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Reconstructions of Antarctic topography and ice sheet volume since the Eocene–Oligocene boundary

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Antarctica's bedrock topography exerts a fundamental control on ice sheet behaviour, and has likely evolved significantly throughout its glacial history. Accurate models of past Antarctic ice sheets therefore require a realistic reconstruction of bedrock topography at the time interval of interest. Here, we present new reconstructions of Antarctic topography at four time slices: the Eocene–Oligocene climate transition (ca. 34 Ma), the Oligocene–Miocene boundary (ca. 23 Ma), the mid-Miocene climatic optimum (ca. 14 Ma), and the mid-Pliocene warm period (ca. 3.5 Ma). To reconstruct past topography we consider a series of processes including ice sheet loading, volcanism, thermal subsidence, horizontal plate motion, erosion, sedimentation and isostatic adjustment, and tie our models to onshore and offshore geological constraints.

Our reconstructions show that the land area of Antarctica situated above sea level was $\sim$25% larger at the Eocene–Oligocene boundary than at the present-day. During the Oligocene, deep near-coastal topographic troughs formed around the margin of East Antarctica, with up to 3 km of material removed by erosion, which in turn drove up to 1.5 km of flexural uplift of adjacent highlands. Contemporaneously, large areas of West Antarctica were experiencing thermal subsidence associated with the West Antarctic Rift System. By the mid-Miocene, the topography of East Antarctica began to closely resemble that of the present-day, and much of West Antarctica had subsided below sea level. After the mid-Miocene, erosion and sedimentation rates in West Antarctica increased by $\sim$50%, whereas rates in East Antarctica decreased by $\sim$50%, with large areas experiencing relatively little modification after ca. 14 Ma.

By comparing modelled ice sheet extents across these climate intervals on our new topographies and the modern topography, we show that ice volumes differ significantly depending on the topography. Our results also imply that early ice sheets were less sensitive to ocean forcing during the Oligocene than at the present-day, owing to the lack of reverse-sloping topography situated below sea level. The landscape evolution model presented here also indicates that glaciers around the margin of East Antarctica would have become vulnerable to marine ice sheet instability sooner than those in West Antarctica. Marine ice sheet instability likely became increasingly pertinent to West Antarctica after the mid-Miocene climate transition.