Stability of interior East Antarctic wind scour and ice flow on glacial-interglacial timescales

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The region between Dome A and South Pole has likely preserved ice older than the current 800-thousand-year limit of continuous ice core records; however, until now this region has been largely unexplored. The Center for Oldest Ice Exploration (COLDEX) is currently performing the second of two planned years of airborne geophysical surveys on the Southern flank of Dome A. These surveys are providing new geological and glaciological constraints that we combine with ice-flow models to help target suitable deep ice core sites with the goal of recovering a continuous ice-core record going back at least 1.5 million years.

Using the new airborne ice penetrating radar data from COLDEX, as well as existing data from the AGAP project, we investigate how local variations in surface conditions may affect the ice record over time. First, we trace englacial layers and date them at the intersection with the South Pole ice core to infer the rate and pattern of past accumulation averaged over different time intervals. Second, we assess the impact of local zones of wind scour that occur on the Southern flank of Dome A (Das et al, 2013), which is at the upstream edge of the COLDEX airborne survey. Local zones of wind scour that lead to ablation or no accumulation, create time-transgressive unconformities that can be mapped from ice penetrating radar data. While the unconformity is initiated due to a relatively local change in surface conditions, the unconformity trace is imaged for many tens of kilometers downstream as it is advected by ice flow. Because the airborne survey flight lines are oriented along flowlines, the unconformities act as particle trajectories.

We use an ice-flow model set up along a flowline to evaluate the surface and flow conditions that develop an unconformity similar to a well-imaged unconformity that is observed in the COLDEX data. The unconformity can be well matched with the simple ice-flow model using a fixed position of the scour zone, indicating that the scour zone has been a persistent feature for the past glacial-interglacial cycle (~100 ka). Consistent with previous work (Das et al, 2013), the scour zones are collocated with subglacial ridges that create steeper surface topography. Thus, the positions of the
scour zones are likely independent of the climate state and permanent features on long timescales.

By modeling this unconformity trace we can constrain the modern horizontal velocity to ~1.5 m/yr near the scour zone that is located ~400 km from Dome A. The unconformity disrupts the continuity of all of the dated internal layers, which extend to 94 ka. Running the model back 1.5 Ma, we can evaluate where the climate record is disrupted at different positions along the flowline. The farther downstream a potential drill site is, the more problematic the unconformities become for obtaining a continuous climate record because the unconformity disrupts the continuity at deeper depths and older ages.