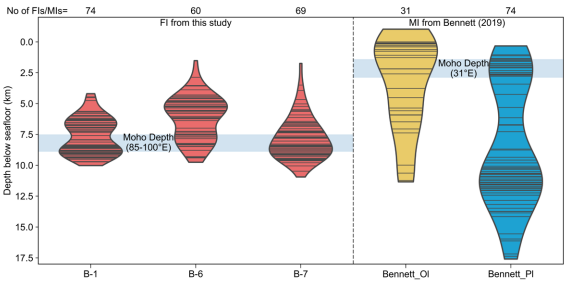
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Fluid and melt inclusions constraint on the magmatic plumbing system architecture beneath Gakkel Ridge (Arctic Ocean)

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Understanding the magmatic plumbing architecture of the global mid-ocean ridge system is critical for gaining deeper insights into the construction and evolution of ridge magmatic systems and the oceanic crust. As the archetype of ultraslow-spreading ridges, the Gakkel Ridge serves as a key natural laboratory for investigating magmatic systems under extremely limited melt flux, offering new insights into how melt supply governs magma storage and crustal construction. Previous studies from the western Gakkel Ridge (3–31°E) suggest that volcanism may have magmatic roots extending deep into the lithospheric mantle, with plagioclase melt inclusions (MIs) crystallizing at greater depths than olivine melt inclusions.

Here we investigate magma storage depths beneath the eastern Gakkel Ridge using seven basalt samples collected from one ridge segment at 85°E using secondary trails of CO_2-rich fluid inclusions (FIs) and MIs hosted in olivine. Raman spectroscopy was used to determine FI densities, from which entrapment pressures were calculated using a mixed CO_2–H_2O equation of state. Our FI-derived results indicate broadly consistent depths of olivine storage among different samples, at ~5–10 km below the seafloor (Fig.1). These depths are significantly greater than previous estimates based on olivine-hosted MIs, which suggested shallow crystallization at ~0–4 km.

The ultraslow-spreading Gakkel Ridge exhibits pronounced along-axis variations in crustal thickness between 31°E and 100°E, decreasing from ~7.5–8.9 km in the east to ~2 km in the west. By systematically comparing magma storage depths along the ridge, we will be able to assess whether magma storage is consistently located near the Moho along this ridge segment, and/or whether there is a correlation between storage depth, spreading rate and magma flux.

We note that these previous studies targeted bubble-free melt inclusions, which may explain the discrepancies if that population was trapped at shallower levels. Our preliminary measurements of bubbles in olivine-hosted melt inclusions record 250-1,240 ppm CO_2, which is comparable to the 94-1,984 ppm CO_2 measured in bubble-free inclusions. FTIR will be used to reconstruct the total volatile budget to compare to fluid inclusion depths. Our results provide independent evidence for deep magmatic roots beneath ultraslow-spreading mid-ocean ridges, even for olivine crystallization.