Grounding line basal melt rates determined from internal stratigraphy

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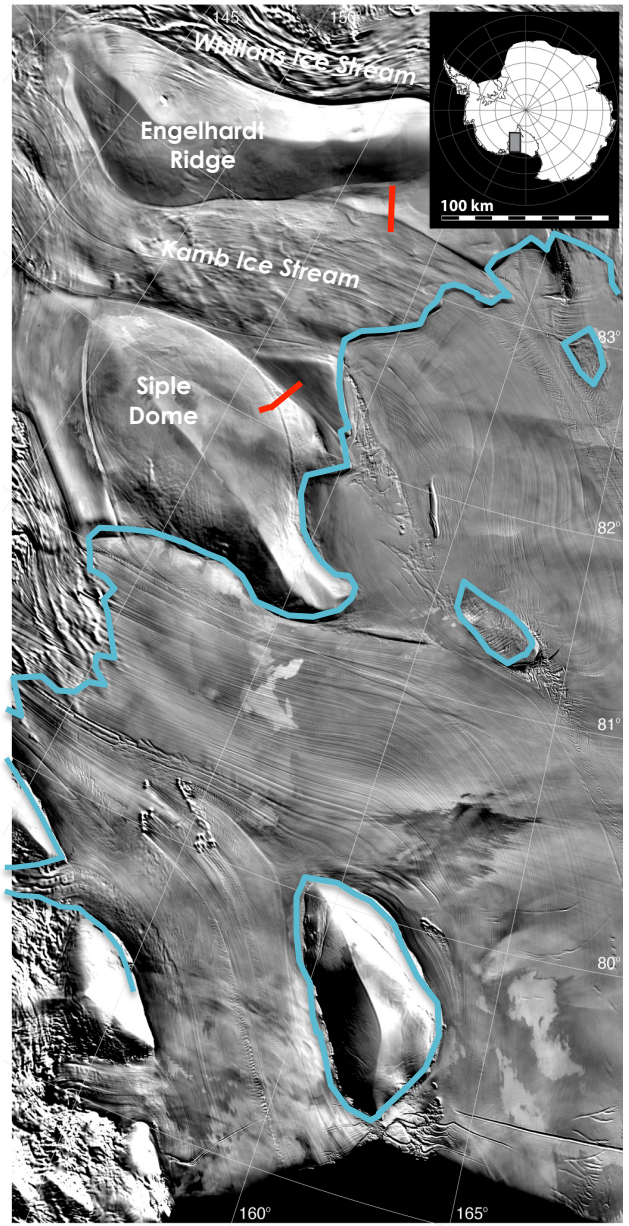
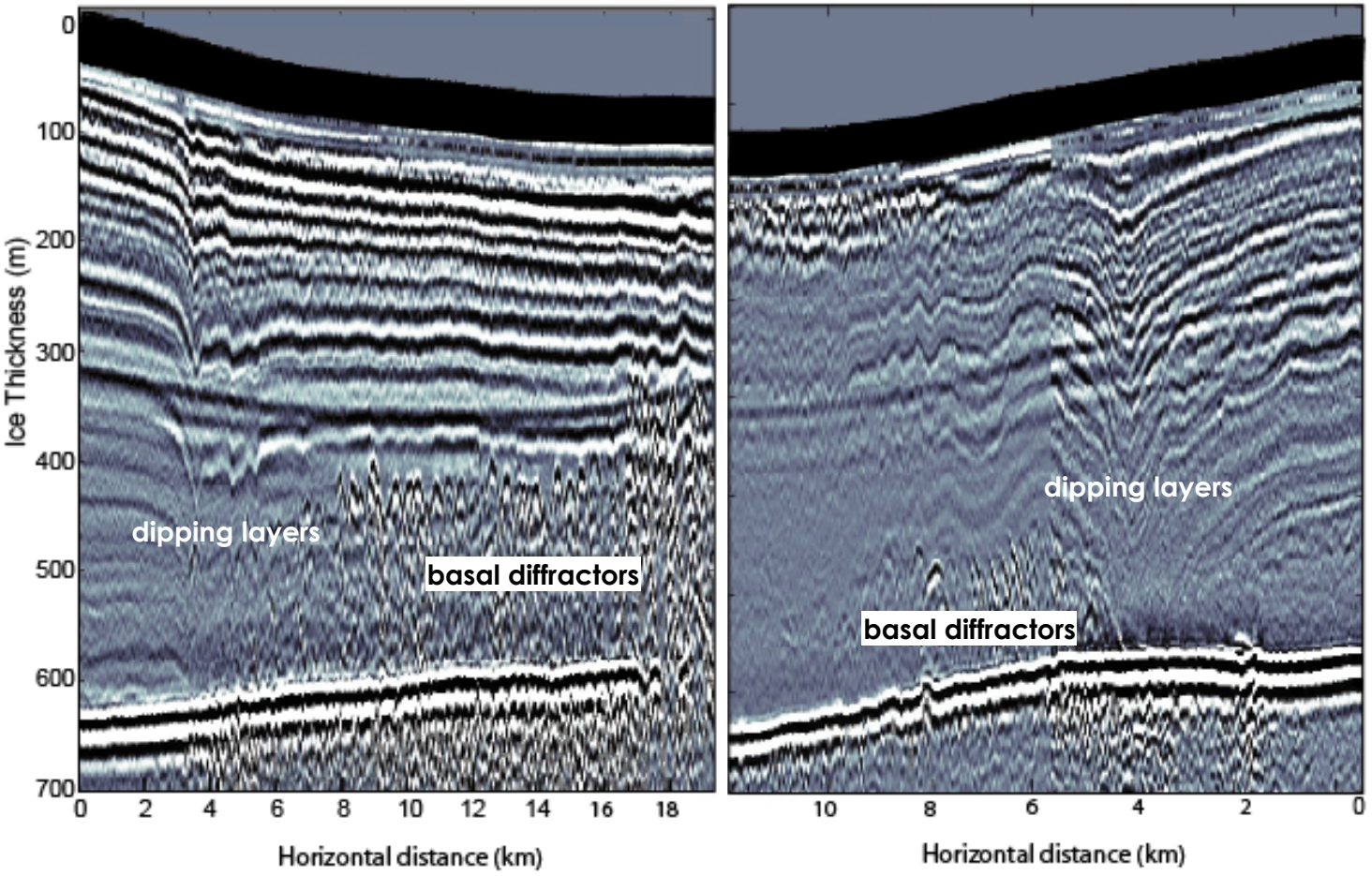
Kamb grounding line melt

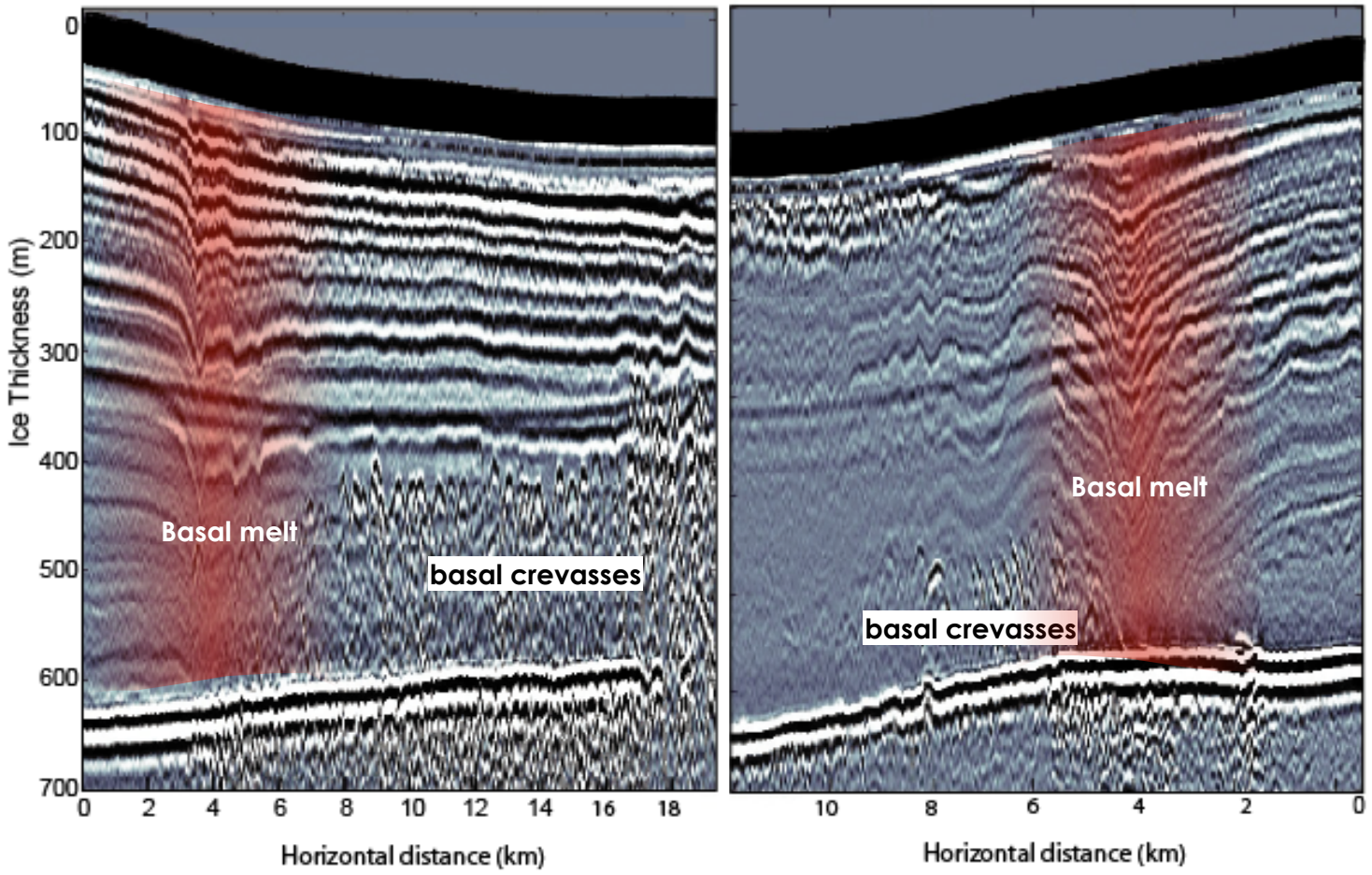
- Kamb Ice Stream shutdown ~160 years ago
- dipping layers and basal diffractors
- affected a widespread (~100 km) region

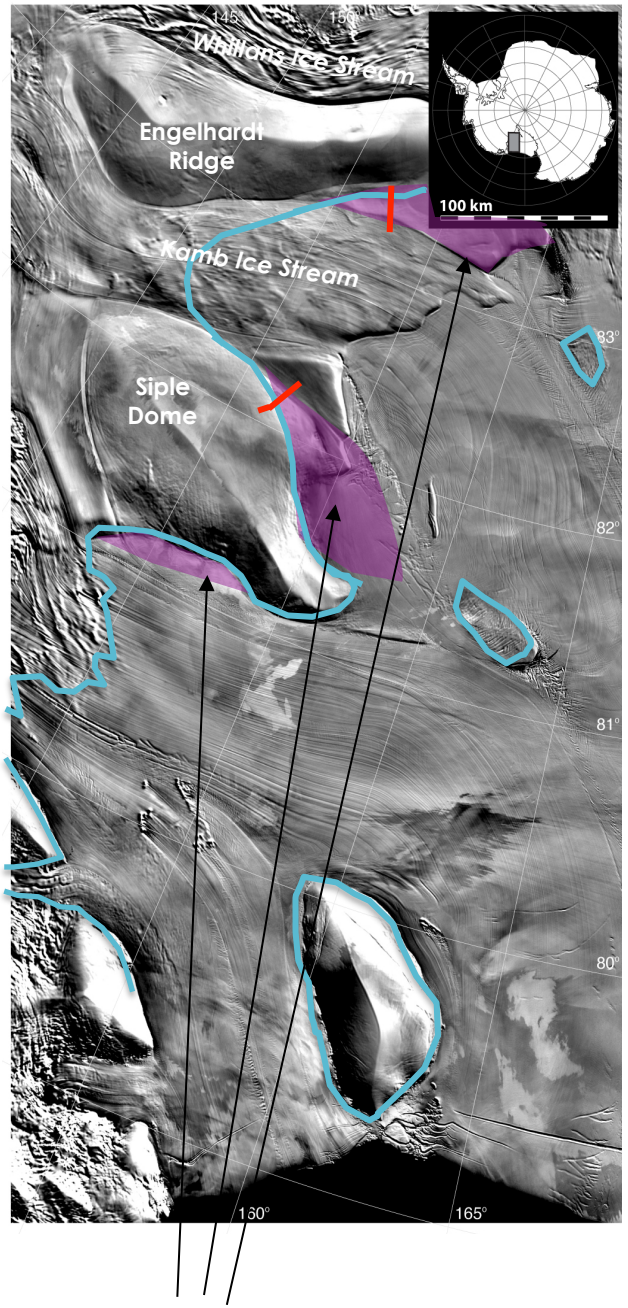




Kamb grounding line melt

- layers warped from grounding line melt in past
- basal diffractors due to basal crevassing
- what do modern grounding lines look like?

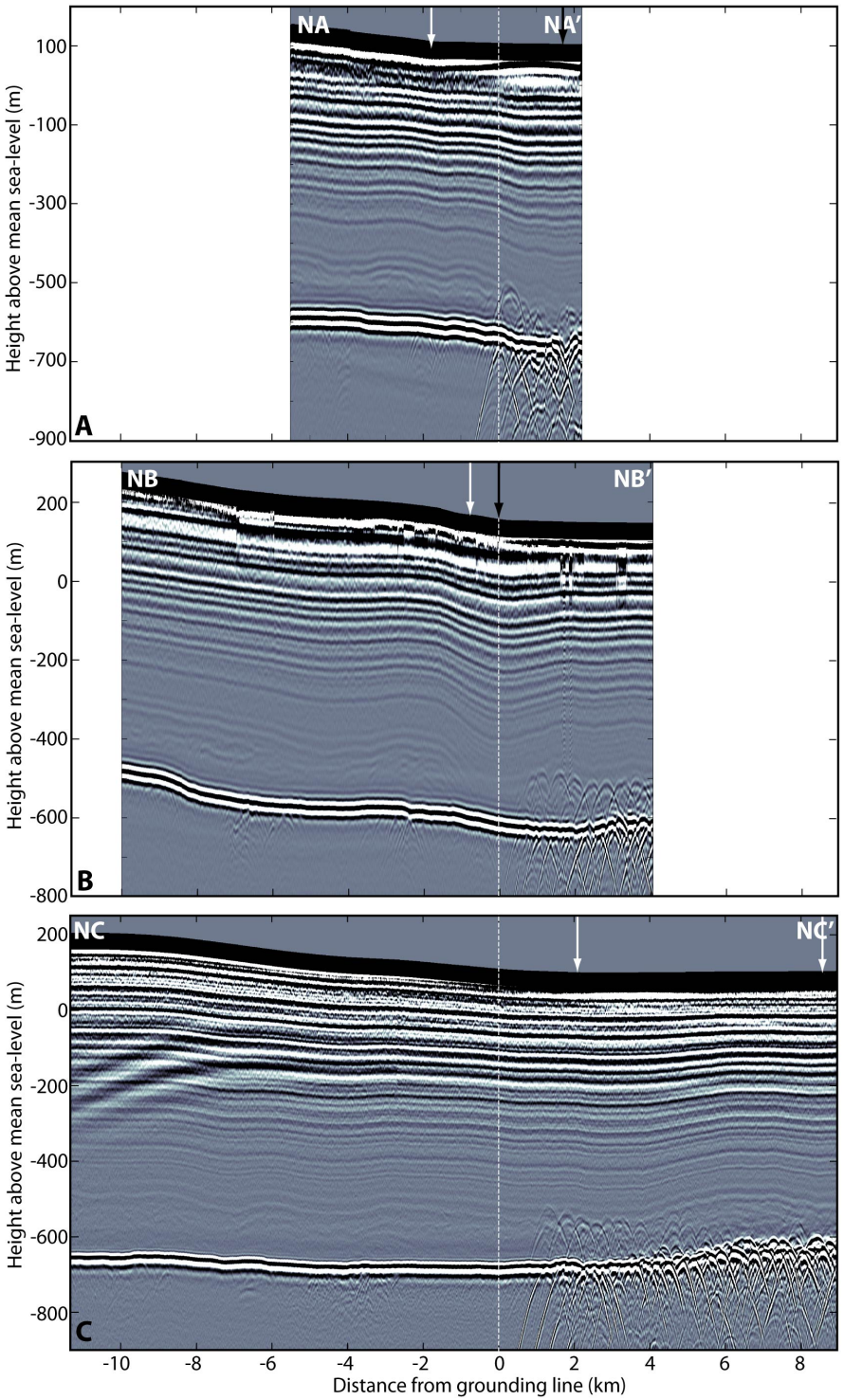


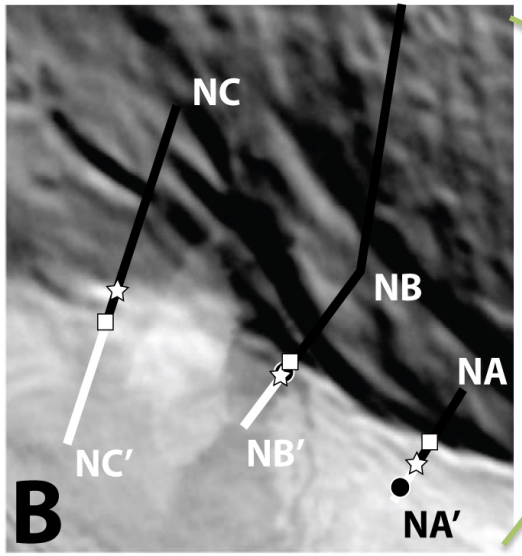


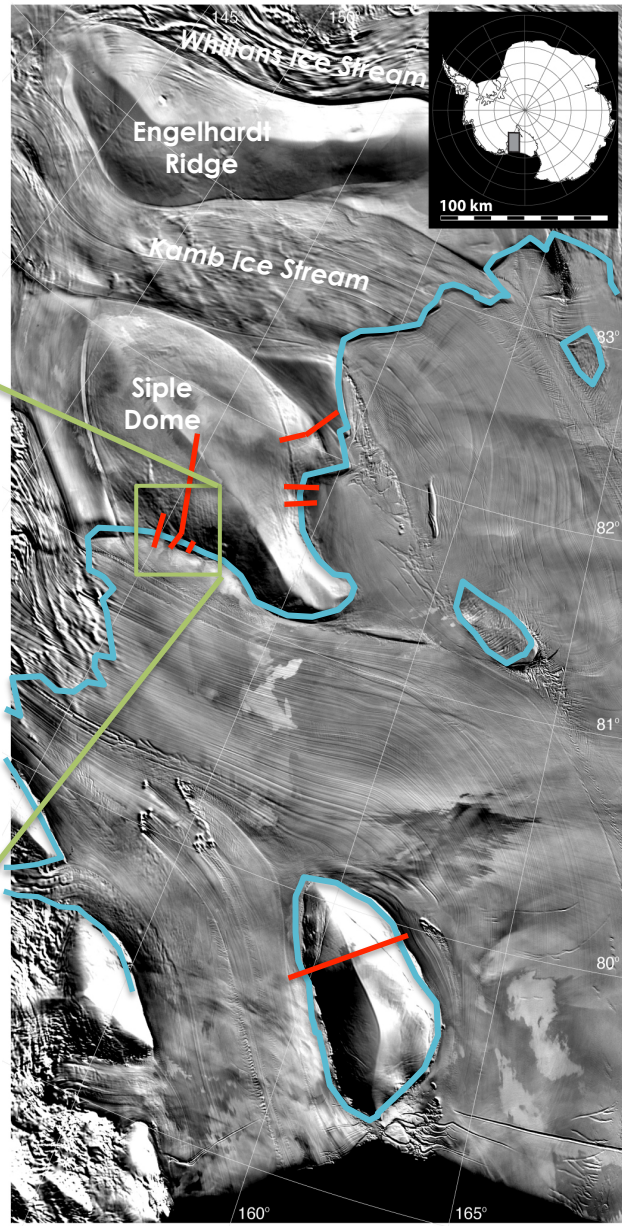
slow moving, floating ice

Catania et al. (2006)

Other grounding line crossings

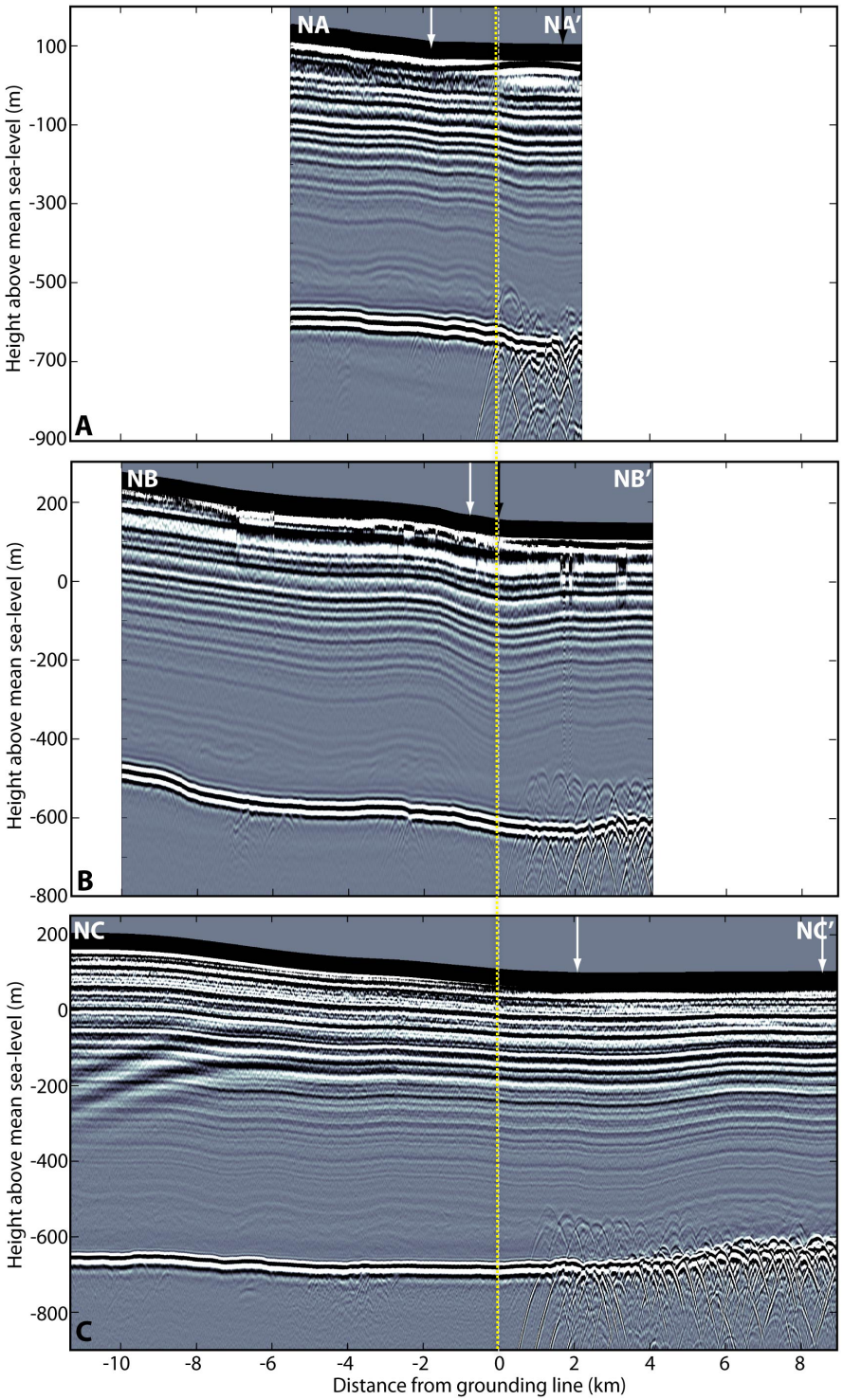


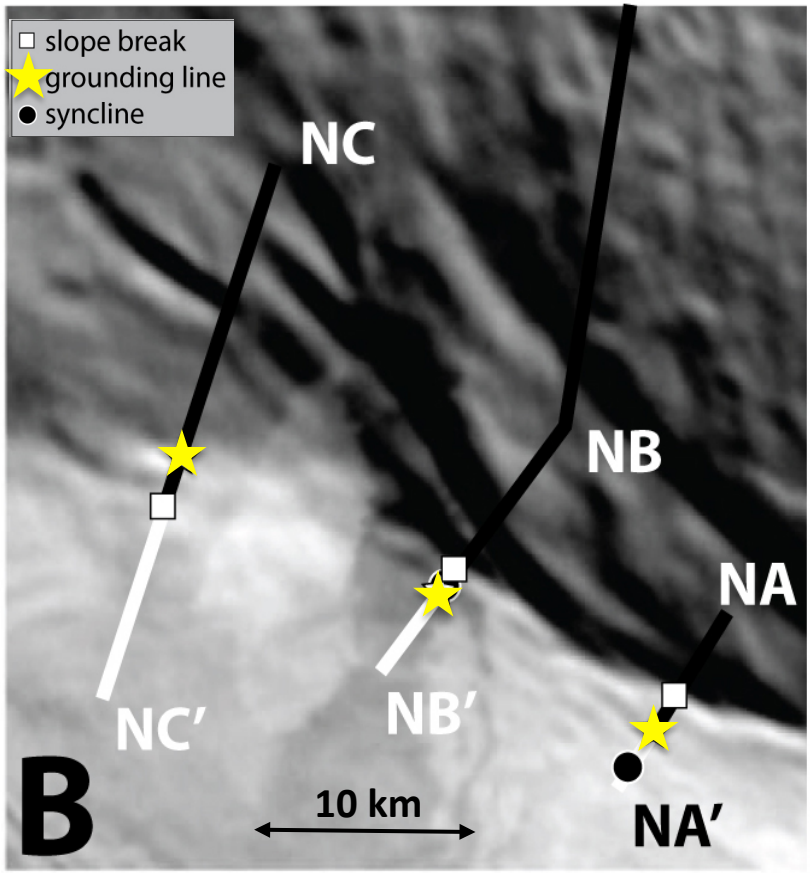




North side of Siple Dome

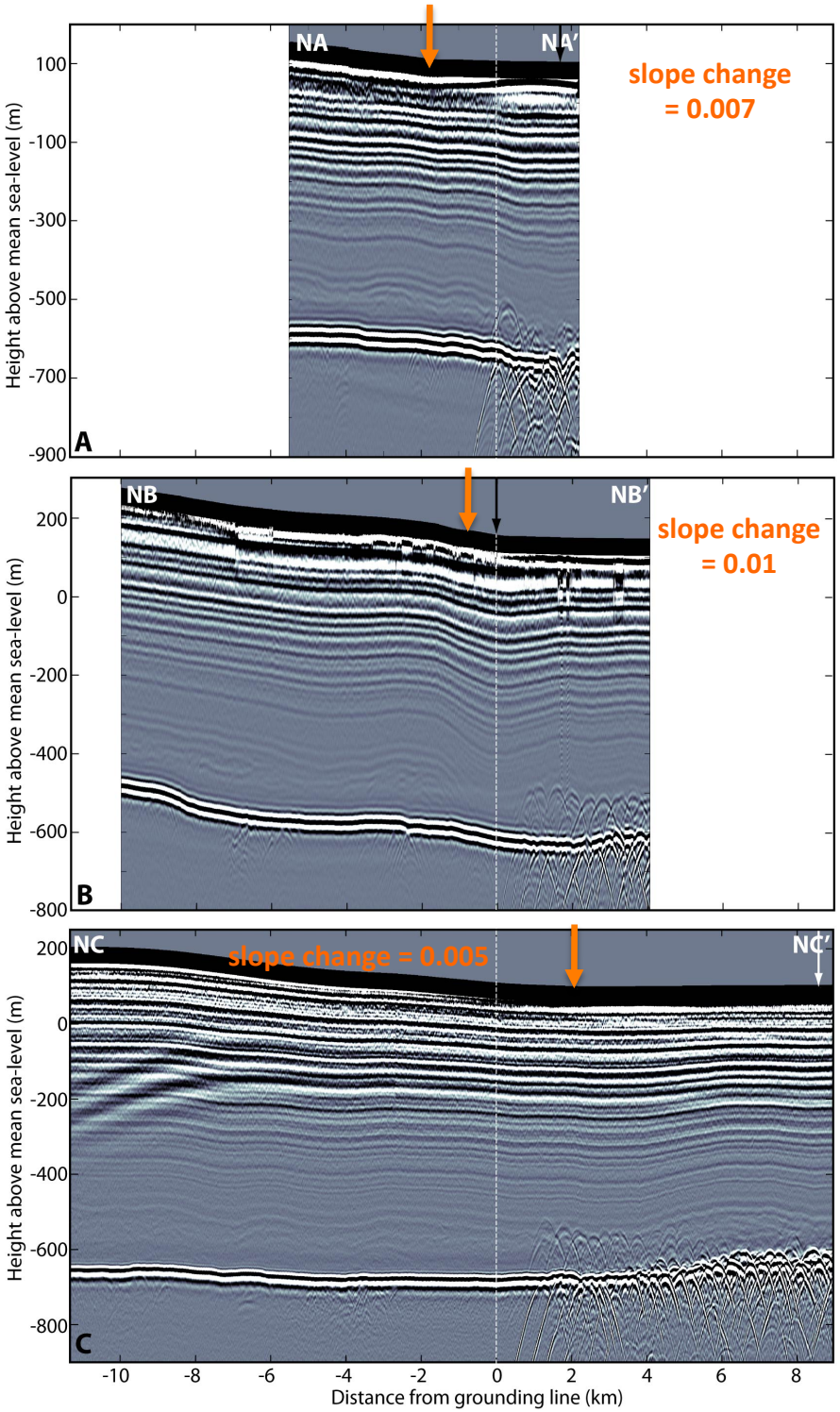
Other grounding line crossings

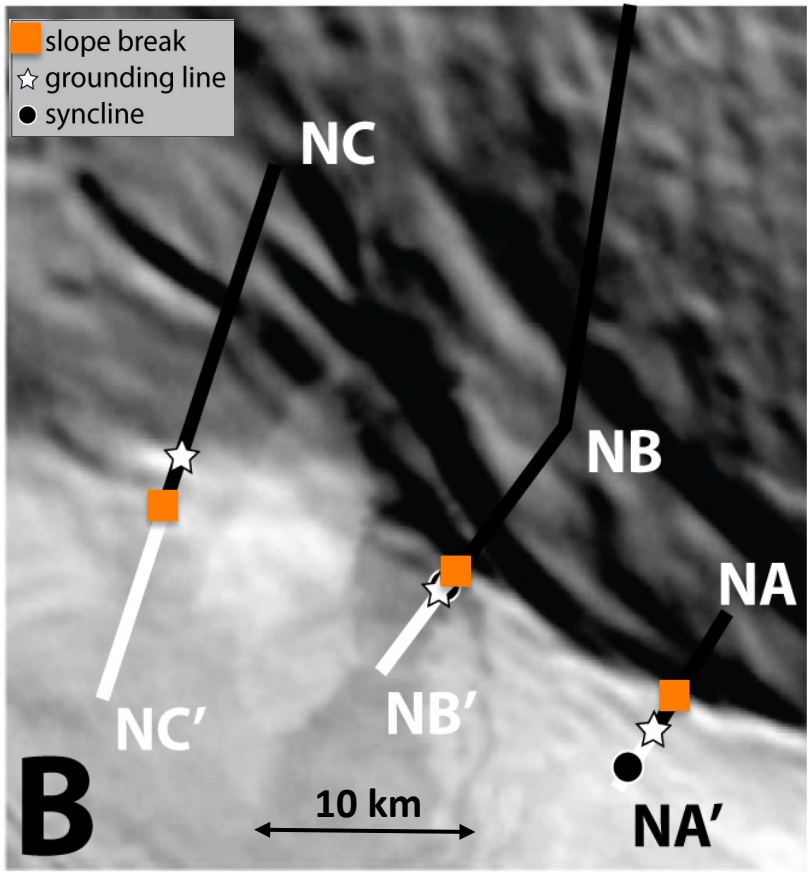




- grounding line picked using ice thickness and determining where the surface is at hydrostatic equilibrium

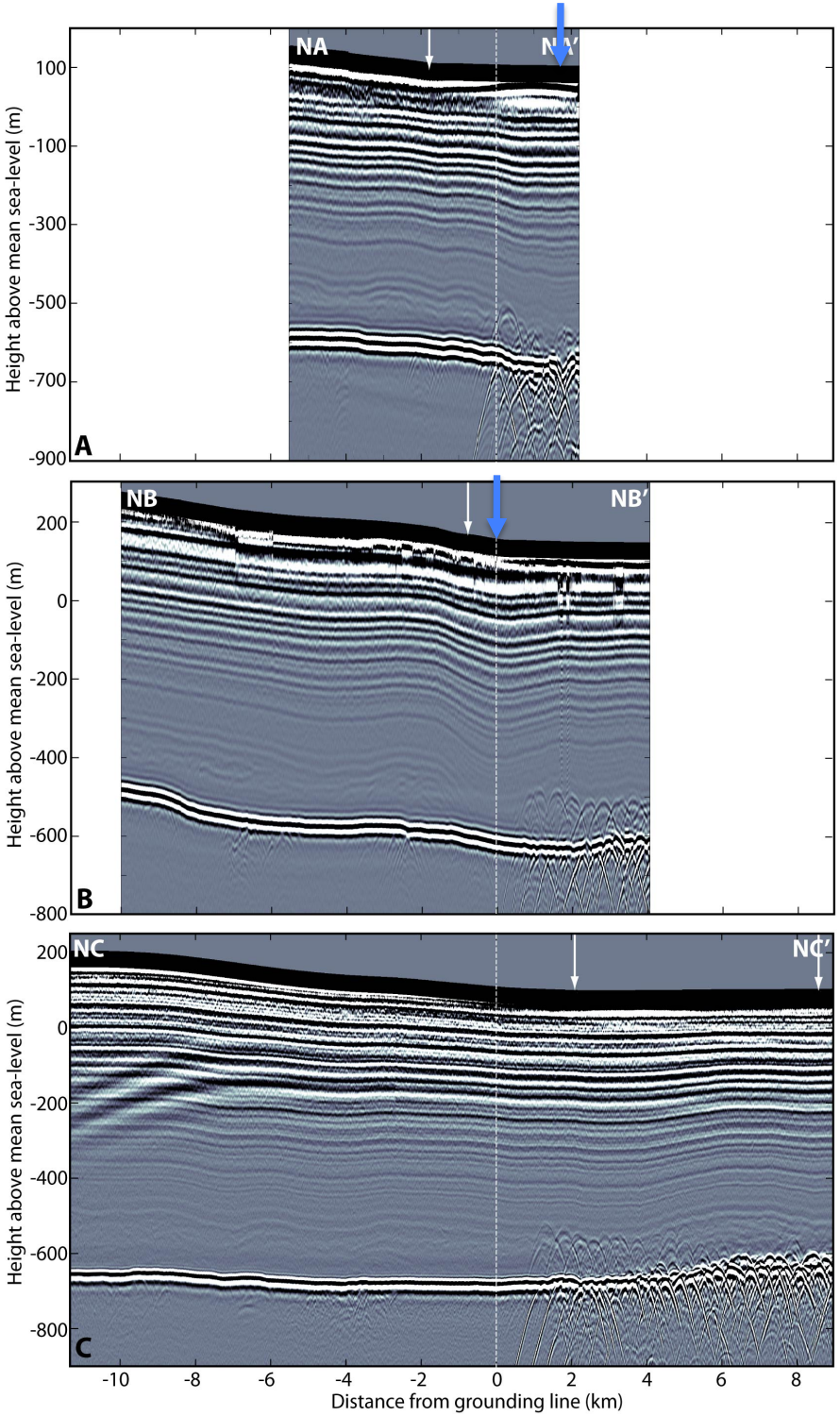
Other grounding line crossings

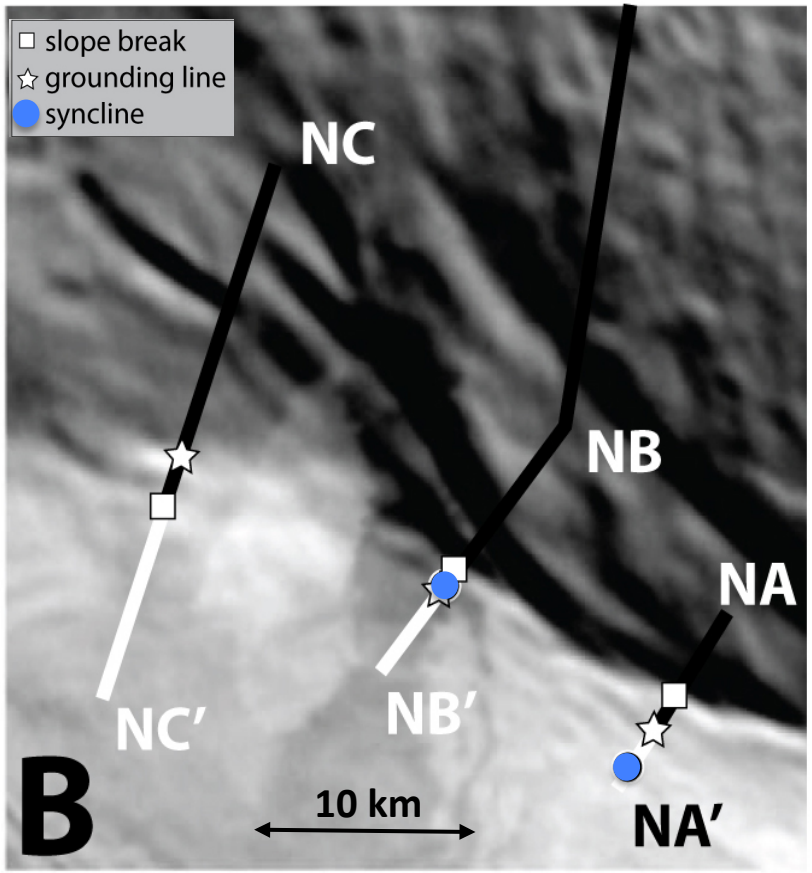




- grounding line picked using ice thickness and determining where the surface is at hydrostatic equilibrium
- slope break defines where the hydrostatic anomaly starts to increase significantly

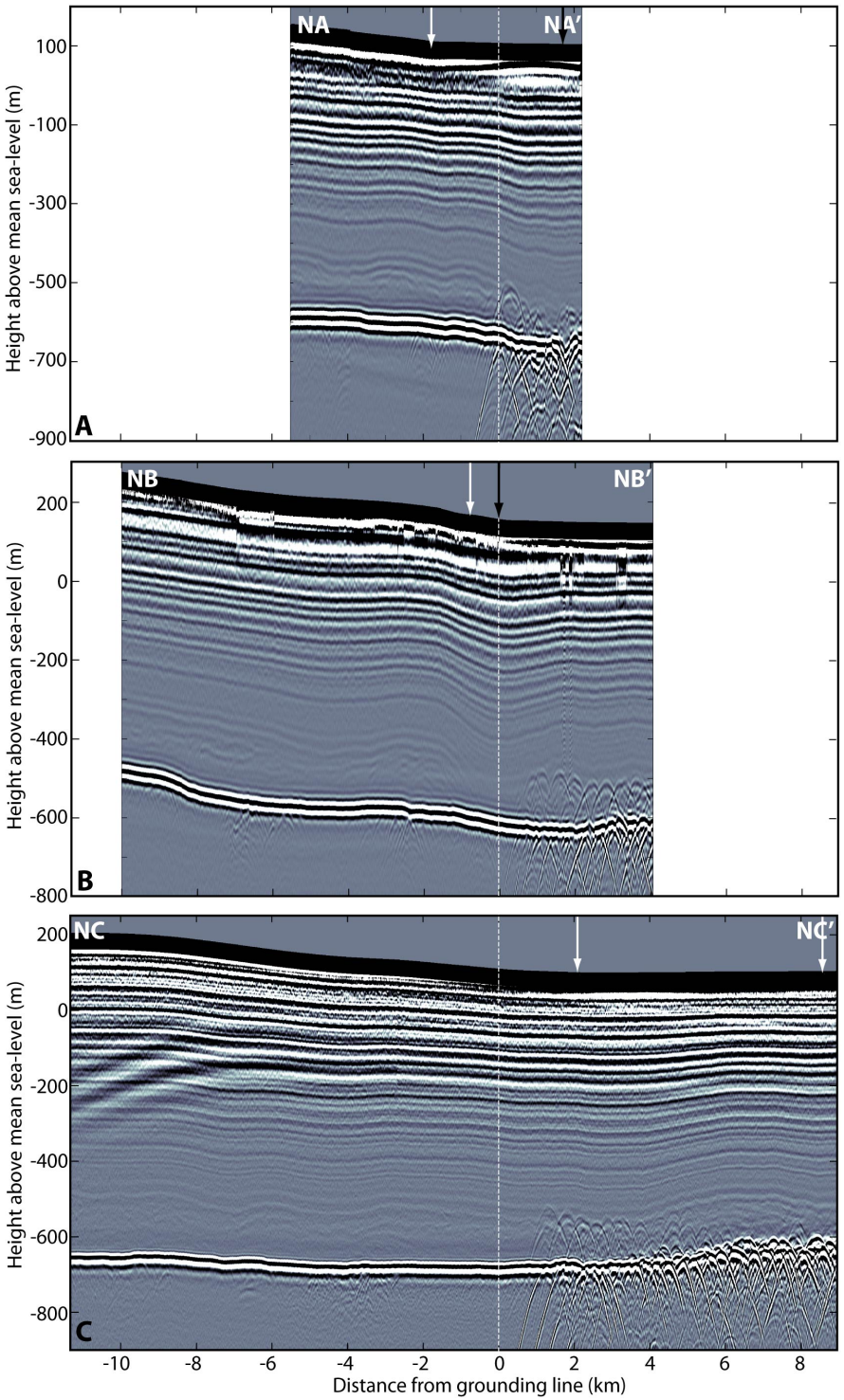
Other grounding line crossings

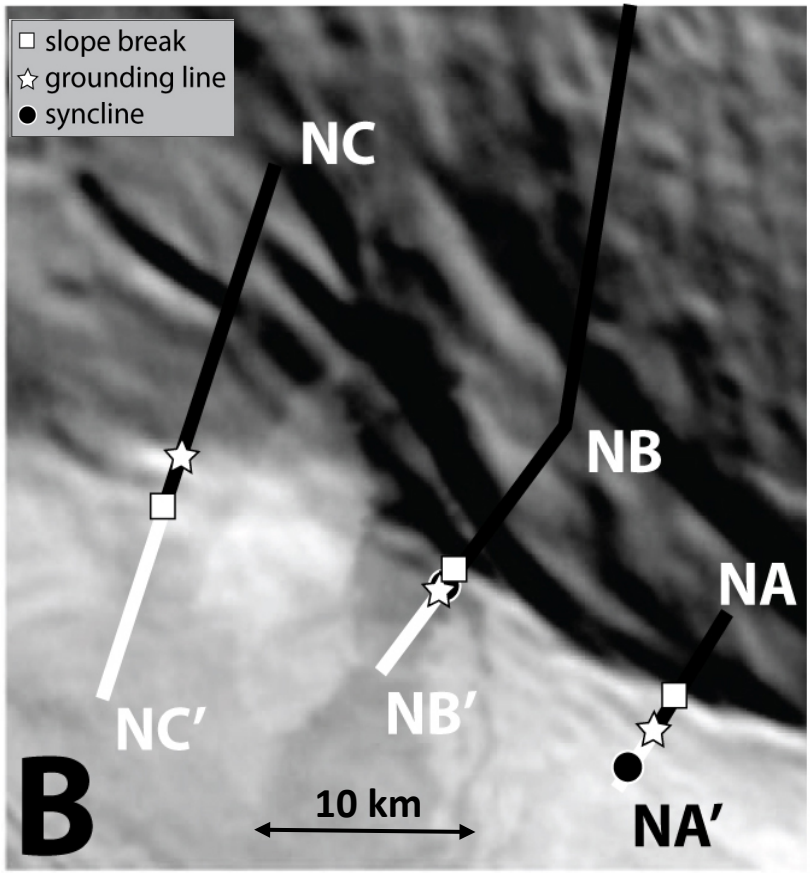




- grounding line picked using ice thickness and determining where the surface is at hydrostatic equilibrium
- slope break defines where the hydrostatic anomaly starts to increase significantly
- location where basal melting is focused picked in layers

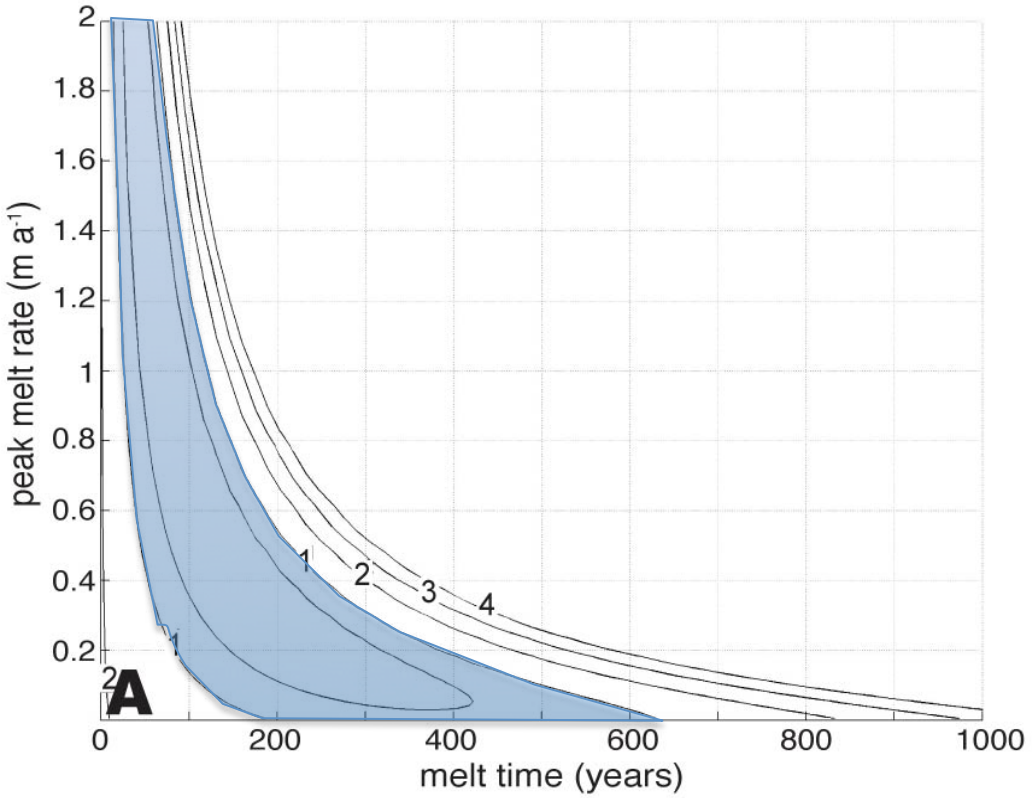
Other grounding line crossings

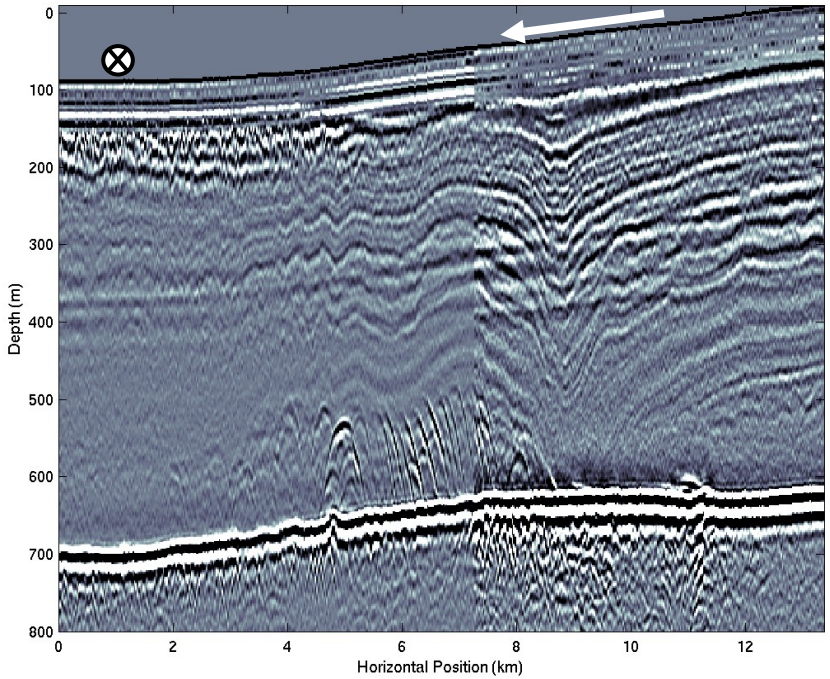


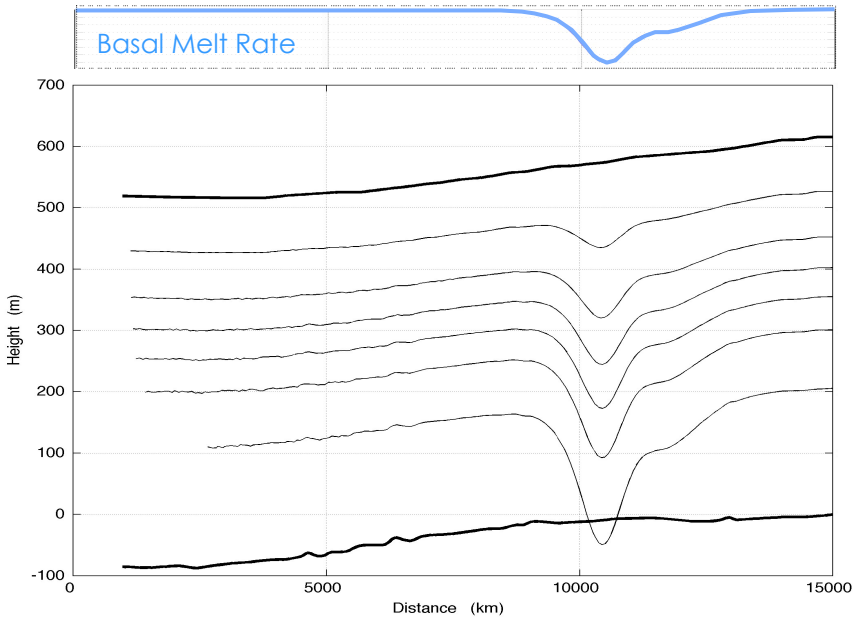


- hydrostatic equil. occurs just upstream of basal crevassing
- melting occurs slightly downstream or at hydrostatic equil.
- heterogeneity in where and how much melting occurs

Other grounding line crossings



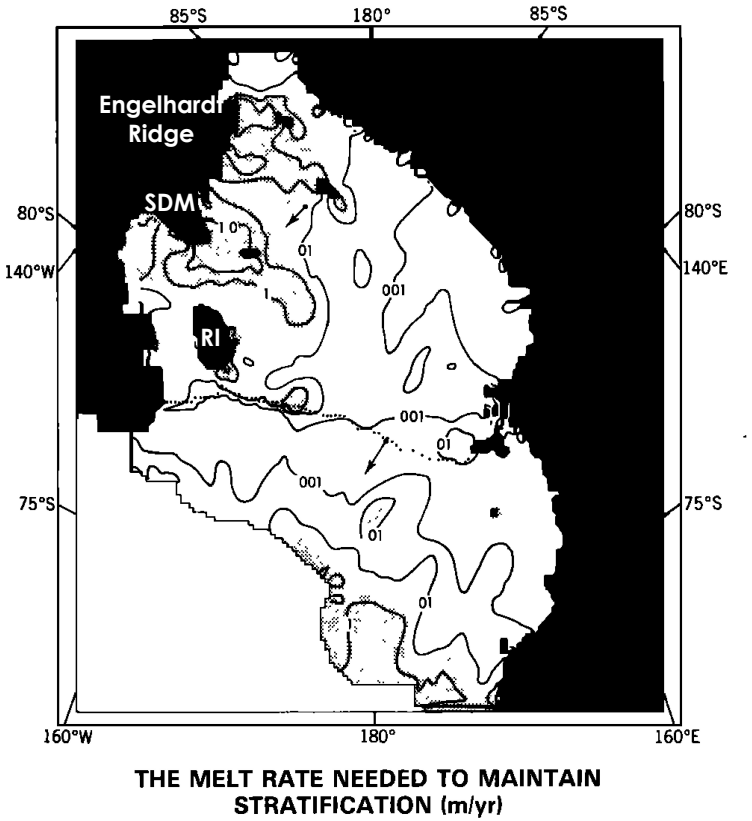




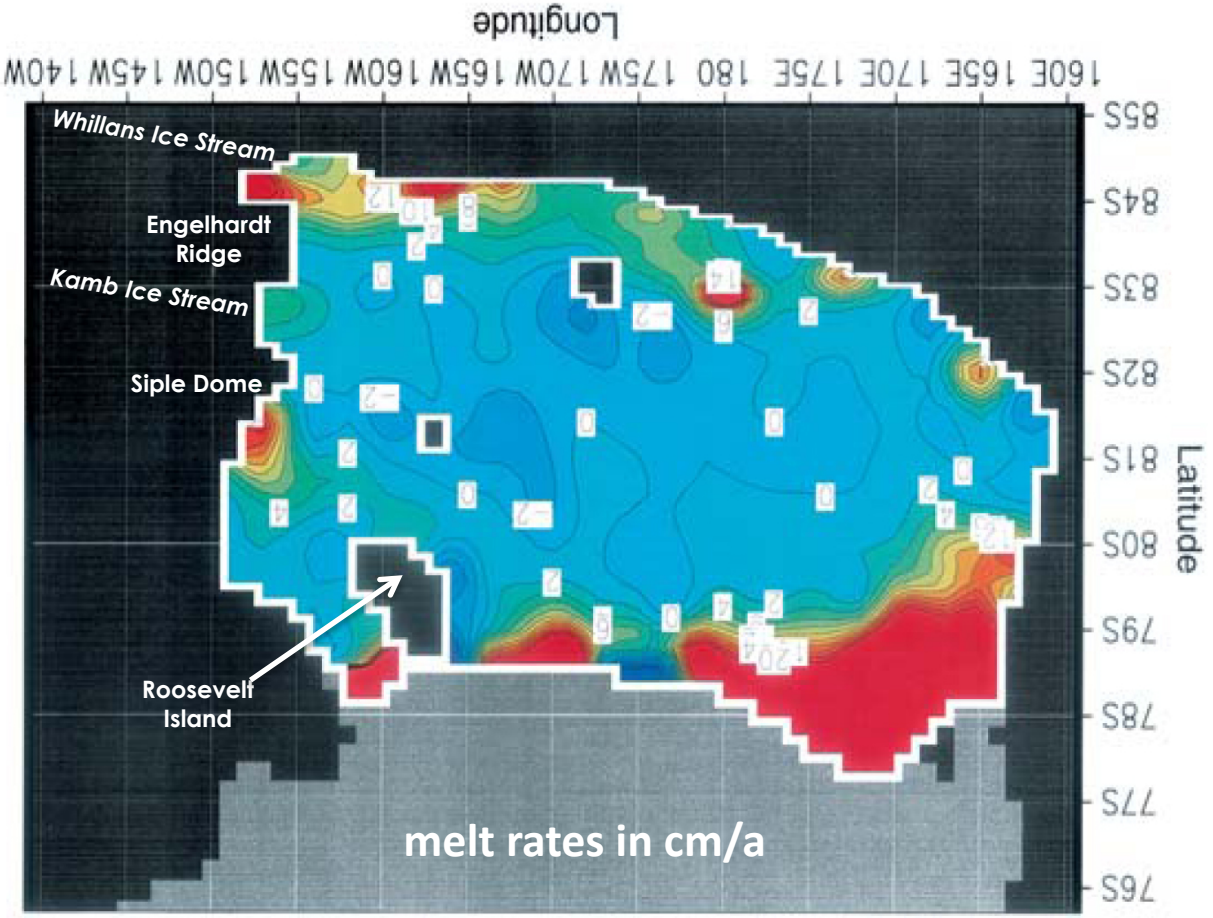
- isochrone model is used to characterize melt
- how long vs. melt rate
- model cannot give exact melt rate; when melting occurred

Catania et al. (2006)

Kamb grounding line melt



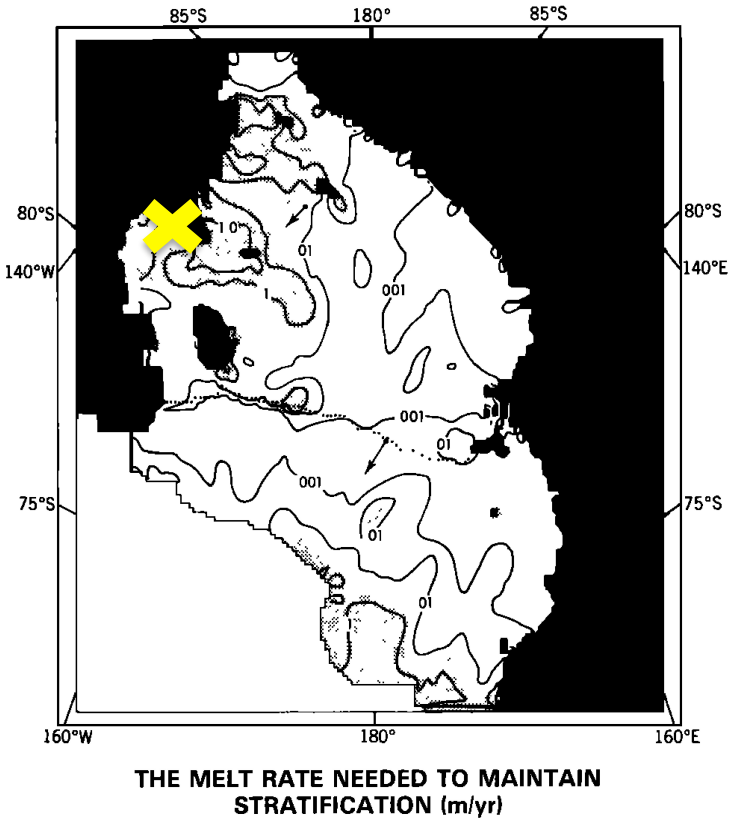
from MacAyeal, (1984)



from Holland et al., (2003)

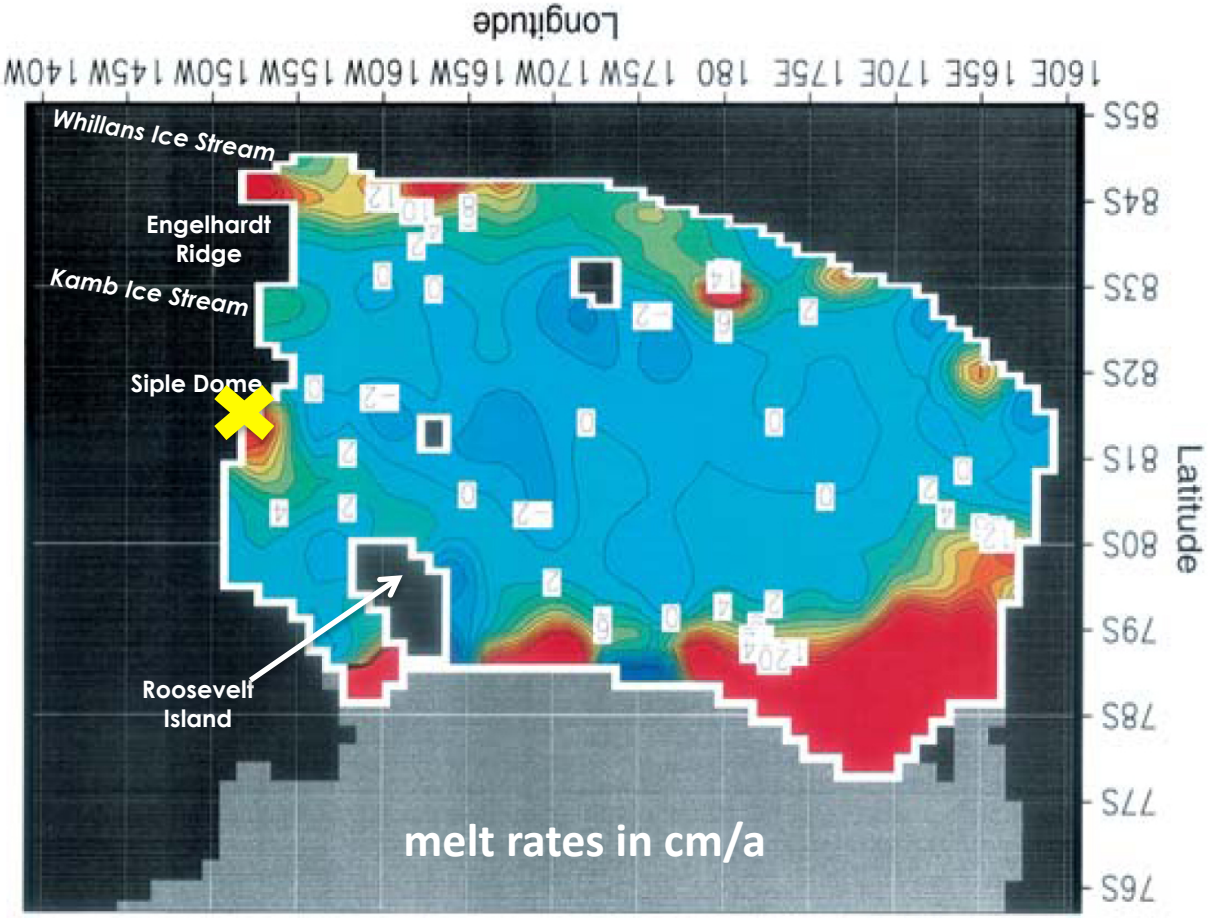
- Holland et al., (2003); sub-ice shelf circulation model
- MacAyeal (1984); tidal mixing model
- both predict modest melt rates (~1 m/a peak melt rates)
- generally agree that grounding line melt is focused along Mercer/Whillans outlet and northern SDM coastline

Other grounding line crossings



THE MELT RATE NEEDED TO MAINTAIN STRATIFICATION (m/yr)

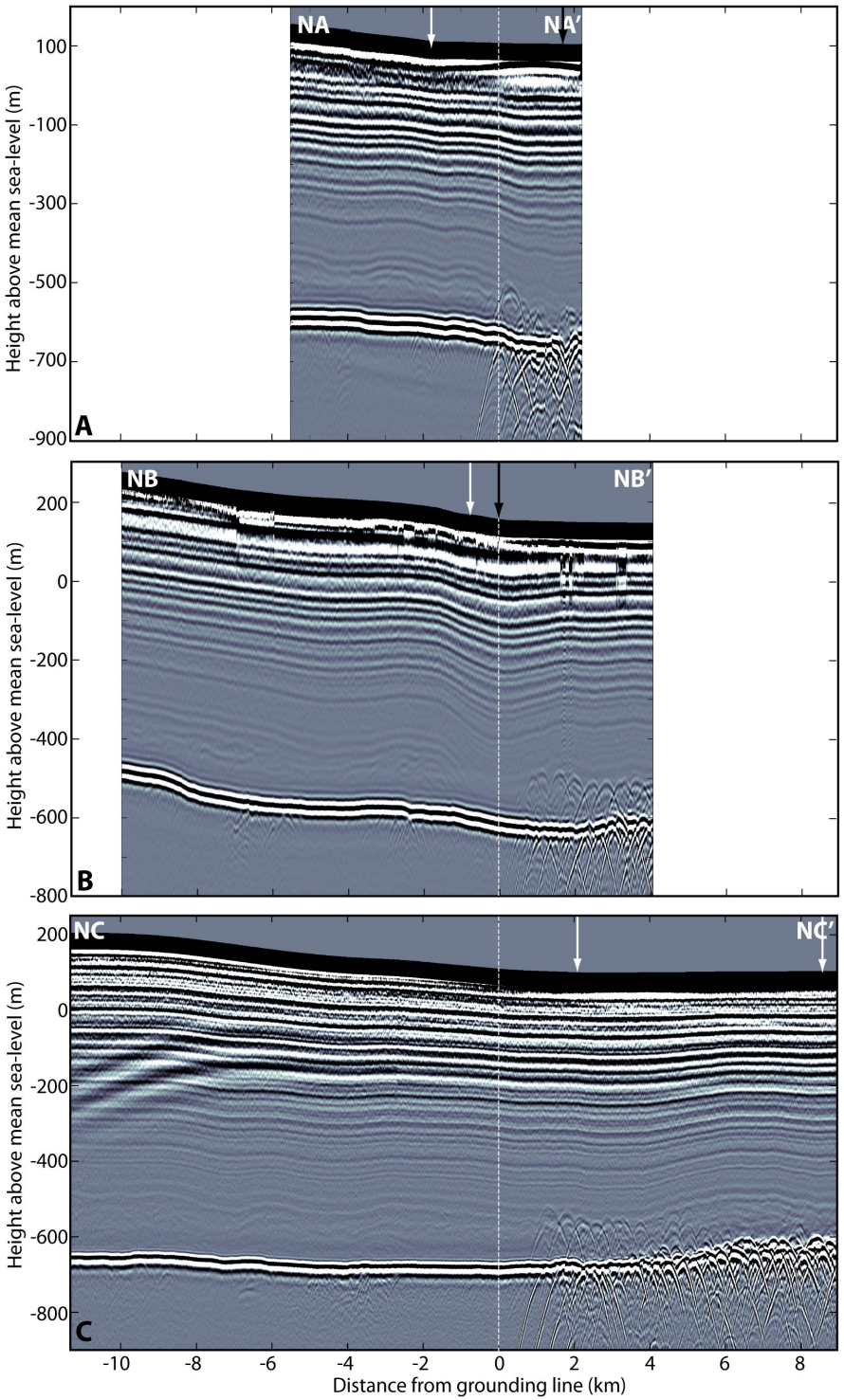
from MacAyeal, (1984)

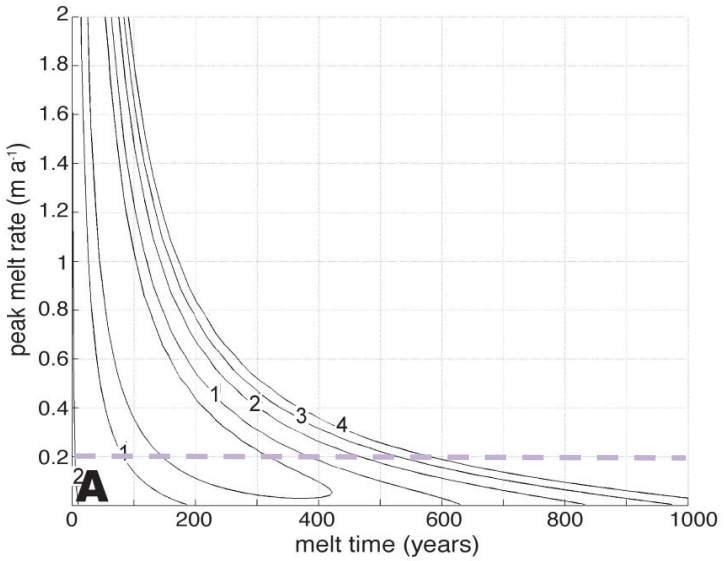


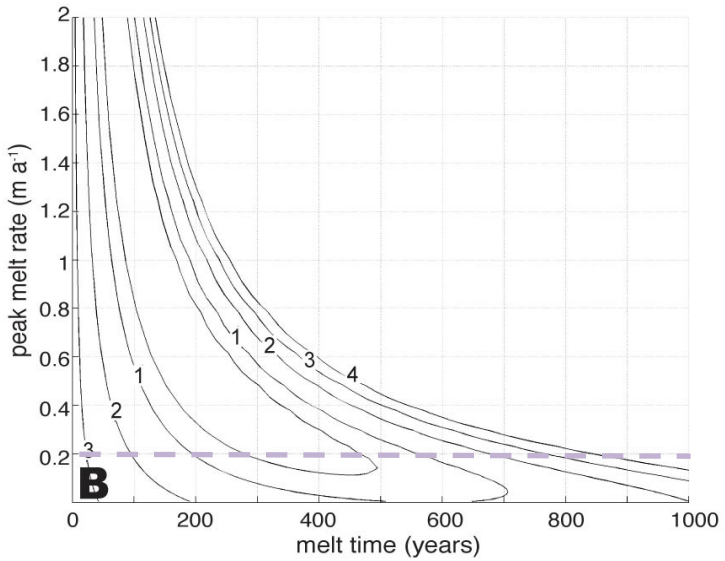
from Holland et al., (2003)

- for Northern SDM margin use melt rate of ~0.2 m/a
- spatial variability in melt rate

Other grounding line crossings

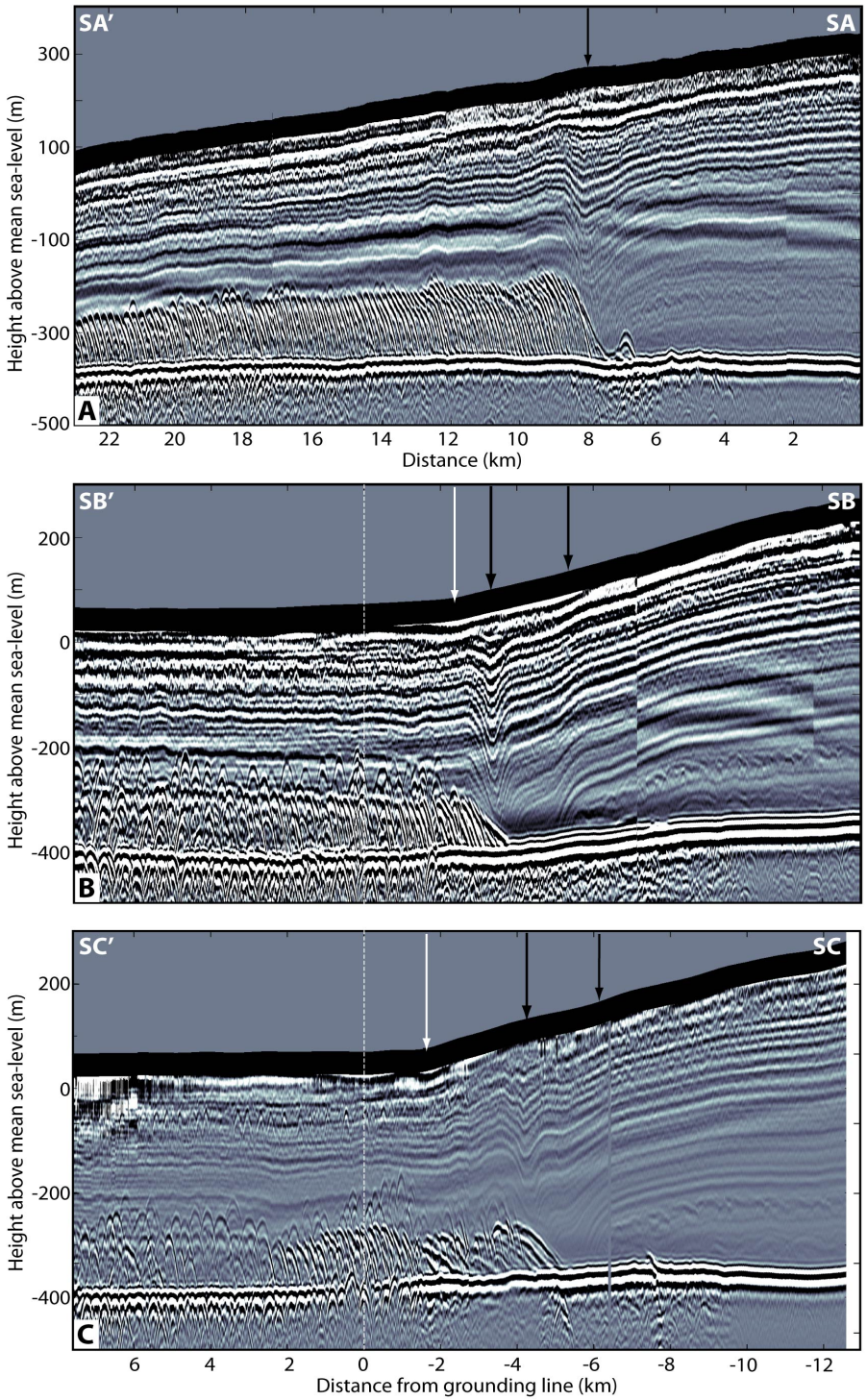


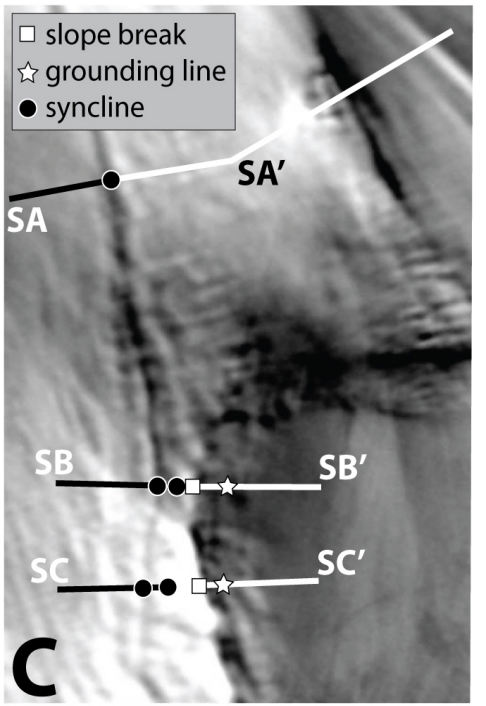


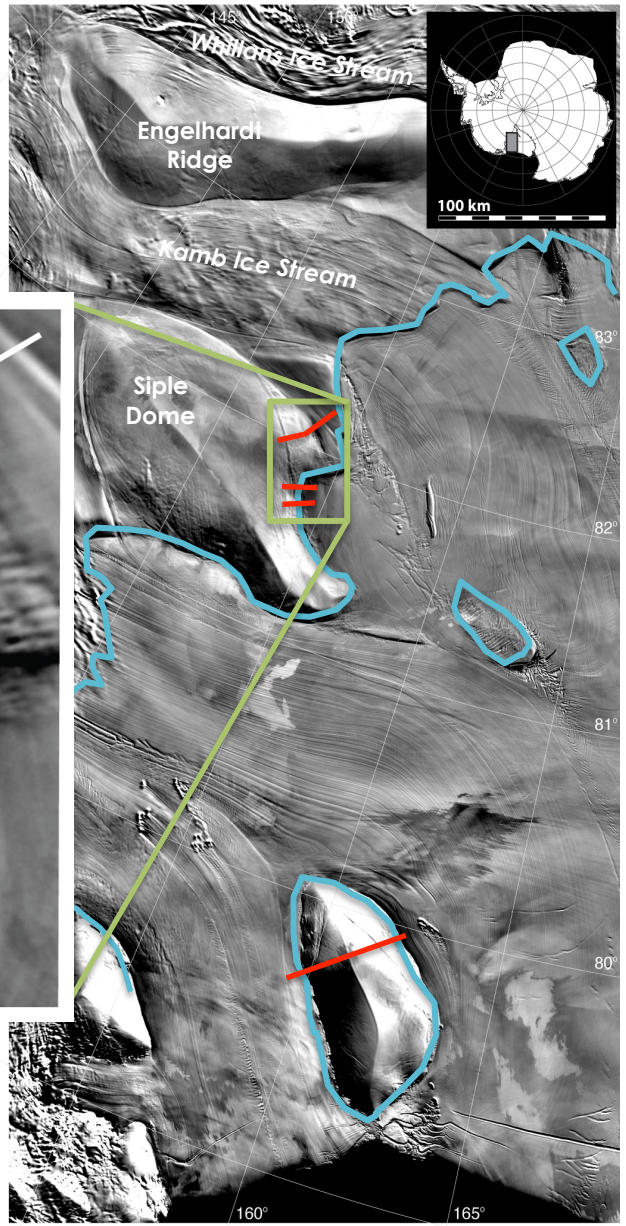


A solution that fits both sets of isochrones with a melt rate of 0.2 m/a gives melt time of ~200-400 years

Other grounding line crossings

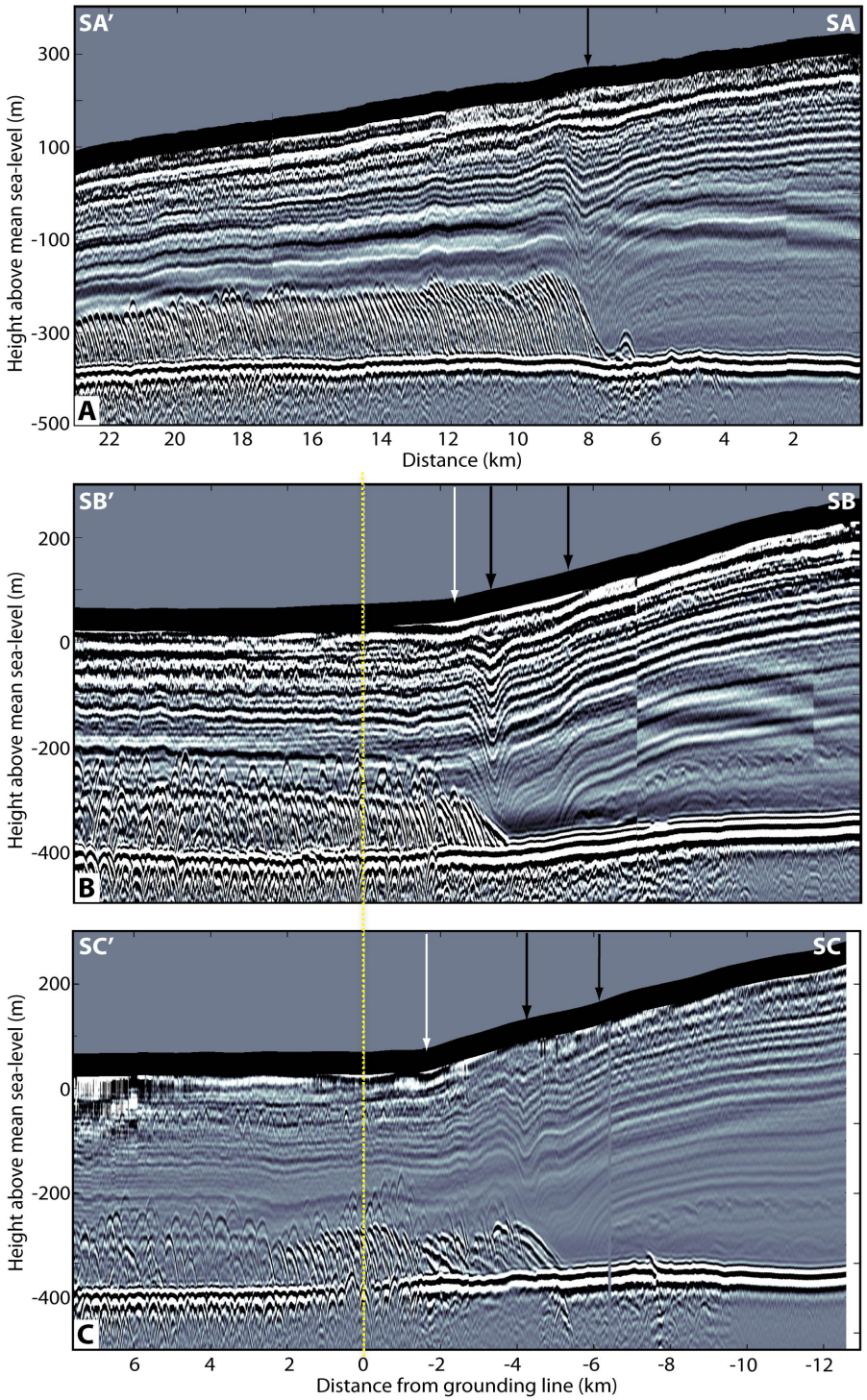


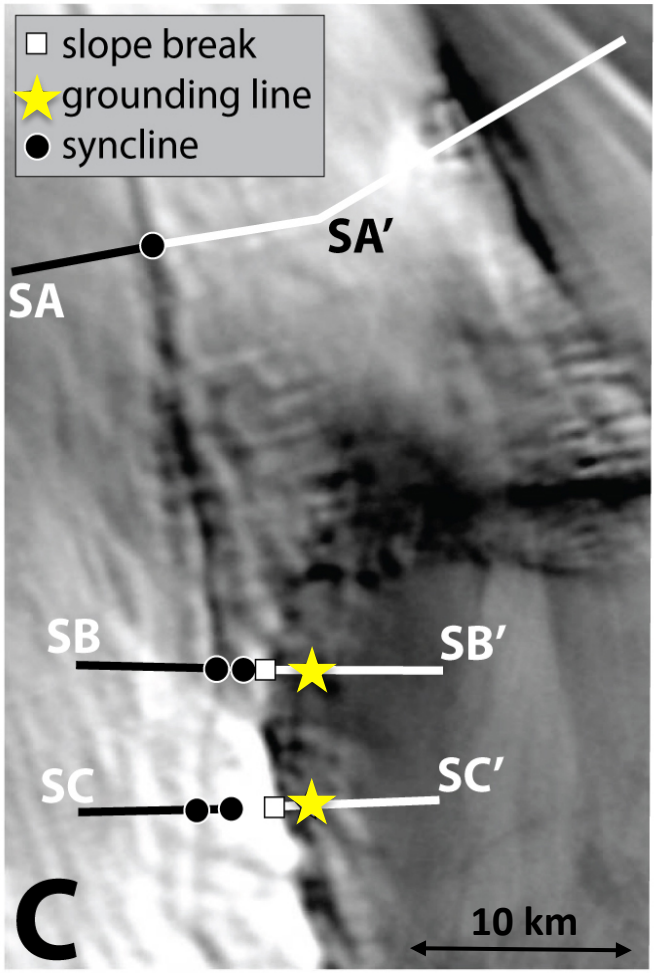




South side of Siple Dome

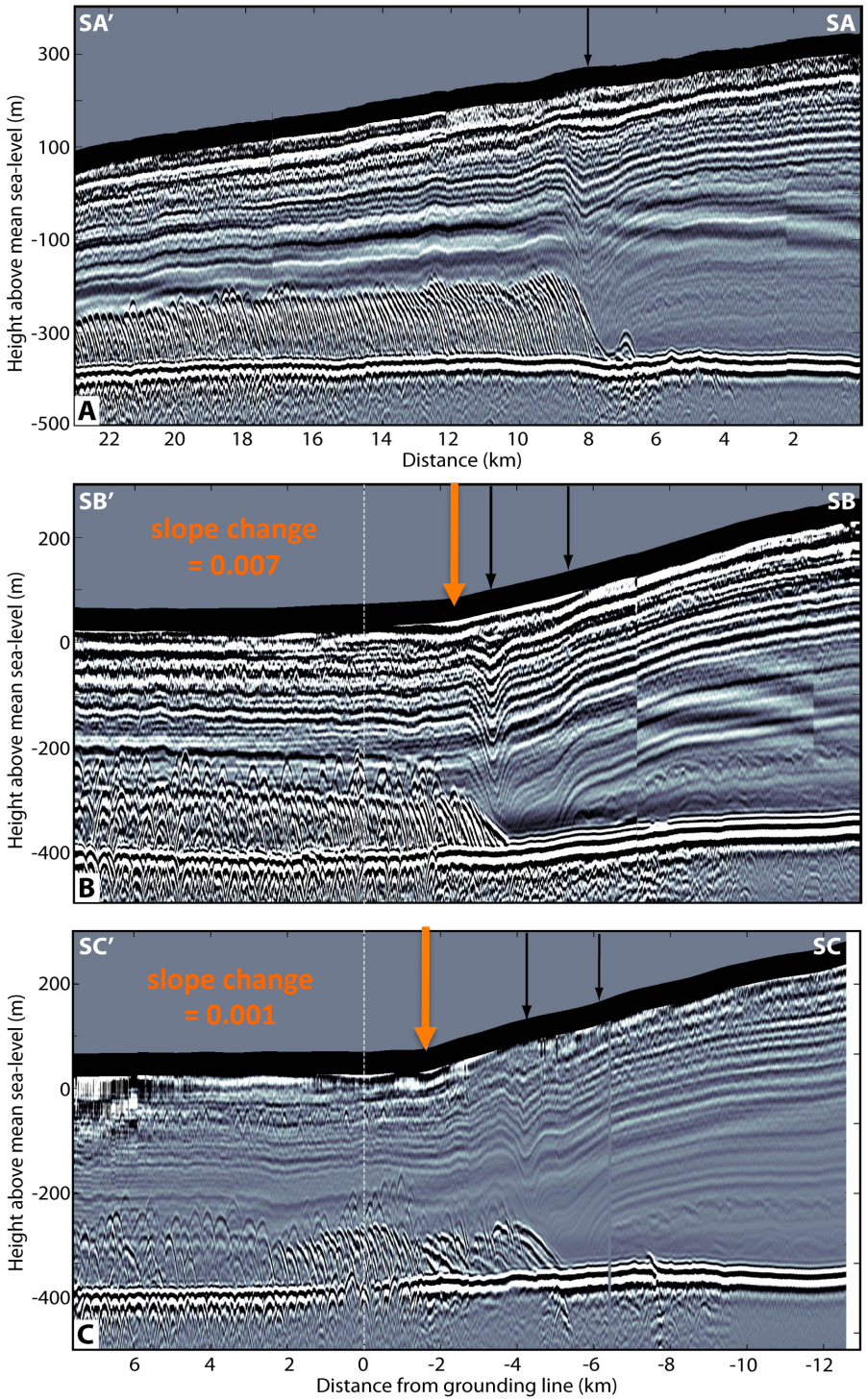
Other grounding line crossings

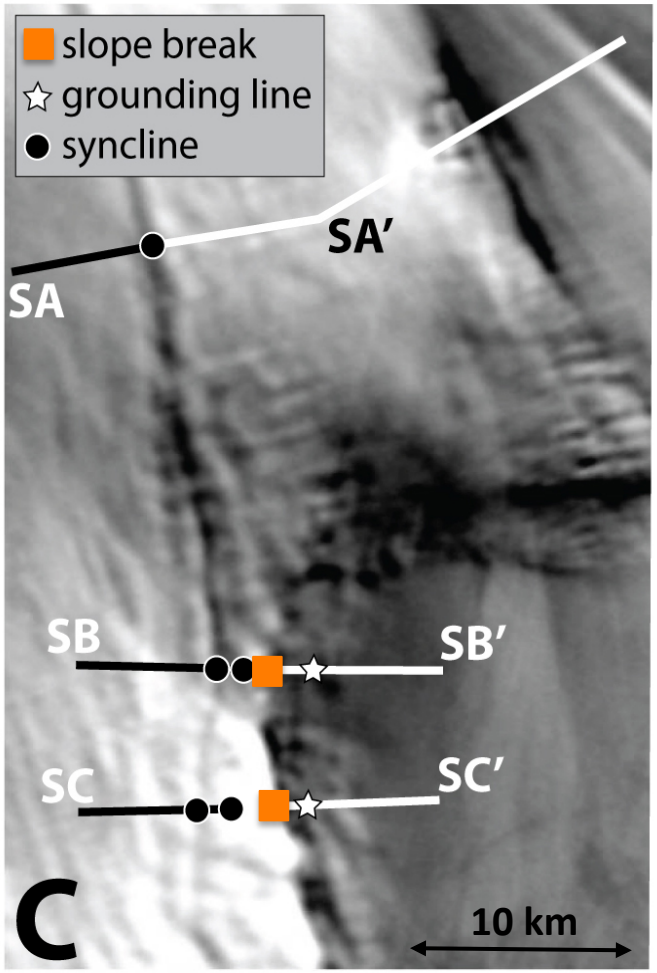




- grounding line picked using ice thickness and surface elevations to find hydrostatic equilibrium

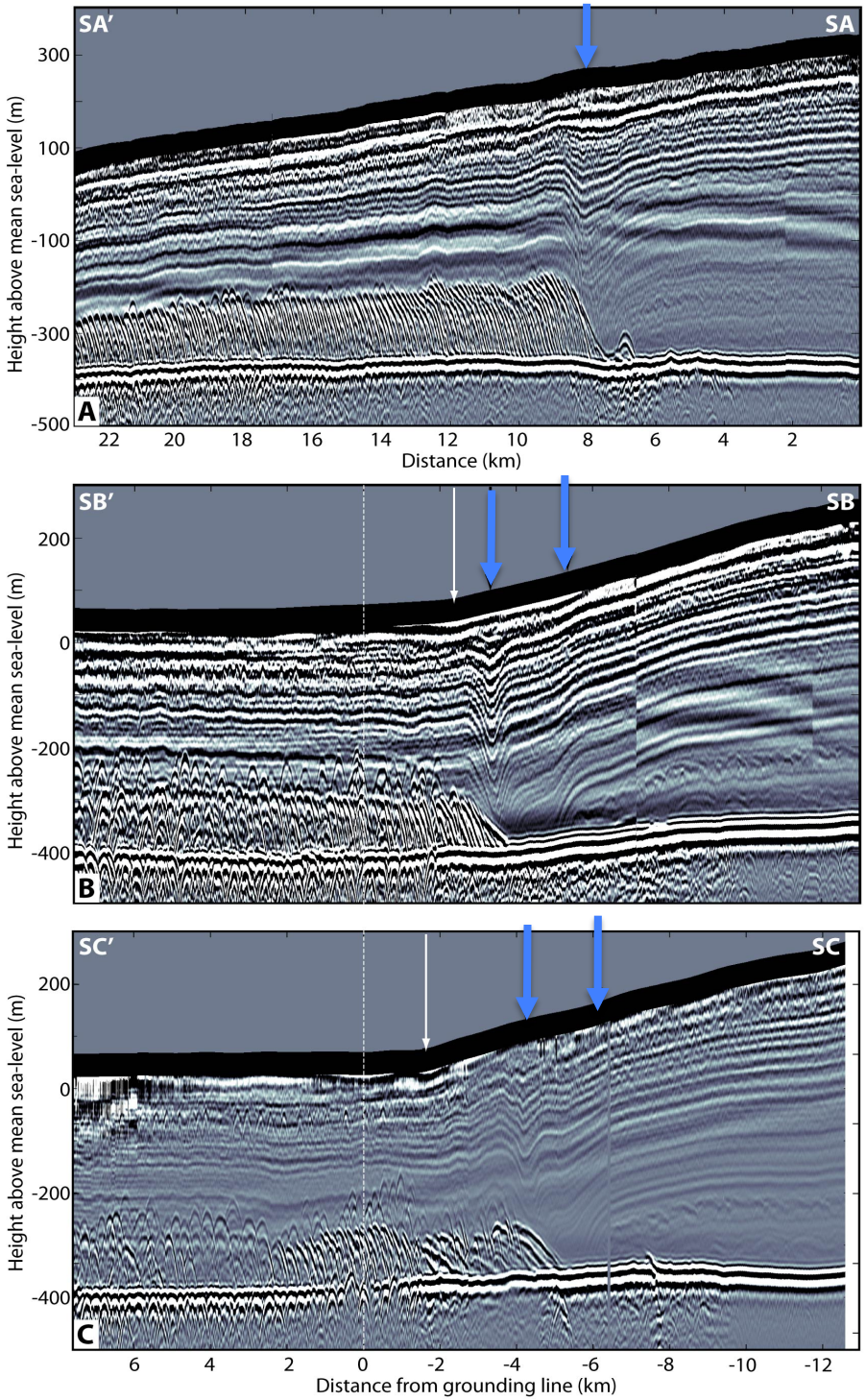
Other grounding line crossings

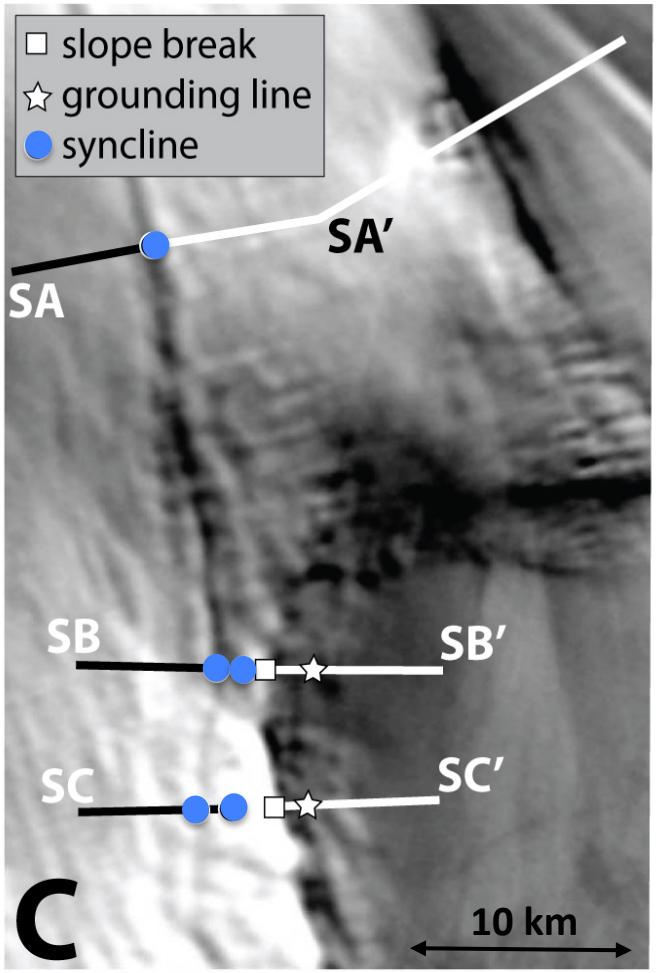




- grounding line picked using ice thickness and surface elevations to find hydrostatic equilibrium
- slope break defines where the hydrostatic anomaly starts to increase significantly

Other grounding line crossings





- grounding line picked using ice thickness and surface elevations to find hydrostatic equilibrium
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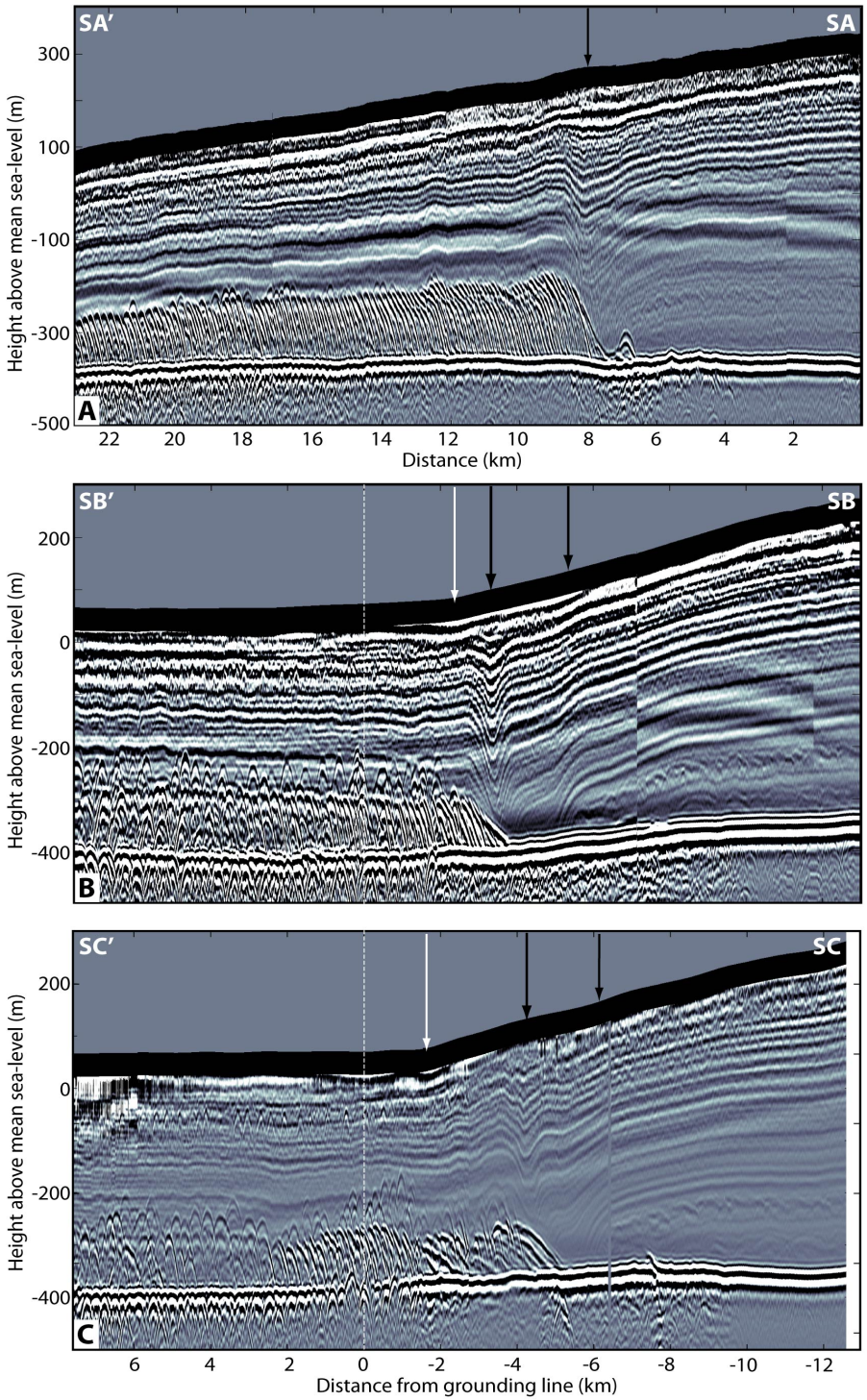
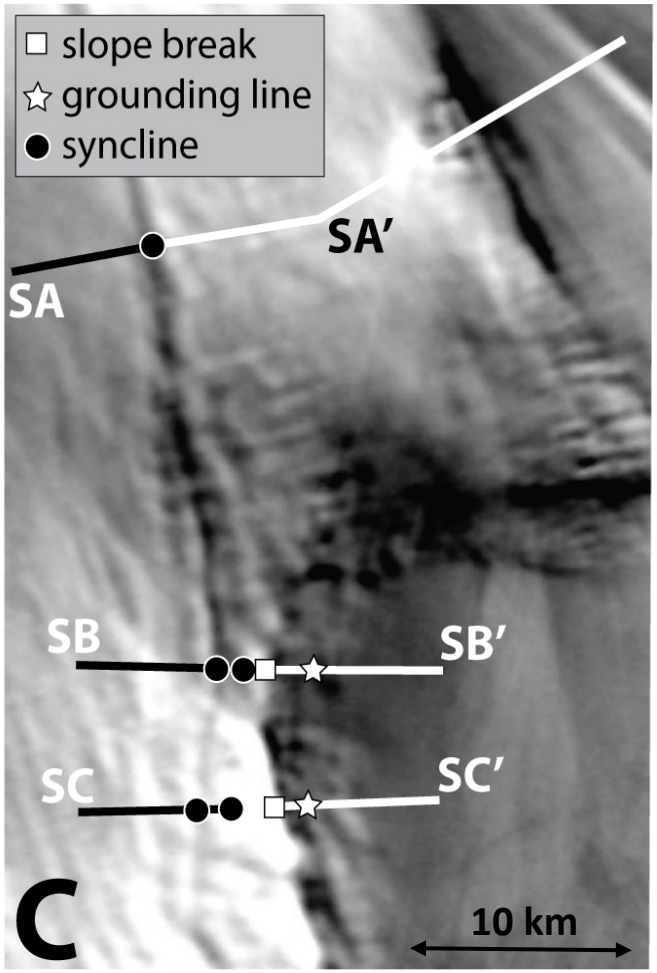
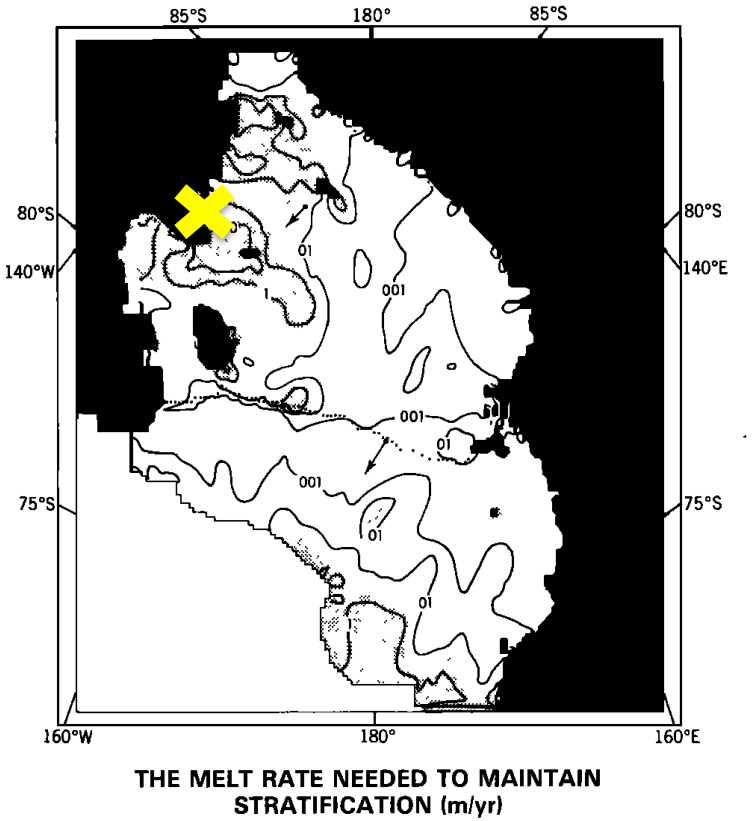
Other grounding line crossings





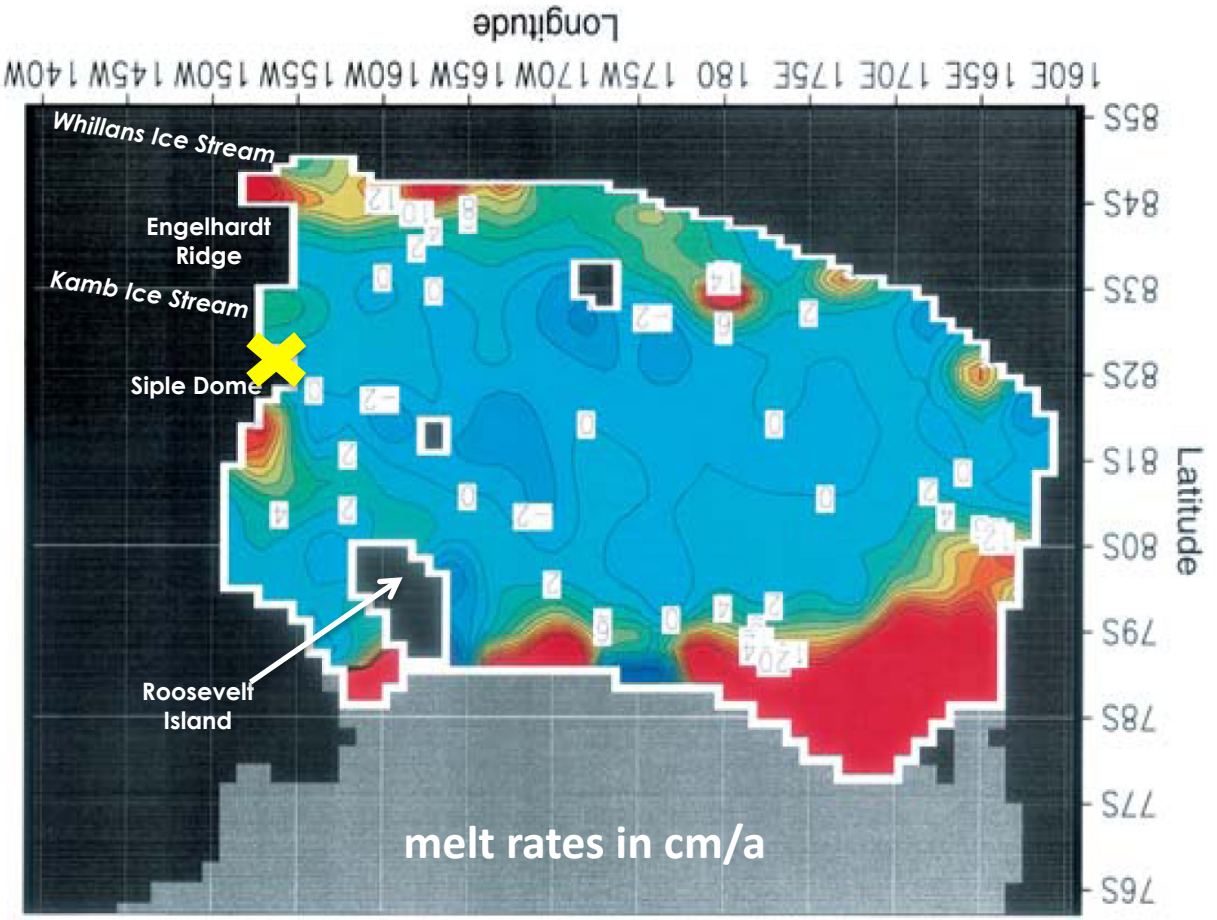
- no melting signature at modern grounding line
- paleo-grounding line left behind a surface scar
- overprinted crevasse sets may be related to g.l. migration

Other grounding line crossings



THE MELT RATE NEEDED TO MAINTAIN STRATIFICATION (m/yr)

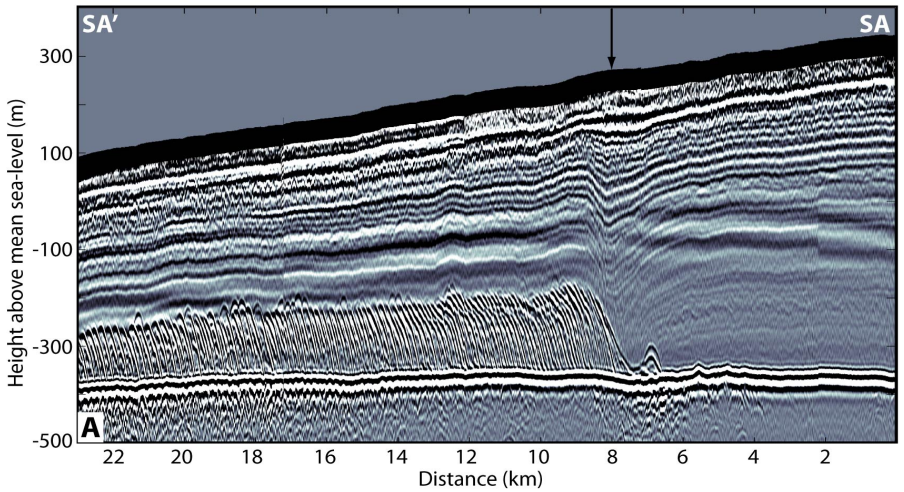
from MacAyeal, (1984)

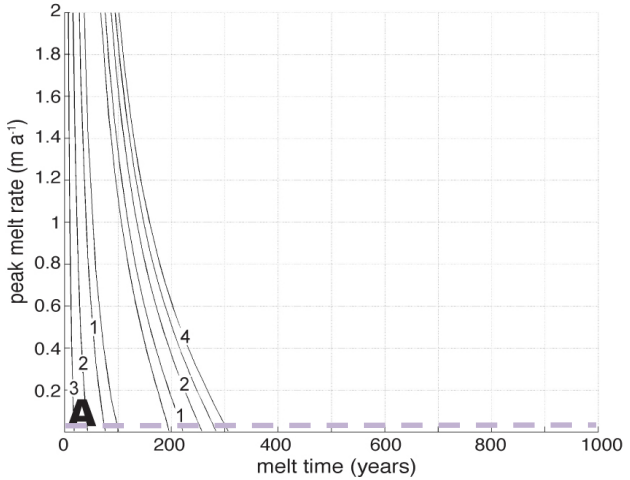


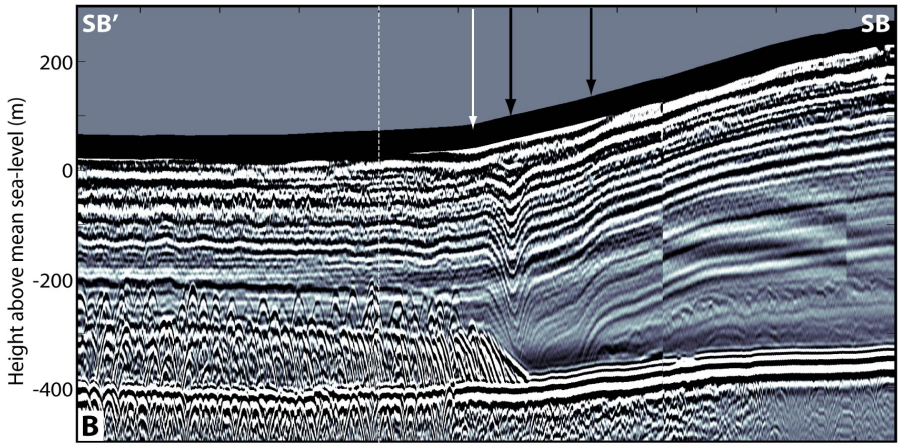
from Holland et al., (2003)

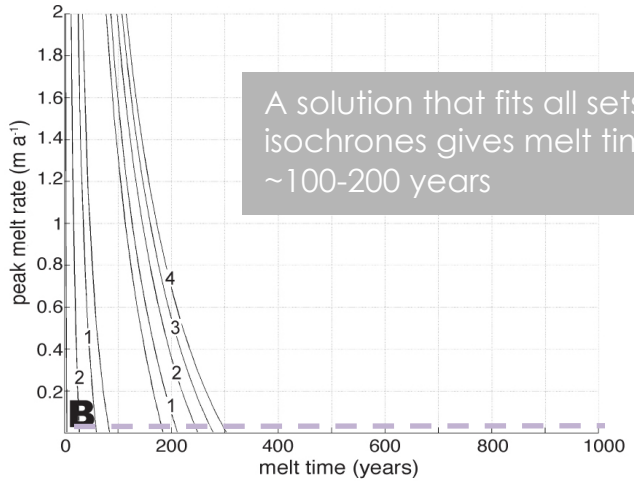
- for Southern SDM margin use melt rate of ~0.02 m/a
- valid for modern melt rates, perhaps not past melt rates

Other grounding line crossings

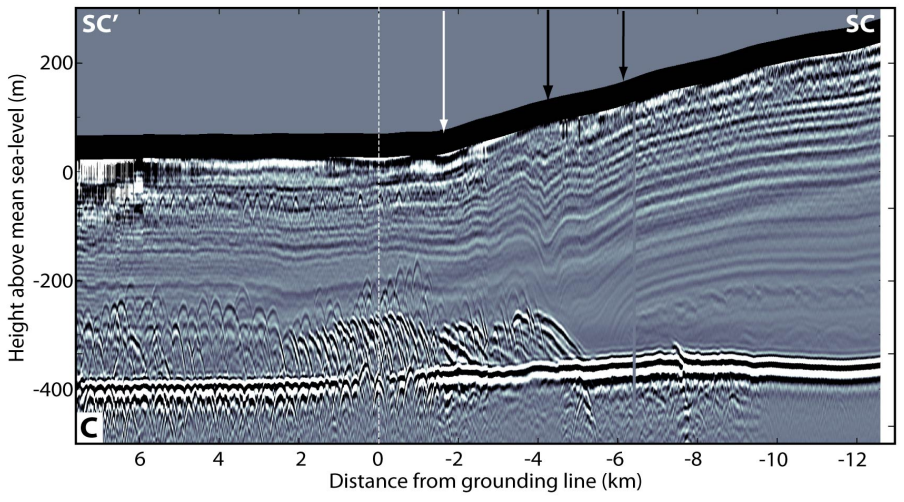


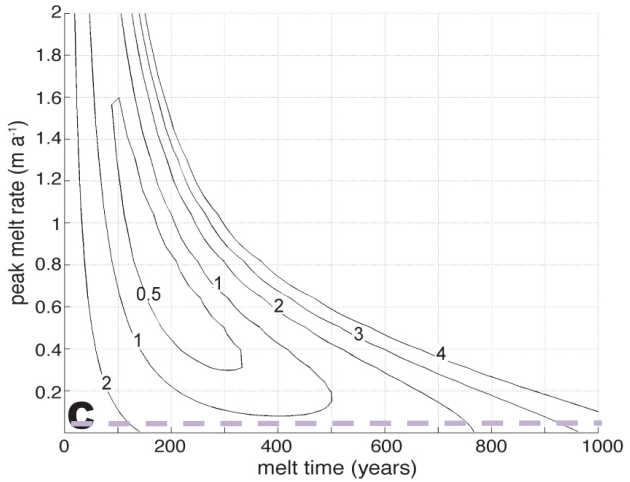






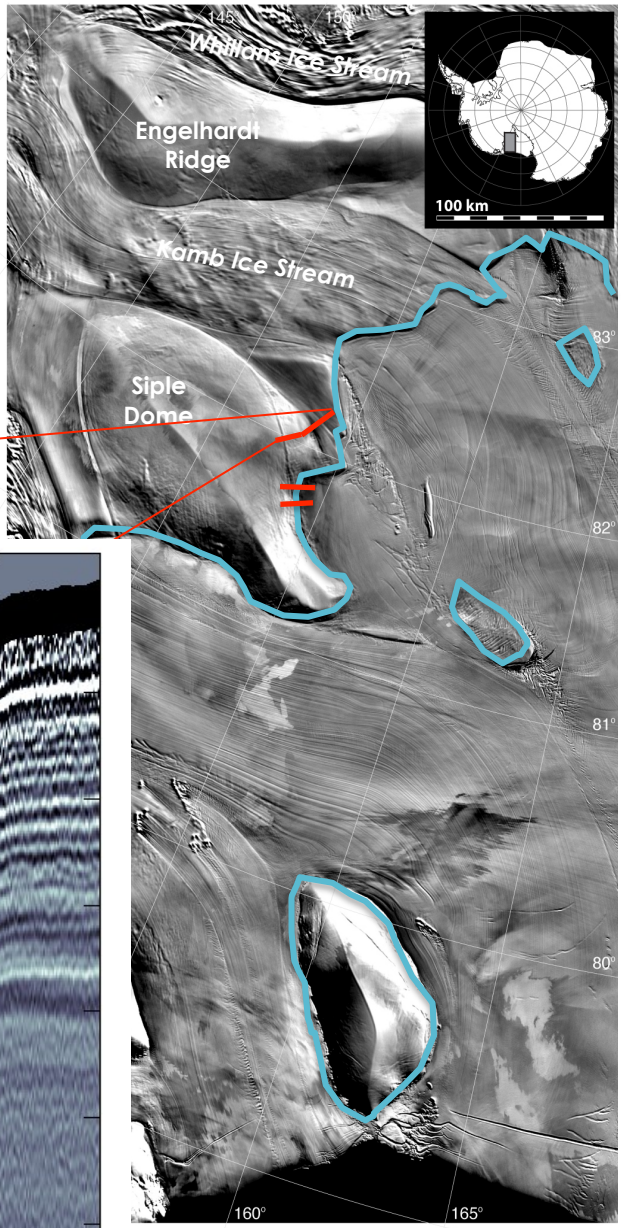
A solution that fits all sets of isochrones gives melt time of ~100-200 years

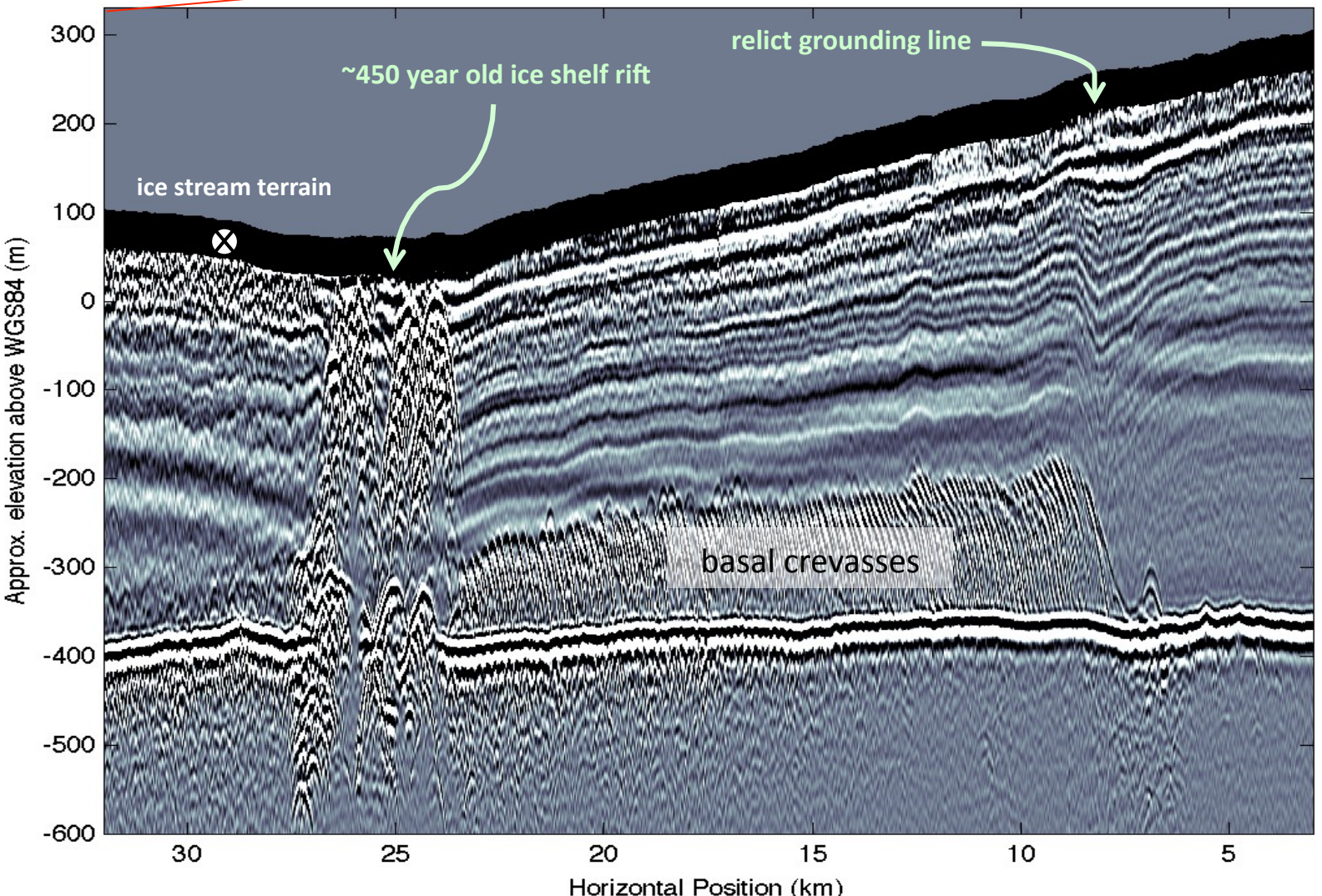




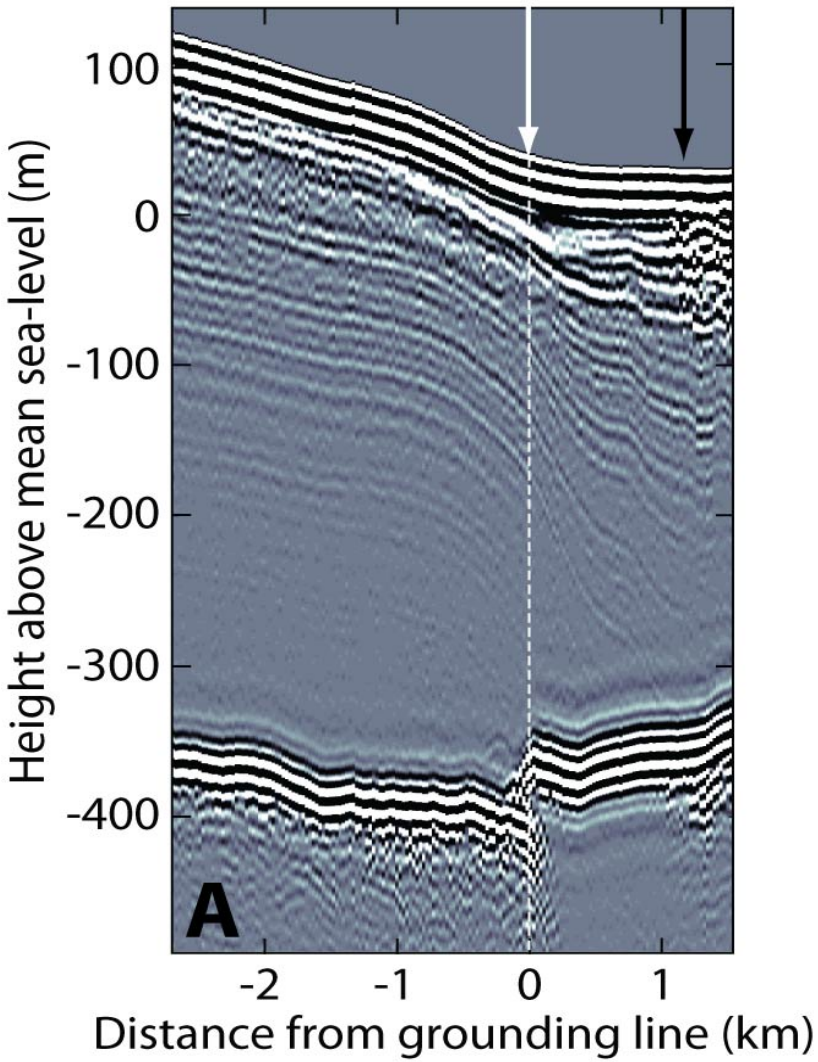
Other grounding line crossings

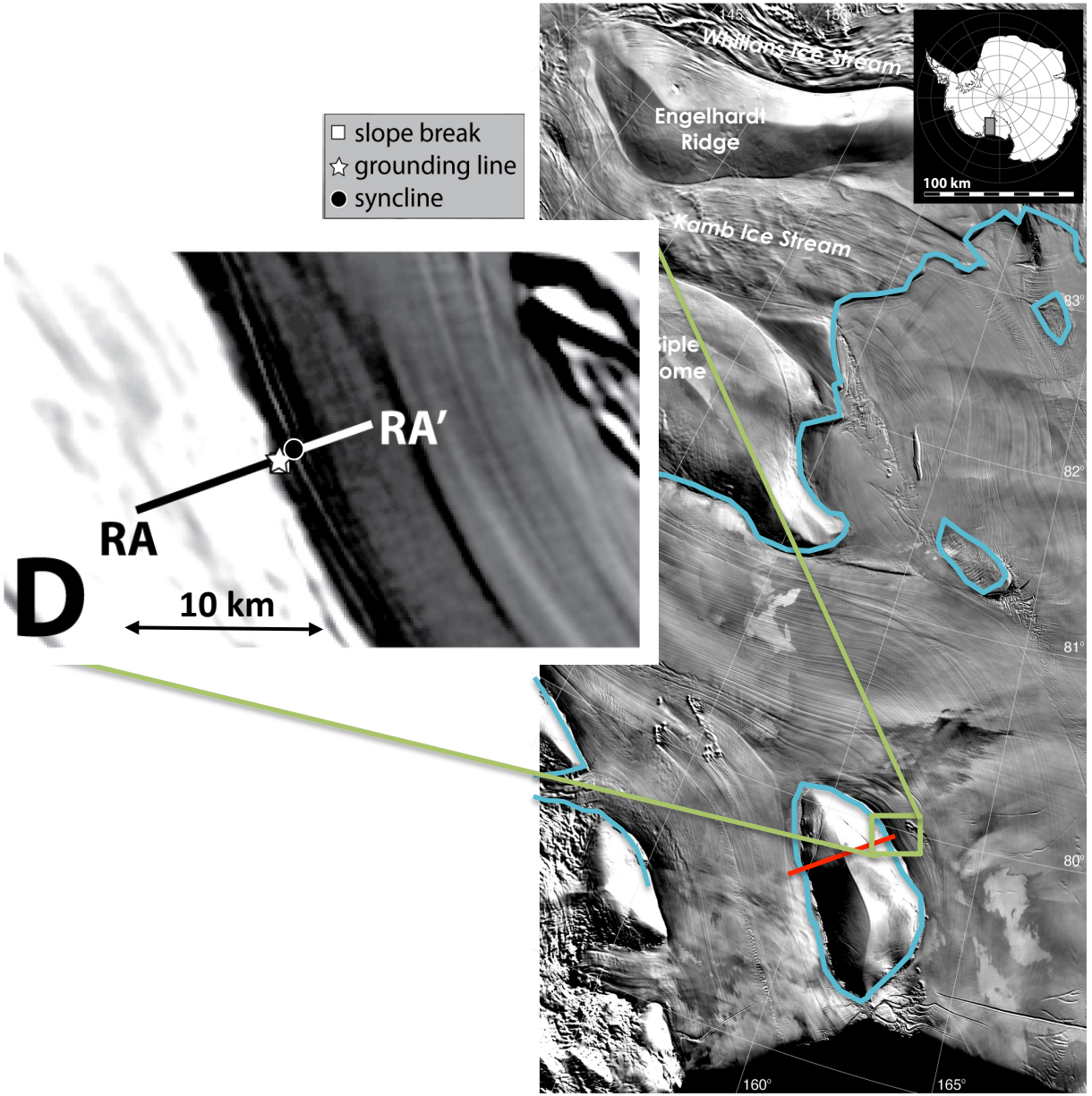
Presence of 450 year old rifted terrain suggests that grounding line was at paleo-location ~650 years B.P.





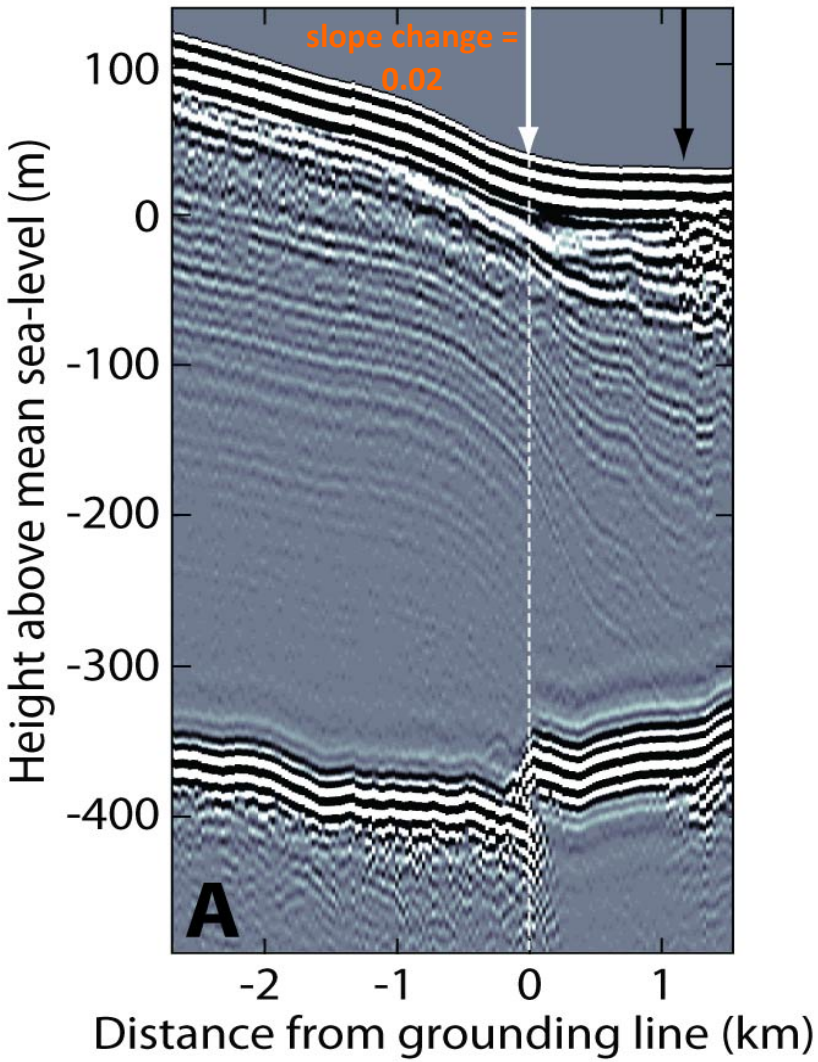
Other grounding line crossings

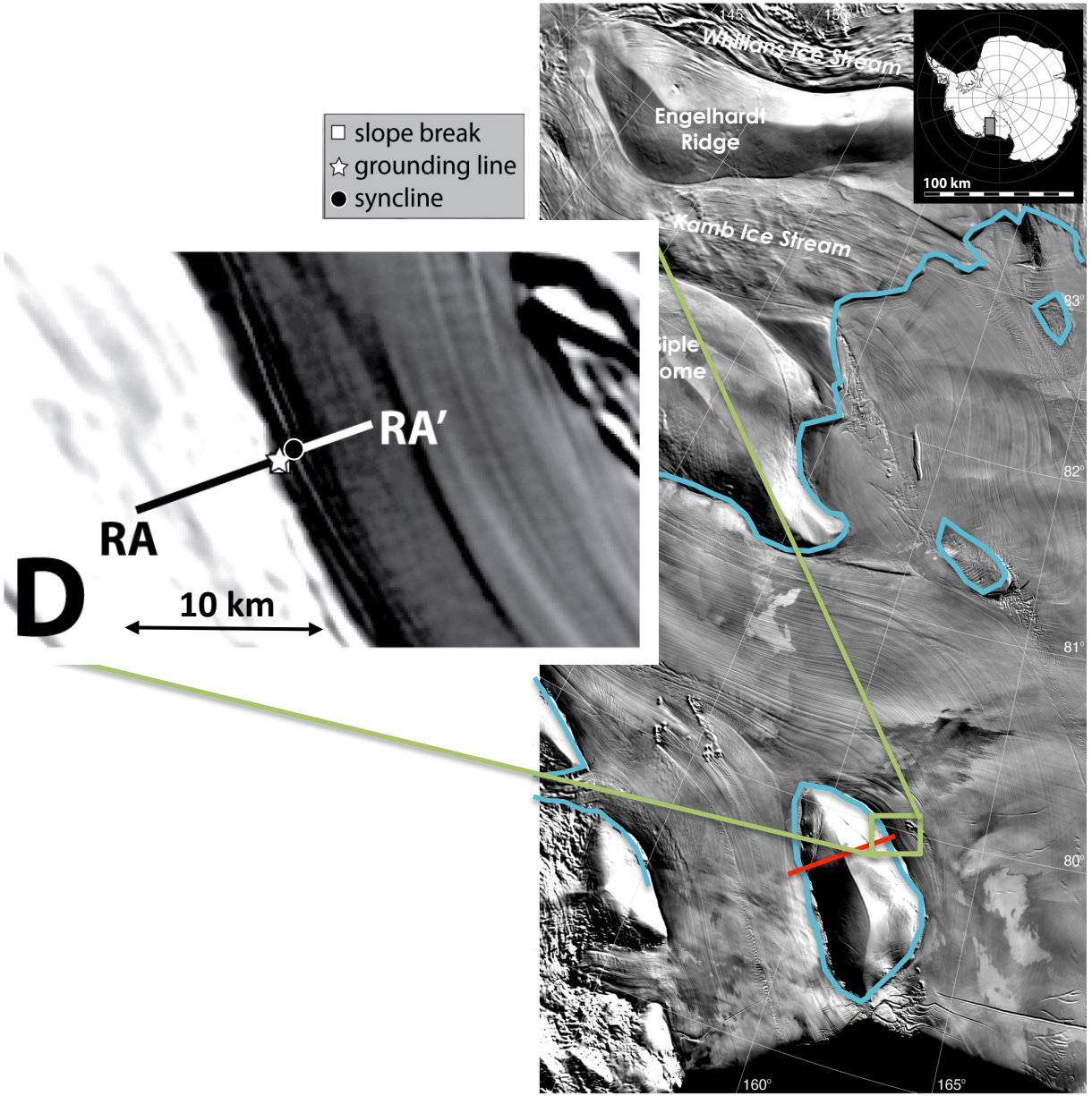




South side of Roosevelt Island

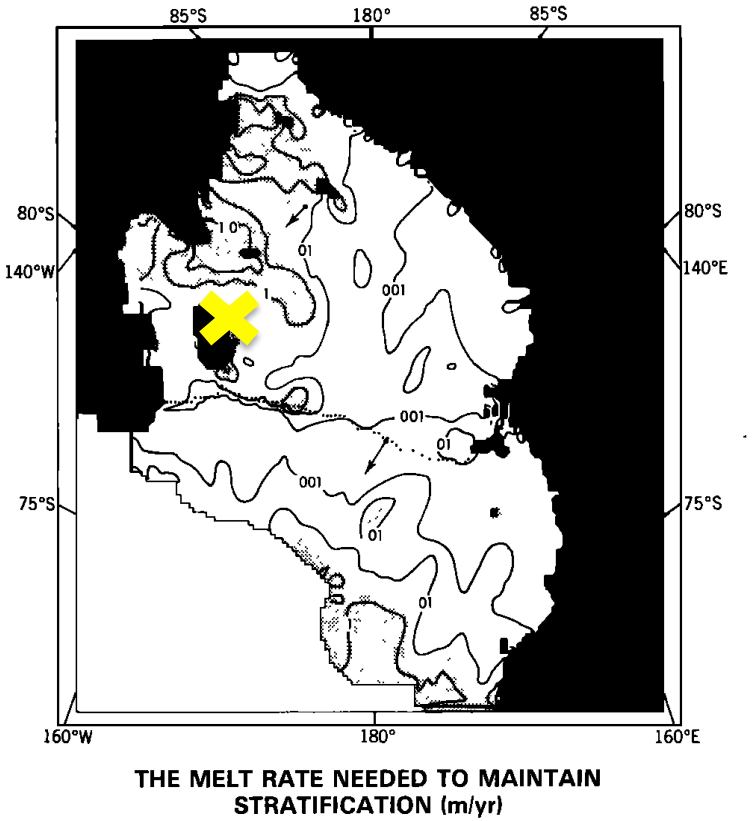
Other grounding line crossings





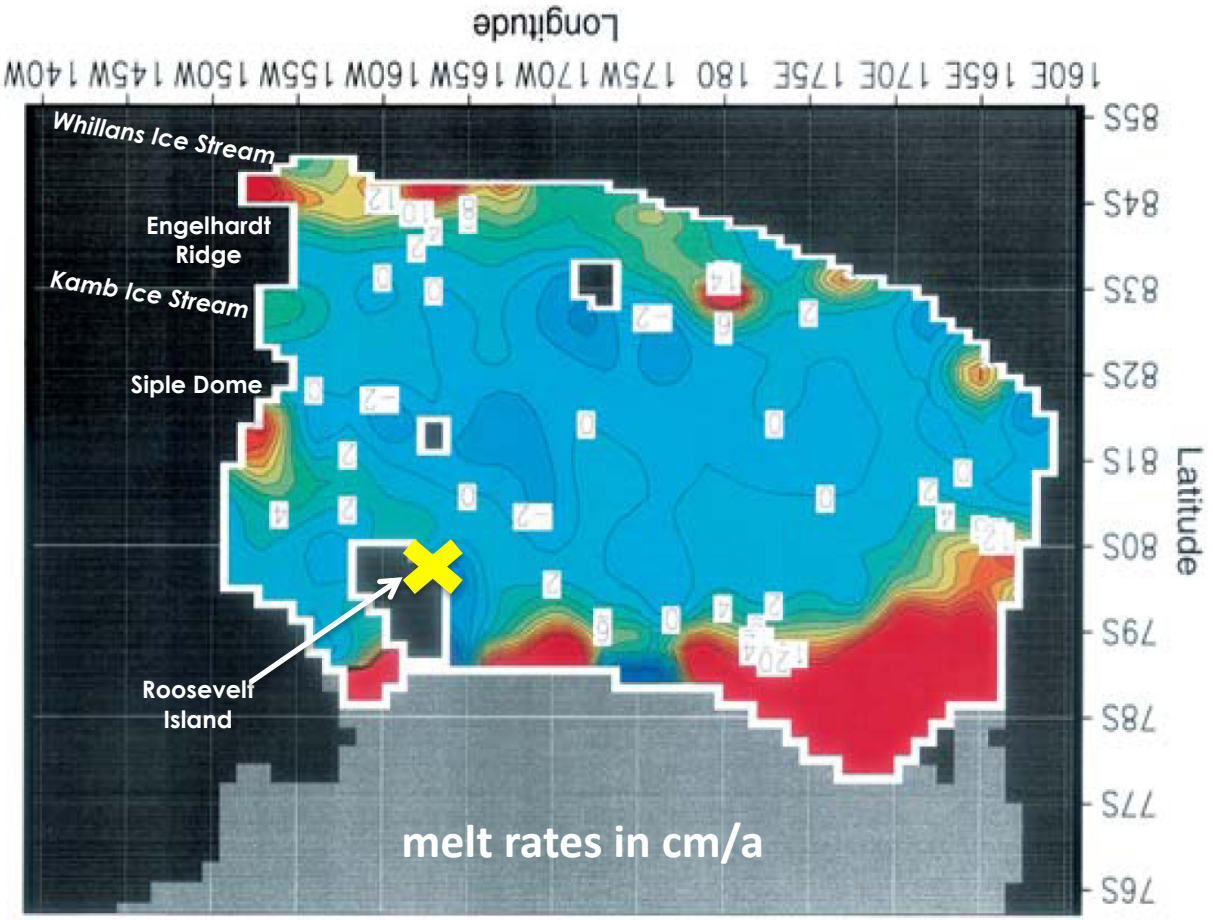
- co-located slope break and floatation point
- largest slope change measured here
- warped layers ~1km downstream

Other grounding line crossings



THE MELT RATE NEEDED TO MAINTAIN STRATIFICATION (m/yr)

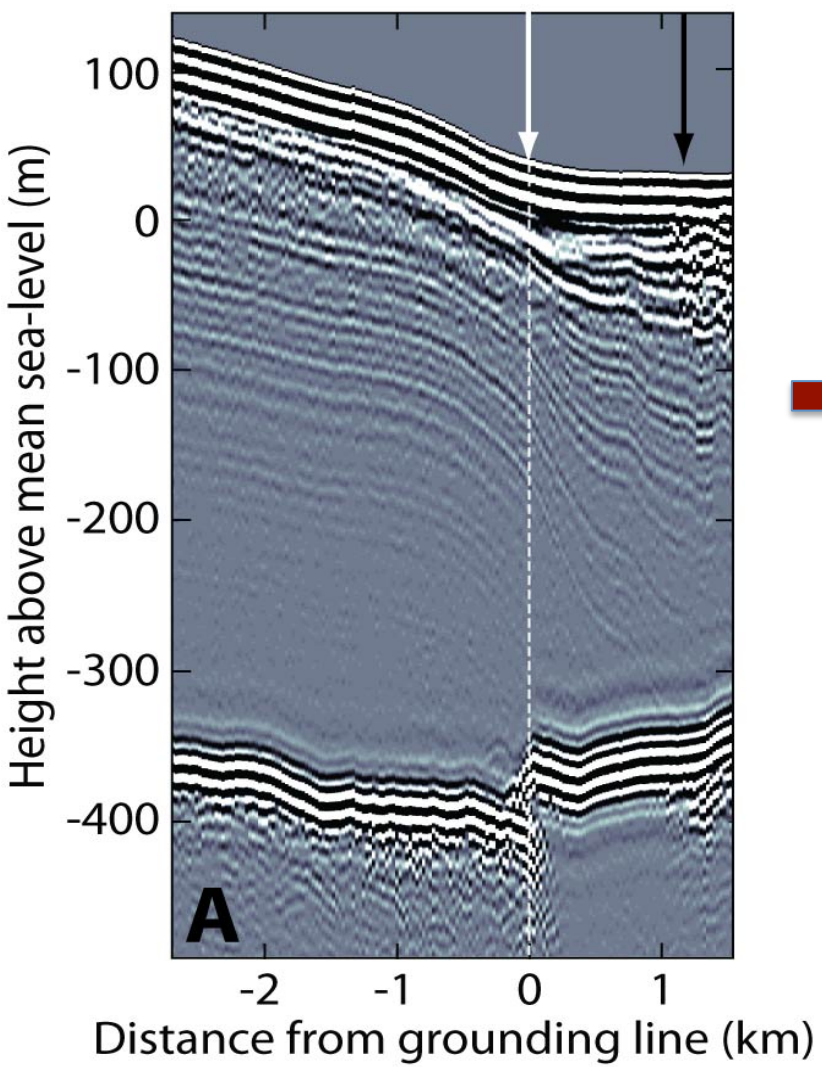
from MacAyeal, (1984)

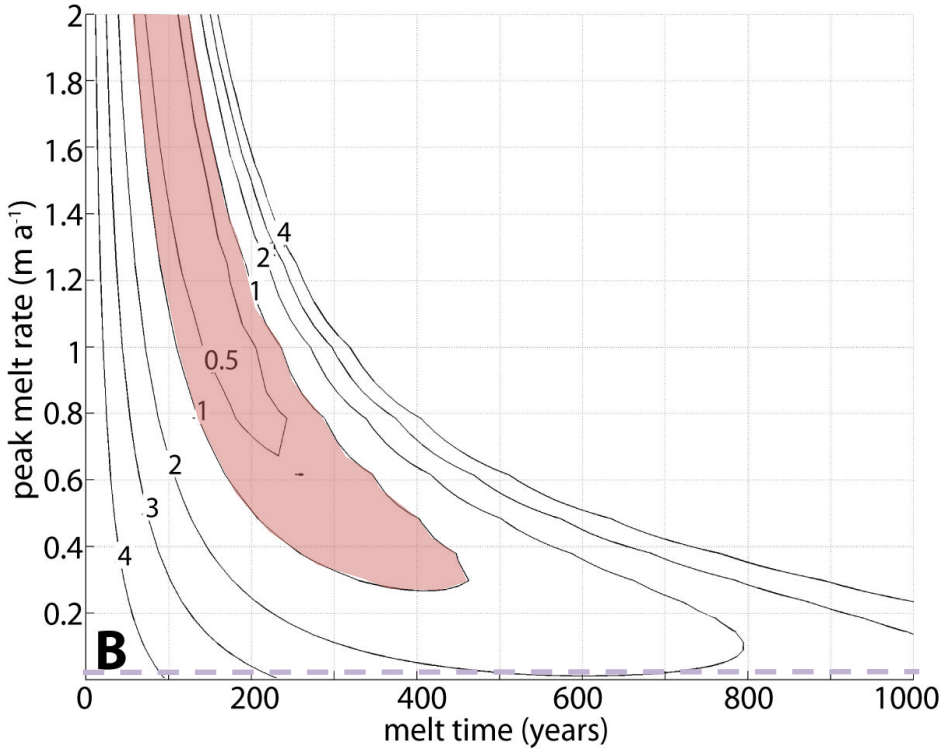


from Holland et al., (2003)

- for Southern Roosevelt Island use melt rate of ~0.02 m/a or lower

Other grounding line crossings

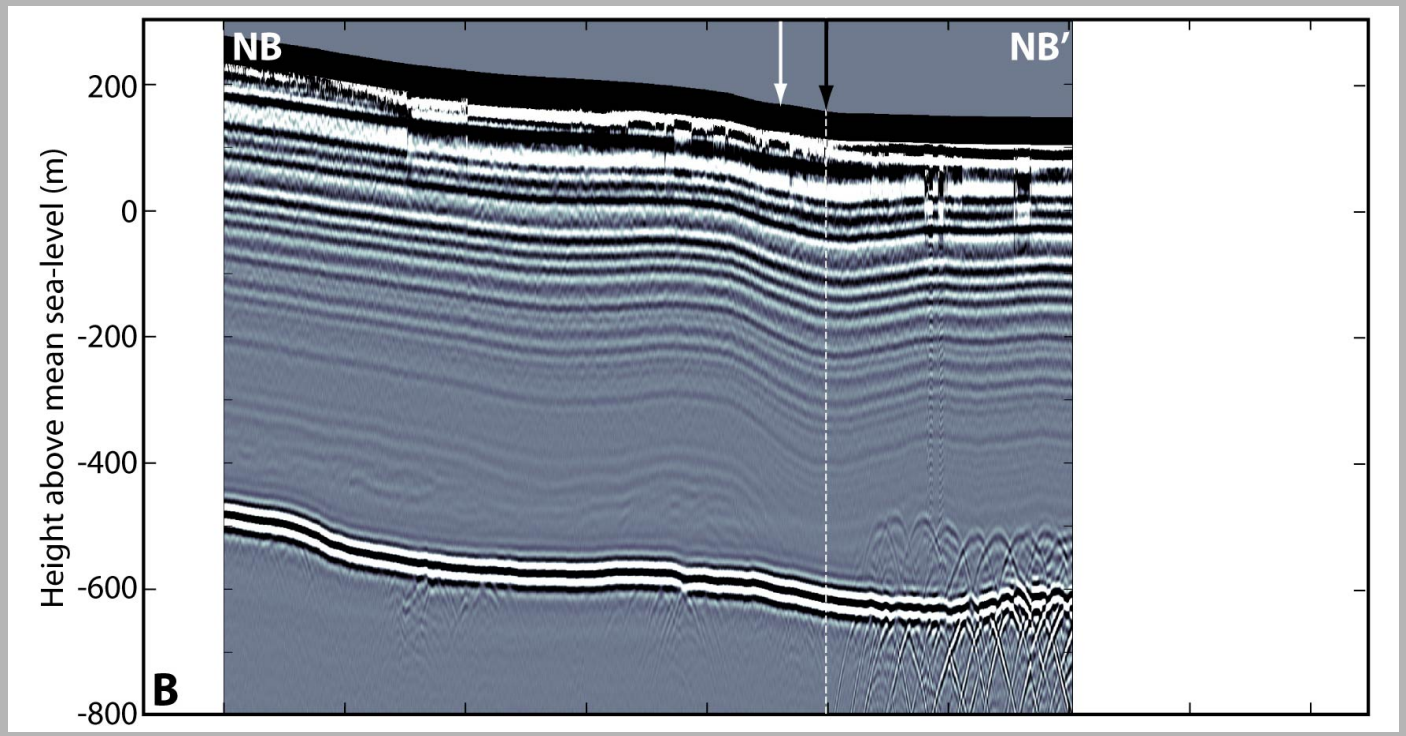




- lowest possible melt rate is ~30 cm/a
- melt rates were higher in the past?
- some process not accounted for in models?
- grounding line here for ~300-450 years at a melt rate of 30 cm/a

Grounding line basal melt rates determined from internal stratigraphy

- grounding line position recorded in internal stratigraphy where ice flow is slow and 2-D



Grounding line basal melt rates determined from internal stratigraphy

- grounding line position recorded in internal stratigraphy where ice flow is slow and 2-D
- variability in melt rate in space and time is observed;
  - North side of SDM: melt rate 20 cm/y = 300-400 years of occupation
  - paleo-g.l. South side of SDM: melt rate 2 cm/y = 100-200 years (beginning 650 y.b.p.)
  - Roosevelt Island: higher melt rate than expected (>30 cm/y) = 300-400 years

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- correlation between amount of layer downwarping and change in slope at grounding line

Location	change in slope	minimum melt rate
Roosevelt Island	0.02	0.3 m/a
North SDM 1	0.01	0.1 m/a
North SDM 2	0.007	0.05 m/a

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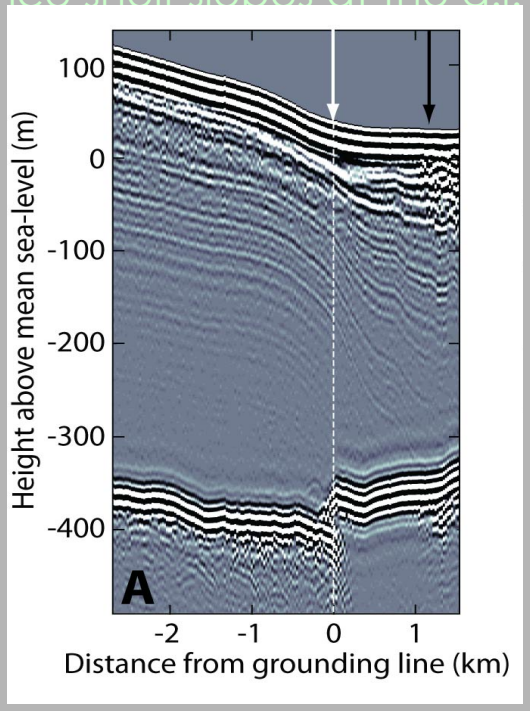
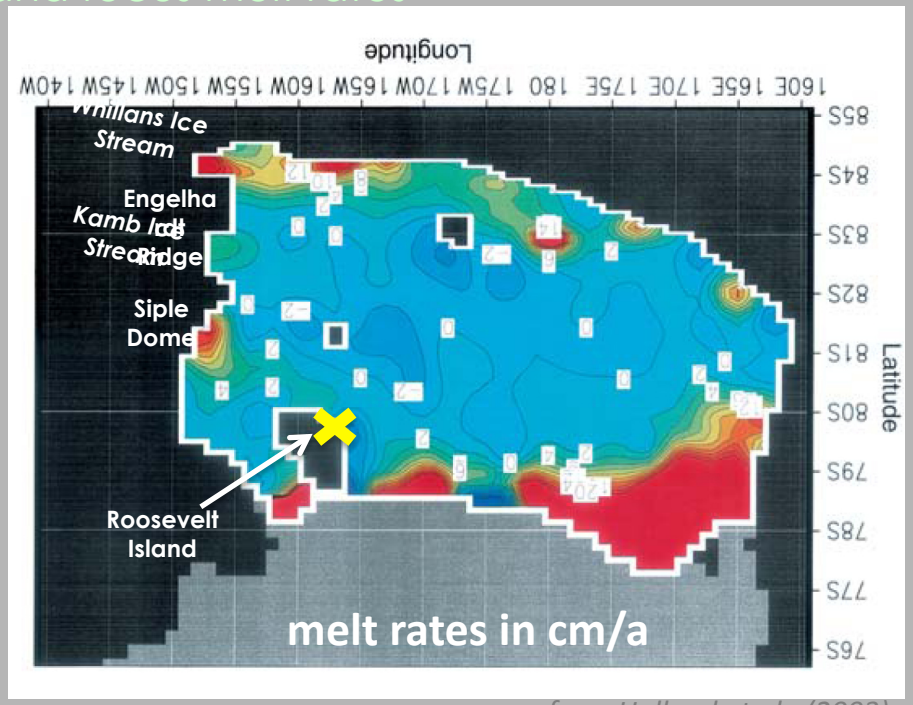
- if surface topography is a proxy for basal topography then this might show that steeper sub-ice shelf slopes of the g.l. increase and focus melt rates





from Holland et al., (2003)