Glaciovolcanic evidence for a polythermal Neogene East Antarctic Ice Sheet

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The basal thermal regime of glacial ice is critical in determining the potential for unstable behavior in an ice sheet. For the East Antarctic Ice Sheet, a paradigm has existed for more than 30 years that its basal thermal regime in Victoria Land made a fundamental transition from wet-based to cold-based in the Neogene, with discussions on the transition timing, i.e. ca. 14 Ma or after ca. 2.5 Ma.

Various methods of investigations have been applied alone or in combination to investigate the ice sheet behavior across this time span, including glacial/erosional studies and cosmogenic nuclide or tephra dating, drill core sedimentology, as well as numerical modelling.

An alternative method is based on terrestrial glaciovolcanic sequences, a uniquely valuable data source for estimating thickness, extent and basal thermal regime of past ice sheets. Volcanic materials also offer the great opportunity of isotopic dating, to constrain in time these ice features. This method offers the advantage of being applicable to the whole time interval of interest (Miocene-present) and over almost 8 degree of latitude: ca. 900 km of the Ross Sea flank of the Transantarctic Mountains are punctuated by volcanic edifices active from the Miocene to the present. Glaciovolcanic sequences in Victoria Land are volcanic sheet-like sequences, glaciolacustrine sequences, scoria cones, tuff cones, and aa lava-fed deltas, the latter representing extraordinarily useful indicators of fossil water/ice levels that were here recently discovered and documented.

Our results indicate that the spatial organization of the basal thermal regime was considerably more complicated than previously inferred, probably comprising a geographically and temporally varying coarse temperature patchwork of frozen-bed and thawed-bed ice, similar to the East Antarctic Ice Sheet today. The basal thermal regime was polythermal overall, thus requiring an important shift in the prevailing paradigm describing its temporal evolution.