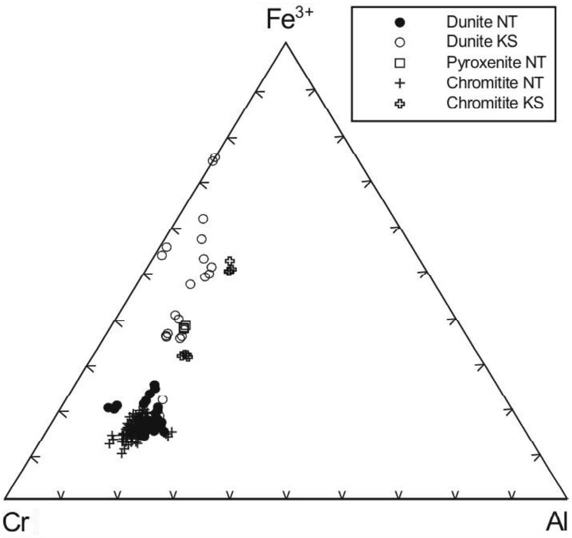

Fig. 2. Composition of chromite in a Cr-Al-Fe^{3+} triangular diagram revealing the Cr for Fe^{3+} substitution and the different chromite composition in the two complexes.

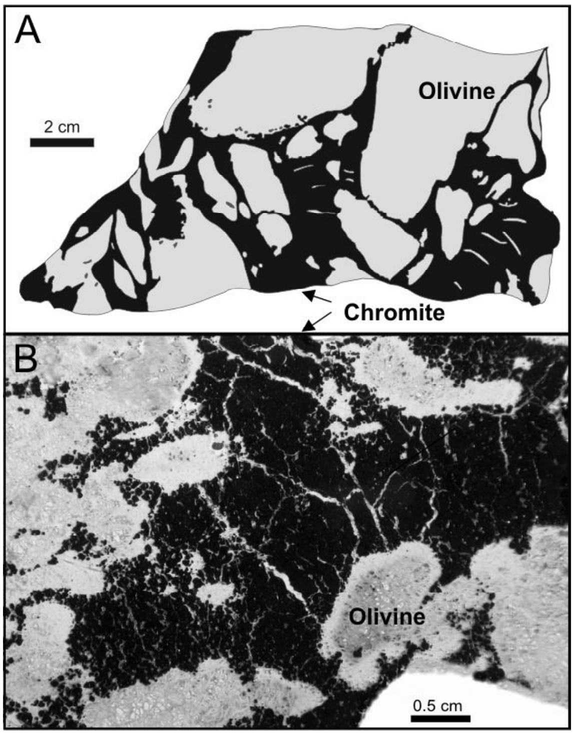

Fig. 3. Typical chromitite texture from the Alexandrovsky mine (Nizhny Tagil Complex).

***A**. Brecciated ore (black = massive chromite, gray = serpentinized olivine; after [2]). **B**. Net-textured ore consisting of dunite nodules in a matrix of submassive chromite (thin-section photo).*

$Mg/(Mg+Fe^{2+})$ = 49.05 and $Cr/(Cr+Al+Fe^{3+})$ = 69.14, $Mg/(Mg+Fe^{2+})$ = 49.81, respectively, Fig. 2]. The larger concentrations of chromite include brecciated and net-textured ore or massive veins (Fig. 3), that reflect the dynamic accumulation of chromite crystals in cavities along magma conduits inside the dunite body. These cavities are analogous to small magma chambers within the consolidated part of the dunite body and, similar to podiform chromitites in ophiolites, were created by continuous feeding of magma to the system.

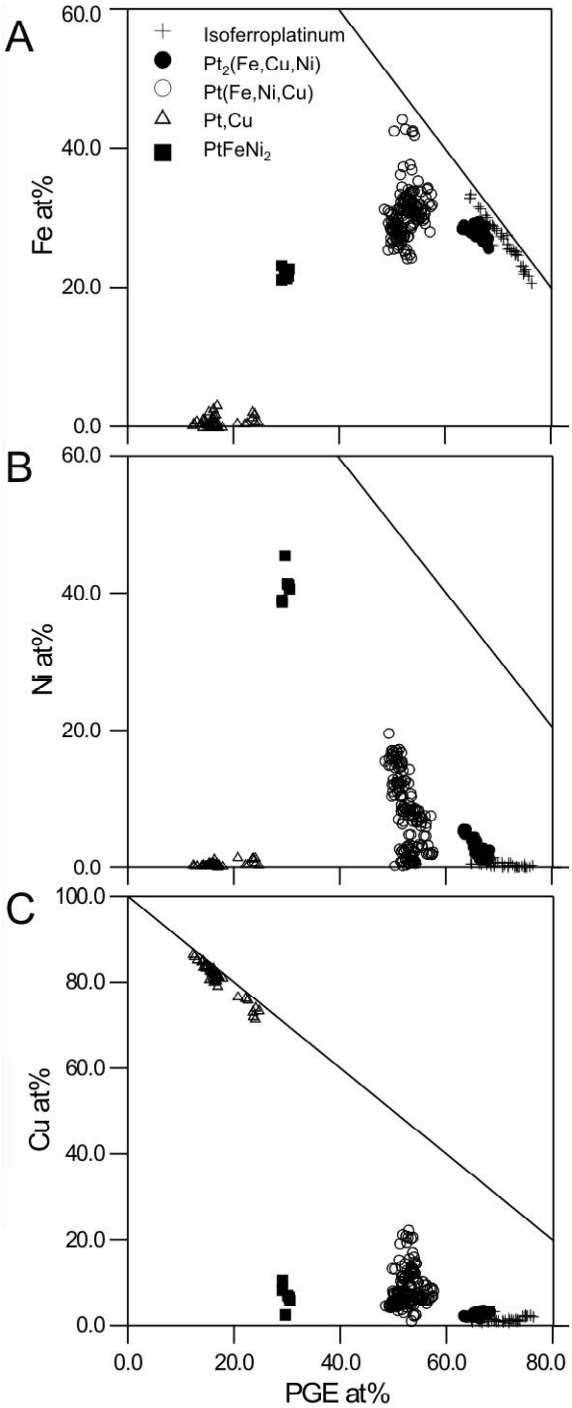

Fig. 4. Plots of Fe (A), Ni (B) and Cu (C) versus total PGE (atom percent) and showing the five categories of Pt alloys identified in Nizhny Tagil chromitites.

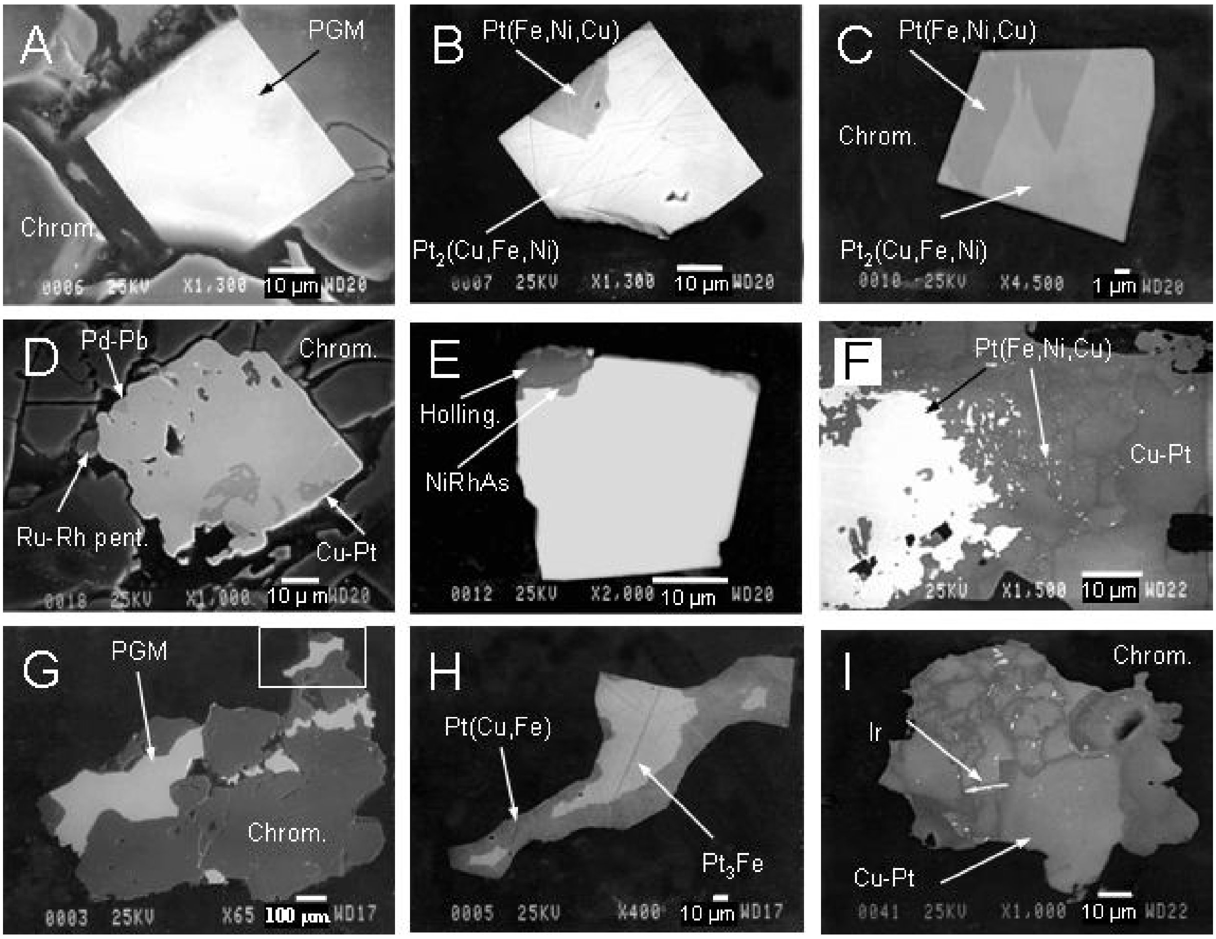

Fig. 5. Scanning electron microscope images of PGM.

A. *Euhedral PGM preserved in fractured chromite.* ***B****. Same image in back-scattered electron mode showing two phases, dark tetraferroplatinum and light Pt_2(Cu,Fe,Ni), the latter containing very small exsolution lamellae.* ***C****. Typical two-phase euhedral PGM inclusion in a chromite crystal.* ***D****. Complex grain in fractured chromite crystals. The main grain is tetraferroplatinum, partly altered to Cu-Pt. Note the presence of a very small Pd-Pb alloy and an adjacent Ru-Rh pentlandite grain.* ***E****. Composite PGM in the silicate matrix. The main grain has a tetraferroplatinum composition with an adjacent composite grain (hollingworthite) and a small NiRhAs grain.* ***F****. Detail showing the PGM alteration. The white phase (core of the grain) is tetraferroplatinum; the dark gray phase is a Cu-Pt alloy (platinian copper).* ***G****. Section of a nugget from Sirkov Log (Nizhny Tagil Complex) showing the relationship between platinum (white) and the chromite grains (dark gray).* ***H****. Detail of image G (box) showing the dark Cu-rich rim resulting from alteration of the Pt Fe core.* ***I****. Typical Cu-Pt grain containing inclusions of an iridium alloy (white). (All images in back-scattered electron mode, except A, in secondary electron mode.).*

The platinum-group element (PGE) content of the chromite-free facies of the dunite is relatively low, Pt being the only significant PGE (typically between 0.3 and 35 ppb, but as much as 98 ppb in one sample, [1]). In contrast, both types of chromite occurrence are enriched in PGE. Two PGE mineralizing episodes are distinguished: an Ir-Ru-(Rh±Os)-rich, Pt-Pd-poor episode in which the platinum-group minerals (PGM) are mainly Ir alloys, and a Pt-(Pd)-rich episode in which the PGM are mainly Pt alloys, i.e., Pt_2(Fe,Ni,Cu), $PtFeNi_2$, and tetraferroplatinum and tulameenite-like compositions (Fig. 4), along with rare hollingworthite and an unidentified RhNiAs mineral. The primary PGM have been affected locally by a serpentinization-related low-temperature alteration that is characterized by addition of copper, with alteration to complex Pt-(Fe,Ni,Cu) alloys of varied stoichiometry, including tulameenite and platinian copper (Fig.4, 5).

The Kachkanar Complex, situated 120 km north of the Nizhny Tagil Complex, has essentially the same characteristics, apart from a slightly different composition of the ultramafic cumulates suggesting that they were derived from a magma of different composition (Fig. 1, 2). The PGM distribution also differs in that it contains more abundant isoferroplatinum than other PGM [1].

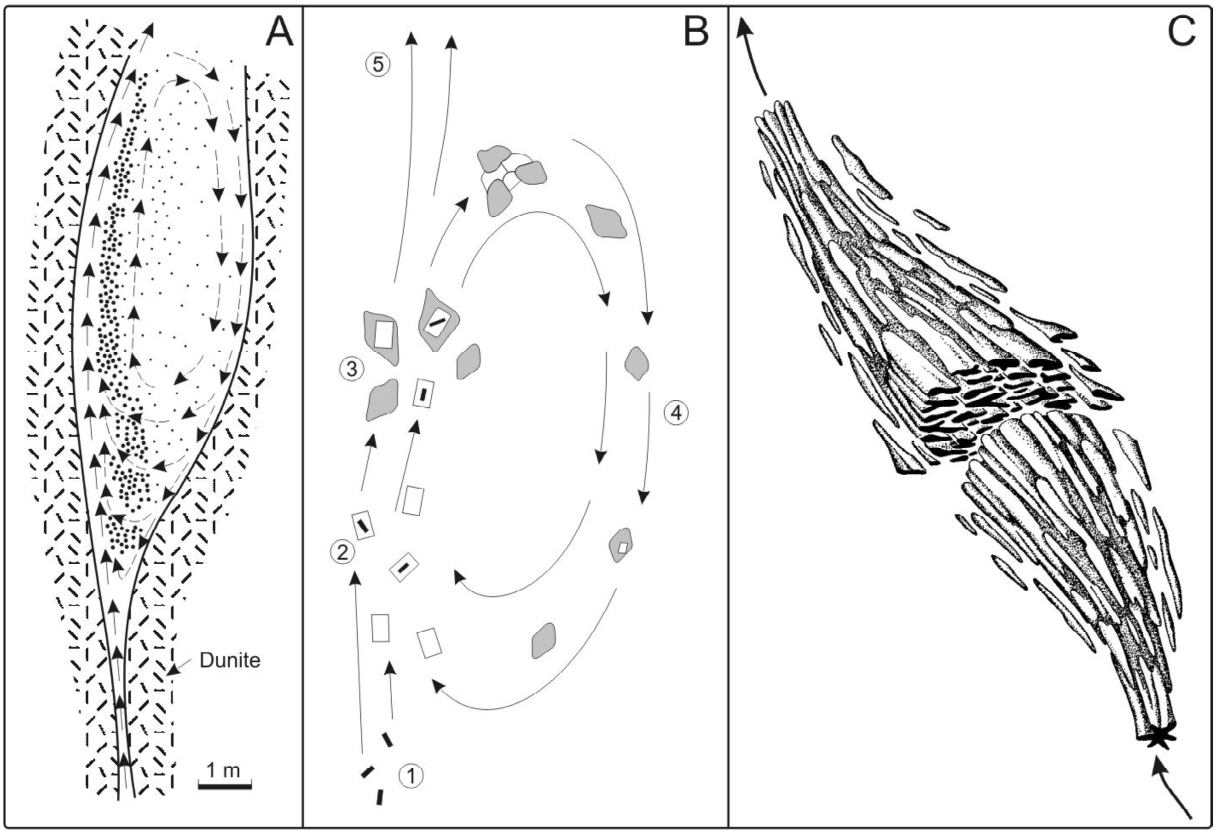

Fig. 6. Chromite/PGE concentration model.
A. *Chromitite formation in a cavity along a magma conduit (inspired by [3]). Dots illustrate chromite accumulation, and flow lines represent magma circulation in the cavity.* ***B***. *Process of PGM trapping in the cavity. A large magma/chromite ratio (*CR factor*) will lead to high PGM enrichment in the chromitite. 1. Early crystallization of the Ir-Os alloys (black rectangle) in the conduit. 2. Crystallization of the Pt alloys (white rectangles) in the conduit and in the cavity trapping most of the Ir-Os alloys. 3. Crystallization of chromite (gray) in the conduit and in the cavity, trapping most of the PGM. 4. Recirculation of the chromite grains in the cavity, favoring the trapping of new PGM. 5. Evacuation of the residual magma.* ***C***. *Reinterpretation of the Goshachta deposit (Nizhny Tagil Complex) using the cavity model. The lens-shaped body corresponds to the final stage of chromite accumulation, following removal of the interstitial magma, and reflects the shape of the initial cavity.*

The high-Pt concentrations are the result of the affinity of platinum minerals for chromite and the mode of chromite deposit formation. In the cavities in which chromite crystallized, PGM tended to be incorporated in chromite or remained attached to chromite crystals. To explain the very high concentrations of chromite-associated PGM we define a CR factor, which is the ratio of the mass of silicate magma to the mass of chromite in contact with the ascending magma. Where the CR is high (i.e., a relatively low proportion of chromite in contact with a large amount of magma crystallizing the Pt minerals), the efficiency of the mechanical collection of Pt minerals is at a maximum, and the Pt concentration (i.e., amount of Pt minerals) will be high. A model is proposed (Fig. 6) whereby the observed chromite and associated Pt mineralization can result from the normal magmatic evolution of the complex, provided that a structural (hydrodynamic) trap is available to concentrate the chromite.

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