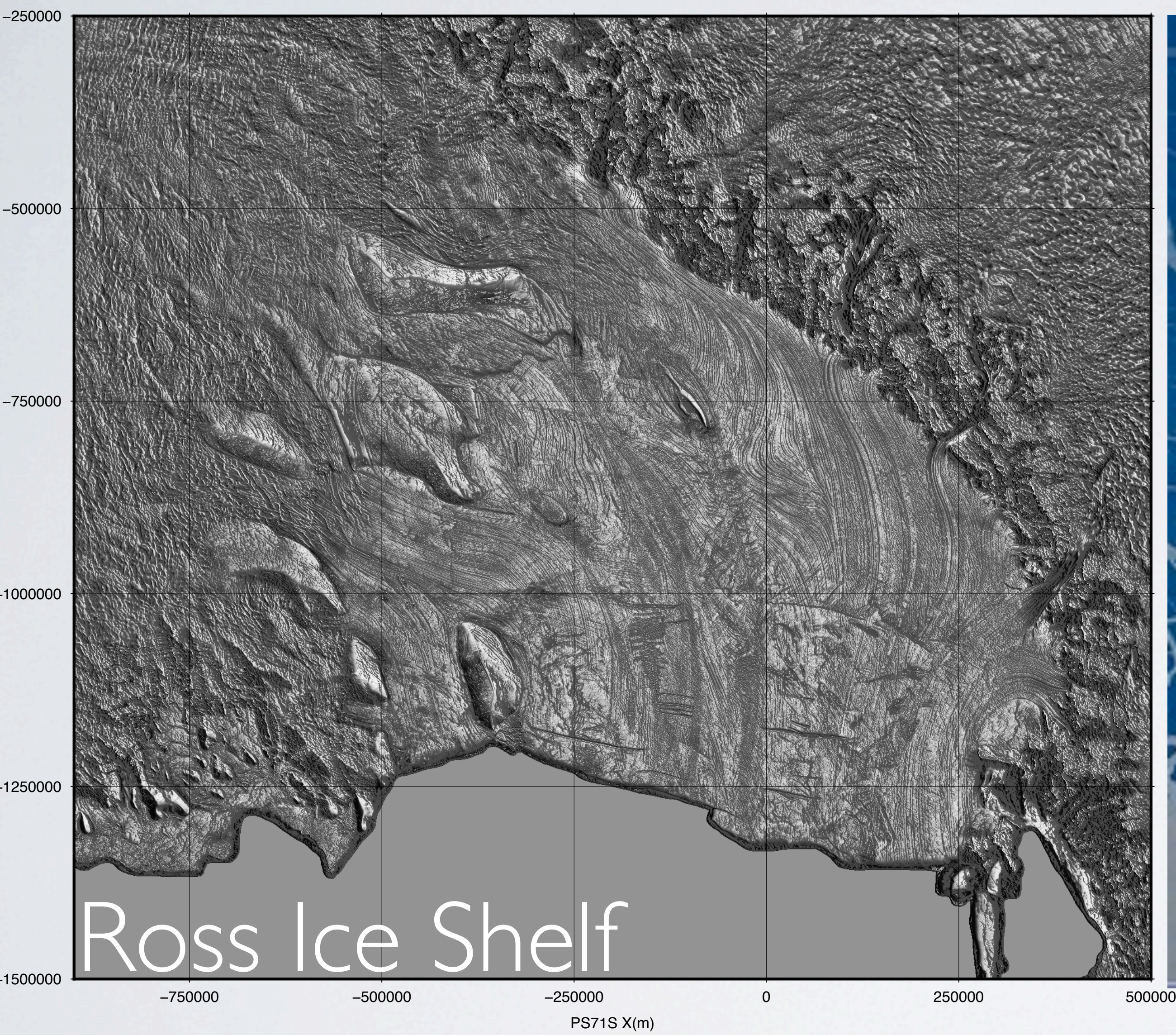
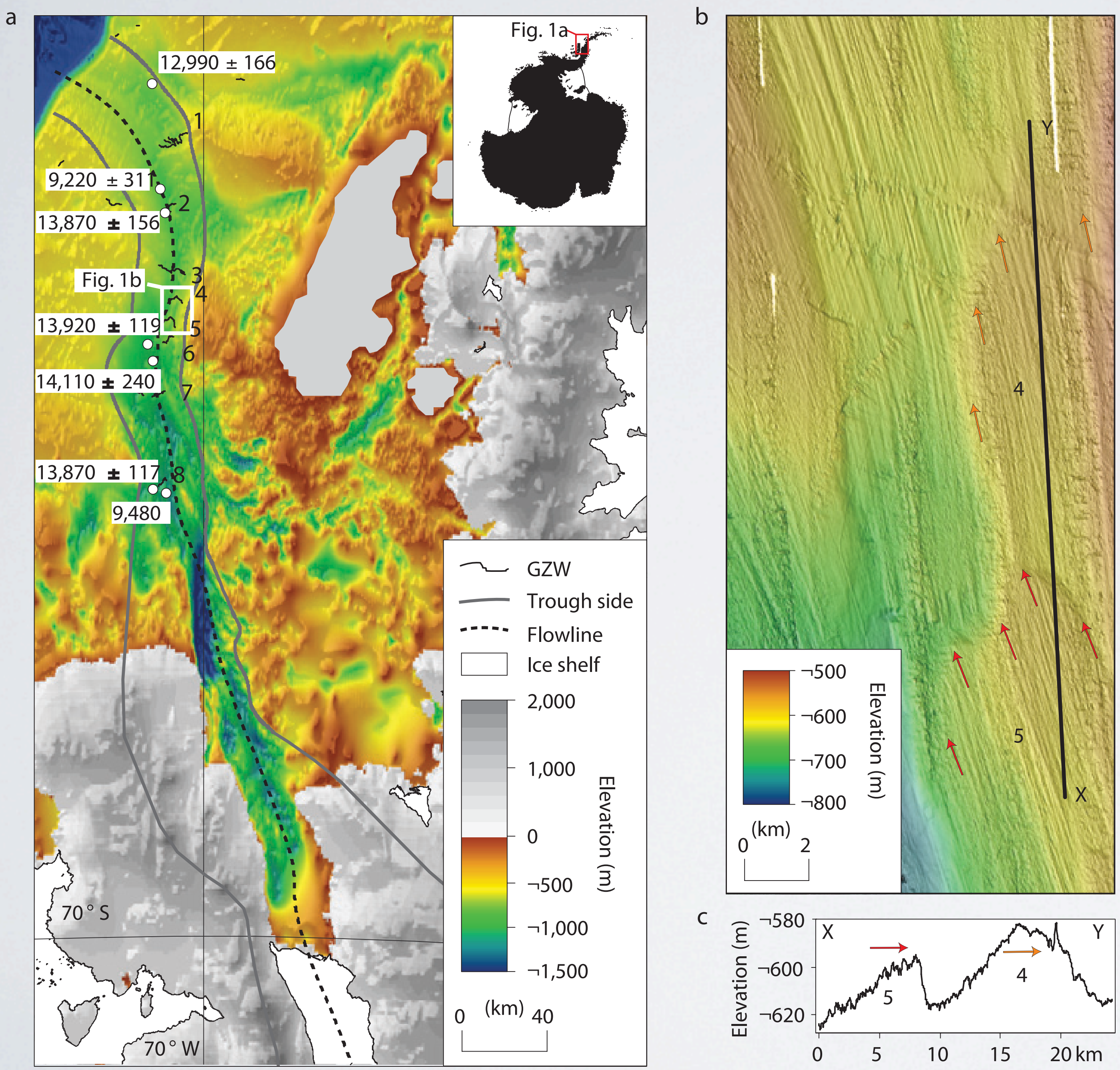
SUBGLACIAL WATER AND SEDIMENT TRANSPORT ACROSS THE GROUNDING ZONE OF WHILLANS ICE STREAM, WEST ANTARCTICA



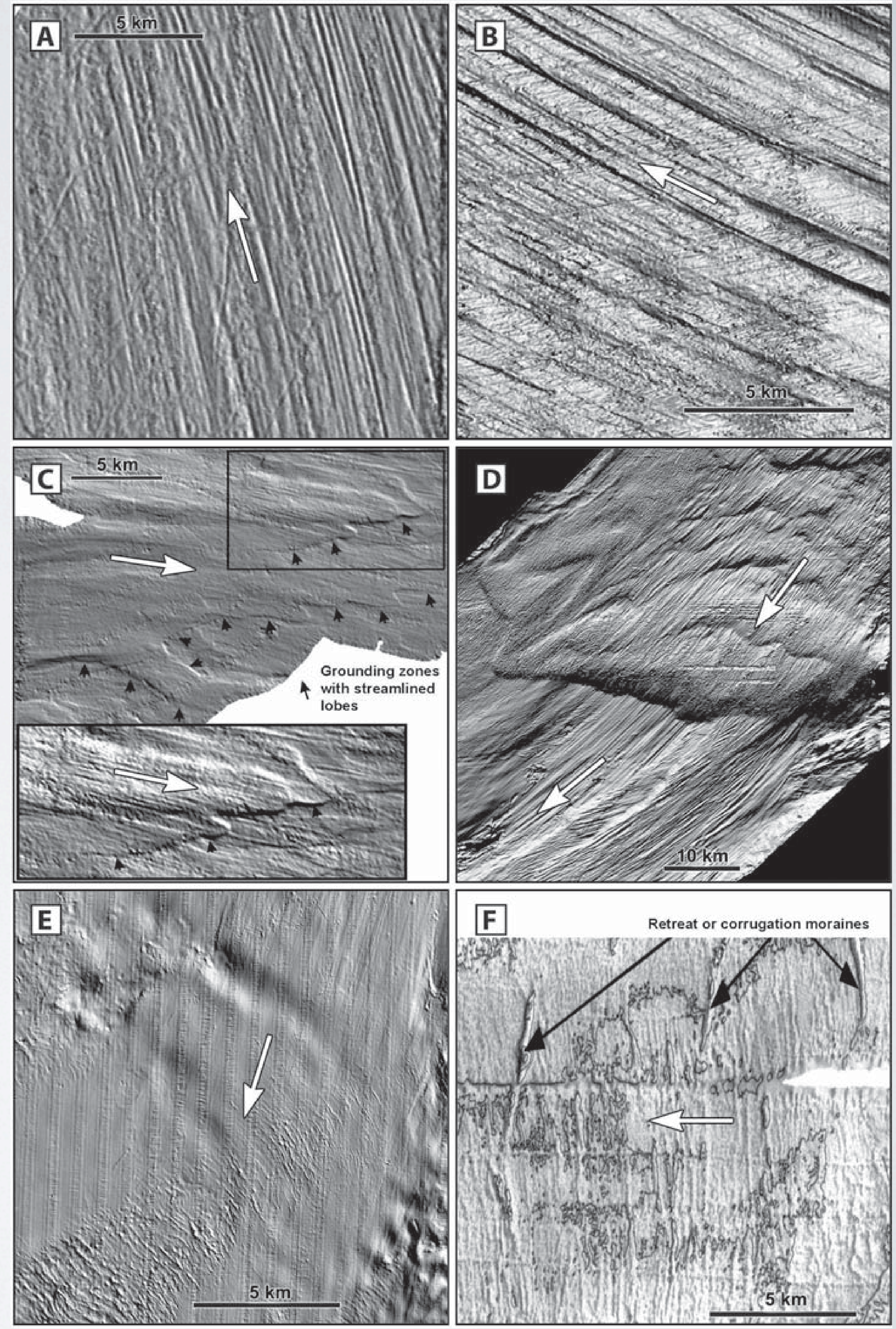
Knut Christianson, Huw Horgan, Byron Parizek, Richard Alley, Ryan Walker, Sridhar Anandakrishnan, Robert Jacobel et al.

(Dowdeswell et al., 2008)

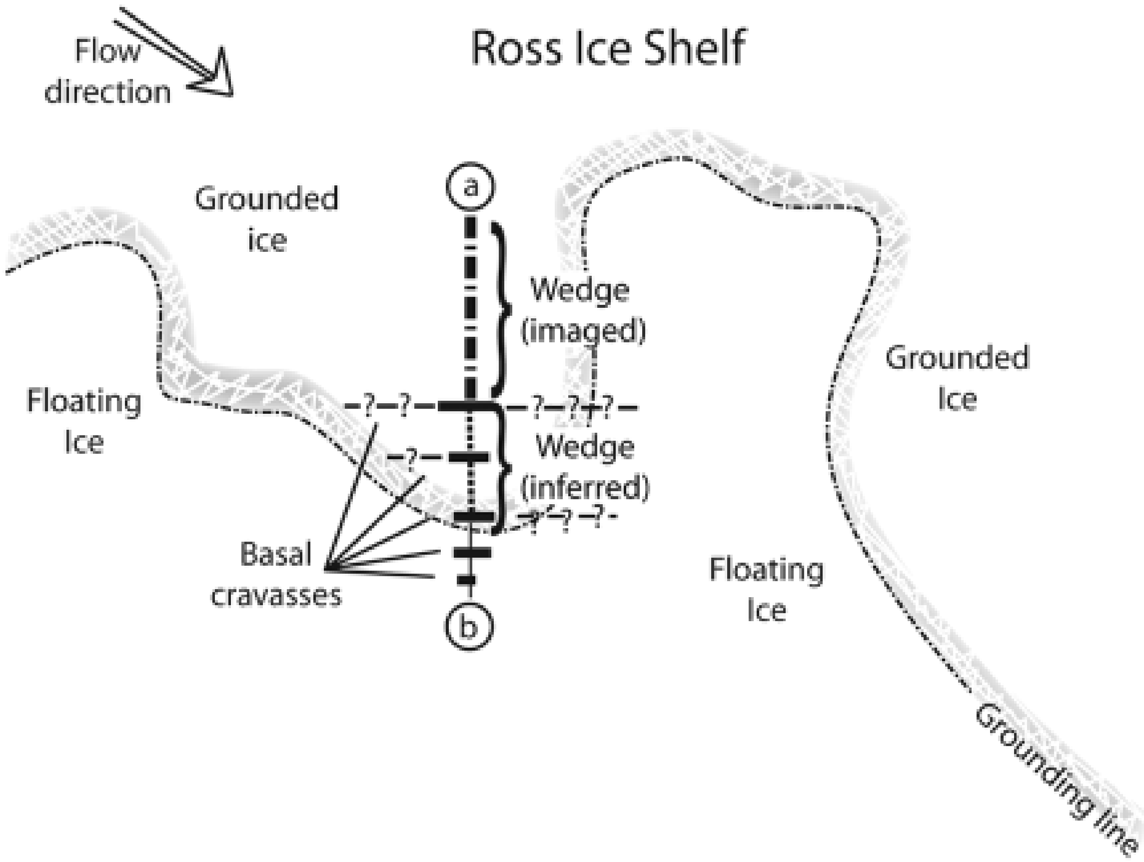
Grounding Zone Expression in Subglacial Geology

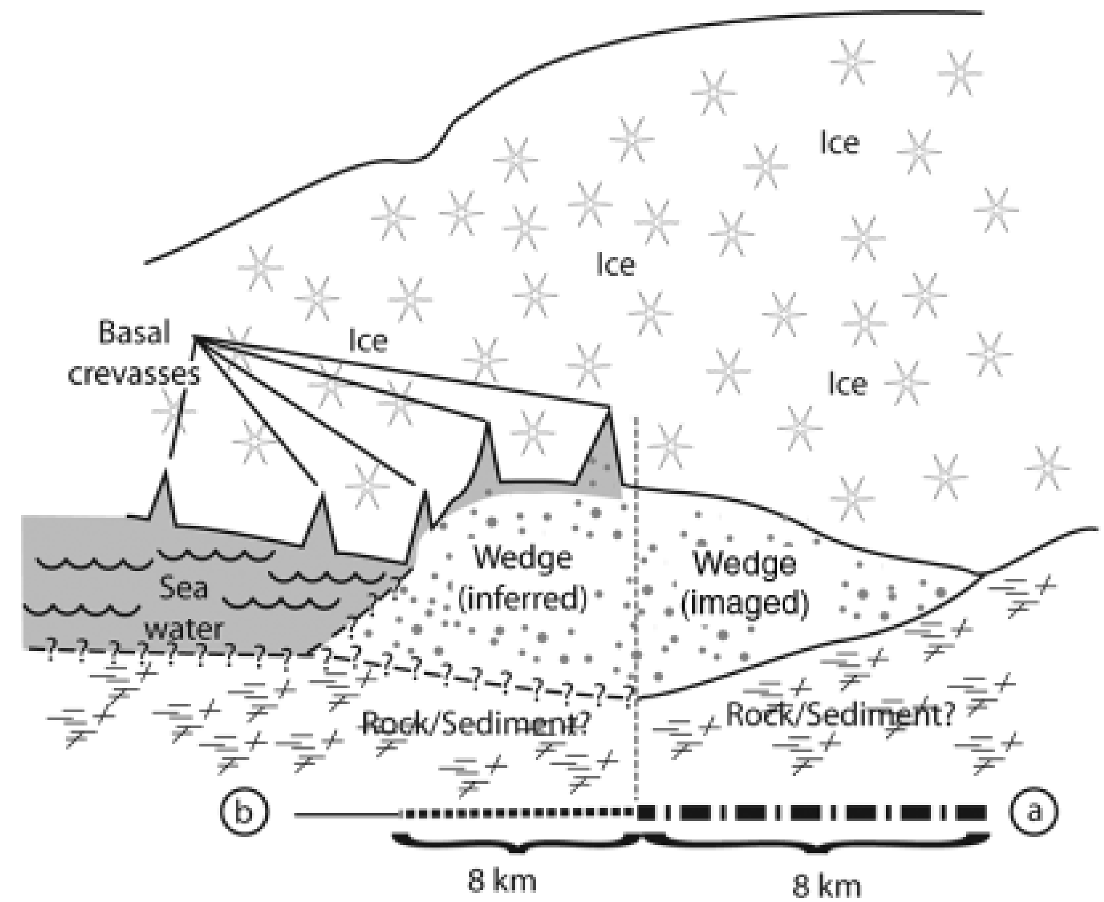


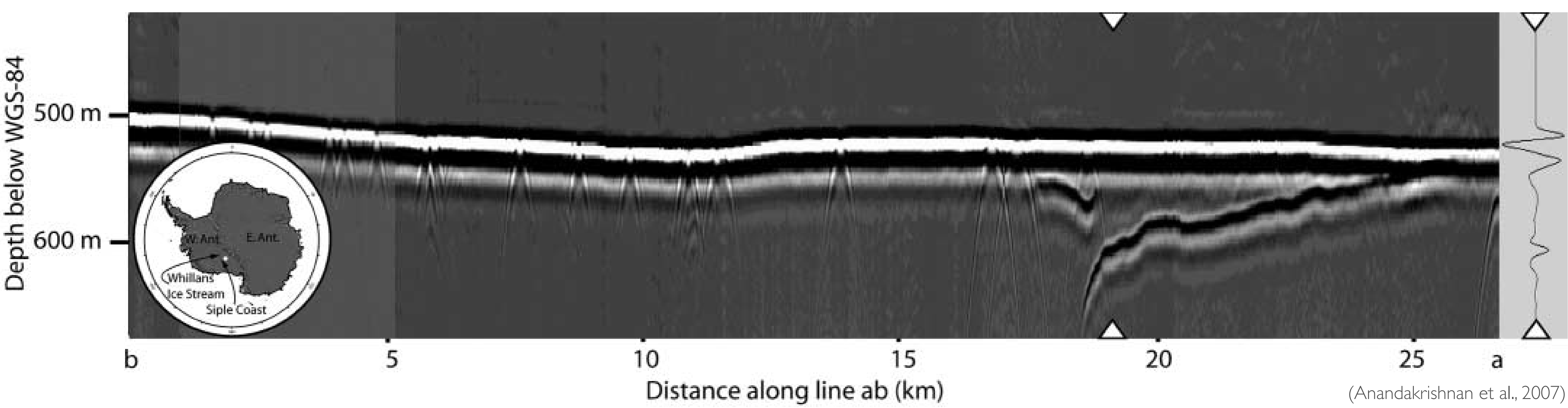
(Jamieson et al., 2012)



Geophysical Imaging of Grounding Zones



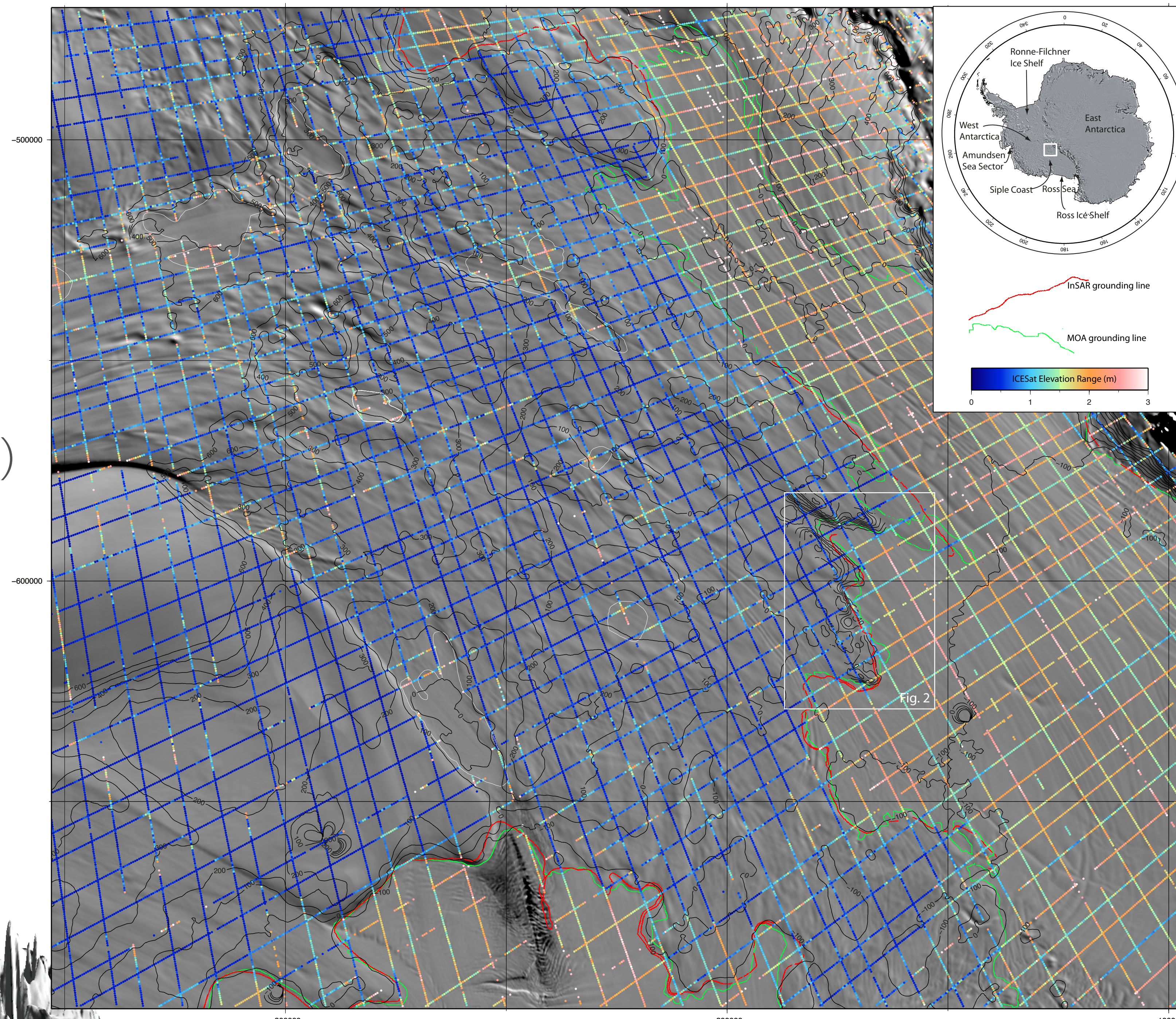


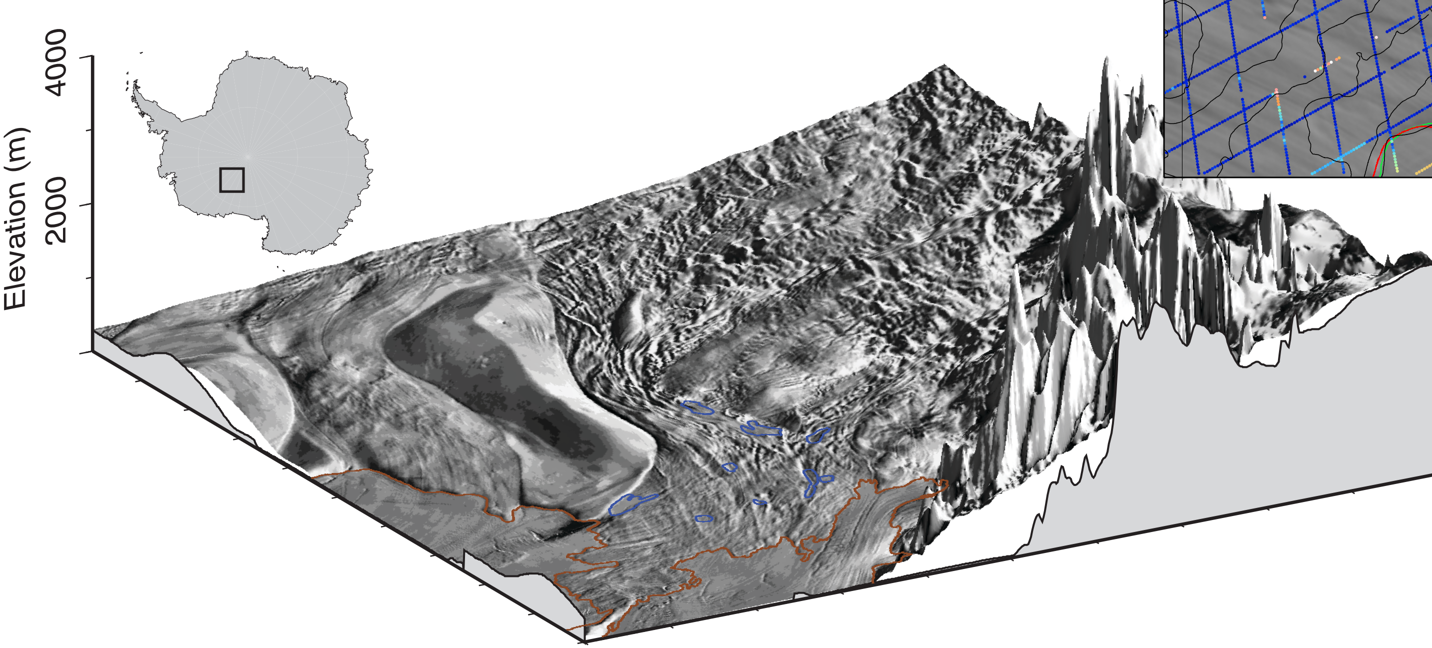


(Anandakrishnan et al., 2007)

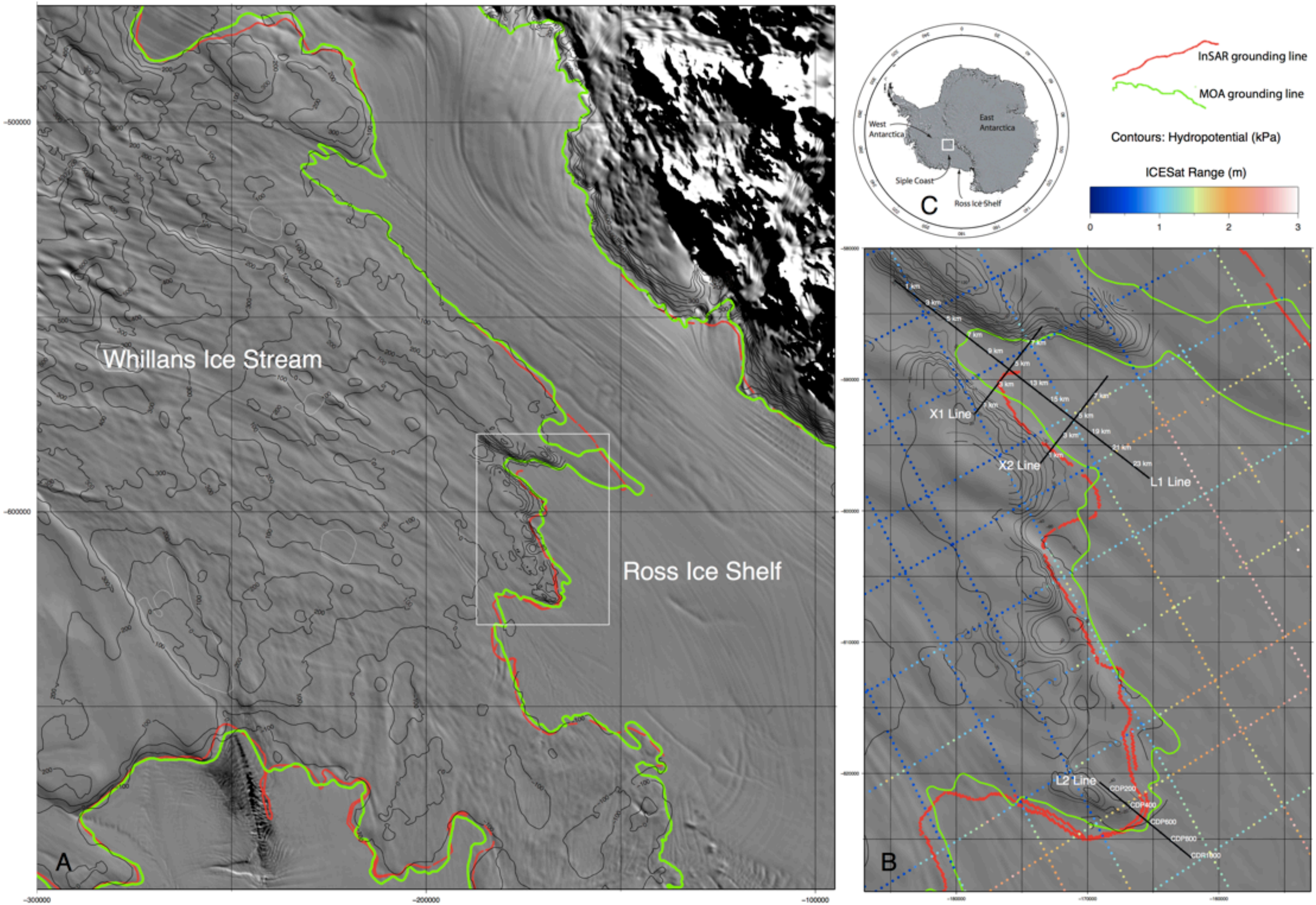
Grounding Zone of Whillans Ice Stream

- Subglacial Embayment
  - Progradational sedimentation
  - Shallow asymmetric sea channel
  - An estuary with flexure?
- Subglacial Peninsula
  - Little evidence of ongoing sedimentation
  - Possible recent retreat (or episodic)
  - Need flexure to explain IRHs
- Conclusions
  - A gradual transition with corresponding gradual processes

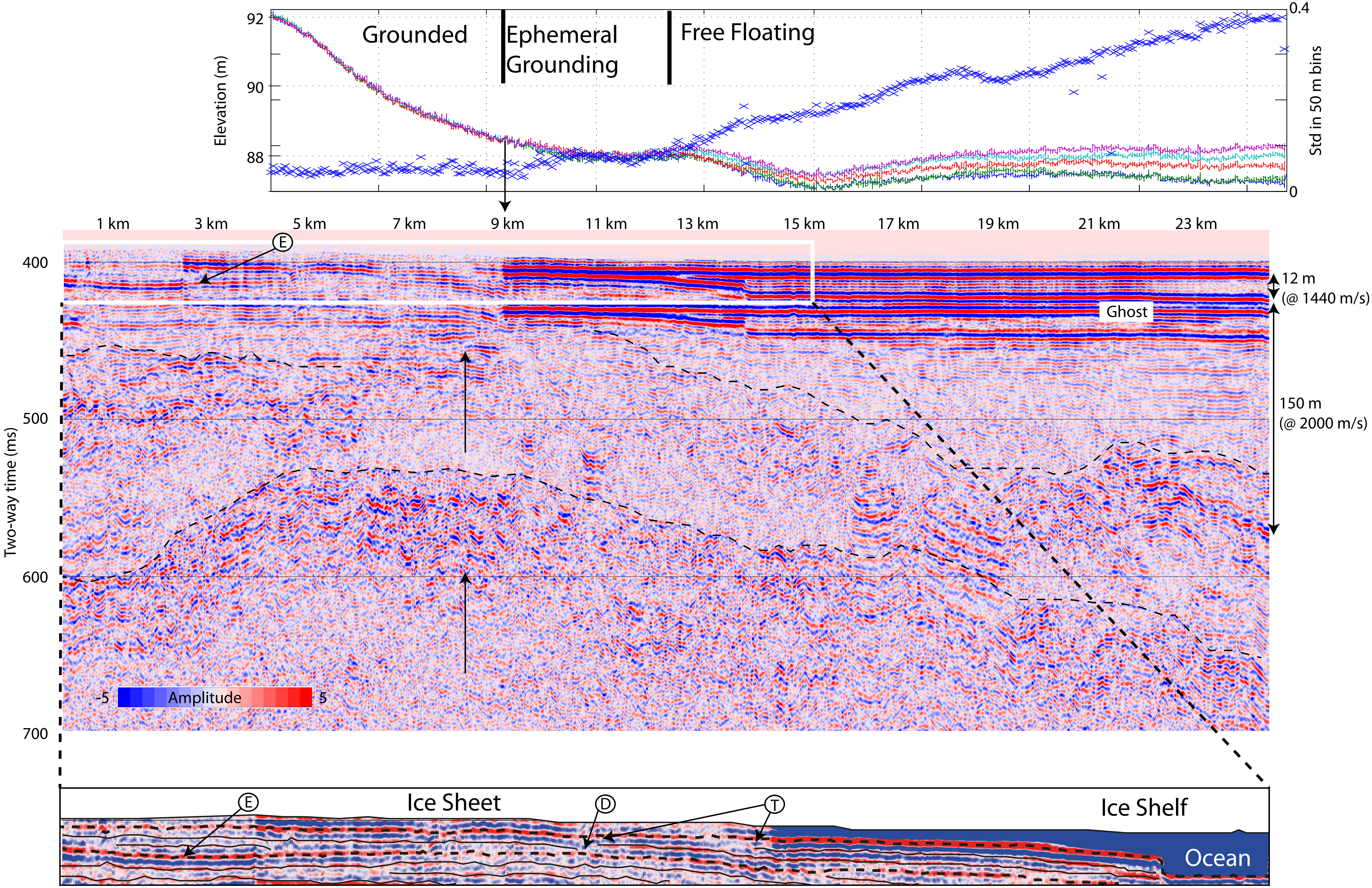




Grounding Zone of Whillans Ice Stream

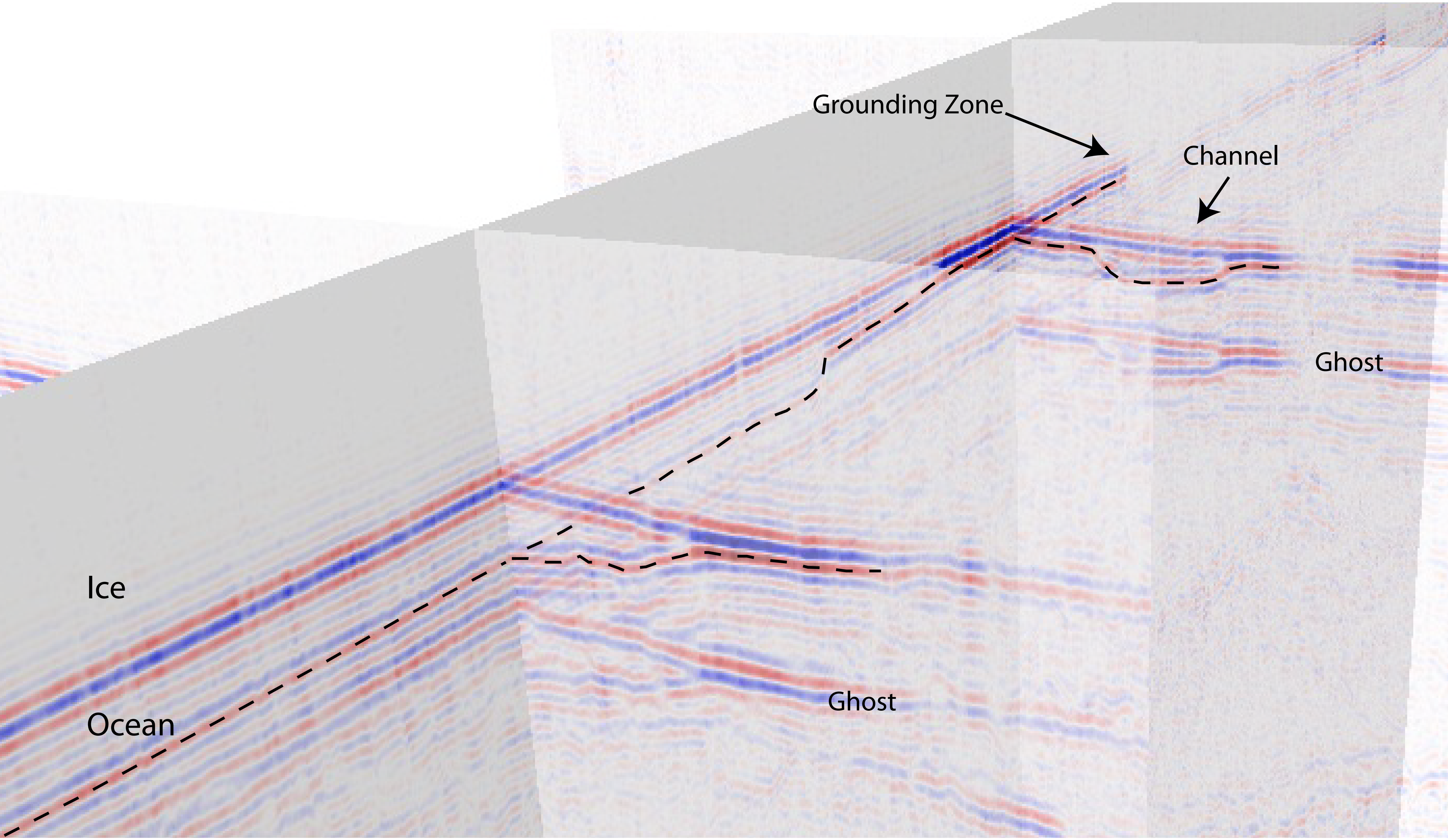


EMBAYMENT LONGITUDINAL LINE



(Horgan et al., in press, a, b)

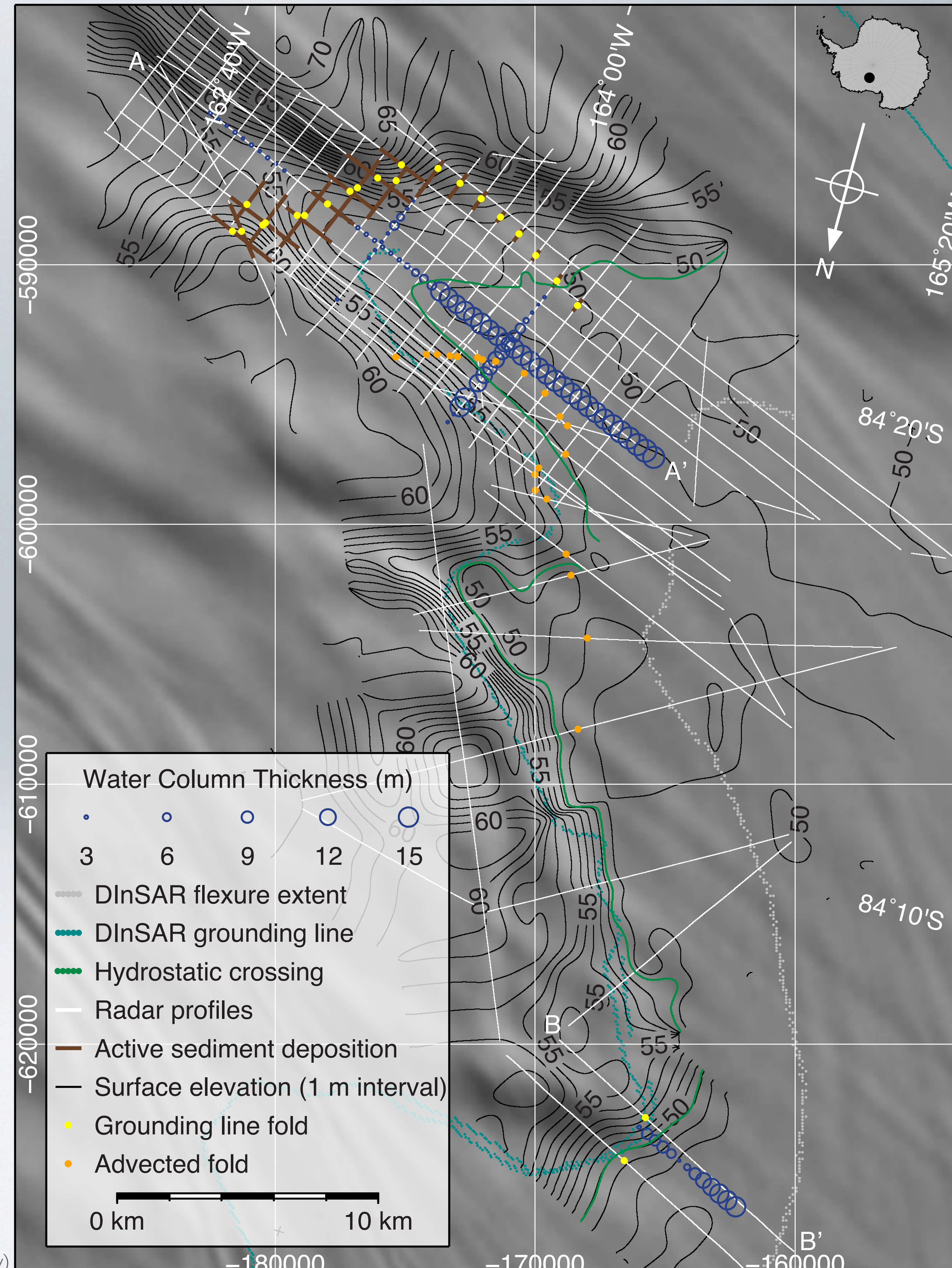
3D VIEW OF THE GROUNDING ZONE



(Horgan et al., in press, a, b)

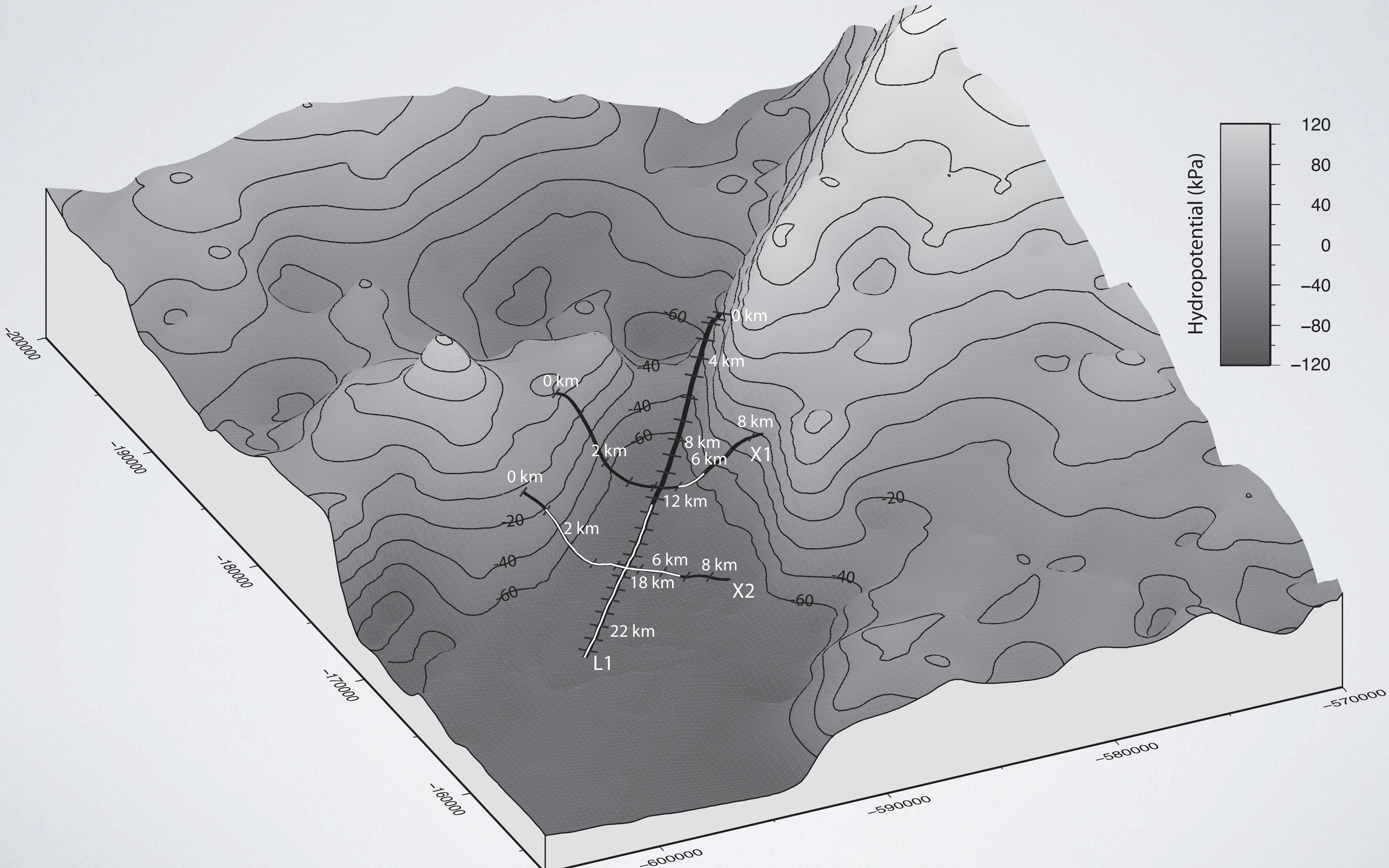
TILL DELTAS, FOLDS, AND CHANNELS

- Joint Radar and Seismic Surveys
  - Identifying salient structures
  - Main and subsidiary channels
  - Correlating with space-based techniques



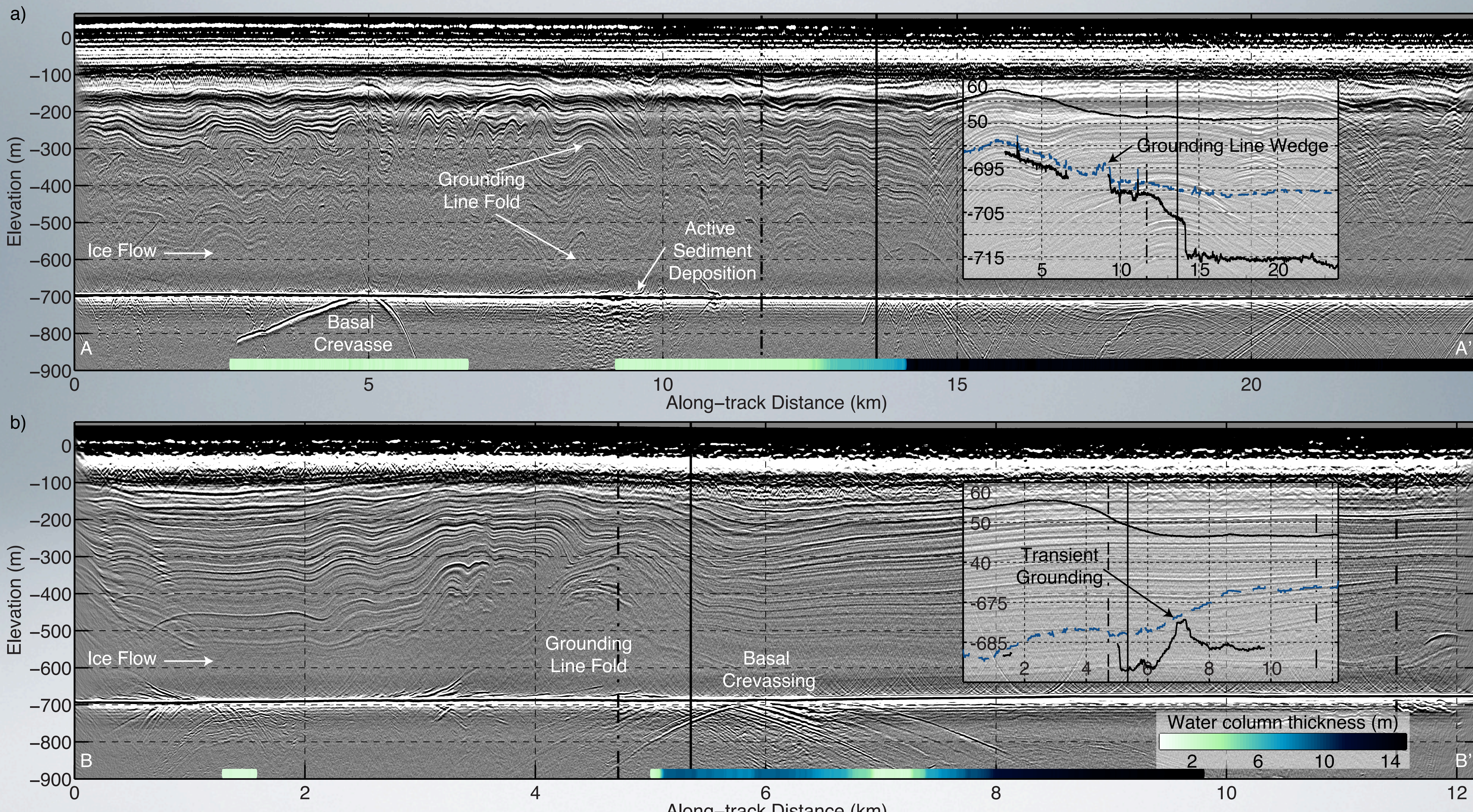
(Christianson et al., in review)

GROUNDING ZONE HYDROPOTENTIAL



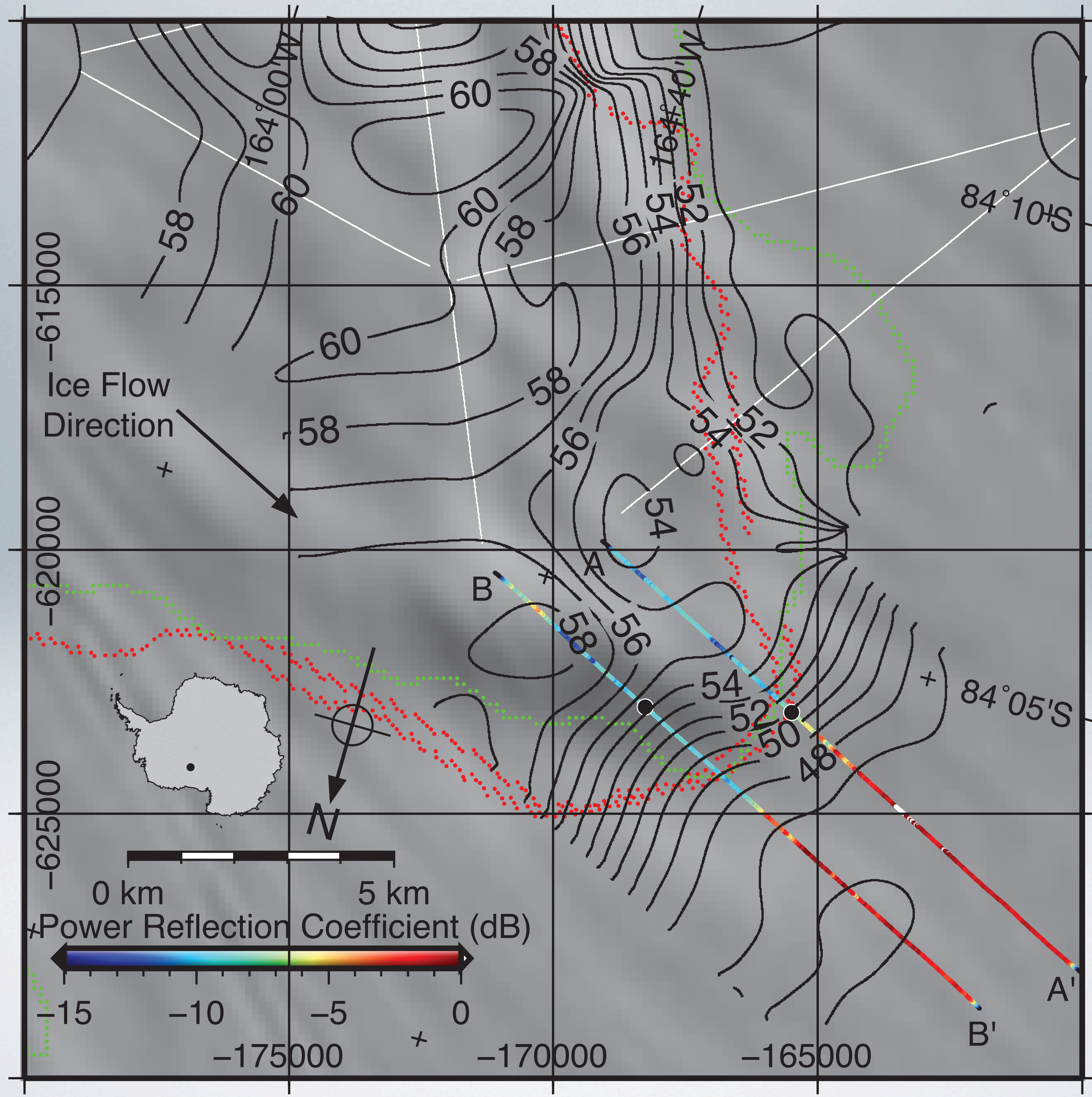
(Horgan et al., in press, a, b)

TILL DELTAS, FOLDS, AND CHANNELS

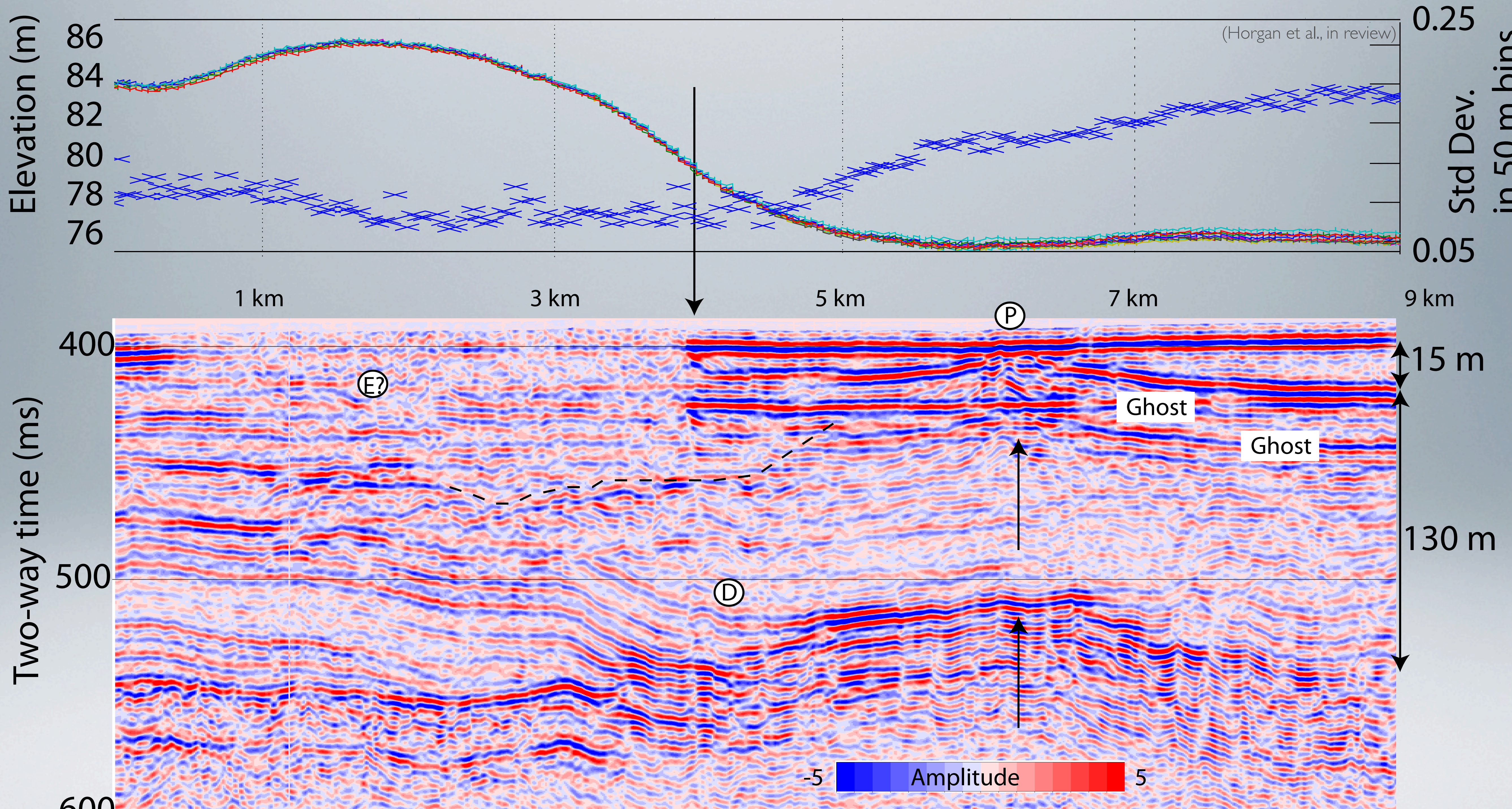


(Christianson et al., in review)

Peninsula Grounding Zone

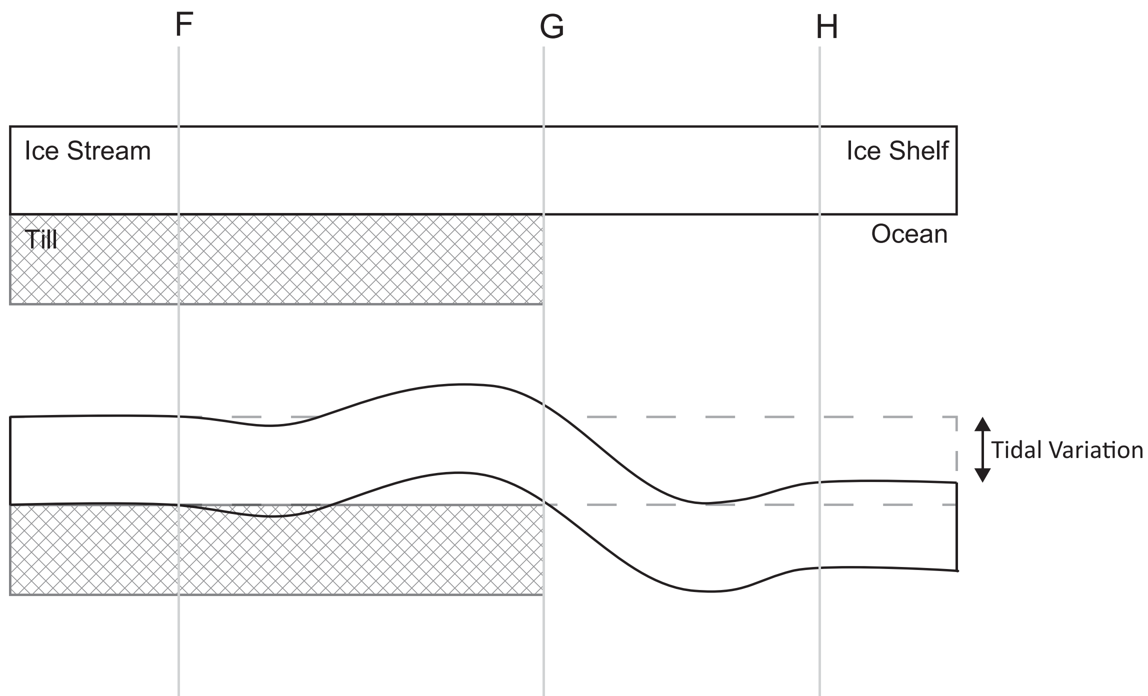


Peninsula GPS and Seismic Profile



(Horgan et al., in press, a, b)

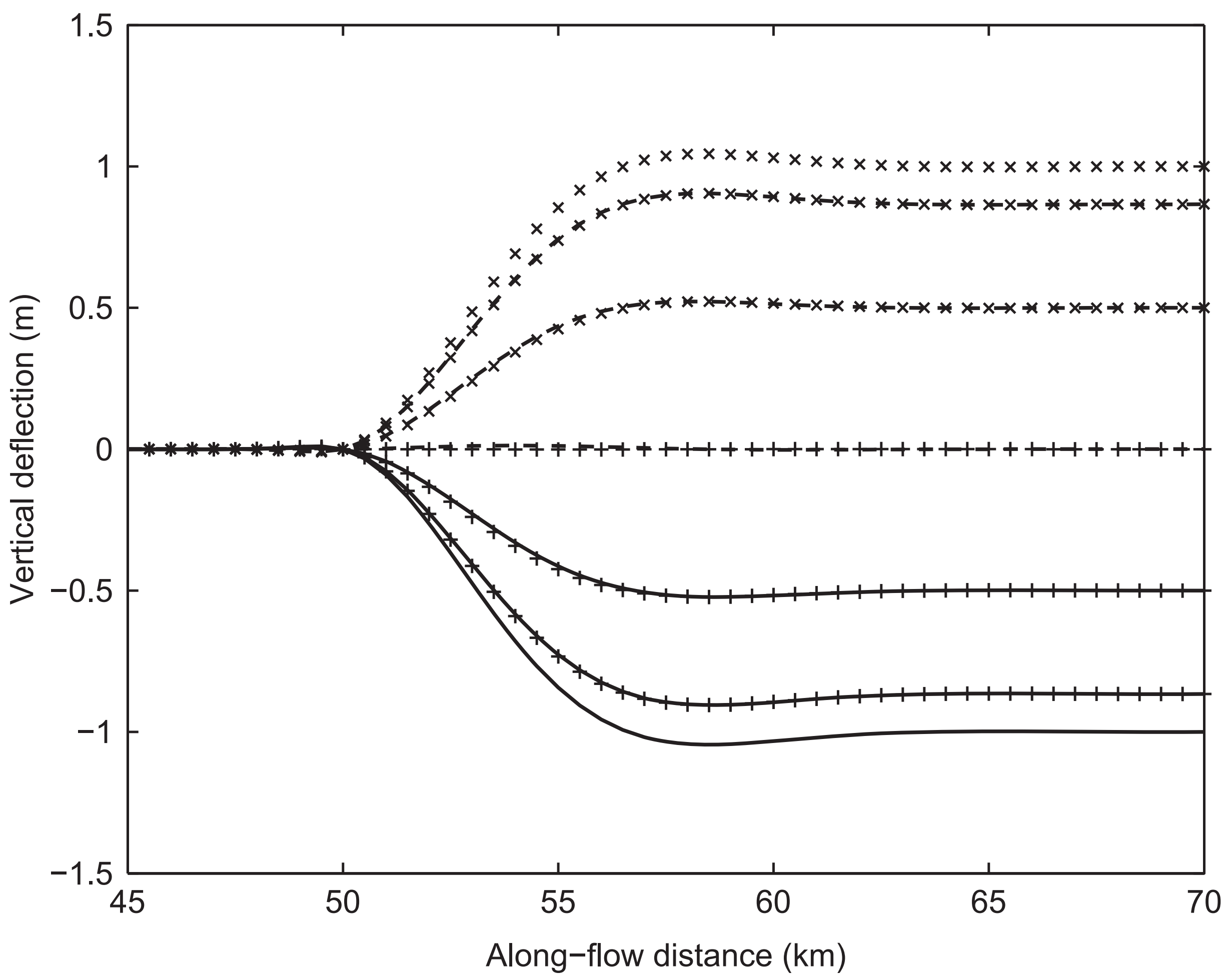
The Effects of Tidal Flexure

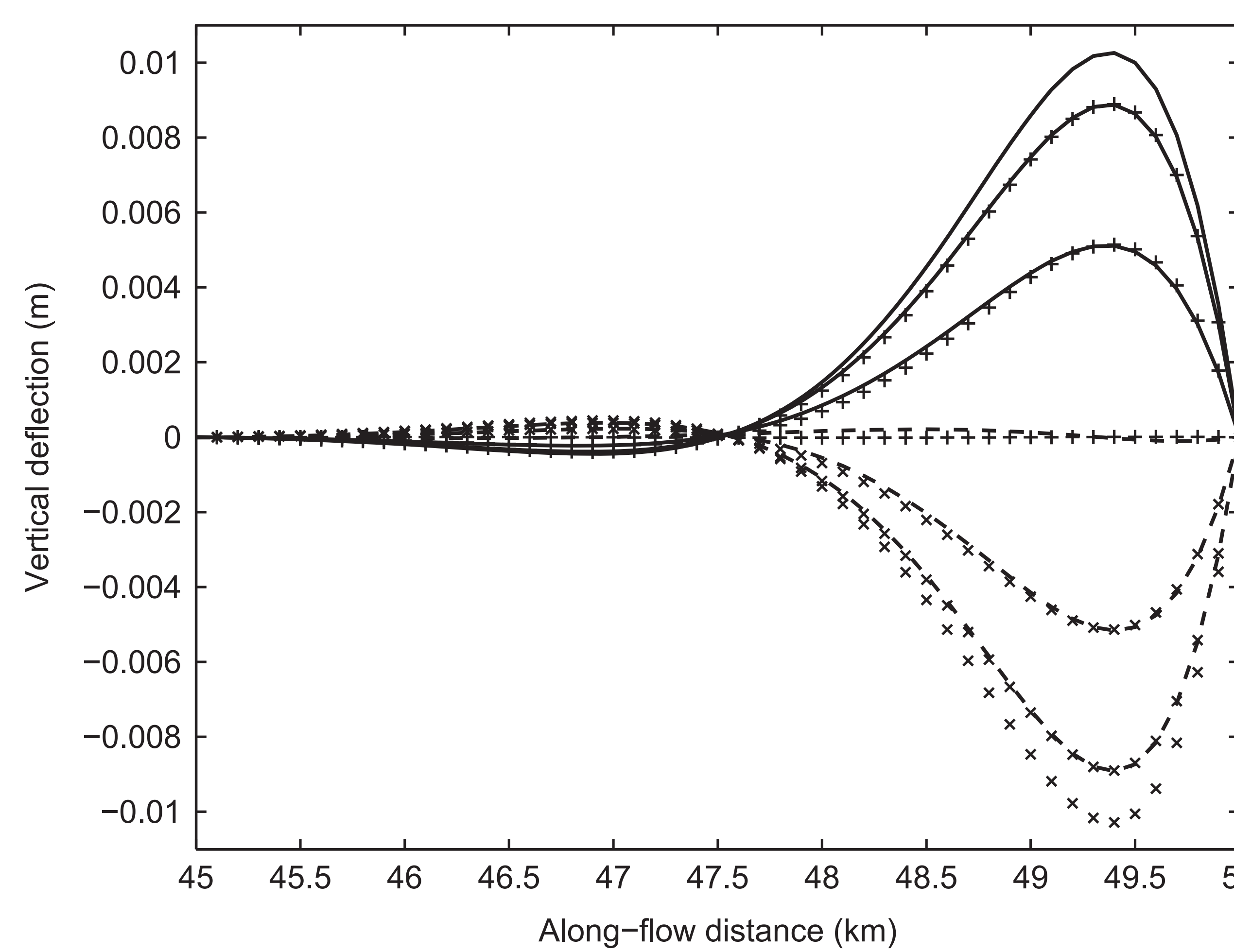


$$\frac{d^2}{dx^2}\left(D\frac{d^2}{dx^2}w\right) = q - kw$$

$$\partial_t(kw + \partial_x^2(D\partial_x^2 w)) + \frac{Ek}{2\nu(1-\lambda^2)}w = \partial_t q + \frac{E}{2\nu(1-\lambda^2)}q$$

$$\nabla\phi_h = \rho_i g\nabla S + (\rho_w - \rho_i)g\nabla B$$

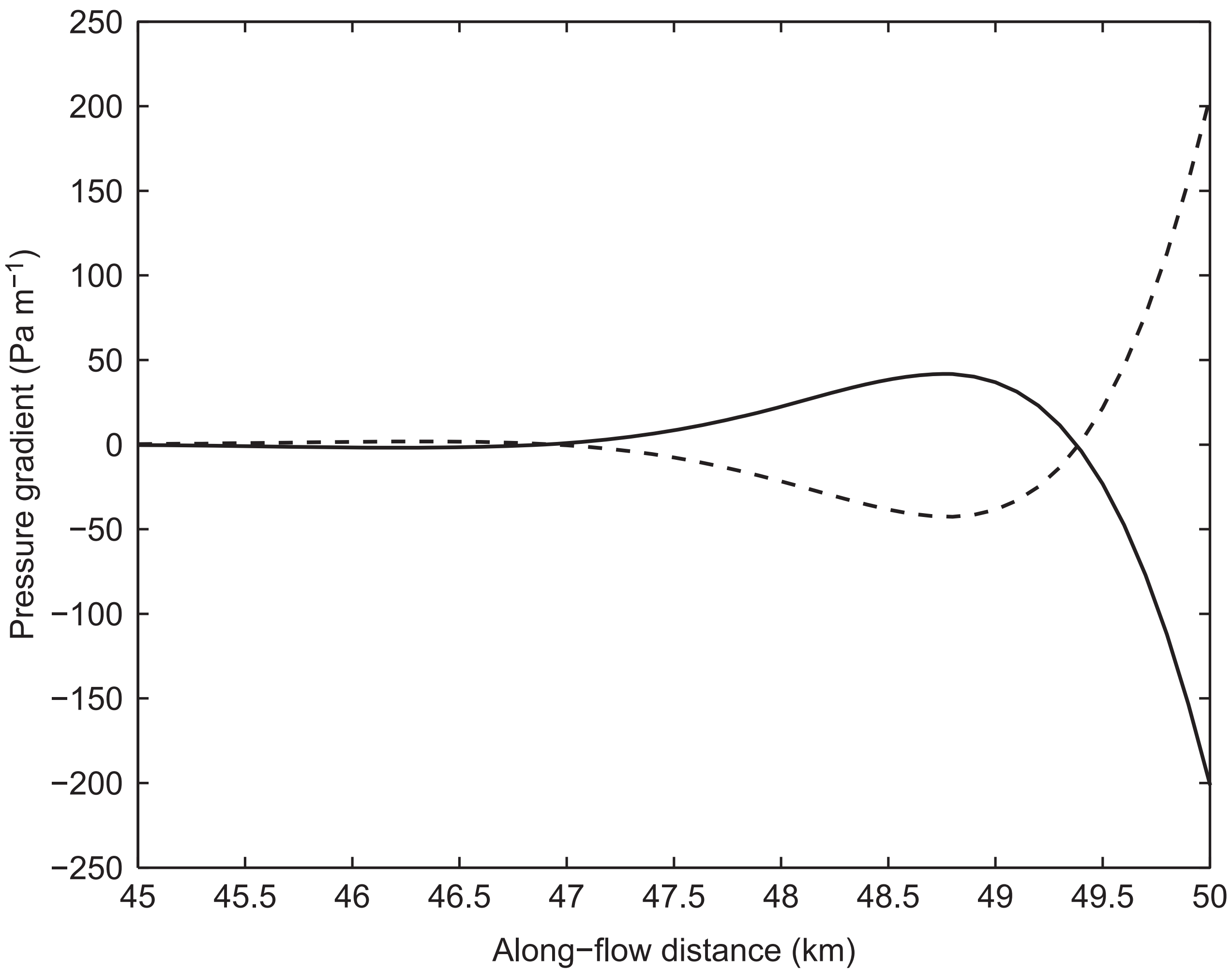


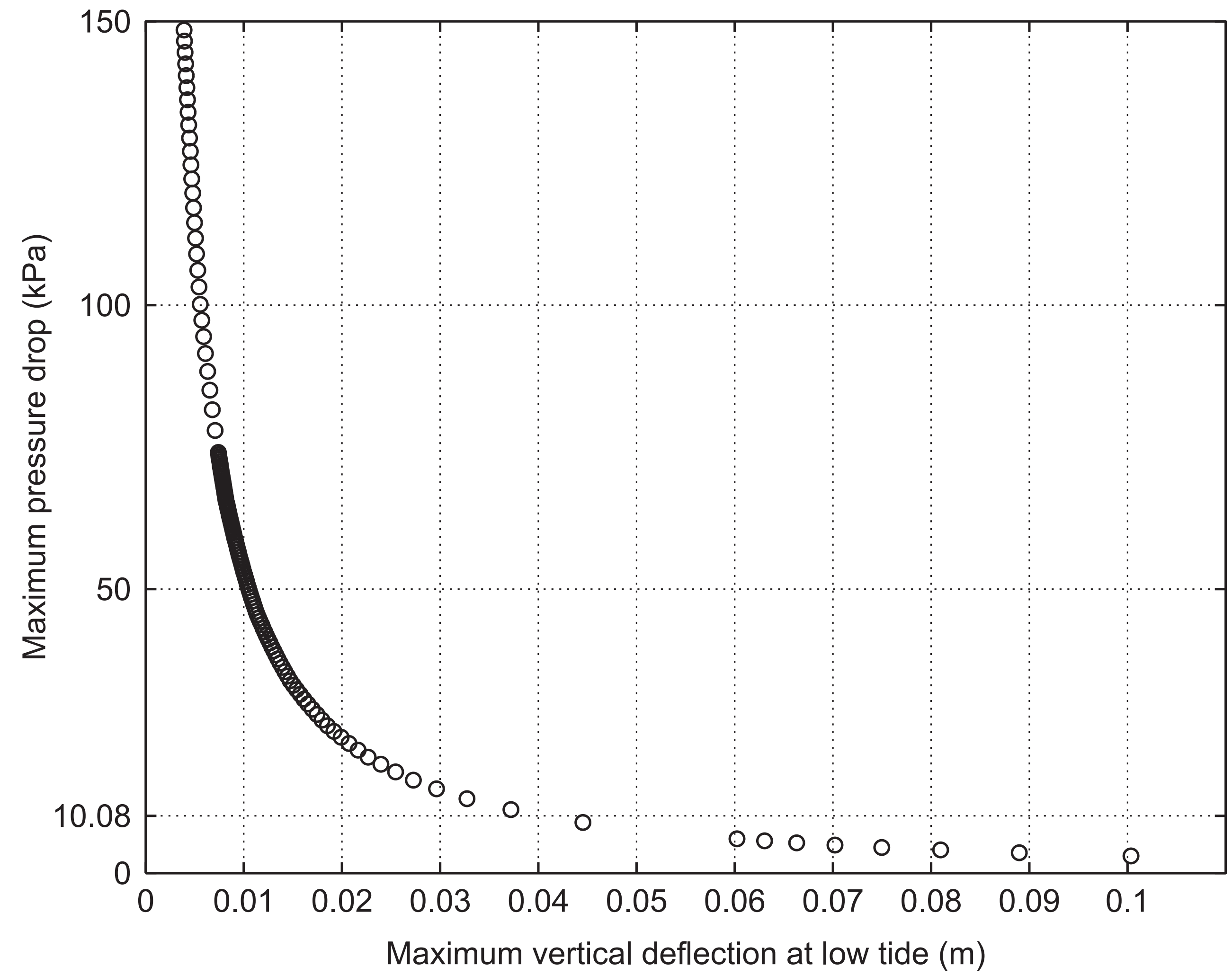


(Walker et al., 2013)

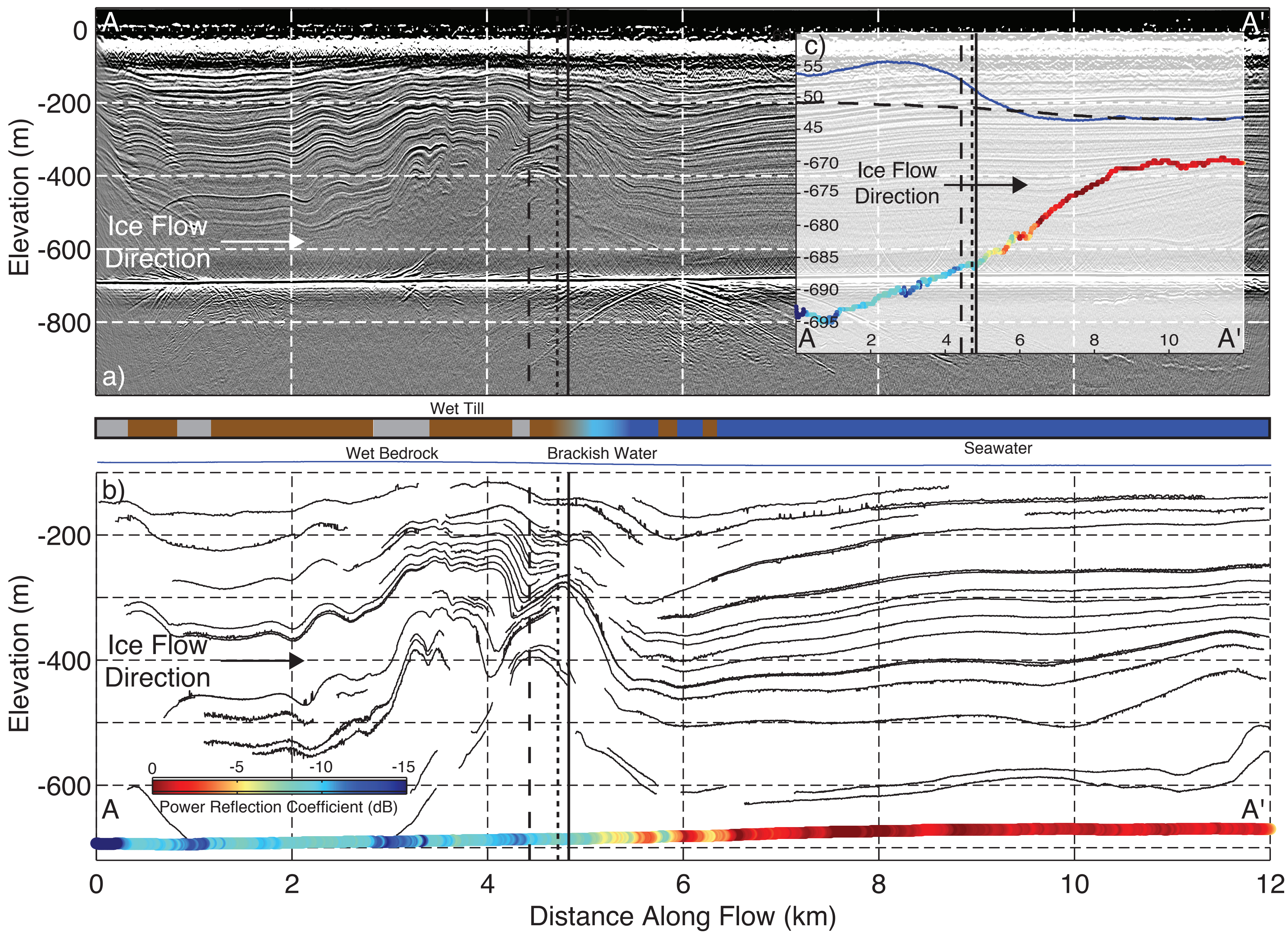
Pressure Fluctuations Upstream of Grounding

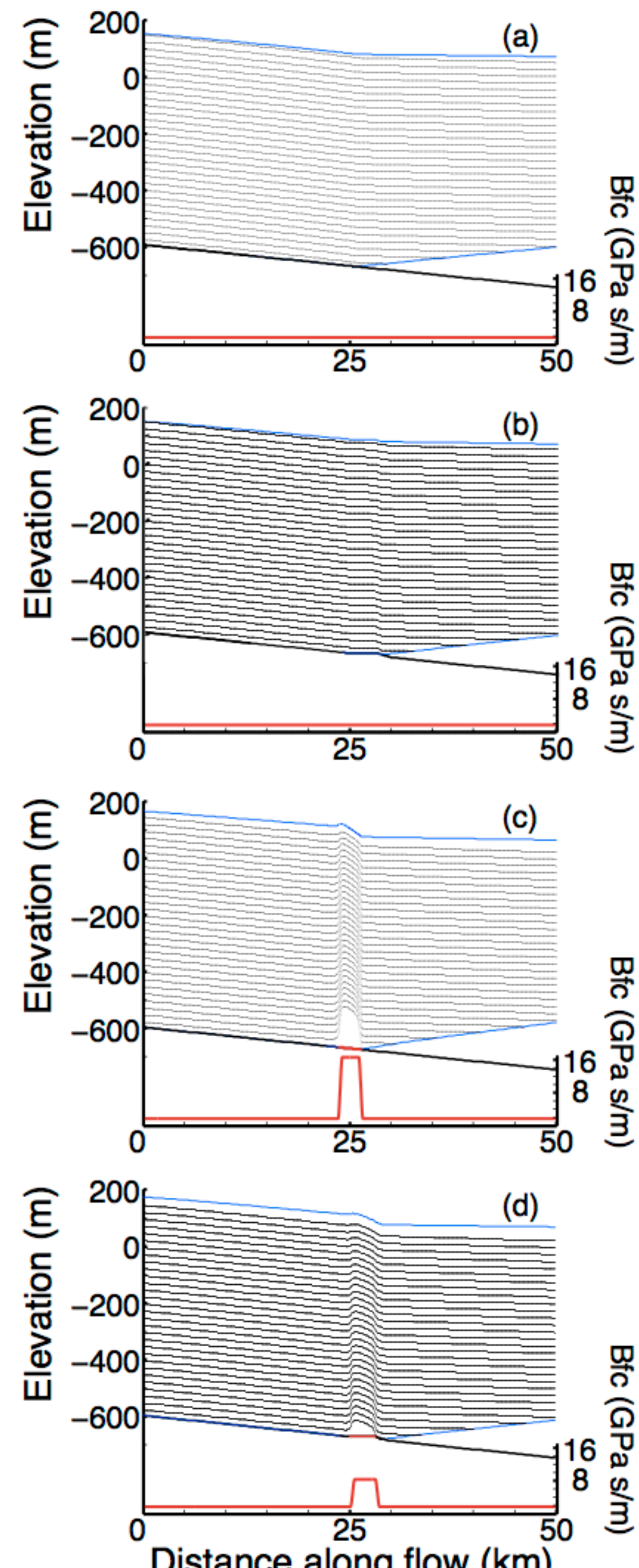
(Walker et al., 2013)





Data Assimilated Modeling and Tidal Flexure

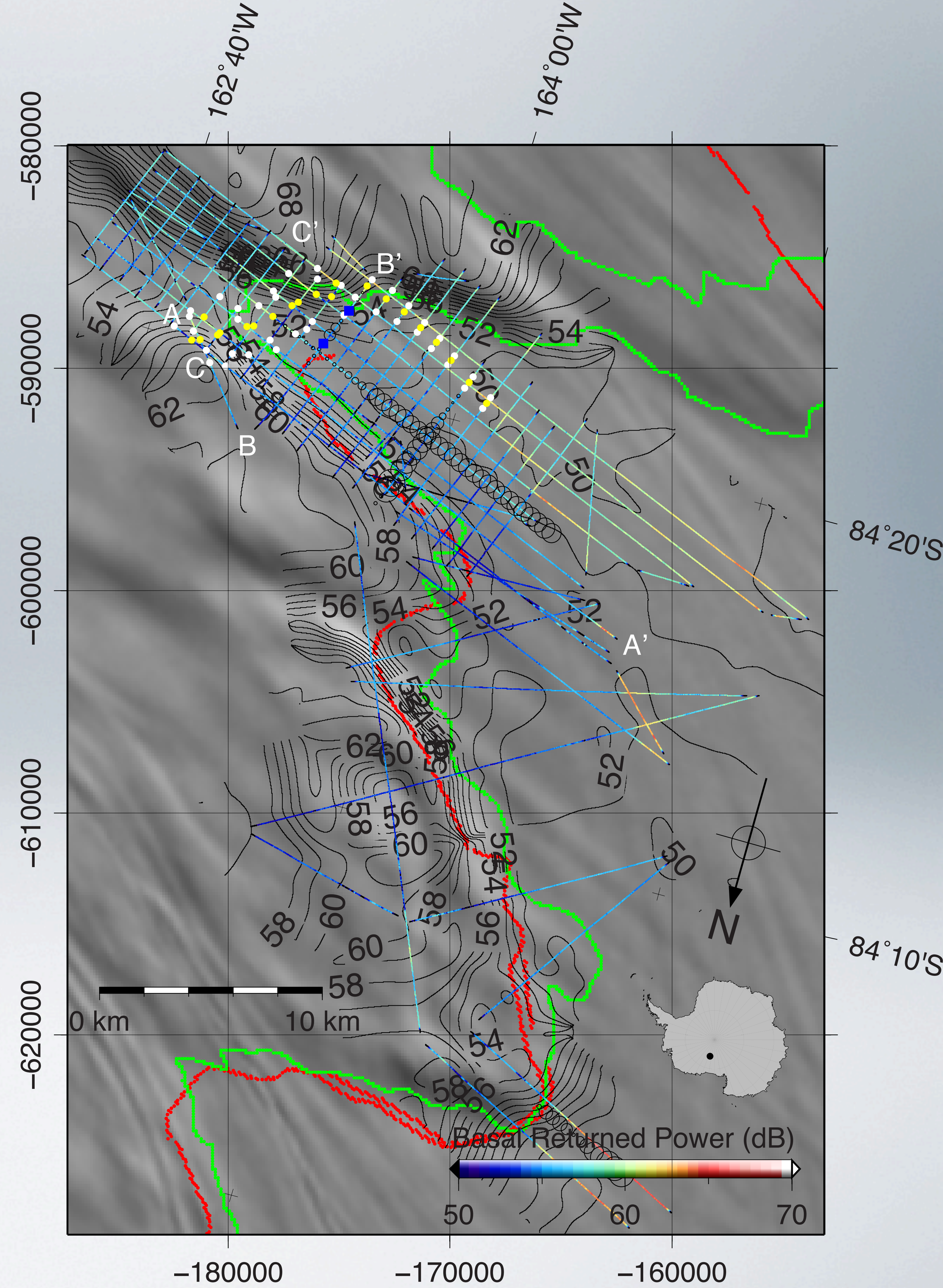




(Christianson et al., in review)

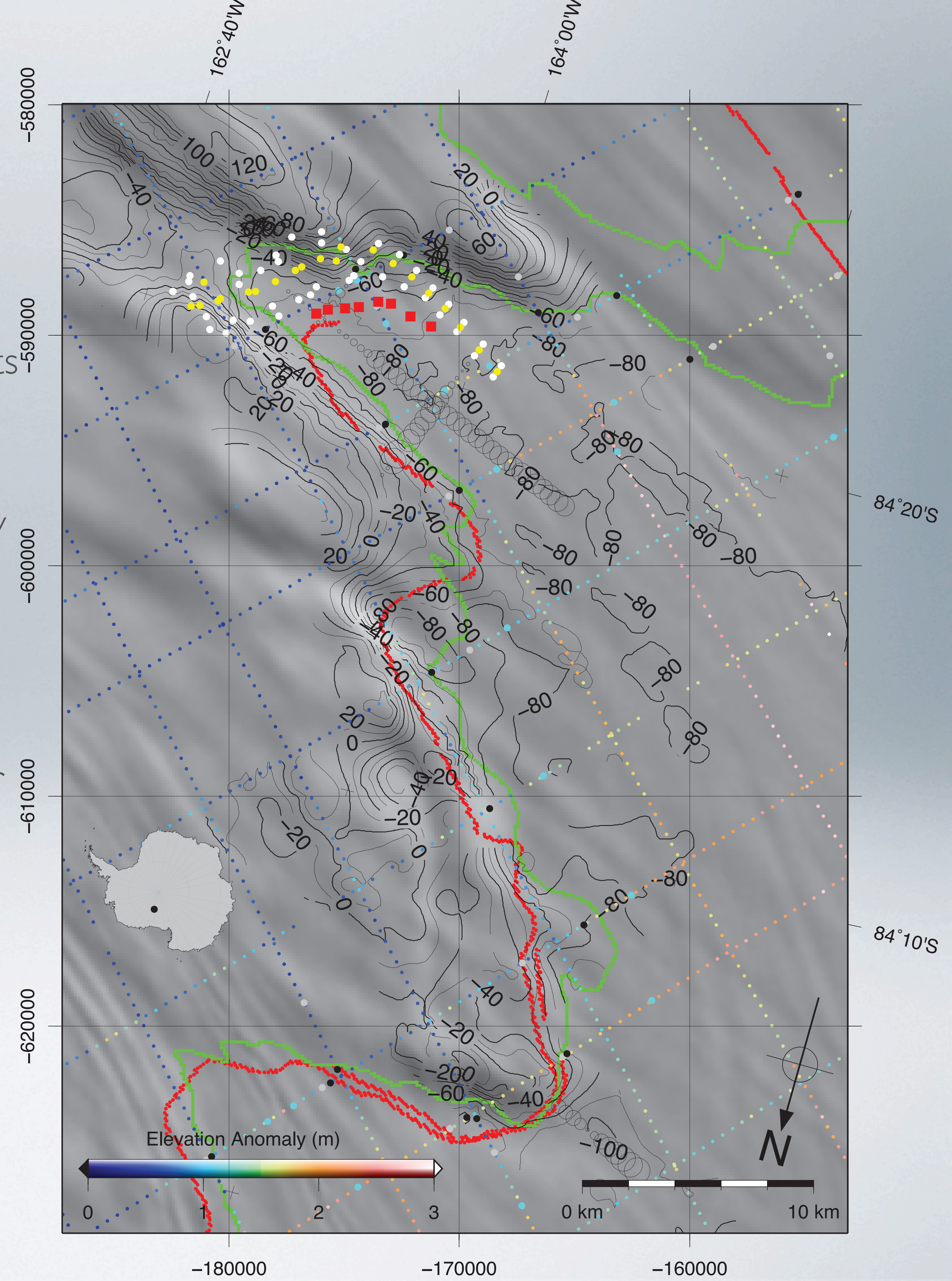
MAKING SENSE OF RADAR REFLECTIVITY

- Subglacial Peninsula
  - Change in reflectivity as expected
- Subglacial Embayment
  - Bright far out in embayment
  - Bright in vicinity of grounding
  - Slightly dimmer upstream of grounding
- Interpretation
  - Waveform modeling shows that basal reflector in till delta are consistent with 2-3 meter layer of till/seawater mixture over seawater
  - Dim reflector further in embayment could be due to
    - fresh water layer
    - scattering off sediment
- Conclusions
  - Depositional delta on one side of embayment (grid east)
  - Grid west side consistent with crevasses



CAVITY ORIENTATION AND TIDAL ANOMALY

- Subglacial Peninsula
  - Some evidence of anomaly inland of grounding
  - Flexure, concavity, and hydrostatic points well-behaved
- Subglacial Embayment
  - ICESat elevation anomaly weakens very gradually
  - Confused flexure, concavity and hydrostatic points--often overlap
- Interpretation
  - Possible for shallow water to ingress far into embayment?



Conclusions

- Grounding Zone Processes Matter
  - High-resolution bed topography
  - Seawater intrusion
  - Tidal flexure, water, and sediment interaction
- Subglacial Till Stiffening Inland of Grounding
  - Effect of tidal flexure
  - Passive seismology confirms (D. Wiens et al.)
- Subglacial Embayments=Estuaries?
  - Till deltas, brackish water, and tidal processes
  - Modeling needed
- Old Picture (wrong)
  - Ice goes from grounded to floating across a line
  - Inland physics instantaneously transition to ice shelf physics (change drive stress, etc. but no anomalous physics or processes)
- New Picture (km-wide unique zone)
  - Tides can pump seawater across zone and inland
  - Modifies till draped over topography and water and till system respond together
  - Example implication: you loose your cantilever from calving-->no till stiffening-->more rapid retreat