# Magmatic and supergene evolution of the unconventional pirogues Pt mineralization in the New Caledonia ophiolite

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**MAGMATIC AND SUPERGENE EVOLUTION OF THE UNCONVENTIONAL PIROGUES Pt MINERALIZATION IN THE NEW CALEDONIA OPHIOLITE**

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ABSTRACT. The New Caledonia ophiolite presents an unconventional Pt-Cr mineralization, located at the base of a magma chamber, itself presenting specific differences compared to the other cumulate sequences of the ophiolite. The primary mineralization and its magmatic environment are presented. The strong weathering having affected the mineralized zone has provoked a decoupling between the Cr and the Pt mineralization, with dissolution of the Pt minerals and their redistribution in the profile owing to heterogeneities in the porosity of the weathered profile. Moreover, weathering conditions having affected the PGM have locally provoked the formation of oxygen-bearing Pt-Fe grains according to a mechanism that will be proposed.

GEOLOGY. The New Caledonia ophiolite, covering about 40% of the island (i.e. about 7500 km²), forms a now discontinuous nappe, 1.0-3.5 km thick, emplaced during the Late Eocene. It is mainly composed of mantle harzburgite with minor dunite bodies, except in its southern part where cumulate series occur, no thicker than 700 m, dominated by ultramafic rocks.

The Pirogues River sequence, one of six cumulate localities, is characterized by an unconventional Pt-Cr mineralization. The sequence consists of a massive basal dunite unit grading up into a layered orthopyroxene-dominated pyroxene-peridotite unit. The upper part of the dunite unit and the whole pyroxene-peridotite unit are cut by dykes of various rock types and thickness, and both units contain rare, small (cm-size), chromite schlieren. The Pirogues River sequence is significantly different in terms of mineral composition from the other five sequences, having a relatively high Fe/Mg ratio in the silicates, highly Al-Cr-impoverished pyroxenes, and $Fe^{3+}$-enriched chromite that suggests derivation from a different magma, possibly with a boninitic composition related to a second-stage hydrous melting in a supra-subduction environment.

The pyroxenite dykes comprise >80% pyroxene along with olivine and rare magmatic amphiboles, and contain disseminated euhedral chromite; most facies are ad- to meso-cumulate. The orthopyroxene/clinopyroxene ratio is varied, generally with dominant orthopyroxene, and the facies include orthopyroxenite, clinopyroxenite, websterite, harzburgite, and lherzolite. The mineralogical composition can change very rapidly, even within a single dyke.

MINERALIZATION. The Pt mineralization at Pirogues is found systematically in chromite-rich rocks. These form: 1) 'stratiform' chromite concentrations in the basal dunite and pyroxene peridotite cumulates; and 2) irregular, commonly elongate, chromitite pockets, systematically PGE-enriched, that can be as much as 1-m long and 10-cm thick with generally sharp and unusual textures. In these pockets, chromite crystals are small (<100 µm) and euhedral. Pt-Cr-rich dykes are distributed within an area of about 1000 by 500 m. Pt in the chromite-rich rocks varies from 500 ppb to 36.5 ppm and roughly correlates with $Cr_2O_3$. Pt systematically dominates the other PGE with a Pt/(ΣPGE) ratio generally ranging between 5 and 15. The PGE form PGM that (>90%) are included in, or attached to, chromite crystals, with the most common phases being Pt-Fe alloys (isoferroplatinum, tetraferroplatinum, tulameenite), followed by cooperite, laurite, bowieite, malanite, cuprorhodsite and a few base-metal sulphides (BMS) with PGE in solid solution.

Like all of New Caldeonia, the Pirogues sector has undergone strong lateritic alteration. Study of PGM in weathering profiles showed Pt mobility with dissolution figures of Pt-Fe grains, as well as images of concentrically zoned PGM grains that were first interpreted as secondary formed particles, similar in texture to iron pisolites. Microprobe analyses of these grains revealed for the first time the natural occurrence of PGE oxides (Augé & Legendre, 1994), which were initially interpreted as formed under surface conditions after remobilization and reconcentration of PGE (and their crystallization as oxides). This model was further supported by that fact that laterite was enriched in Pt, disconnected from any Cr enrichment.

Detailed investigation of the weathering profiles confirmed that Pd is more mobile than Pt (Traoré et al, 2008, Fig. 1). However, it also showed that PGM liberated during the supergene dissolution of chromite can accumulate in the lower parts of the profiles, fine Pt-rich particles being driven by water percolation through the connected pore space and accumulating in the lower part of the profile where porosity decreases, thus explaining the decoupling between Pt and Cr concentrations.

However, the origin of the Pt-Fe oxides remains partly unknown, with for example two-phase grains composed of a Pt-Fe alloy associated with a Pt-Fe oxide. Further work on characterizing such grains (Hattori et al., 2010) explained the formation of the O-bearing Pt-Fe with the following process. In Stage 1 within ultramafic rocks, highly reducing alkaline waters can remove $Fe^0$ from isoferroplatinum as $Fe^{2+}$. The removal of $Fe^0$ likely produces the porous texture and shrinkage cracks of isoferroplatinum grains, common in the area. During this stage, $Pt^0$ is stable and likely remains in isoferroplatinum. Further erosion of the rocks leads to an incursion of oxygenated alkaline surface water that dissolves $Pt^0$ and washes Pt away as soluble $Pt^{2+}$-OH complexes. $Fe^{2+}$ in solution starts to precipitate in voids as $Fe^{3+}$-O-OH. This simultaneous dissolution of $Pt^0$ and precipitation of $Fe^{3+}$-O-OH likely produced a delicate mixture of isoferroplatinum and $Fe^{3+}$-O-OH, which initially was interpreted as PGE oxide.

CONCLUSIONS. The Pirogues River ultramafic sequence in the New Caledonia ophiolite has many unique aspects. It is a quite uncommon occurrence of Pt-rich chromite mineralization in ophiolite, generally characterized by an Os-Ir-Ru PGM mineralization in podiform chromitite. In adition, it is also a spectacular example of the effect of strong lateritic weathering on Pt-mineralization and Pt minerals.

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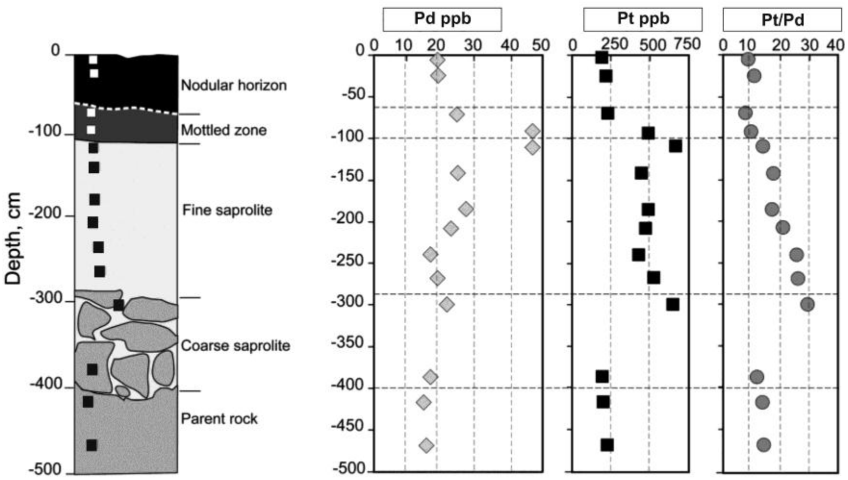


Fig 1. Pd, Pt and Pt/Pd ratio of samples collected in the weathered profile of the Pirogues mineralized area. Position of the samples in the profile is indicated by squares (after Traoré et al., 2008)