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Rhyolite volcanism in the Marie Byrd Land volcanic province, Antarctica: New evidence for pyroclastic eruptions during latest Pliocene icesheet expansion

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IODP Expedition 379 deep-sea drilling in 2019 (Gohl et al. 2021, doi:10.14379/iodp.proc.379.2021), offered an opportunity to obtain chronostratigraphic control for seismic reflection data for Amundsen Sea shelf and slope deposits that record Miocene to Present fluctuations in volume of the West Antarctic ice sheet. Here we report the age and interpret the provenance of a volcanic ash bed recovered at/near the Plio-Pleistocene boundary at 31.51 meters below sea level in Hole U1533B and 33.94 mbsf in Hole U1533D. With distinctive geochemistry and inferred wide regional distribution, the bed may serve as a reliable age marker.

In Hole 1533B, the fresh tephra forms a discrete layer interstratified within uniform brown marine mud. The layer has a sharp base and upper boundary that is gradational over 5 cm into overlying mud. Color reflectance and density data aided identification of the tephra horizon (diffuse) in Hole 1533D, ~1000m away. A possible on-land source for ash is the Miocene to Pleistocene Marie Byrd Land volcanic province, comprising 18 large alkaline volcanoes dominated by effusive lavas. Products of pyroclastic eruptions are uncommon, mainly occurring as distal englacial, and probably marine, tephra.

We undertook an offshore-onshore comparison by first characterizing samples of Site U1533 tephra from a petrographic and geochemical standpoint, using thin section observations, EMPA-WDS glass compositions, and $^{40}Ar/^{39}Ar$ dating. We then identified onshore exposures with similar characteristics. The offshore tephra are composed of coarse (50-300µm) cuspate glass shards with elongated vesicles. The glass composition is rhyolite, with 75-79wt.% SiO_2, ~4wt.% FeO and 0.0wt.% MgO. Single-crystal feldspar $^{40}Ar/^{39}Ar$ dates are 2.55±0.12 and 2.92±0.02 Ma for U1533B and 2.87 ±0.45 Ma for U1533D. The geochemistry, shard morphology, discrete bed expression, and lateral continuity between Holes U1533B-U1533D indicate that the rhyolite tephra formed as airfall settled to the deep seabed. The ca. 2.55 Ma age based on youngest feldspar grains differs

slightly from the 2.1 to 2.2 Ma result obtained from in-progress core bio-magnetostratigraphy.

Rare exposures of rhyolite are found in the Chang Peak/Mt. Waesche centers, 1080 km from Site U1533. We obtained pumice sample MB.7.3 (prior-published age of 1.6±0.2 Ma), which displays elevated FeO and F content, and MB.8.1, a specimen of porphyritic cryptocrystalline lava. Single-crystal sanidine $^{40}Ar/^{39}Ar$ dates are 1.315±0.007 Ma (MB.7.3) and 1.385±0.003 Ma (MB.8.1). Site U1533 samples share a geochemical affinity with these on-land rhyolites, expressed as similar SiO_2, CaO, TiO_2, MgO and FeO content, suggesting an origin for Site U1533 tephra in the Chang-Waesche volcanoes. A possible explanation for the distinctly greater age, and observed contrasts in Al_2O_3, Na_2O and F percentages, is that Site U1533 tephra are older and erupted from a source entirely concealed beneath subsequent eruptions and the ice sheet. Our results suggest that rhyolite volcanism initiated earlier, was of longer duration than previously known (2.92 to 1.315 Ma), and dispersed tephra far offshore. The finding is significant because ash and aerosols produced by large eruptions may influence regional climate. Antarctica cooled significantly and ice sheets expanded in latest Pliocene time (McKay et al. 2012, doi:10.1073/pnas.1112248109).

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