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Investigating intraplate volcanism and the role of the lithospheric mantle: Drilling petit-spot magmas at the Japan Trench subduction zone on IODP^3 Expedition 502

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The lithospheric mantle is critical in shaping intraplate magmatism. Petit-spot volcanoes represent melts within the low-velocity zone (LVZ) that are extracted via tectonic mechanisms [1]. These magmas have been sampled only by dredging or submersible operations, limiting stratigraphic and petrologic context. During International Ocean Drilling Programme (IODP^3) Expedition 502, conducted aboard the drilling vessel *Chikyu* (October 30–November 24, 2025), petit-spot basalt and overlying sediment were cored at the outer rise of the NW Pacific subduction zone, near the Japan Trench. Three coring boreholes at Site C0027 reached depths of up to 106.5 m below seafloor and recovered ~40 m of alkaline-rich basalt. These lavas are fresh and relatively evolved, with bulk compositions of 53–55 wt% SiO_2, 6–7 wt% Na_2O+K_2O, and 6–9 wt% MgO. They are more Si-rich than previously studied petit-spot lavas (45–53 wt% SiO_2), thereby extending the known compositional range of these magmas. However, the processes responsible for this diverse chemistry remain enigmatic. The variation may reflect differences in mantle source composition, melting conditions, or metasomatic modification associated with melt extraction from the LVZ.

A defining characteristic of petit-spot magmatism is the relatively differentiated composition of erupted lavas, with Mg# values as low as ~50 despite the absence of large (>2 mm) phenocrysts. Moreover, some petit-spot lavas contain xenoliths equilibrated under garnet-facies conditions [2], implying that magmatic differentiation occurred at depths prior to xenolith entrainment, followed by rapid magma ascent. These observations challenge the classical view of magmatic differentiation and show that chemical evolution can begin at the base of the lithosphere.

Using the new samples, we discuss the magmatic processes that may explain these petrogenetic signatures and assess the lithospheric control on intraplate lava compositions. Specifically, we test whether magmatic differentiation occurs at the source within deep-seated reservoirs or through alternative mechanisms such as percolative fractional crystallization during ascent. Constraining the depth of fractional crystallization will help characterize the role of lithospheric heterogeneities in the compositional diversity of intraplate volcanism.

[1] Hirano et al. (2006), *Science* 313, 1426–1428.
[2] Pilet et al. (2016), *Nature Geoscience* 9, 898–903.
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