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# Geochronology of the Qeqertaa Diamondiferous Ultramafic Lamprophyre, West Greenland

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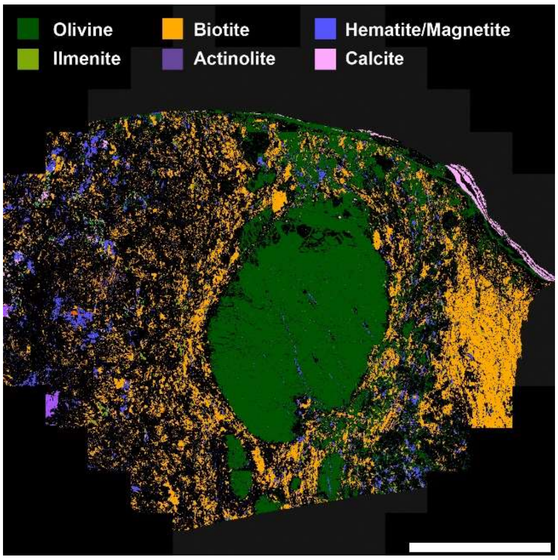
## Introduction

Greenland's geological architecture largely comprises Archean and Proterozoic crust exposed at the surface or underlying younger sedimentary basins. The thickness and age of the lithospheric mantle under much of Greenland is suitable for the formation of diamonds (Wittig et al., 2010), which are known among abundant surface occurrences of aillikites and kimberlites (Hutchison and Frei, 2009; Hutchison, 2020). In contrast to the North Atlantic Craton where dated lithological associations imply continental break-up and formation of the nascent Iapetus Ocean around 600 Ma (Larsen et al., 2009), the geochronological record of the Rae Craton, to the north, is less constrained, particularly among diamondiferous rocks. Unlike typically pristine aillikites and kimberlites in the North Atlantic Craton, the Rae Craton diamond-prospective rocks are often metamorphosed, increasing complexity but also providing an opportunity for reflecting a spectrum of geological events. The Qeqertaa ultramafic lamprophyre dyke system (Bernstein et al, 2013), within Disko Bay, is the most diamond-rich body known within the Rae Craton. While exhibiting a size distribution dominated by microdiamonds, it yields diamond crystals of high quality (over 80% of stones being colourless and octahedral; Hutchison, 2020). Although metamorphism has not allowed full preservation of the original mineralogy, it is likely to be an aillikite, or kimberlite – an interpretation consistent with its diamond xenocrysts and abundant deep mantle-derived dunite xenoliths (Bernstein et al., 2013).

## Methodology and Analytical Results

Four Qeqertaa drillcore samples were selected for isotopic investigation. The samples are blue, grey, and greenish-grey aphanitic to medium grained ultramafic lamprophyres with occasional weak foliation, and with few uranium-bearing accessory minerals. Calcite (Lu–Hf) and monazite (U–Th–Pb) were investigated, the latter because it may constrain the timing of magmatism. Calcite is abundant in all samples and is interpreted to be influenced by metamorphic recrystallisation (Figure 1). Monazite was identified as euhedral grains up to 130 μm, but more typically as smaller, interstitial grains.

Measurements were conducted at Curtin University, Perth, Western Australia. Monazite U-Th-Pb isotope data were acquired by LA-ICPMS using an Agilent 8900 quadrupole. Calcite Lu-Hf isotope data were acquired by the same instrumentation but using the collision cell reaction gases to obtain the masses of interest.



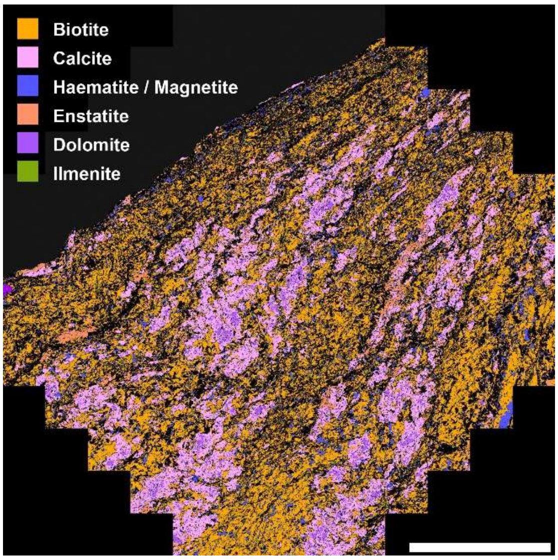




**Figure 1:** TESCAN TIMA classification maps of Qeqertaa aillikite samples. Scale bars are 5 mm. a. Sample MMRQQ10-1c mostly showing a suite of primary minerals, including large (up to 10 mm) olivine xenocrysts. b. Sample MMRQQ10-5 showing a more pronounced fabric indicative of metamorphism. Calcite, used from Sample MMRQQ10-4 for geochronology, occurs abundantly.

**Monazite U-Th-Pb Geochronology**

| Sample | Th/Pb age | n | MSWD |
|---|---|---|---|
| MMRQQ10-1c | 1718±23 Ma | 16 | 2.2 |
| MMRQQ10-1d | 1788±16 Ma | 24 | 2.1 |
| MMRQQ10-5 | 1822±24 Ma | 15 | 2.4 |

**Calcite Lu-Hf Geochronology**

| Sample | Inverse isochron age | n | MSWD |
|---|---|---|---|
| MMRQQ10-4 | 1346 ± 89 Ma | 21 | 0.7 |

**Table 1.** Summary of geochronology data for samples of the Qeqertaa diamondiferous aillikite

Results are compiled in Table 1. Two overlapping monazite samples yield (concordant) Th–Pb weighted mean ages of 1822±24 Ma (Figure 2a) and 1788±16 Ma, interpreted to reflect metamorphic or hydrothermal (re)crystallization, consistent with the low U content and ragged morphology of interstitial grains. A third sample yields a Th–Pb age of 1718±23, implying later monazite growth or alteration via renewed fluid rock activity. A hydrothermal genesis for this generation is consistent with their steep REE profile. In the same sample, a single analysis also retained a 1962±80 Ma age. Given the low grade of metamorphism and high closure temperature of monazite, it is reasonable to assume that the Qeqertaa dyke emplacement is best evidenced by this earliest monazite age, whereas the spectrum of younger monazite ages captures a cryptic record of multiple fluid rock interaction events. Measurement of calcite in one sample implies closure to diffusive Hf loss at around 1350 Ma (Figure 2b), suggesting calcite (re)crystallization during an even later stage of fluid/rock interaction.

## Discussion and Conclusions

Early Proterozoic magmatism (1700-1900 Ma) in west Greenland is interpreted as representing continental collision followed by subsequent rifting (Larsen and Rex, 1992). Assuming that the early 1962 Ma monazite age from Qeqertaa is not inheritance, it is consistent with a model of magmatic emplacement of asthenospheric melt generated by lithospheric thickening and heat generation on collision between the Rae and North Atlantic Cratons at the early part of this age range. The dominant, c. 1800 Ma monazite ages are within uncertainty of previously reported ages from the 60-km distant Oqaatsunnguit lamproite pipes and

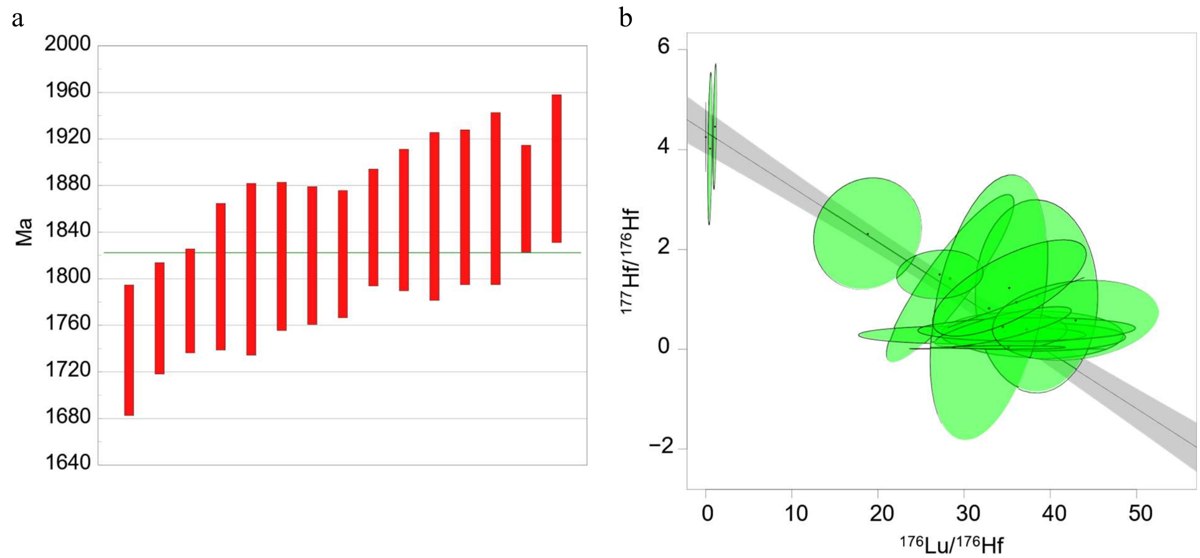



**Figure 2:** a. Th/Pb age ranges of seventeen analyses of MMRQQ10-5. Box heights are 2σ b. Calcite Lu-Hf inverse isochron diagram from sample MMRQQ10_4. The solid black lines indicate an isochron fit through all the data. Error ellipses and regression envelopes are shown at 95 % confidence. $(^{177}Hf/^{176}Hf)_0$= 4.36 ± 0.44.

a nearby ultramafic lamprophyre dyke (Larsen and Rex, 1992). With the new Qeqertaa data, these Disko Bay ages appear to evidence episodic pulses of heat and hot fluids generated as the collided continental blocks relaxed. The 1346 Ma calcite age is coincident with ages of the 270 km-distant lamproites of Nordre Strømfjord (Larsen and Rex, 1992) and close to the earliest ages of Gardar alkaline magmatism a further 730 km to the south (Upton et al. 2006). Therefore, finally, by the Middle Proterozoic, and with west Greenland's continental blocks assembled, Qeqertaa was positioned to evidence a distant echo of the rifting and magmatism relating to incipient break-up of the Paleopangaea Continent.

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