Eight million years of polar ice sheet variations from cosmogenic nuclides in marine sediments

JEREMY D. SHAKUN¹ PAUL R. BIERMAN² LEE B. CORBETT² KRISTEN UNDERWOOD³, DONNA M. RIZZO³, SUSAN R. ZIMMERMAN⁴, MARC W. CAFFEE⁵, TIM NAISH⁶, NICHOLAS R. GOLLEDGE⁶, CARLING C. HAY¹

¹Earth and Environmental Sciences, Boston College

³Civil and Environmental Engineering, University of Vermont

⁴Center for Accelerator Mass Spectrometry, Lawrence Livermore National Laboratory

⁵Earth, Atmospheric, and Planetary Sciences, Purdue University

⁶Antarctic Research Centre, University of Wellington

Ice-sheet melt will dominate sea-level rise over the coming centuries, but projections are hindered by uncertainty in how they responded to past warm periods, for example during the Pliocene (5.3-2.6 Myr ago) when atmospheric CO_2 concentrations were last \geq 400 ppm. This uncertainty stems from difficulty in extracting the sea-level signal from the marine δ^{18} O record and paleo-shorelines, and the patchy terrestrial record of glaciation on land. In contrast, material shed continuously from continents is preserved as marine sediment that can be analysed to infer the time-varying state of major ice sheets. We have measured several multi-million year-long records of glaciation from cores offshore Greenland and Antarctica based on the ¹⁰Be and ²⁶Al concentrations in quartz sands sourced from the adjacent continent. These nuclides monitor ice sheet history and process because they are produced in land surfaces when exposed to cosmic radiation, but are removed by decay and erosion when ice covered. The results suggest that the Greenland Ice Sheet was persistent but dynamic over the past several million years, while terrestrial ice in East Antarctica was stable and experienced minimal retreat onto land. Our results point toward Pliocene sea levels in the range ~10 to 30 m above present.

²Geology, University of Vermont