Global Tectonics and Chromite – Platinum Mineralization Monitoring Genesis and Evolution of Ural–Alaskan type Complexes

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INTRODUCTION.

Ural-Alaskan type complexes are a special category of ultramafic-mafic intrusive bodies which have attracted the attention of modern geologists because they host economic deposits of precious metals, mainly platinum, and represent a puzzling geological feature due to their distinctive internal structure, peculiar petrologic affinity and uncertain tectonic setting.

For more than one century, before the historical discovery of the giant platiniferous reefs in the Bushveld complex of South Africa (1927), the great bulk of the world Platinum production was supplied by placer deposits in the Ural mountains of Russia (Duparc and Tikonowitch, 1920) and in a few other localities of the five continents. During one century, between 1824 and 1925, the placer deposits of the Urals produced more than 400 tons of platinum nuggets. It was soon realized that all of these placers were related with the erosion of small ultramafic-mafic intrusions subsequently named "Ural-Alaskan complexes" by Taylor (1967).

The Ural-Alaskan type complexes consist of km-scale, intrusive bodies of dunite, chromitite, wehrlite, clinopyroxenite, amphibole gabbro, and hornblendite arranged in a broad concentric zoning. They are believed to have been emplaced as sub-vertical pipe-like bodies, intruding gabbro-diorite and/or high-grade metamorphic rocks of the deep crust. Ural-Alaskan types complexes are relatively young, concentrating in Palaeozoic (Urals, Australia), Mesozoic (Alaska, Canada), and Tertiary times (Colombia). Global tectonics indicate preferential location at modern and ancient convergent plates and subduction-influenced settings, e.g. along the Kamchatka – Aleutian Islands – Alaska – Rocky Mountains – Andean orogenic systems, and the Silurian Island-Arc belts of the Urals and SE-Australia. This observation coupled with geochemical evidence led to conclusion that these complexes were products of syn-subduction igneous activity at the root of island-arcs, possibly representing the feeder pipes of andesitic volcanoes. Consistently, their ultramafic-mafic assemblages resemble cumulates from hydrous, high-Mg basaltic magmas having andesitic lavas as the complementary liquid fraction (i.e. Murray, 1972). There are, however, some contrasting exceptions to this rule. In fact, Mesozoic and Tertiary Ural-Alaskan type intrusions also occur several hundred kilometres far away from subducting plates, emplaced into deep continental crust of the Russian Far East, and East Sayan.

Bulk rock mineralogy indicates successive crystallization of olivine-chromite, clinopyroxene-olivine-chromite, clinopyroxene-spinel-Cr-magnetite, and clinopyroxene-plagioclase-magnetite-ilmenite, hornblende-plagioclase-magnetite. All these rocks contain primary amphibole and phlogopite. Bulk-rock and clinopyroxene have high CaO/Al_2O_3 ratio and show negative REE patterns, being enriched in light and middle REE. K-feldspar and nepheline may appear in gabbros, consistent with an alkaline affinity (Krause et al., 2007; Fershtatter et al., 1999). Dunite typically lacks primary orthopyroxene that locally occurs as reaction rims. Chromitites are characterized by Al_2O_3 < 20wt%, and progressive increase of TiO_2 (0.35-3.5 wt%), Fe^{2+}# and Fe^{3+} substitution for Cr, with increasing differentiation. Chromitite initially forms by mixing of new magma with evolved residual liquid after the onset of dunite crystallization (~1200°C): "*syngenetic chromitite*". Chromitite formation is protracted down to lower temperatures by infiltration-reaction of most evolved hydrous fluids with solid dunite (~900-700°C). This process generates "*epigenetic chromitite*" consisting of chromitite-dunite breccias or chromitite-amphibole-clinopyroxenite veins, in which chromite has the highest Fe^{2+}#, TiO_2 and Fe^{3+}# contents, in front the lowest Cr_2O_3 and Al_2O_3 (Betechtin, 1961; Garuti et al., 2011).

Locality (country)	*Year of discovery*	*Pt-production before 1927*
Ural Mountains (Russia)	*1819*	*93%*
Chocò (Colombia)	*1557*	*6%*
Fifield (Australia)	*1887*	*0.5%*
Goodnews Bay (Alaska)	*?*	*0.3%*

Tabla 1. *Platinum placer production related to Ural-Alaskan type complexes before 1927.*

All rocks, display slightly positive chondrite-normalized PGE patterns, i.e. (Pt+Pd+Rh)/(Os+Ir+Ru) > 1, and show positive Pt anomaly decreasing from dunite to wehrlite, clinopyroxenite and gabbro. Chromitites can be extremely rich in PGE, typically showing "M" shaped PGE patterns, characterized by marked positive peaks in Ir and Pt. Accordingly, PGM mineralogy consist mainly of Pt-Fe and Ir-Os alloys accompanied by accessory Pt-Rh-Ir thiospinels, Ru-Os sulfides, and minor Pd-minerals. The PGM mostly occur as microscopic inclusions in fresh chromite, although spectacular deposition of Pt-Fe

palabras clave: Complejos tipo Alaska-Ural, Cromita, Platino.

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alloys forming, massive aggregates of some kilogram in weight is observed in epigenetic chromitite-dunite breccia (Betechtin, 1961), while late chromitite-amphibole-clinopyroxenite veins contain abundant Potarite (PdHg) (Zaccarini et al., 2011).

Ural-Alaskan type intrusions may have genetic relationships with “ankaramitic” magmas (Irvine, 1973; Krause et al., 2007), which forms in island-arc and oceanic-island settings. However, ankaramites appear to have derived from more Cr-rich, primitive magmas compared with Ural-Alaskan rocks. Mineral chemistry of Ural-Alaskan type chromitites of the Urals and Kamchatka, indicate parental melts comparable with Island-arc, high-K and calc-alkaline basalts, i.e. the Roman volcanic province, and Aeolian arc (Batanova et al., 2005; Garuti et al., 2011). The persistent Pt-Ir anomalies in chromitite and dunite may represent a distinctive signature of Ural-Alaskan type magmas, possibly inherited from their mantle source (Garuti et al., 1997, 2003). This is explained by the evidence that asthenospheric melts display significant negative anomalies of Ir and Pt, suggesting that these metals were retained in the mantle source, by accumulation of refractory alloys during partial melting. Second-stage melting of such a mantle source, under the action of metasomatic fluids, may be at the origin of Pt-Ir rich Ural-Alaskan type magmas.

The root of Island arcs is the most obvious locus for fluid-driven metasomatism and repeated partial melting of the mantle residing above subducted crustal slabs. However, zoned intrusions of the Aldan shield and Russian Far East were emplaced in sub-continental settings, locally associated with alkaline magmatism, thus suggesting that generation of melts with Ural-Alaskan type distinctive signature may be not an exclusive feature of Islands-arc systems. Evidence acquired so far is not conclusive, and several important questions concerning global tectonics and origin of platinum mineralization in the Ural-Alaskan type complexes still remain open.

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