Subglacial Landform Analysis and Reconstruction of Miocene Paleotopography of Marie Byrd Land

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Analysis of sub-ice bed topography datasets from Marie Byrd Land (ASE05, WMB (SOAR), BEDMAP1_plus), undertaken as part of the international Antarctic paleotopography, or ANTscape, program (www.antscape.org), reveals subglacial landforms that may have implications for ice sheet history, ice dynamics, and determination of isostatic responses of the crust of Marie Byrd Land (MBL) since the onset of continental glaciation. These include subglacial volcanoes, alpine glacier valleys upon elevated topography of volcanos, and a flexural moat around the Executive Committee Range volcanic field (Fig. 1). Observations from the geophysical datasets are augmented by the Landsat Image Mosaic of Antarctica (LIMA) and high resolution commercial imagery held by the Antarctic Geospatial Information Center (AGIC).

Whereas the WAIS initiated at *ca.* 34 Ma *(DeConto et al., 2007, Pollard and DeConto, 2003)*, the volcanoes in the MBL volcanic province are 17 Ma to present (Mt Petras and Reynolds, excepted). Thus, central MBL volcanoes were not present to serve as high elevation sites for ice cap nucleation during the early history of the WAIS. During and after formation, the 2000+m volcanoes would have affected precipitation patterns and been sites of volcano-thermal perturbations that promoted warm-based glaciation, conducive to glacial erosion and development of alpine glacier valleys during times of reduced ice sheet extent. Such considerations, arising from study of bedrock geology and landforms, are the basis for our effort to reconstruct the Early Miocene (*ca.* 21 Ma) paleotopography of Marie Byrd Land through inferring subglacial bedrock response to surficial processes. Our results will be integrated into paleotopographic reconstructions of Antarctica that are being prepared by ANTscape for 6 time intervals (spanning 92 Ma to present) that have paleoclimate and tectonic significance. The geospatial data for the reconstructions of past landscapes are intended for use as inputs for future ice sheet-ice shelf models and for visualizations of Antarctic paleogeography and paleoenvironments.

Cross-sectional profiles of ASE05 and BEDMAP1_plus bed topography data show a pronounced narrow downwarp, bordered by a broad bulge, on the north and south margins of the Executive Committee Range (Fig.2). Sequential topographic profiles at 5 km spacing show that the features are laterally continuous for >40 km and systematic in geometry, suggesting that there is a volcanic moat formed from elastic response of the lithosphere to the lithostatic load of the Executive Committee range. Therefore, our paleotopography reconstruction for pre- Early Miocene time must both remove volcano elevation and allow isostatic rebound from volcano load (subaerial and shallow crustal components) and ice sheet.

Qualitative observations of bed topography of the Executive Committee Range reveals the presence of narrow, steep-walled valleys that we postulate were formed by alpine glacier erosion at a time when WAIS was of reduced extent and the Executive Committee Range hosted alpine glaciers in an environment similar to the present-day Southern Alps of New Zealand. The five major volcanoes of the Executive Committee Range are younger than 14 Ma (LeMasurier and Rocchi, 2005; Smellie et al., 1990), and so provide a maximum age constraint on a time when warm-based ice retreated to the upper elevations of the volcanoes. The finding of warm-based glacial erosion features formed at high elevations at a time after the mid-Miocene climate transition – when there was a change to hyper arid climate and onset of cold-based mode of Antarctic glaciation (Jamieson and Sugden, 2008) – is a possible indication that basal thermal conditions were elevated in the vicinity of the volcanoes.

Following the mid-Miocene climate transition, Antarctica entered an arid period when extensive areas of the ice sheets became cold-based. Warm-based glacial erosion became focused within preexisting drainages at low elevation, leading to development of deeply incised outlet glacier troughs (Jamieson and Sugden, 2008). Therefore, our paleotopography reconstruction restores post-Miocene incision by outlet glaciers and ice streams. Restoration of the changes in elevation due to volcano construction and glacial incision results in an Early Miocene subdued landscape with ~1100 m of topographic relief (Fig. 3), which we will use for calculation of isostatic corrections for removal of volcanic rock and ice. Our ongoing work assesses structural inheritance and the possibility that fault reactivation may be linked to glacial erosion-induced exhumation, tectonic influences, and fluvial or glacio-fluvial processes.

References Cited
DeConto, R. et al., 2007, *Paleoceanography*, 22, PA3214, doi:10.1029/2006PA001350.
Jamieson, S. S. R. & Sugden, D. E., 2008. In: Cooper, A.K. et al. (eds.), Antarctica: A Keystone in a Changing World - Proceedings of the 10th ISAES, National Academies Press, Washington D.C., 39-54
LeMasurier, W.E. & S. Rocchi, 2005, *Geografiska Annaler*, 87 (1), 51-66.
Pollard, D. and R. M. DeConto, 2003, *P^3*, 198 (1-2), 53-67.
Smellie, J.L. et al., 1990, *Antarctic Science*, 2, 353-354.

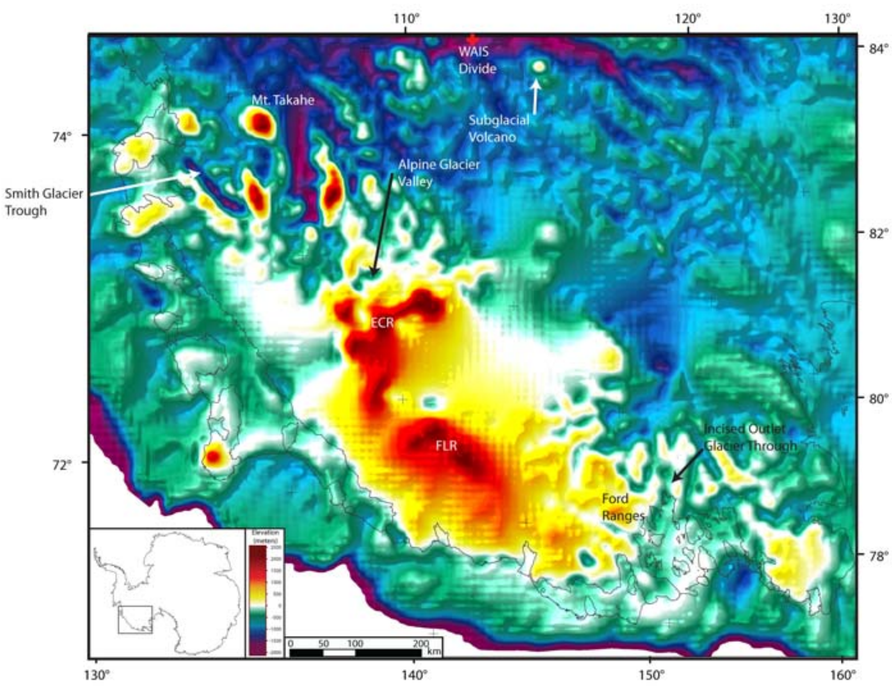

Figure 1. Shaded relief DEM of subglacial topography of Marie Byrd Land and location map for features under study, from BEDMAP1_plus (http://websrv.cs.umt.edu/isis/index.php/Present_Day_Antarctica).

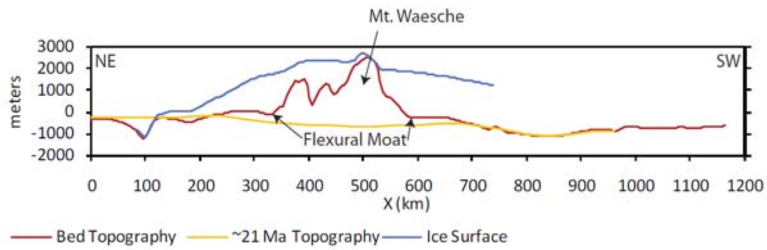

Figure 2. Profile of bed topography (BEDMAP1_plus, 2009), ice surface topography (ASE05), and reconstructed Early Miocene (21 Ma) topography across the Executive Committee Range, MBL. The feature inferred to be a "moat," or circumferential depression around the volcanic field, has topographic relief of ~450 m.

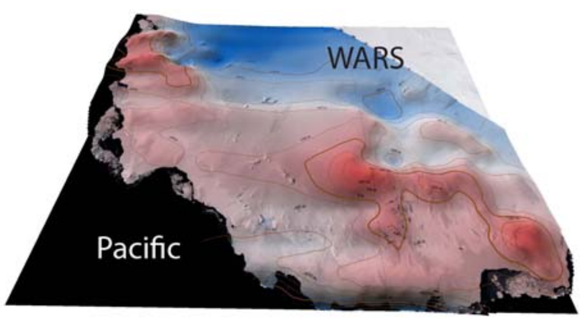

Figure 3. Oblique perspective view to SE of the reconstructed Early Miocene (*ca.* 21 Ma) landscape of Marie Byrd Land, rendered in Fledermaus (ivs3d.com). For purposes of geographic location, the Landsat Image Mosaic of Antarctica (LIMA) is incorporated in the visualization. Broad regions that are at depths <-1000 m correspond to extended (subsided) crust of the West Antarctic rift system.