Subglacial structure of the Whillans Ice Stream from inversion of Rayleigh wave velocities and H/V ratios

*Douglas Wiens[1], Martin Pratt[1], Weisen Shen[1], Paul Winberry[2], Sridhar Anandakrishnan[3]

1. Dept Earth & Planetary Sciences, Washington University in St Louis, St Louis, MO USA, 2. Central Washington University, Ellensberg, WA, USA, 3. Pennsylvania State University, University Park, PA, USA

The Whillans Ice Stream (WIS) is unique in that it represents the only place where large-scale ice stream stick-slip motion has been detected. Tidally controlled stick–slip events occur approximately twice daily, with slip propagating outward from one of two different initiation points [e.g. *Pratt et al.,* 2014]. The locations of the rupture initiation points and the slip characteristics are likely controlled by bed conditions. It is thought that the frictional properties of the WIS ice–bed interface are highly heterogeneous, including stick-spots of high friction, possibly as a result of compacted sediment or bedrock, and active subglacial lakes where frictional coefficients are effectively zero. Here we analyze Rayleigh waves from earthquakes and ambient noise correlograms recorded by 35 broadband seismic stations deployed for 50 days on the WIS during 2010–2011. Rayleigh wave phase and group velocities at 4–20 s period from ambient noise correlograms constrain the structure at crustal depths, and horizontal-to-vertical (H/V) ellipticity ratios of Rayleigh waves from both ambient noise and earthquakes at periods of 5–40 s constrain the shallow (< 5 km) velocity structure. H/V ratio modeling results suggest that ratios are highly sensitive to sedimentary layer thickness. The datasets are jointly inverted using a Bayesian Monte-Carlo formalism [*Shen and Ritzwoller,* 2016] to determine the best fitting shear velocity structure with depth. The results show a highly variable sedimentary layer beneath the WIS, with sediment thickness ranging from 1 km on the northeast side of the array to 5 km on the southwestern side, towards the Transantarctic Mountains. The rapid thickening may correspond to sedimentary infill of a rift structure just outboard of the similarly oriented Transantarctic Mountain Front. There is also evidence that the water content of the uppermost sediment layer immediately below the ice is highly variable, with low water contents inferred for the “sticky spot” where the high tide WIS slip events initiate. This study demonstrates that shallow (< 5 km depth) subice structure can be reliably retrieved from a passive broadband seismic deployment of less than two months duration.

Pratt, M. J., J. P. Winberry, D. A. Wiens, S. Anandakrishnan, and R. B. Alley, 2014. Seismic and geodetic evidence for grounding-line control of Whillans Ice Stream stick-slip events, *J. Geophys. Res., Earth Surf., 119,* pp. 333–348.

Shen, W. and Ritzwoller, M.H., 2016. Crustal and uppermost mantle structure beneath the United States. *J. Geophys. Res, Solid Earth, 121(6),* pp.4306-4342.

Keywords: West Antarctica, Ambient Noise Correlation, Subglacial material properties, Crustal Structure

