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Tectonic and erosion-driven uplift in the Gamburtsev Subglacial Mountains of East Antarctica

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Understanding the mechanisms leading to intraplate mountain building remains a significant challenge in Earth Sciences compared to ranges formed along plate margins. The most enigmatic intraplate mountain range on Earth is the Gamburtsev Subglacial Mountains (GSM) located in the middle of the Precambrian East Antarctic Craton. During the International Polar Year, the AGAP project acquired 120,000 line km of new airborne geophysical data (Bell et al., 2011, Science) and seismological observations (Hansen et al., 2010, EPSL) across central East Antarctica. Models derived from these datasets provide new geophysical perspectives on crustal architecture and possible uplift mechanisms for the enigmatic GSM (Ferraccioli et al., 2011, Nature).

The geophysical data define a 2,500-km-long Paleozoic to Mesozoic rift system in East Antarctica surrounding the GSM. A thick high-density lower crustal root is partially preserved beneath the range and has been interpreted as formed during the Proterozoic assembly of East Antarctica. Rifting could have triggered phase/density changes at deep crustal levels, perhaps restoring some of the latent root buoyancy, as well as causing rift-flank uplift. Permian rifting is well-established in the adjacent Lambert Rift, and was followed by Cretaceous strike-slip faulting and transtension associated with Gondwana break-up; this phase may have provided a more recent tectonic trigger for the initial uplift of the modern GSM.

The Cretaceous rift-flank uplift model for the Gamburtsevs is appealing because it relates the initiation of intraplate mountain-building to large-scale geodynamic processes that led to the separation of Greater India from East Antarctica. It is also consistent with several geological and geophysical interpretations within the Lambert Rift. However, recent detrital thermochrology results from Oligocene-Quaternary sediments in Prydz Bay (Tochlin et al., 2012, G3) argue against the requirement for major Cretaceous rift-related exhumation in interior East Antarctica. This raises the question of whether the modern Gamburtsevs may instead have been uplifted solely in response to changes in Cenozoic erosion patterns during the early stages of East Antarctic Ice Sheet formation superimposed upon an a Permian-age rift flank, or an even older highland.

To address this question we combine results from: i) analyses of the subglacial landscape for the GSM (Rose et al., 2013 EPSL) with; ii) 2D and preliminary 3D flexural models of peak uplift caused by the isostatic responses to fluvial and glacial valley incision processes. We also compare geophysical relief and isostatic model outputs with estimates of erosion rates since the Oligocene and the total amount of incision estimated for the adjacent Lambert rift region (Thomson et al. 2013, Nature Geoscience). Flexural modelling outputs were also compared against the present-day elevations of up to 1500 m a.s.l of uplifted Oligocene-early Miocene glacial-marine sediments in the Lambert Glacier (Hambrey et al., 2000, Geology). Flexural models yield new estimates of peak uplift and regional lowering for continuous and broken-plate approximations respectively. These results can also be used to re-assess the possible ranges of pre-incision elevations of the "Gamburtsev plateau", which is of key importance when modelling early East Antarctic ice sheet development (e.g. De Conto and Pollard, Nature 2003).