Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.32391

Origin of High and Very High Titanium Basalts in IODP Expedition 391 Site U1578 and the Tristan-Gough-Walvis Hotspot Track

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The distinct spatial and temporal geochemical variation within the guyot province 'trident', of the Tristan-Gough-Walvis (TGW) hotspot system has been well documented in the Tristan and Gough tracks, however, the origin of central track compositions remains ambiguous. IODP Expedition 391 penetrated 302 m of basement on the central track at Site U1578. Whole rock major and trace element analyses of Site U1578 drill core samples demonstrate uniformly alkali ocean island basalt (OIB) compositions. Among the major elements, TiO_2 is higher relative to other Expedition 391/397T sites, but similar to concentrations measured in several TGW dredge samples (Hoernle et al., 2015). Specifically, high TiO_2 (HT) basalts (2-3.5 wt%) in Site U1578 are found in the upper and lower portions of the drill core, while very high TiO_2 (VHT) basalts (3.5-4.8 wt%) occur within a central ~100 m interval. Dredging programs have identified additional VHT (3.6-4.1 wt%) compositions in the Gough track and Walvis Ridge (Hoernle et al., 2015).

Overall, multielement and REE patterns in Site U1578 basalts align with global OIB trends. VHT basalts have higher high field strength element (HSFE) and generally lower LILE concentrations compared to HT basalts. VHT and HT basalts have similar Zr/Nb ranges, but HT basalts have higher Nb/Yb values. Ti/V values also show variability: VHT basalts have Ti/V between 52-71 while HT basalts show a wider range from 48-84, both within the alkaline OIB field of Shervais (2022). In contrast, dredged VHT basalts from the Gough track and Walvis Ridge generally show higher Ti/V, HFSE, and LILE than U1578 VHT and HT basalts but have lower HREE.

Major and trace element distributions for Site U1578 VHT and HT basalts suggest both garnet-bearing peridotite and pyroxenite mantle melt sources. Prytulak and Elliot (2007) demonstrated that Ti concentrations in OIB are inconsistent with generation from depleted MORB mantle (DMM) and thus require an additional enriched source. We suggest that TGW HT basalts were generated as low degree partial melts of an enriched mantle (EM1) source and the VHT basalts record an additional pulse of a highly enriched source component, consistent with eclogite and/or subcontinental lithospheric mantle (SCLM).