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Anatomy of a LIP-forming conduit system in the Deep Crust: The Seiland Igneous Province, Northern Norway

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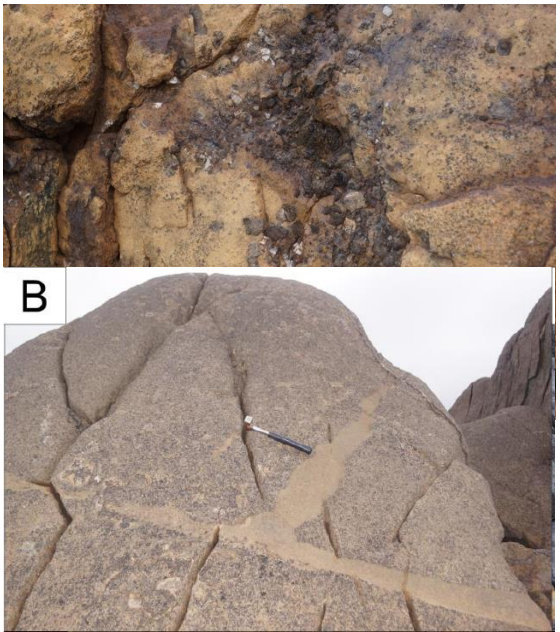
The Seiland Igneous Province (SIP) consists of >5,000 km^2 of mafic, ultramafic and alkaline melts that were emplaced into the lower continental crust (25-35 km depth) in <10 Ma (570-560 Ma) during mantle plume upwelling. We argue that the SIP was the deep-seated conduit system of a large igneous province (LIP), making the region a key location in which to study the ascent, emplacement and modification of dense mantle melts enroute to more shallow igneous systems. In nearly all other LIPs of the Earth, only the uppermost parts of the LIP, with flood basalts and layered gabbros, are exposed. Here, in SIP, we have a much higher proportion of juvenile ultramafic rocks and may study igneous processes that relates to asthenosphere deep-lithosphere interaction processes prior to the melt-modifying processes that influence the parent melts during ascent towards the shallow crust.

Ultramafic complexes dominated by peridotitic cumulates occupy 1/3 of SIP and comprise the conduits along which ultramafic magma migrated throughout the continental crust. The Reinfjord Complex is an excellent example of one of these conduit systems.

The picritic to komatiitic melts in the Reinfjord Complex were emplaced into gabbros in three major pulses punctuated by several smaller replenishment events. The first two pulses, the lower and upper layered series (LLS + ULS) comprises modally layered ol – cpx ±opx cumulates. The final phase, the central series (CS), comprises dunitic cumulates in the centre of the intrusion. The CS intruded into a crystal-melt mush of the ULS. The CS-forming melt was saturated with ol and assimilated ULS cpx to form discordant replacive dunites. Super-imposed upon these major events, cryptical zonation of ol and cpx reveal several replenishment episodes. We have identified 15 events over only 700 metres of cumulates. Field observations document smaller replenishment events of pyroxenitic melts. They occur as irregular dykes that intersect semisolid cumulates before dissipating in mushy melts higher up in the stratigraphy.



One such event is associated with the formation of a 5 metres thick PGE-Ni reef with 0.8 ppm Pt, Pd and Os. We also observe that the melt-mushes of CS were intruded by several events of alkaline CO_2-H_2O rich melts forming veinlets of feldspathoids, amphibole, carbonates, opx and cpx.

Together, this rich diversity of igneous rocks documents the complexity of melts that are produced during plume assisted emplacements of very large volumes of mafic-ultramafic melts. Not least, in Reinfjord we learn to appreciate the importance of melt modification (mixing-assimilation etc.) of mantle derived melts in the deep crust before the "homogenized" products are emplaced in shallow magma chambers or flows.

Figure 1. Top: recharge of dense pyroxenitic melts (dark) in dunitic mush (yellowish) forming px-pegmatite. Bottom: Dunite (yellowish) forming by cpx-assimilation of wehrlitic cumulates (grey)