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# DEPTH-DEPENDENT ICE CREEP AT PRINCESS ELIZABETH LAND, EAST ANTARCTICA

Quantifying the depth-dependent rheology of Antarctic ice is essential for understanding ice sheet dynamics and their response to environmental forcing. In recent decades, borehole-based deformation measurements—including inclinometers, tiltmeters, optical strainmeters, and borehole imaging—have provided new insights into the internal mechanics of ice sheets and glaciers across Greenland, Antarctica, and selected alpine sites. Extensive campaigns in Greenland's ablation and marginal zones, the French Alps, and at Siple Dome, Antarctica, have revealed pronounced seasonal and depth-dependent variability in ice creep and basal sliding, with field measurements demonstrating that the flow law parameters governing ice deformation can vary substantially with both depth and time. These studies have established the crucial role of in situ, depth-resolved observations for constraining the partitioning of basal sliding versus internal deformation, quantifying the influence of temperature, water content, and microstructure on creep rates, and supporting model development for predicting ice sheet behavior under changing climatic conditions. Despite these advances, large areas of East Antarctica—particularly Princess Elizabeth Land—remain under-sampled, and little is known about their depth-dependent ice rheology.

In this study, we present borehole-based measurements of ice deformation at the IBED-2 site in Princess Elizabeth Land, East Antarctica. Temperature measurements carried out at the bottom of the borehole immediately after drilling termination revealed a cold underlying base (Talalay et al., 2025). To study internal deformation processes, 10 months after drilling was completed, a borehole was logged to approximately 9/10 of total borehole depth (541 m), because the lower part of the borehole was plugged by ice chips. To capture both spatial and temporal variability, a multi-armed logger was deployed to measure borehole diameter, inclination, and temperature profiles from the surface to the base. Between 9 January and 2 February 2025, a total of 11 logging campaigns were conducted, yielding a high-frequency time series of depth-resolved data that spans nearly one month. These repeated measurements resolve temporal and vertical variations in strain rate through the ice column.

We present direct observations of strain-rate profiles with depth and analyze their implications for Glen's flow-law parameters. Our results reveal substantial variation in creep rate with depth, highlighting the influence of ice temperature, and possibly ice microstructure. Comparative discussion of our borehole measurement approach is provided, referencing previous deployments in polar and alpine settings. Our findings contribute to the growing body of field-based evidence characterizing the spatial and temporal variability of Antarctic ice rheology and provide important constraints for the understanding and modeling of polar ice sheet dynamics.

References

Talalay PG, Leitchenkov G, Lipenkov V., Sun Y, Zhang N, Gong D, Liu Y, Li Y, Sun Y, Abdrakhmanov I, Vorobyev M, Khalimov D, Fan X, Salamatin A, Ekaykin AA, Bing Li B (2025). Rare ice-base temperature measurements in Antarctica reveal a cold base in contrast with predictions. Commun Earth Environ 6, 189. https://doi.org/10.1038/s43247-025-02127-1

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