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Lithospheric Evolution, Ultramafic Magmatism and Diamond Potential of the Norwegian Lapland

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Most of the Norwegian Lapland is underlain by Precambrian rocks of the Norwegian craton (NC) which belongs to a system of North Atlantic cratons along with Kola, Scotland and West Greenland terrains. NC is composed of Archean amphibolite- to granulite-facies gneissic complexes intruded by TTG and dissected by Proterozoic greenstone belts. Recent U-Pb dating of zircons from basement gneisses in eastern Finnmark suggests presence of an early Archean crustal component dated at 3.69 Ga, as well-as a follow-up thermal episode at 3.2 Ga [1]. Major crustal growth phase within the NC occurred at 2.8-2.9 Ga while the final consolidation event associated with intrusion of K-granites is dated at 2.5 Ga. Greenstone belts in Norwegian Lapland are composed of pillow-textured ultramafic lavas and differentiated calc-alkaline series which are believed to have formed between 1.7 and 1.9 Ga. NC is characterized by a thick crust (40-70 km) as well as low heat flow typical of diamond-bearing cratons worldwide.

Gneissic terrains within the NC contain numerous dikes, sills and plugs of ultramafic to mafic composition typically localized in extensional structures (paleo-rifts). Main rock types are Fe-picrites, mica picrites, ultramafic to shoshonitic lamprophyres, and high-Mg alkaline and sub-alkaline basalts. These rocks exhibit trace element characteristics consistent with their derivation from a variety of mantle sources ranging from N-MORB through E-MORB to OIB mantle. Geochemically, parental ultramafic magmas in NC could have originated from a veined mantle source composed of depleted and enriched domains partially affected by an addition of subducted component (marked depletions in Ti, Nb and Ta contents coupled with enrichment in Th and U and other large-ion lithophile elements). Petrologic affinities of some magmas in Norwegian Lapland suggest their possible derivation within the diamond stability field in the upper mantle (ultramafic and shoshonitic lamprophyres).

Till sampling established presence of mineral trains composed of Cr-diopside, Mg-spinel, Mg-olivine and eclogitic garnet along with “exotic” indicator minerals such as corundum and uvarovite that are interpreted as being derived from mantle peridotite and eclogite assemblages upon erosion of their kimberlitic and/or lamproitic and lamprophyric hosts. 70% of Cr-diopside compositions in till samples from Eastern Finnmark plot into the diamond inclusion field [1]. Corundum exhibits two populations of Cr/Ni ratios – 3-6 and 203-315 which are similar to Cr/Ni ratios in white corundum and ruby inclusions in diamonds respectively [2]. The low Cr/Ni group also displays elevated Ca contents of 9 to 99 ppm consistent with their mantle origin [2]. Most minerals exhibit only limited degree of chemical abrasion (local sources) while few grains suggest either long-transport distances (> 100 km), or long residence times in secondary sedimentary collectors. Presence of these indicator minerals along with chemical characteristics of post-Precambrian ultramafic rocks, Early Archaean (3.69-3.2 Ga) basement ages, geophysical characteristics of the NC crust as well as earlier discoveries of gem diamonds in Pasvik River sediments suggests that Norwegian Lapland has high potential of hosting primary diamond deposits.

[1] Kepezhinskas P (2011) In: *Abstracts and Proceedings 1*: Geological Survey of Norway, 48-49
[2] Hutchinson M et al. (2004) Lithos 77: 273-286