

Evidence for Craton-wide Ferropicritic Underplating of the Neo-archean Ungava Craton

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Introduction

Significant debate exists over the tectonic mechanisms responsible for the origin and assembly of the Archean Ungava Craton with one model calling for a plate tectonic process involving lateral accretion, subduction and arc magmatism (Percival et al., 2001), while a competing model advocates for a vertical lithospheric process operating on an autochthonous construction (Bédard et al., 2003). The identification of a large number of Fe-rich mafic/ultramafic plutonic bodies at various localities within the Ungava peninsula (Fig. 1) indicates that mantle derived ferropicritic magma may have played a significant role in cratonization of the peninsula.

The Qullinaaraaluk suite

Geochronological (Simard, 2008) and field information indicates that mafic/ultramafic intrusive bodies, collectively referred to as the Qullinaaraaluk suite, were emplaced coevally with the relatively potassic ca. 2.74-2.72 Ga granitoids (Maurice et al., 2009) that dominate the crustal architecture of the Ungava Craton. The intrusions occur as dykes, stocks and tectonic enclaves that range from small intrusions less than 100 m across to larger bodies in excess of $\sim 10\text{km}^2$. The ultramafic bodies are commonly brecciated by the surrounding granitoids, in apparent conflict with the age relationships implied by the dyke bodies, and thus suggesting near-synchronous emplacement of the two lithologies.

The intrusions are internally zoned, exhibiting gabbro-noritic outer margins, and hornblende-websteritic to peridotitic cores. The suite as a whole is exceptionally fresh for its Archean age, retaining much of the primary igneous mineralogy. The peridotite cores contain abundant olivine chadocrysts enclosed by hornblende and clinopyroxene oikocrysts. Measured olivine compositions ($\leq \text{Fo}_{83}$) require a picritic parental magma ($\text{Mg}\# \leq 59.4$) that is significantly more Fe-rich than modern hot-spot or subduction related picrites. Furthermore, the suite's whole-rock and olivine compositions define a Ni vs. Mg# trend that rises asymptotically at Mg# ~ 83 , implying a ferropicritic parental liquid for the suite (Fig. 2).

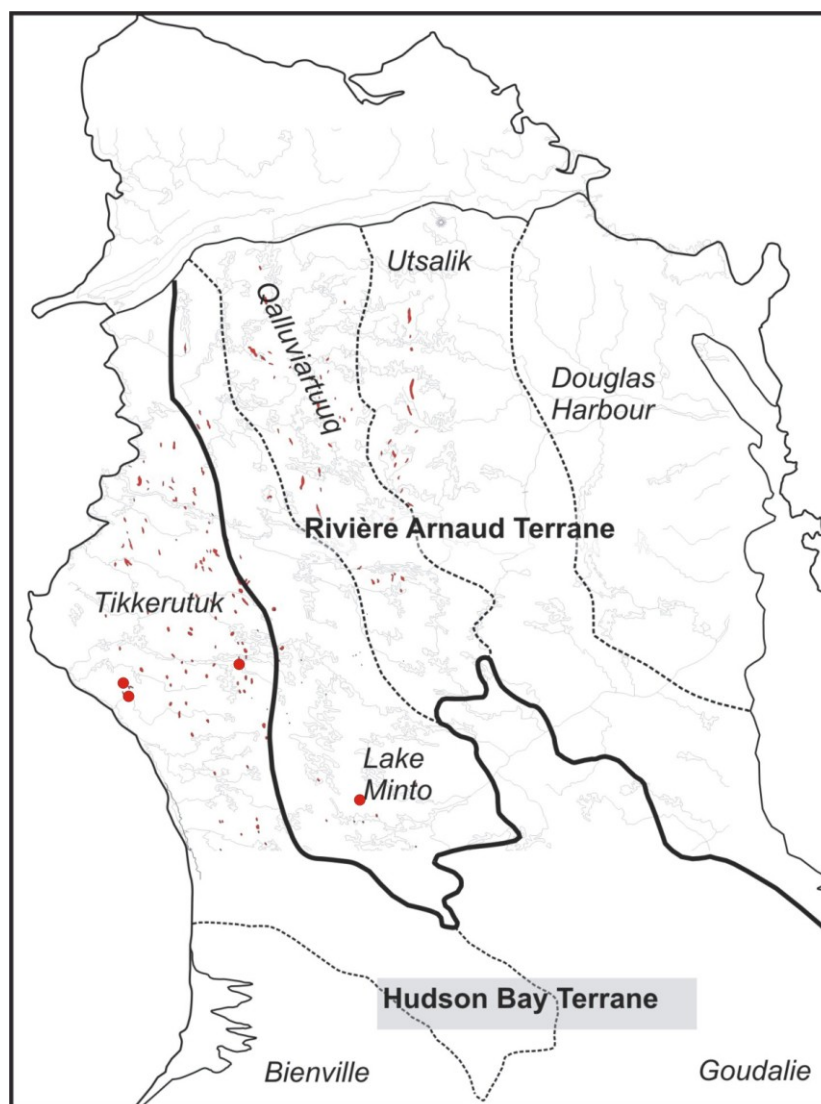


Figure 1. Map of the Northeastern Superior Province (NESP), showing the lithotectonic domains (Leclair, 2005) and isotopic provinces (Boily et al., 2009). Shown as small red polygons are the reported outcrops of the Qullinaaraaluk suite as reported by the Ministère des Ressources Naturelles et de la Faune. Larger red circles emphasize the general locations from which our samples were sourced. Map modified from Maurice et al. (2009).

With the exception of olivine-bearing peridotites, which are relatively depleted in the HREE, the mafic and ultramafic rocks of the Qullinaaraaluk suite are enriched in incompatible trace elements relative to the primitive mantle values. An important characteristic of the suite is its relative HFSE depletion as indicated by $(\text{Nb}/\text{La})_n$ and $(\text{Zr}/\text{Gd})_n$ ratios less than 1. Moderate enrichments in LREE ($(\text{La}/\text{Sm})_n < 6$) and relatively flat HREE ($(\text{Gd}/\text{Yb})_n < 3.6$) are typical of the suite, and increase with the decreasing MgO content. The striking similarity between the suite's trace element patterns and those of the surrounding granites suggests either significant assimilation of the country rock, or genetic link between the two.

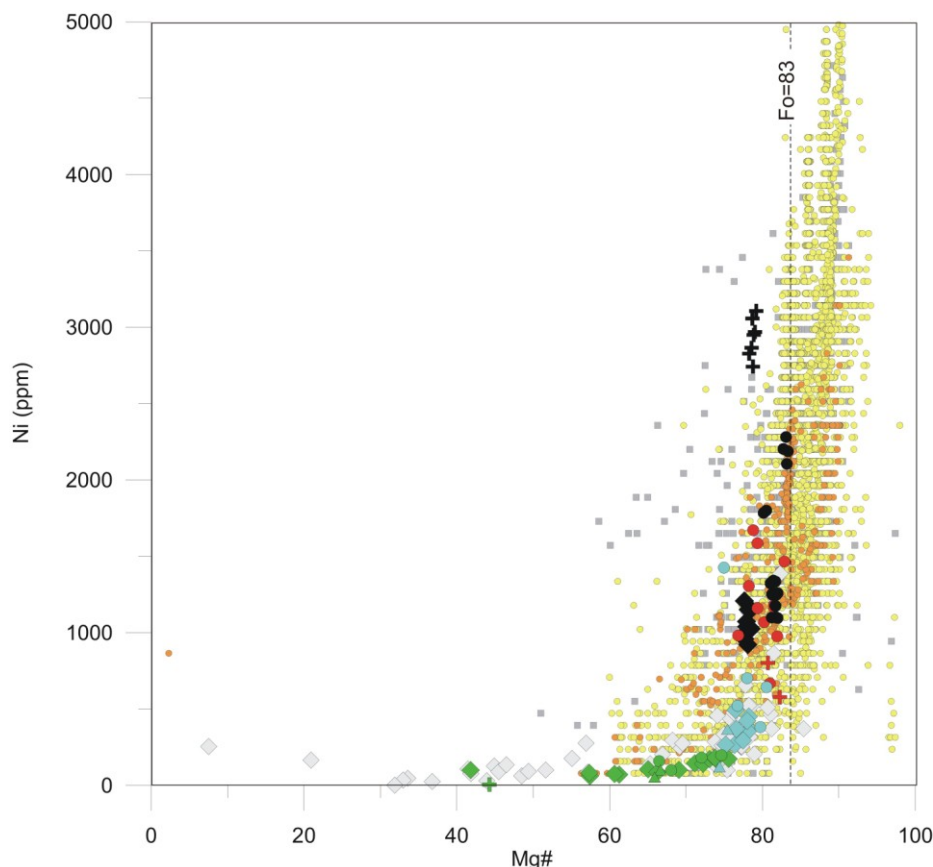


Figure 2. Ni vs. Mg# for the select whole-rock samples and olivine of the Qullinaaraaluk suite. The black symbols are olivine analyses, red symbols represent peridotite analyses, blue symbols are pyroxenite analyses, and green denotes gabbro-norites. Light grey diamonds denote analyses from the Qullinaaraaluk type locality by Giroux et al. (2001) and Baker (2005). Small grey squares, orange circles and yellow circles represent olivine analyses from Hawaii, Iceland and convergent margins, respectively.

Conclusions

Small mafic/ultramafic intrusions that are peppered across the Ungava Craton appear to be derived from a ferropicritic parental magma. Field relations and limited geochronological data indicate that the intrusions were emplaced synchronously with voluminous granitic melts, during a major regional tectonic episode at ca. 2.74-2.72 Ga that stabilized the Ungava Craton. These two observations may indicate that ferropicrite magmatic underplating was in part responsible for the stabilization of the neo-Archean Ungava Craton.

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