Using seismology to understand ice sheet dynamics

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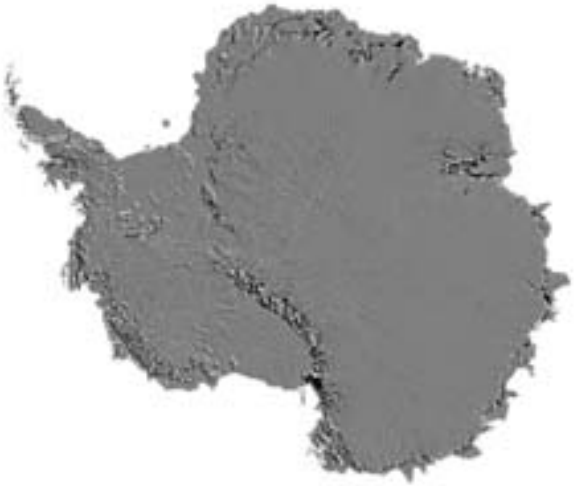
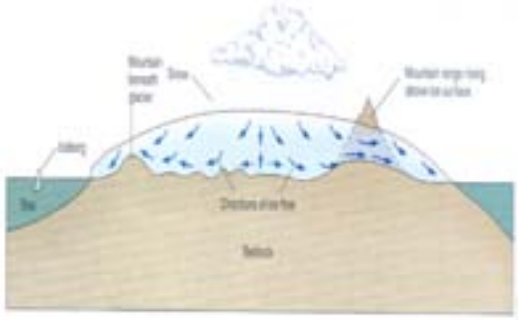
Ice on the earth is changing fast

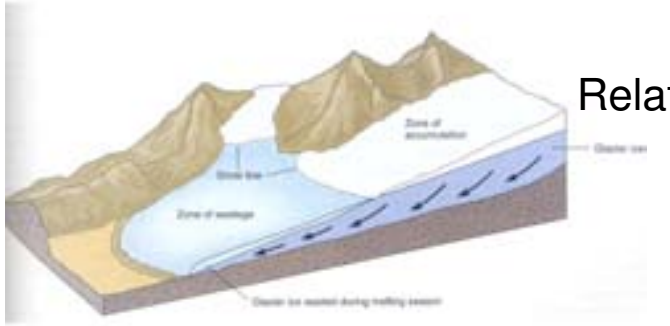
Ice moves under its own weight

Continental Ice Sheets





Valley Glaciers



For ice deformation speed need to know:

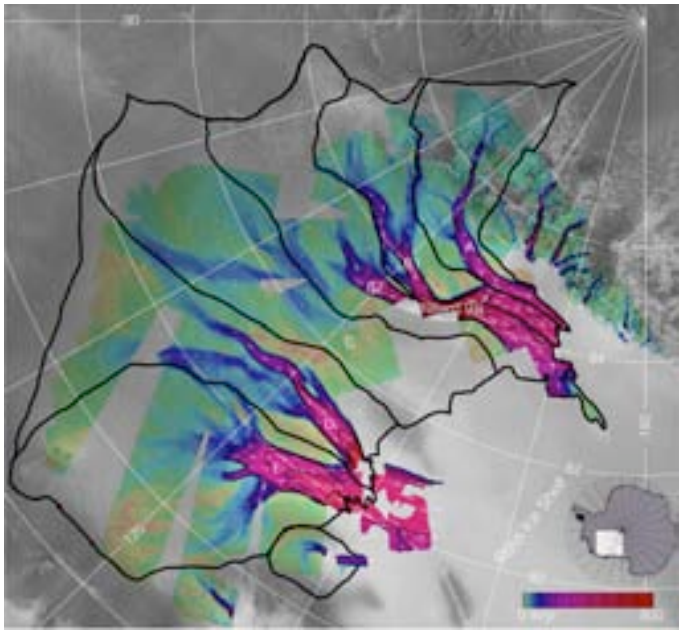
- Ice thickness
- Surface slope
- Ice temperature

Relatively slow and Predictable

But a lot of ice goes a lot faster!

InSAR Velocities of West Antarctica

ice is flowing upper-left to lower-right



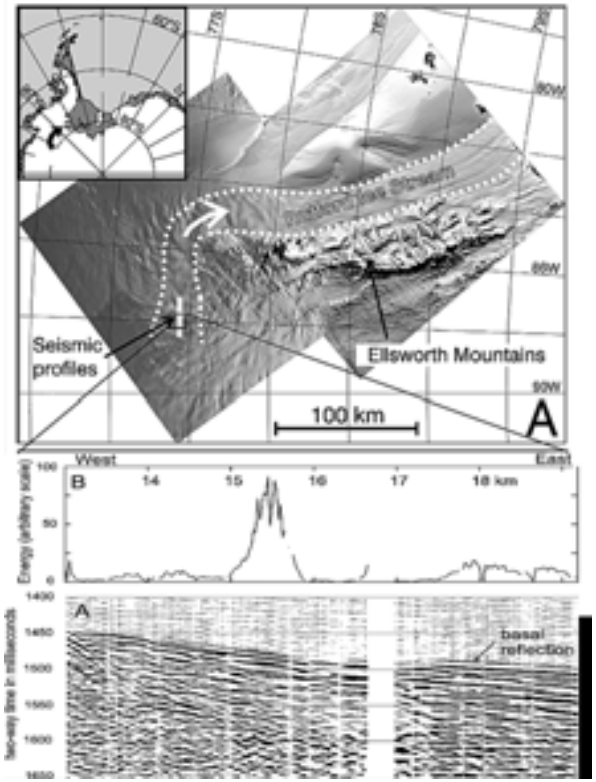
Joughin et al. 2002

South Margin of Bindschadler Ice Stream

the transition is sharp, a few kilometers

Ice streams go fast, but why?

Seismic Reflection data from Rutford Ice Ice Stream



King et al. 2004

- Where people have looked ice streams are underlain by water saturated sediments
- Creates a slippery bed

Ice steams have slippery beds

InSAR Velocities of West Antarctica

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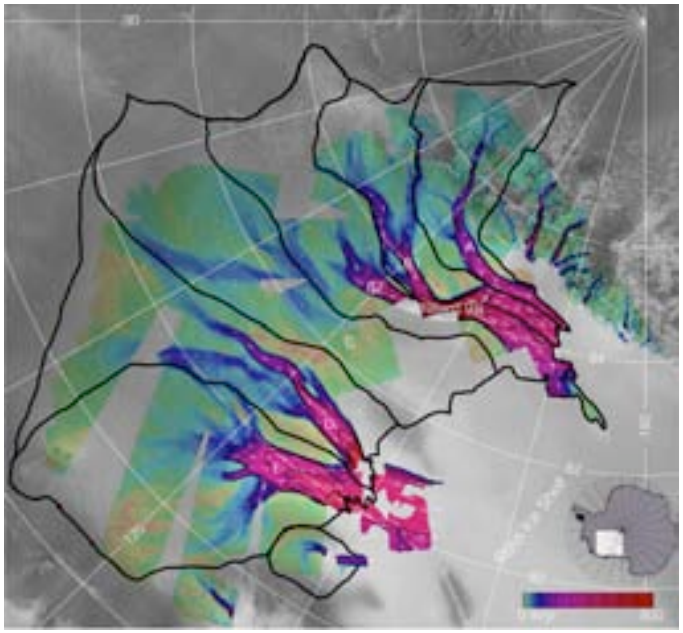
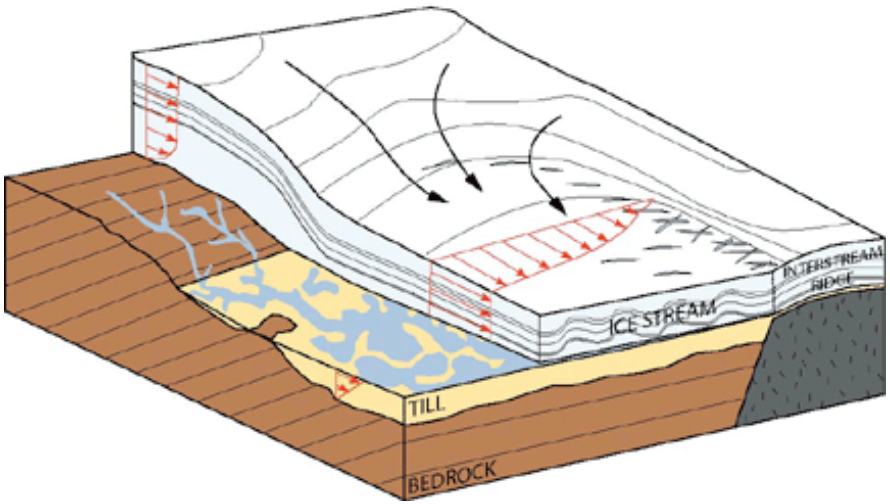


Joughin et al. 2002

Ice stream Schematic

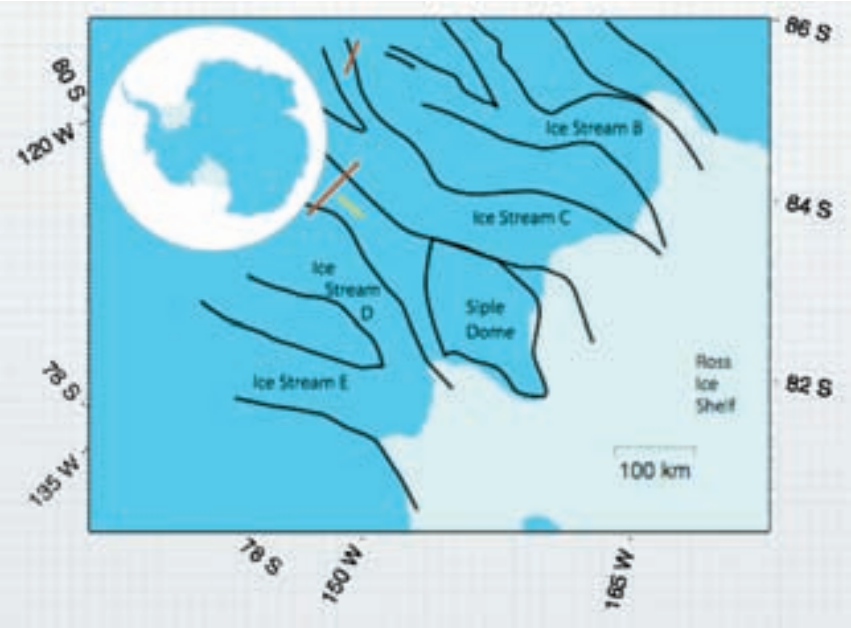


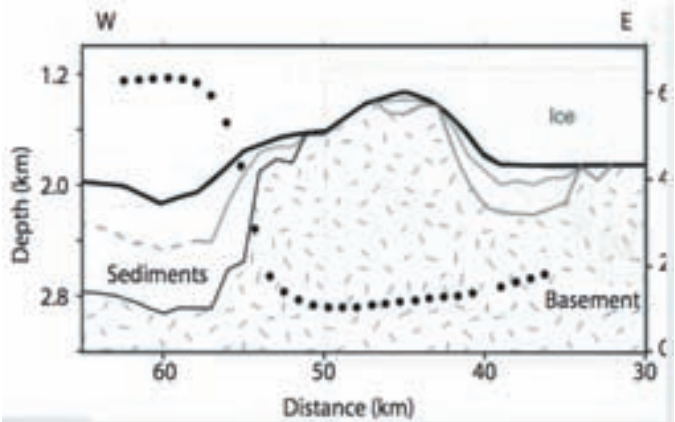
from the website of Don Blankenship

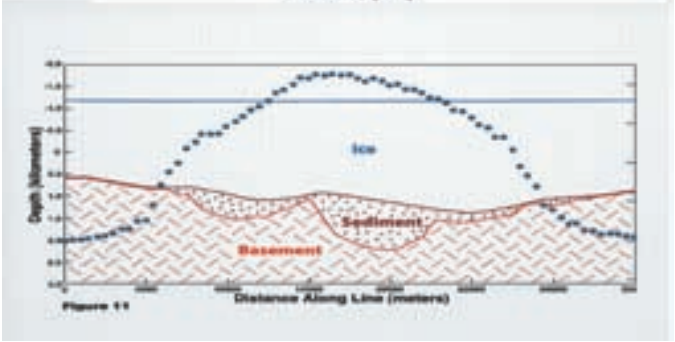
Sediment Supply

- The presence of sediments help a provide lubricated bed
(Also need water!)
- Glacier and ice sheets move lots of sediments
- Seismic reflection experiments have looked at the near ice-bed interface < 20 meters
- How thick are the sediment packages beneath ice streams?

Sediment Supply-Imaging "Deep" with Seismic Refraction Experiments







Passive seismic imaging

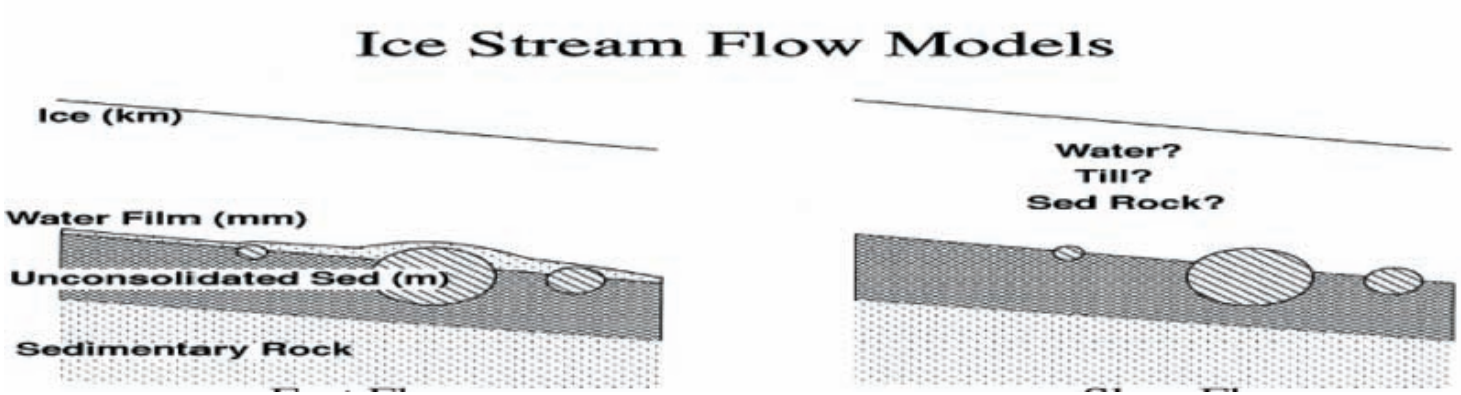
We would like dynamic observations of bed conditions

- Active seismic observations tend to take 2-D snapshots of the bed.

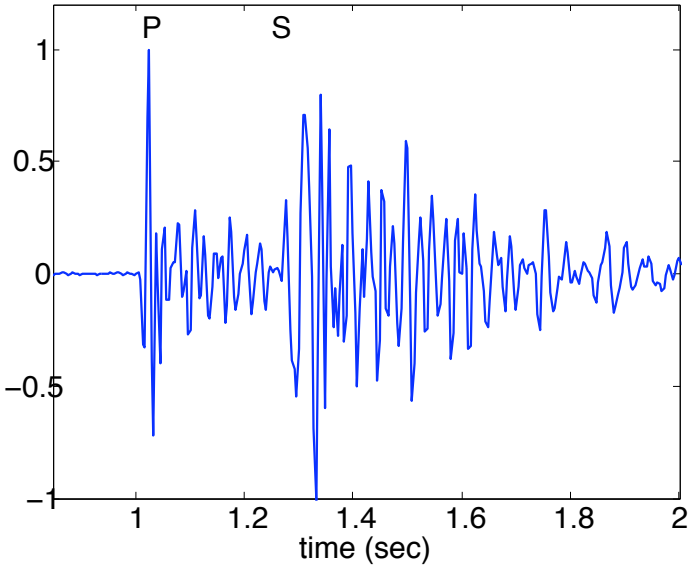
Passive seismic observations can provide

- insight into spatially extensive areas of the bed
- insight into temporal behavior of the bed

Passive seismic imaging

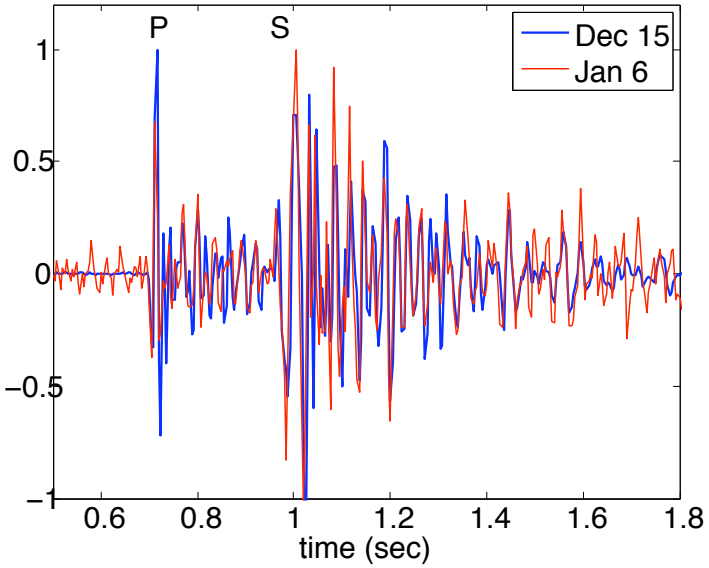


Passive seismic imaging



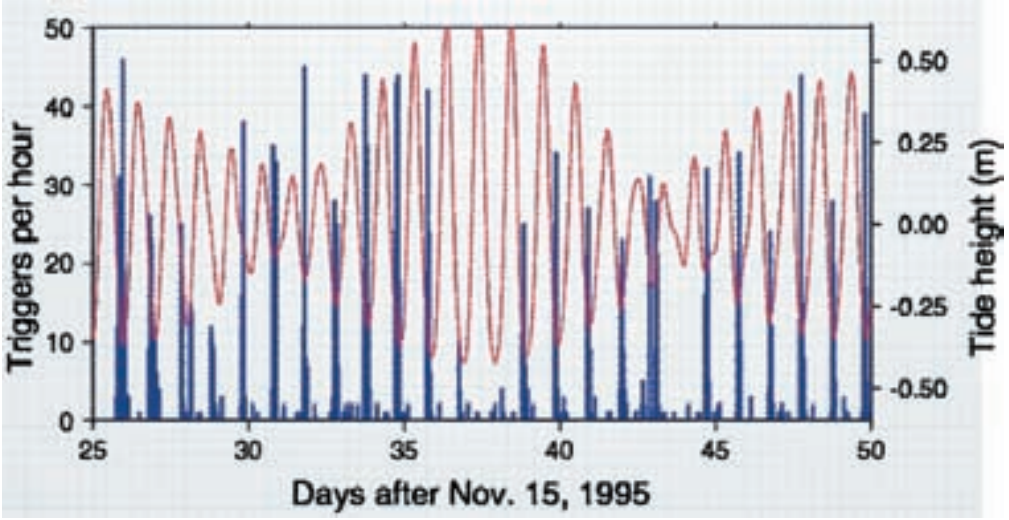
- Typical thrust event from the bed
- Events occur at discrete locations, not uniformly distributed over the over the bed
- Suggest bed is heterogeneous

Passive seismic imaging



- Locations are stable in time
- Suggest bedrock asperities may play an important role in controlling ice stream motion

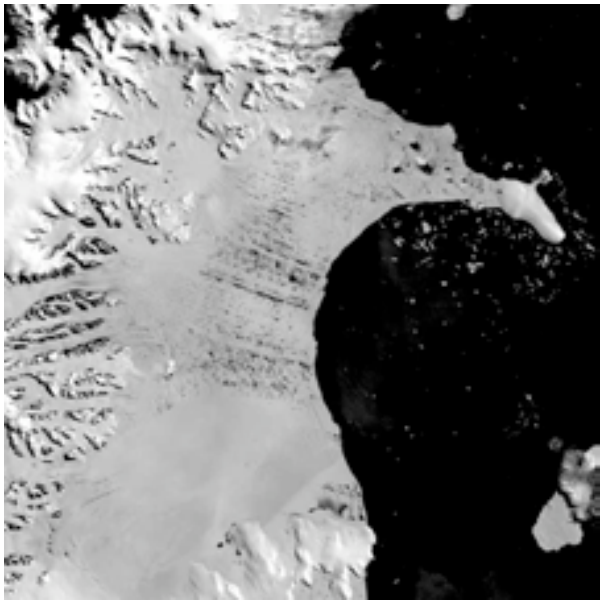
Tidal forcing of basal seismicity



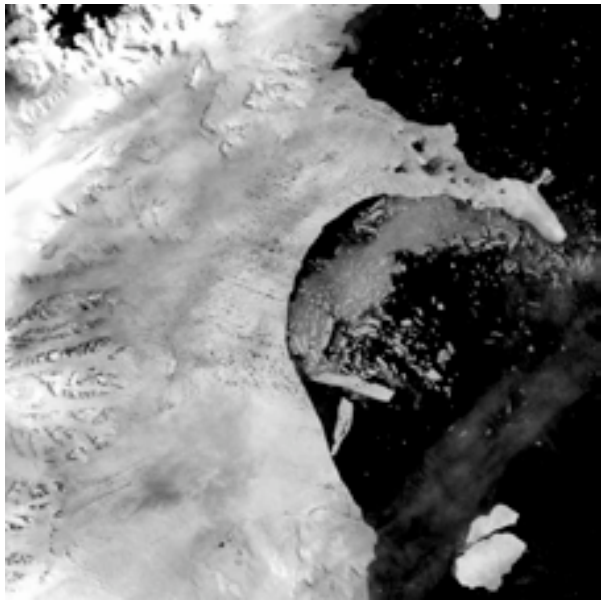
- Rate of seismicity is correlated with tides
- Ocean tide modulate the stress regime of the glacier

Fast ice goes faster-breakup of Larsen B ice shelf

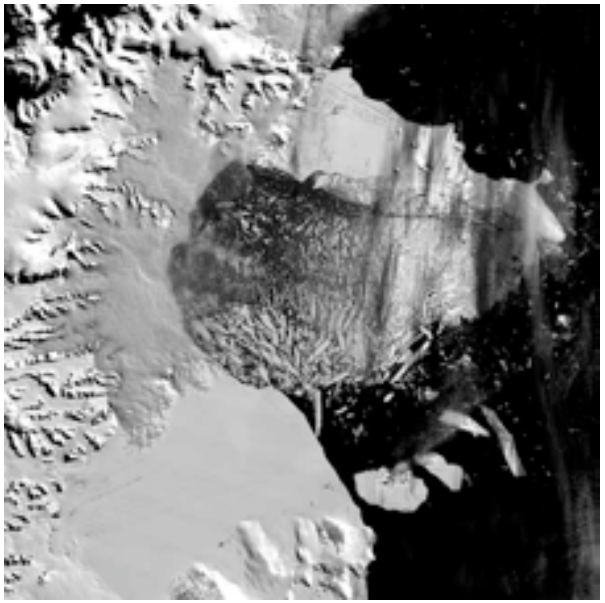
January 31



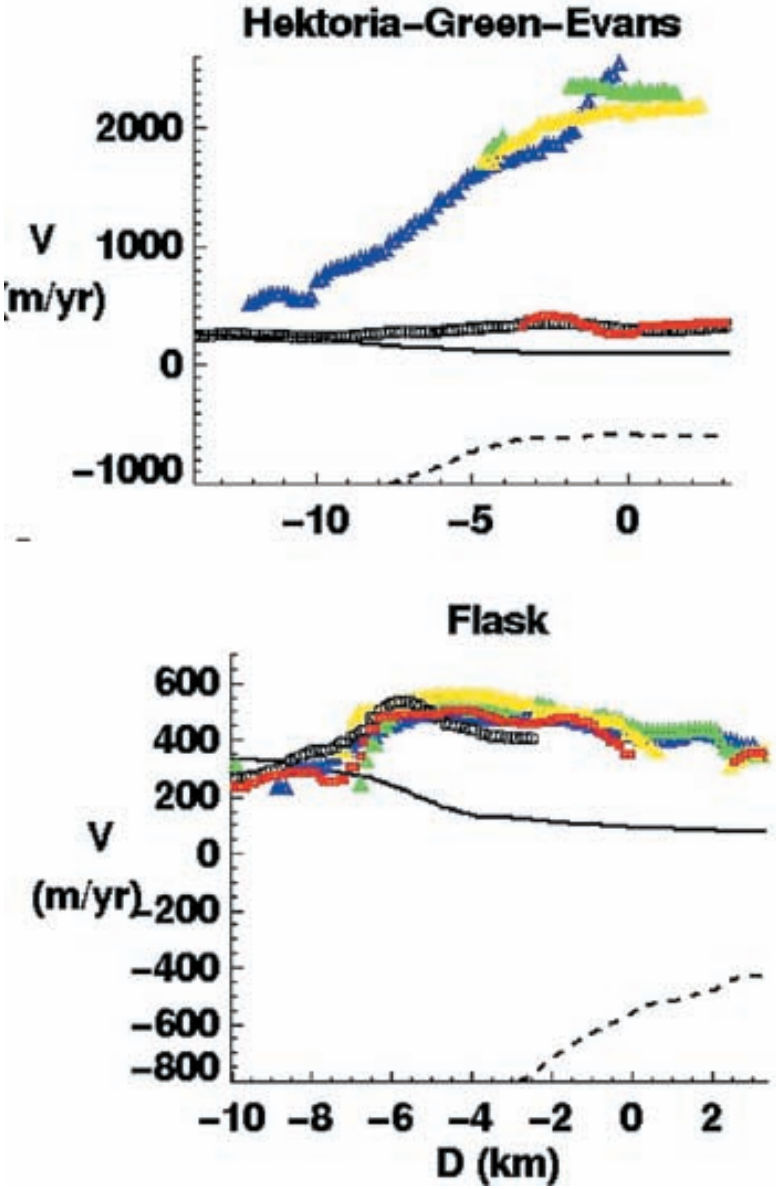
February 17

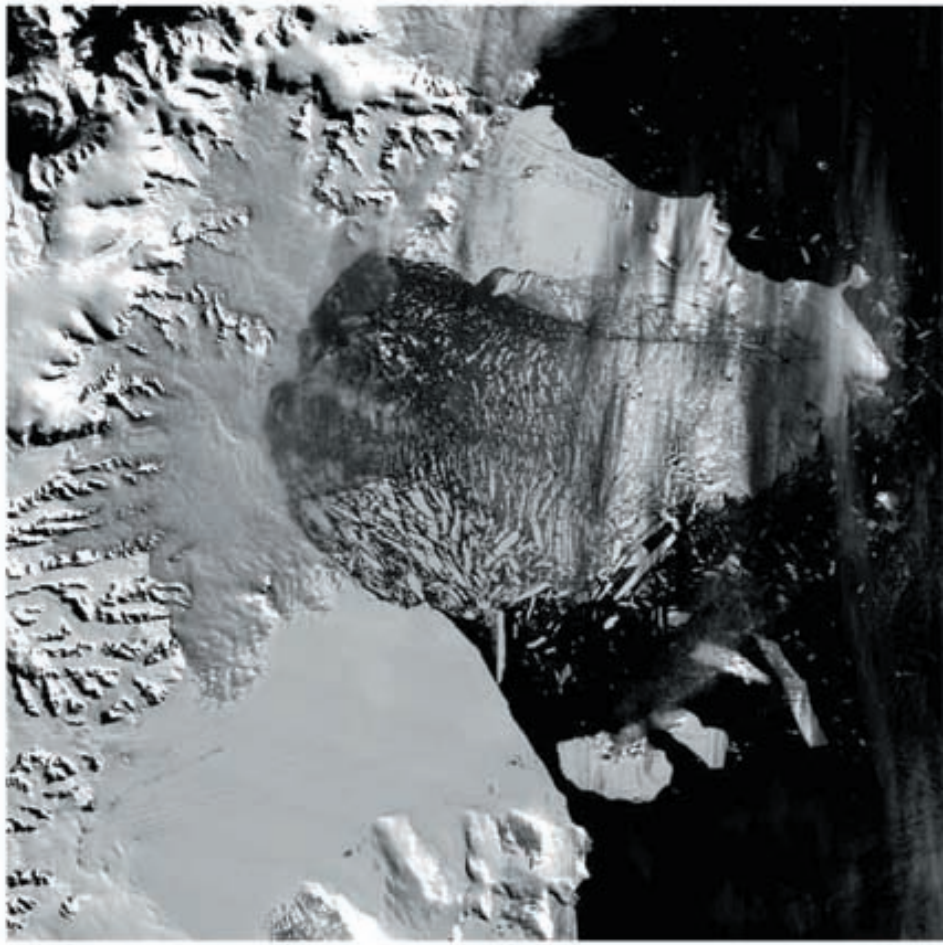


March 5

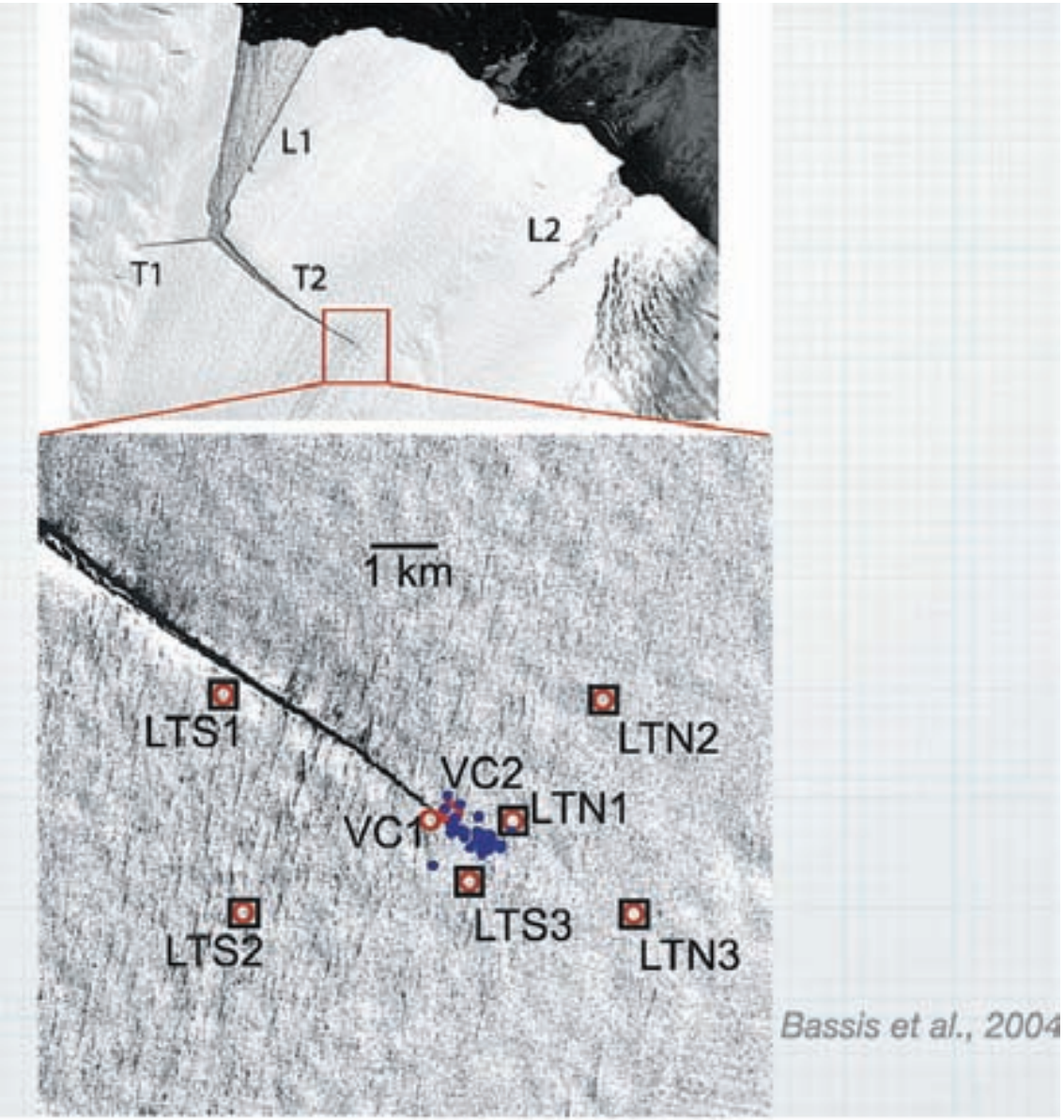


Fast ice goes faster-breakup of Larsen B ice shelf



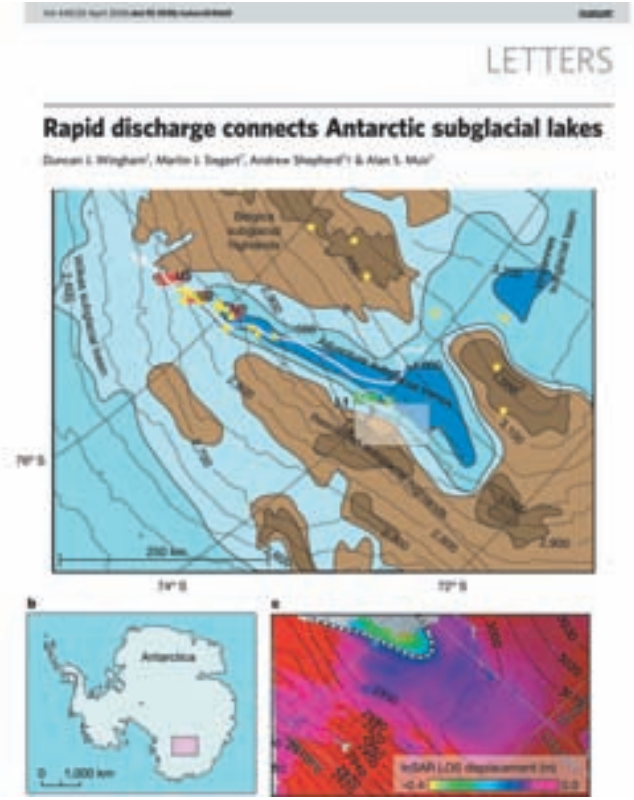


Passive seismic observations of Amery ice shelf rifting

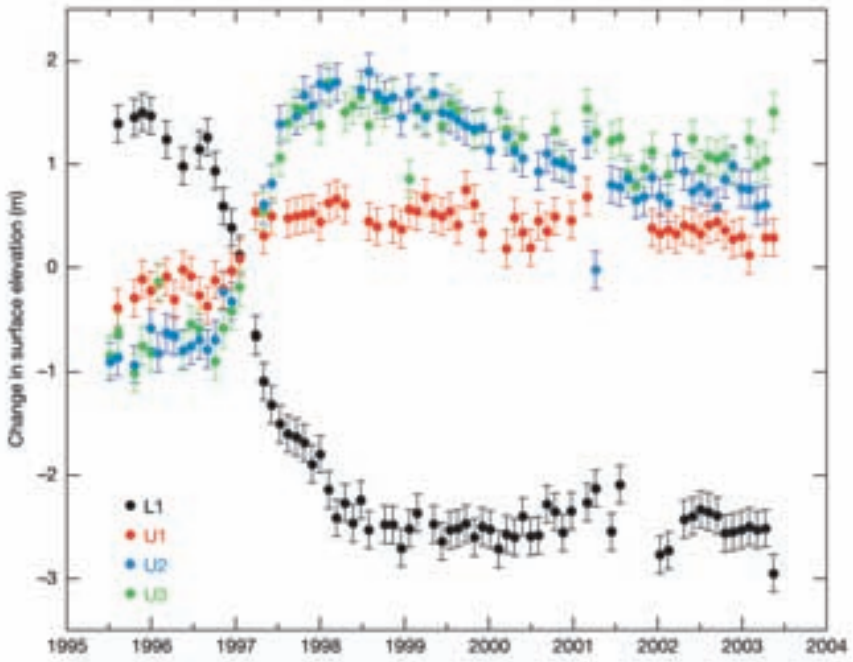


Bassis et al., 2004

Lakes of water moving around


LETTERS

Rapid discharge connects Antarctic subglacial lakes



Summary

Seismology provides fundamental contributions to our understanding fast glacier motion:

- Subglacial geology
- Subglacial water distribution
- Ice shelf processes