Englacial Seismic Reflectivity

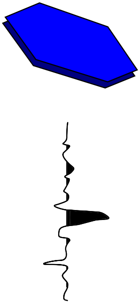
Imaging Crystal Orientation Fabric in West Antarctica

Huw Horgan[1], S. Anandakrishnan[2,3], R. B. Alley[2,3], L. E. Peters[2,3]

(1) Antarctic Research Centre, Victoria University of Wellington, New Zealand
(2) Dept. of Geosciences, Pennsylvania State University
(3) Earth and Environmental Sciences Institute, Pennsylvania State University

WAIS Workshop, 2011

Crystal Orientation Fabric (COF)



- Can we contribute an extra dimension to our understanding of COF in ice sheets?
- We use active source seismic reflection techniques. Imaging contrasts in acoustic properties, which we show are due to contrasts in COF.
- Examples from WAIS Divide, Upstream and Downstream Thwaites Glacier, and Bindschadler Ice Stream

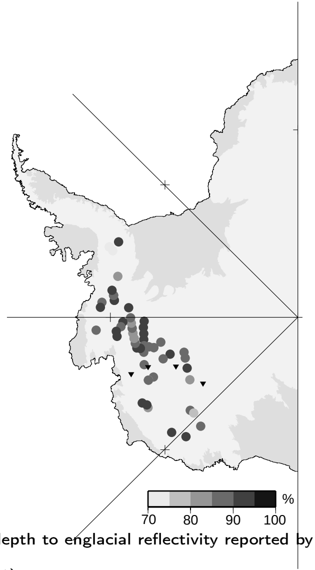
Seismic acquisition

- Hot water or mechanical drilling
- Explosive source shot at a depth dependent on firn thickness
- Shallow refraction surveying for velocity structure

$$R = \frac{Z_2 - Z_1}{Z_2 + Z_1}$$

(R denotes reflection coefficient, and Z_i denotes acoustic impedance (Z=density x velocity).)

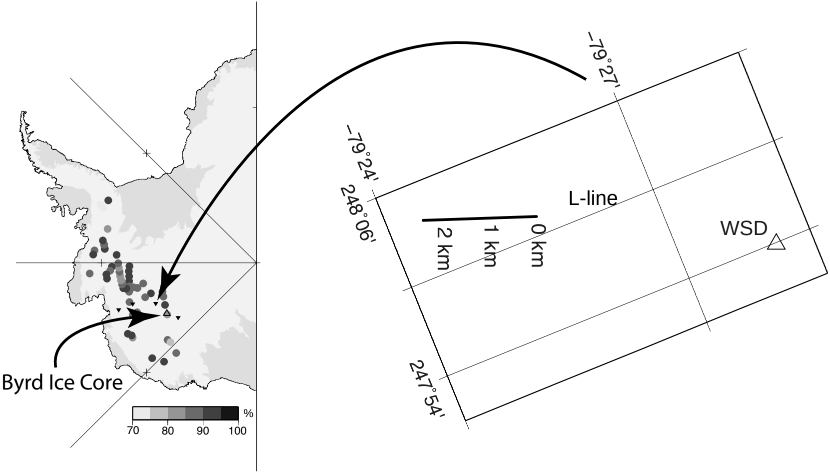
Englacial Seismic Reflectivity



Percentage depth to englacial reflectivity reported by Bentley (1971).

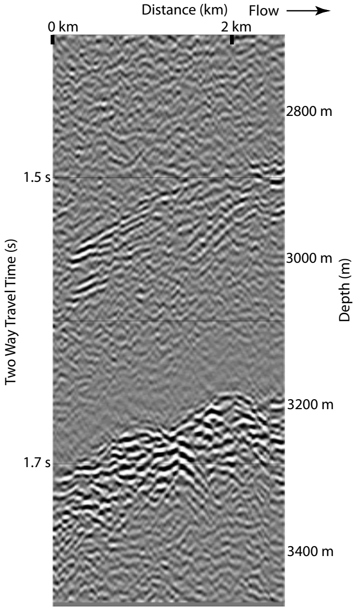
- Englacial Seismic Reflectivity - Bentley (1971)
- Moraine or Crystal Orientation Fabric?
- Previously, amplitude and seismic character have been used to support a morainal genesis.

WAIS Divide



Left: Location map showing percentage thickness of Bentley's (1971) englacial reflectors. Right: Seismic profile basemap.

WAIS Divide



* Shallow shots, 5 km from WAIS Divide. Englacial reflector 300 m above the bed.
* Englacial reflector at an average depth of 91% of ice thickness
* We await physical properties from the WAIS core

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* 10 km from the Byrd core Bentley (1971) reported an englacial reflector at 82% of the ice thickness.
* A change from fine grain vertical fabric to distributed recrystallization fabric occurs at this depth in the Byrd core.

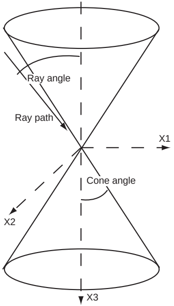
The Origin of Englacial Reflectivity

Pure Ice ($R = \frac{V_2 - V_1}{V_2 + V_1}$)

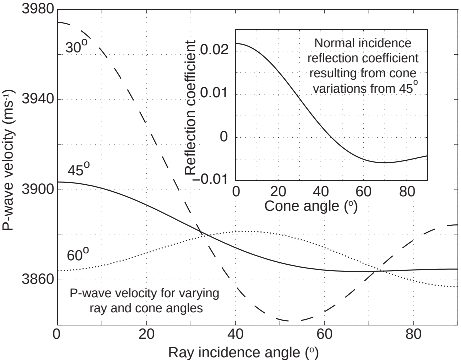
- ~~Temperature Contrasts~~
- ~~Bubbles~~
- Crystal Orientation Fabric

Impure Ice ($R = \frac{\rho_2 - \rho_1}{\rho_2 + \rho_1}$)

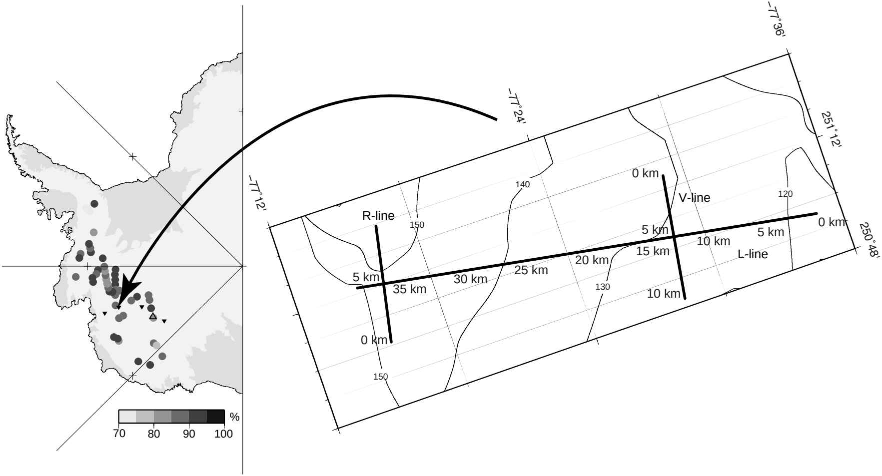
- ~~Entrained moraine~~
- ~~Impurities (direct)~~



Fabric cone and seismic ray geometry

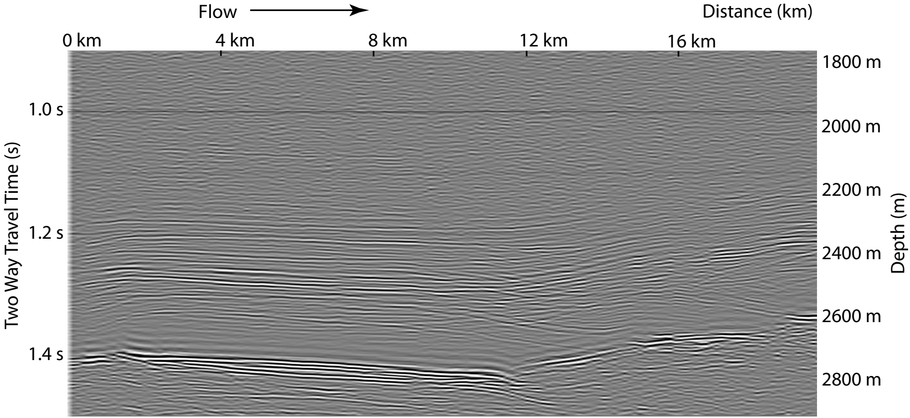


Upstream Thwaites Glacier

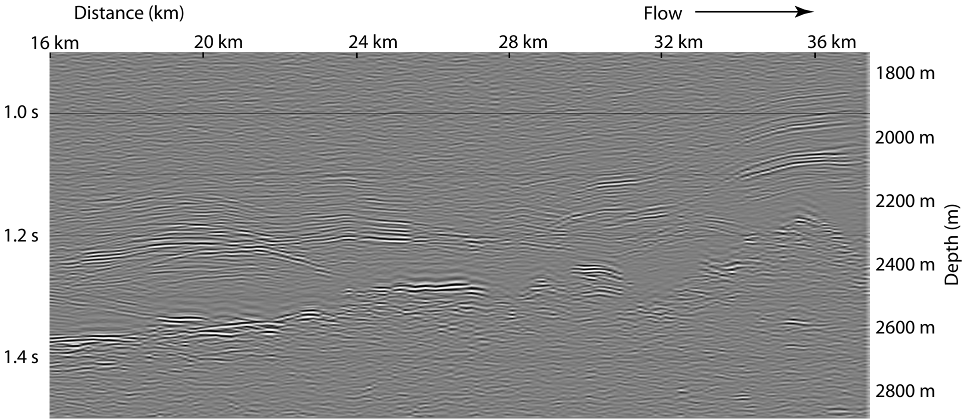


Left: Location map showing percentage thickness of Bentley's (1971) englacial reflectors. Right: Seismic profile basemap overlain on velocity contours (m s^{-1}).

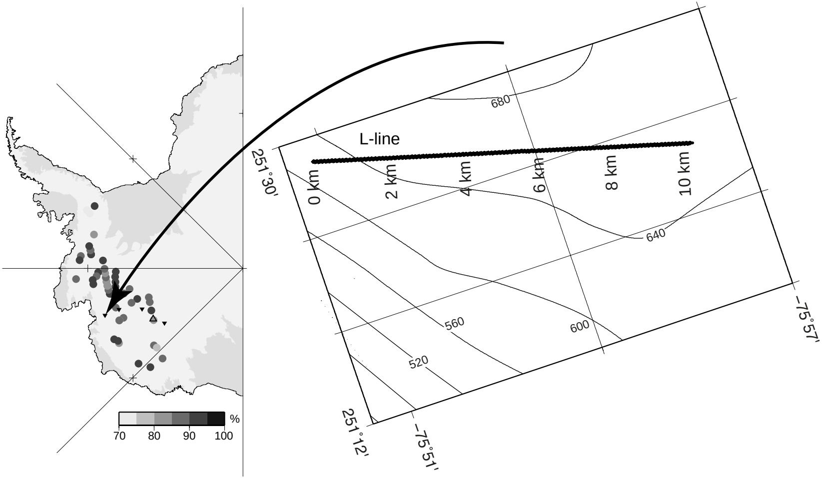
Thwaites Glacier (Part 1/2)



Thwaites Glacier (Part 2/2))



Downstream Thwaites Glacier



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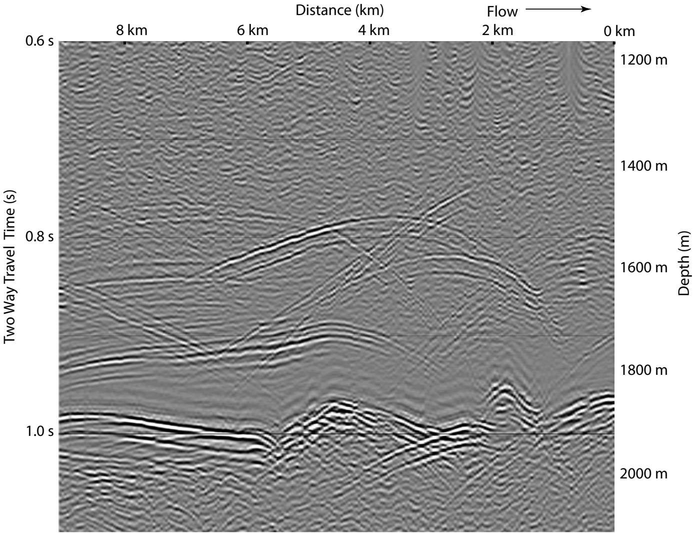
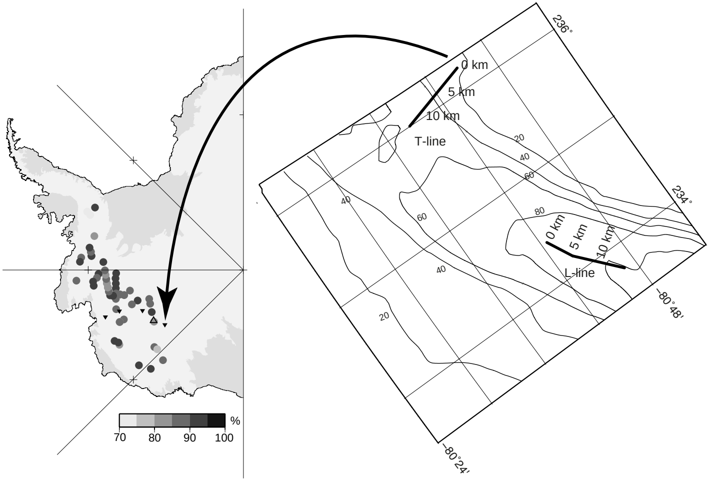
Downstream Thwaites Glacier



Bindschadler Ice Stream



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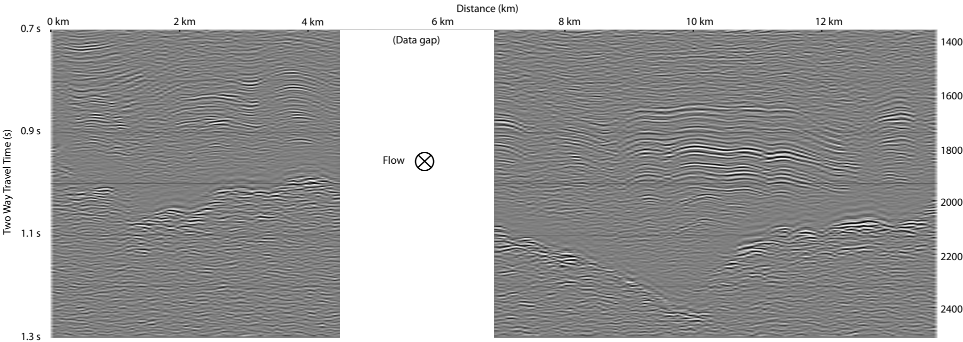
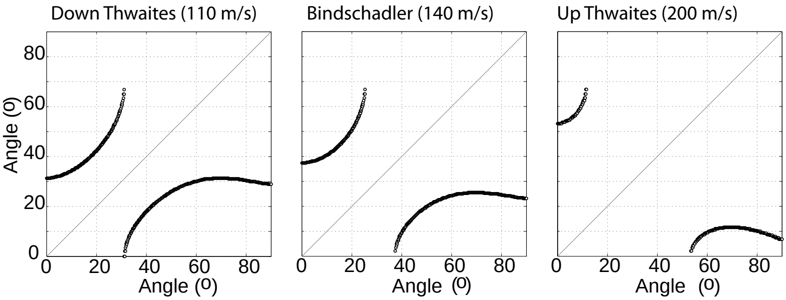


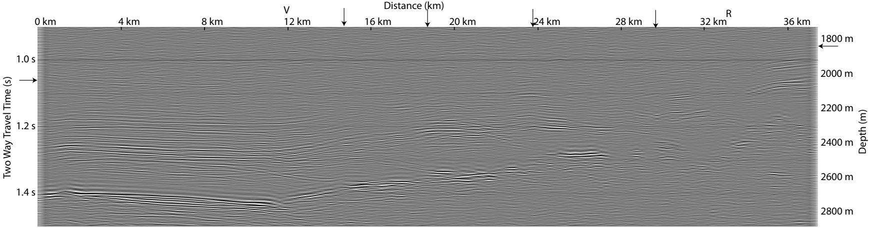
(Note: shorter spatial-wavelength of cross-line englacial reflectivity.)

Amplitude Analysis



- Analysis followed Holland and Anandakrishnan (J. Glac. 2009)
- Raytracing for path amplitude factors
- Optimized search of Zoeppritz Equations for velocity contrast
- All amplitudes can be explained by Crystal Fabric contrasts

Summary and conclusions



- We can learn something about COF and ice deformation from active source seismology.
- Emphasizes the difference between ice-divide and ice-stream fabrics
- These results await comprehensive ground truthing.

Thanks and acknowledgements

P. Braddock, K. Christianson, R. Greschke, J. MacGregor, A. Mironov, A. Morton, S. ONeel, M. Nolan, A. Smith, D. Voigt, J. P. Winberry, and L. Zoet., and the Penn State Ice and Climate Group

H. J. Horgan, S. Anandakrishnan, R. B. Alley, P. Burkett and L. E. Peters, 2011. Englacial Seismic Reflectivity - Imaging Crystal Orientation Fabric in West Antarctica, **Journal of Glaciology.** 57(204) 639–650