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Major Subglacial Meltwater Channels Reveal Former Dynamic Ice Sheet in West Antarctica

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The Eocene-Oligocene boundary (ca. 34 Ma) marks the onset of widespread, continental-scale glaciation in Antarctica, due to declining atmospheric carbon dioxide levels and the opening of the Drake Passage. The marine-based West Antarctic Ice Sheet (WAIS) is considered highly susceptible to change, experiencing numerous oscillations since its formation. In order to assess how past changes to the WAIS are relevant for understanding its future behaviour, it is important to comprehend the glaciological processes involved in those changes. Central to this is an appreciation of climate and ice flow regimes, in particular the extent to which former ice sheets have experienced surface melting (as in Greenland today). Geomorphic analysis of subglacial topography has played a key role in reconstructing the nature of former ice masses in Antarctica, as landscape form can be linked to glacial process. While radio-echo sounding (RES) is the primary tool used to map boundary conditions beneath ice sheets, recent developments have demonstrated that satellite imagery of the ice surface can provide insights into subglacial topography, where RES is unavailable.

Using this combination of datasets, we have identified a series of major, elongate subglacial features, which we interpret as preserved subglacial channels, developed through the action of water. They are incised into a subglacial plateau in the region between the Möller and Foundation ice streams (MIS and FIS, respectively), in West Antarctica. The channels are observed across an area of $\sim$17,700 km2 and extend 200 km inland from the grounding line. They are located below sea level and track over present-day reverse slopes, indicating a subglacial (rather than pre-glacial) fluvial origin. In order to form, these channels require significant, probably periodic (seasonal), meltwater inputs to the base of the ice sheet. We suggest the channels are the result of meltwater inputs to the subglacial environment from the ice surface, in a setting analogous to present-day Greenland. This allows us to bracket the most recent date at which this may have occurred.

The Pliocene (2.6-5.3 Ma) represents the most recent period in the geologic past when atmospheric temperatures for West Antarctica were high enough to generate surface melt comparable to that observed on the Greenland Ice Sheet today. These features provide evidence for temperate basal thermal conditions and thus, a former ice flow regime that differs markedly from the present-day polar ice sheet conditions of West Antarctica. We envisage bed channel formation occurred under temperate ice sheet conditions, when the subglacial plateau was overridden by a temperate ice mass. If this interpretation is correct, it means that ice was still present (at least periodically) in this location, during the warm conditions of the Pliocene. The discovery of these channels also highlights what little was known about this large region of West Antarctica, prior to the Institute-Möller geophysical survey.