Role of magmatic and hydrothermal processes in PGE mineralization, Ferguson Lake Deposit, Canada

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The Ferguson Lake Ni-Cu-PGE deposit in Nunavut, Canada, is hosted by a metamorphosed gabbroic intrusion. Magmatic massive sulphides (MS) containing PGE occur towards the hanging wall of the meta-gabbro. A low-sulphide high-PGE style of mineralization (sulphide veins and disseminations) locally occurs ~30 to 50 m below the main MS. The genetic link between these two styles of mineralization is undetermined.

Magmatic sulphides are represented by the MS and interstitial sulphide in the high-PGE zones. Sulphides also occur in undeformed veins with associated chlorite ± epidote ± quartz alteration, and as disseminations throughout the host meta-gabbros. In detail, sulphides and alteration minerals have veined and replaced metamorphic hornblende and biotite. Barren chlorite-quartz-carbonate veins are also present. Platinum group minerals (PGM) occur as: inclusions in magmatic pyrrhotite and chalcopyrite in both the MS and high PGE zones; at the contact between sulphides and hornblende or magnetite inclusions in the MS; in the undeformed sulphide veins and adjacent chlorite and/or epidote halos; in hornblende adjacent to hydrothermal veins; and in plagioclase-chlorite aggregates replacing garnet cemented by sulphide. PGM are mainly represented by the kotulskite (PdTe) – sobolevskite (PdBi) solid solution, but also include sperrylite ($PtAs_2$), michenerite (PdBiTe), froodite ($PdBi_2$), mertieite I ($Pd_{11}(Sb,As)_4$) or mertieite II ($Pd_8(Sb,As)_3$). PGM in the MS are generally sobolevskite whereas those in the high PGE zone are kotulskite. The association of PGM with magmatic sulphides in the MS and high-PGE zones indicate that PGE mineralization was initially controlled by sulphide liquid segregation. However, the occurrence of PGM in underformed sulphide-bearing veins and in their chlorite-epidote haloes, and differences in PGM chemistry, indicate that hydrothermal fluids were responsible for late- or post-metamorphic redistribution and dispersion of PGE.

Cratons and continents: A view from below

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This contribution reviews petrological, geophysical, geochronological and geological data that bear on the origin and stability of deep mantle lithospheric ‘roots’. The origin of mantle lithosphere underlying Archean crustal provinces is most consistent with depletion at low pressures in the spinel facies under degrees of melting higher than observed today in modern ocean basins. Depleted sections of the lithosphere created in convergent margin settings were underthrust and stacked to build a thick root with time. Geochronologic and geologic evidence can be interpreted to show that the final formation and amalgamation of the bulk of the ‘mantle root’ occurs 0.5 – 1 Ga later than the age of lithosphere from which it is comprised. Statistically, “Silica enrichment” is not common in the mantle beneath Archean crustal provinces, and where it occurs may be a heterogeneous feature possibly imparted by marine weathering of peridotite on the (Archean) ocean floor before it was stacked to form a mantle root.

In the Slave Province, the mantle can be considered in steady state at the time sampling by kimberlites for the past 550 m.y. The thermal history of crust and mantle is decoupled however considering the thermal time constant for a ~ 200 km thick root is 1 to 2 Gy (Mareschal and Japuart, 2006). If the lithosphere was to remain strong and stabilize the craton, its initial temperature must be below the steady state regime so commonly recorded by ‘paleogeotherms’, a condition made permissible if the lithospheric root formed by accretion of ‘cold’ subducting plates. When this happened may vary for different continents but in North America it appears to be an early Proterozoic phenomenon. A search for processes that link Archean crust with its mantle root during its formation may be futile if the two are considered to be decoupled from one another. Questions remain - Why does lithospheric stacking not occur today? Did plate thicknesses and lengths in the Archean and early Proterozoic differ enough from the modern case to engender a more neutral buoyancy required for shallow subduction and ‘stacking’ (Davies, 1992). The level of depletion seems key but more ‘sluggish’ plate tectonics in the Archean has been proposed (Korenaga, 2006). Slower plates and fewer convergent margins with early ‘continents’ may explain the time lag of 0.5 – 1 Ga between lithosphere age and the age of actual mantle ‘root’ formation and craton ‘stabilization’.