The Vision of a Polar Observing System - Seismology

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Autonomous Polar Observing
Systems Workshop, Sept 30, 2010

Outline

- Why do we need a polar obs. system for seismology? – The pressing science
- Steps already taken – progress report
- A larger vision – what is needed to achieve the science goals

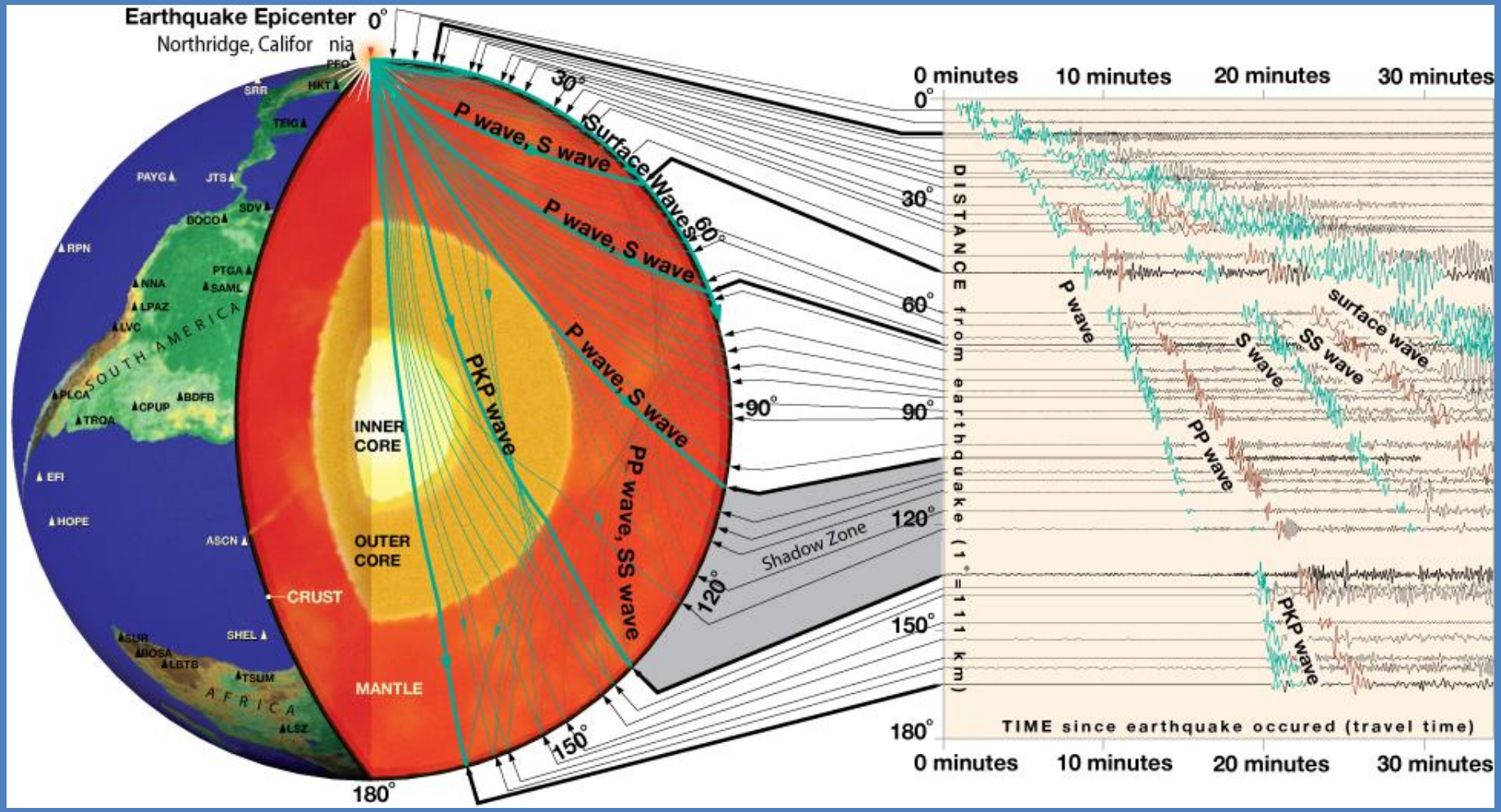
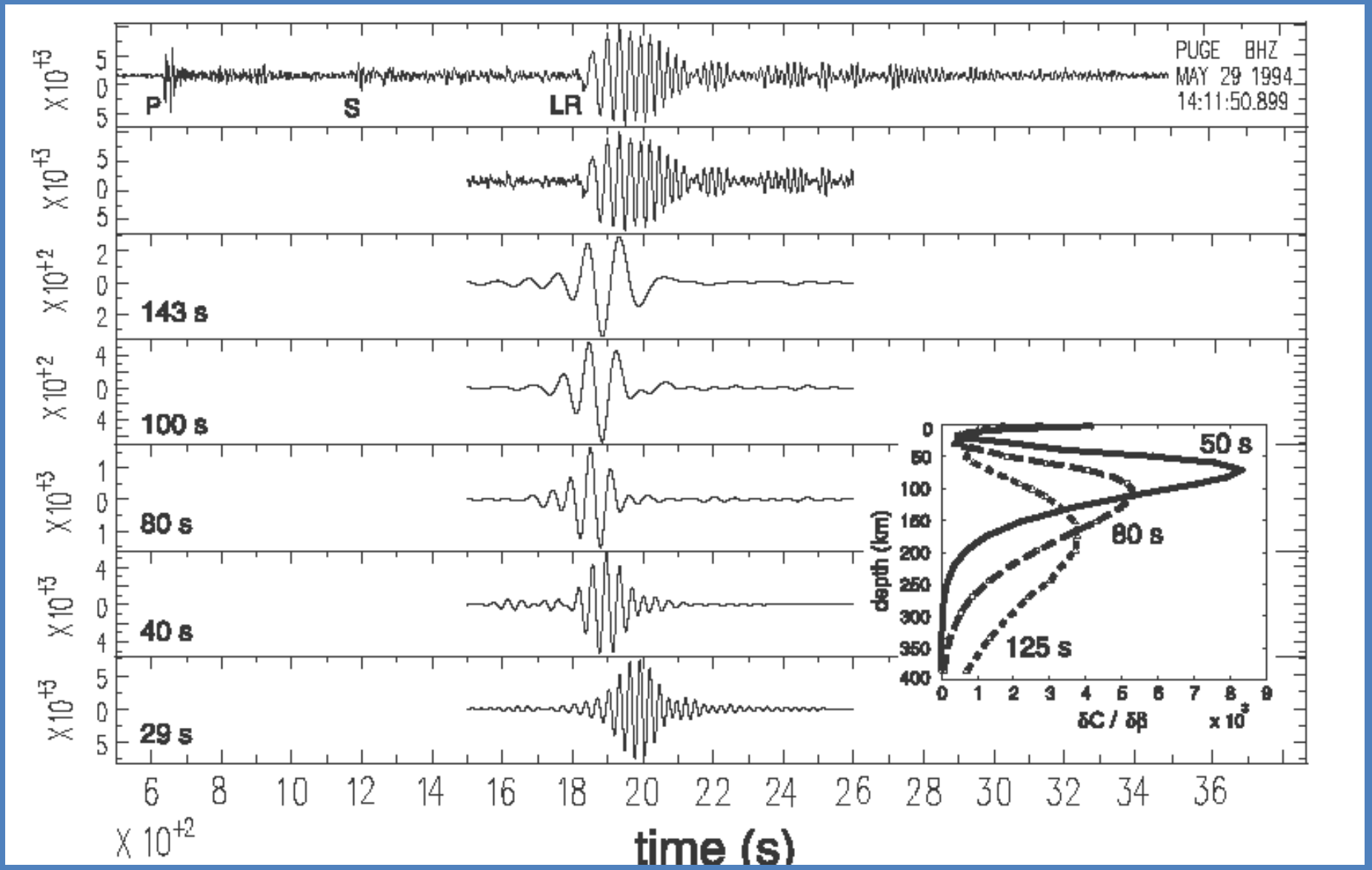


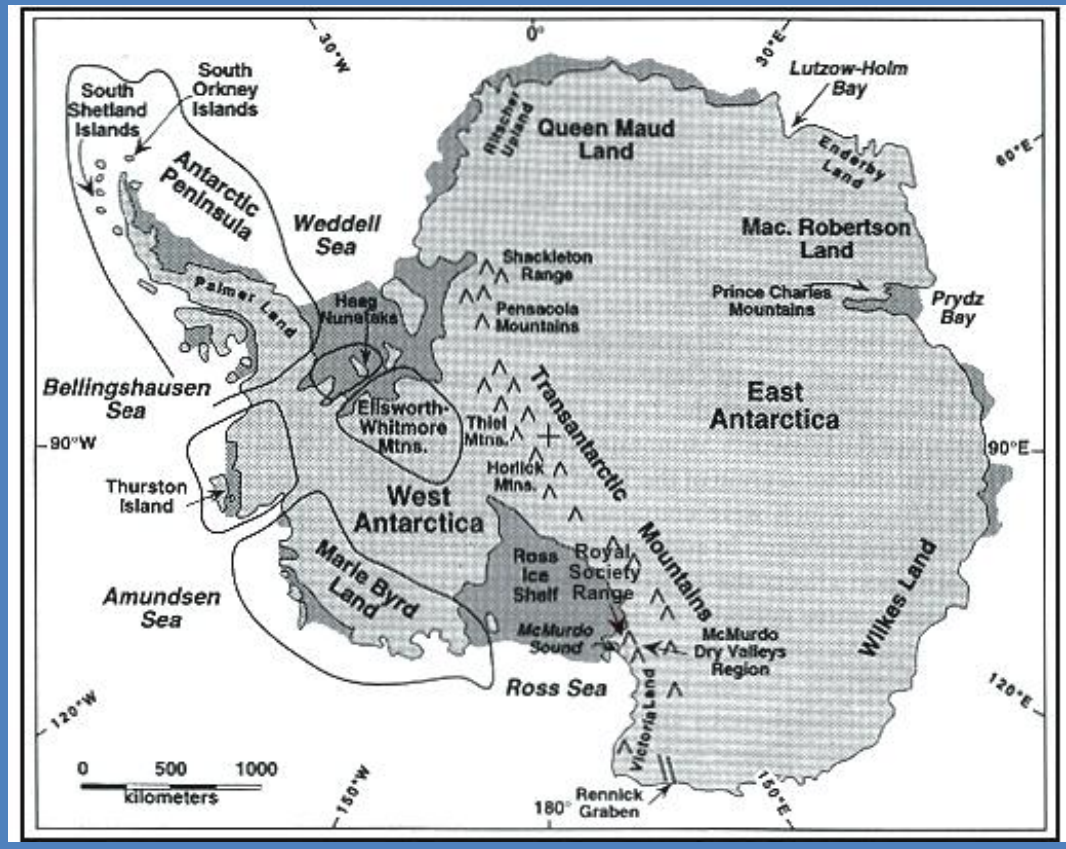
Image from IRIS E&O program


PUGE BHZ
MAY 29 1994
14:11:50.899
P
S
LR
143 s
100 s
80 s
40 s
29 s
X 10+3
X 10+2
X 10+2
time (s)
depth (km)
50 s
80 s
125 s
δC / δβ
x 10⁴

Science Questions – Antarctica (relevant to Greenland also)

What is the neotectonic framework of the Antarctic plate?

- **Microplates in W. Antarctica?**
- **Are there bits of the E. Antarctic craton in W. Antarctica?**

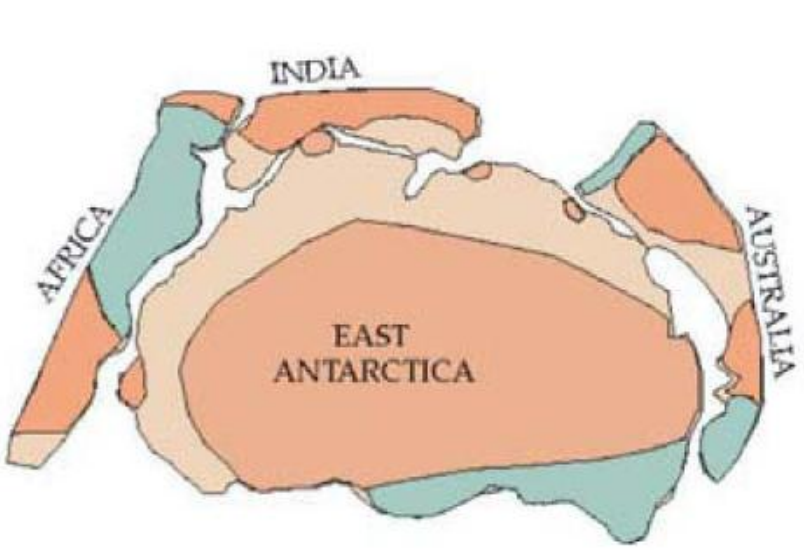


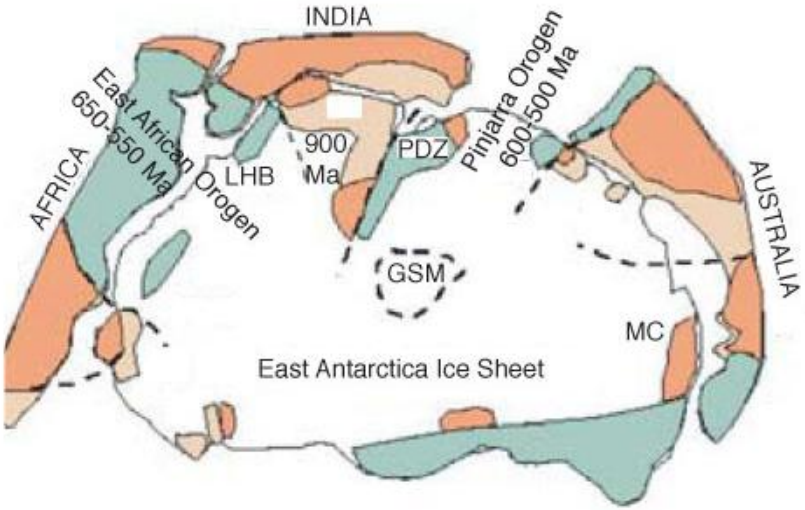
Modified from Anderson (1999)

Two views of the Geology of East Antarctica

Archean Craton
(Tingley, 1991)

More Recent Orogenic Belts
(Fitzsimons, 2003)





Archean

Proterozoic

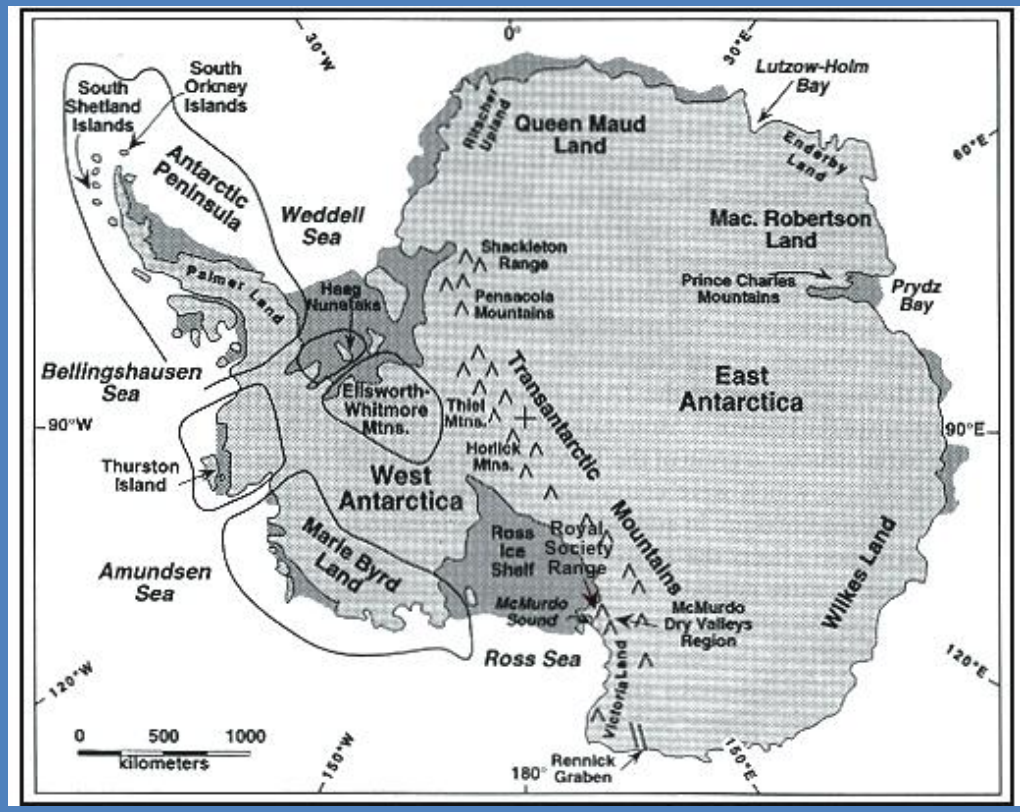
Proterozoic-Paleozoic

GSM Gamburtsev Subglacial Mts
LHB Lutzow Holm Belt
MC Mawson Craton
PDZ Prydz Bay

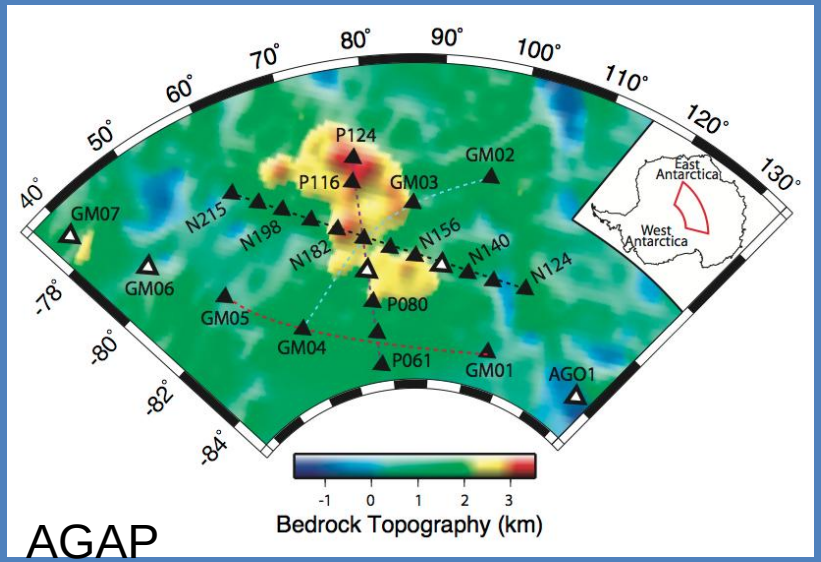
Science Questions

What is the structure and origin of major tectonic features?

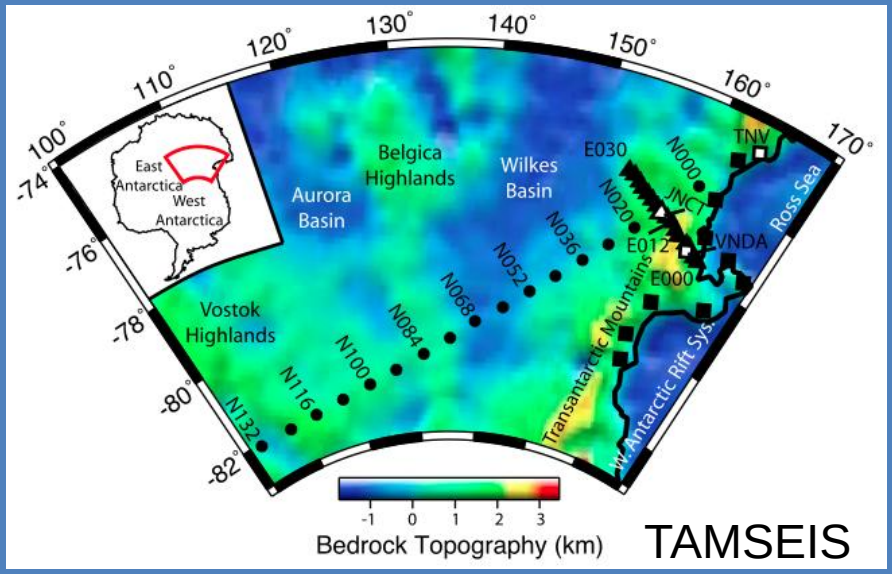
- **the Transantarctic Mountains**
- **West Antarctic Rift System**
- **East Antarctic Craton – basins, mtns, rifts**



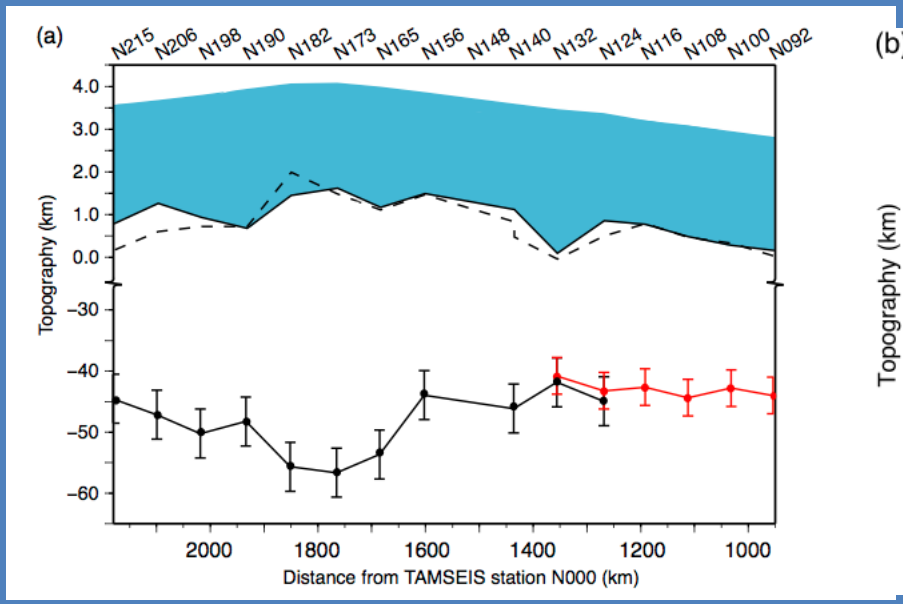
Crustal Structure from S-wave Receiver Functions



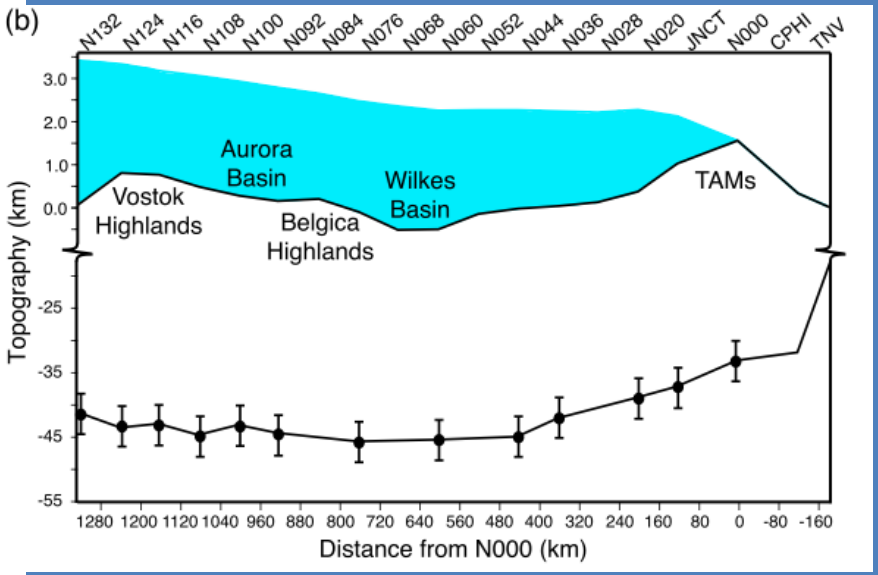
AGAP



TAMSEIS



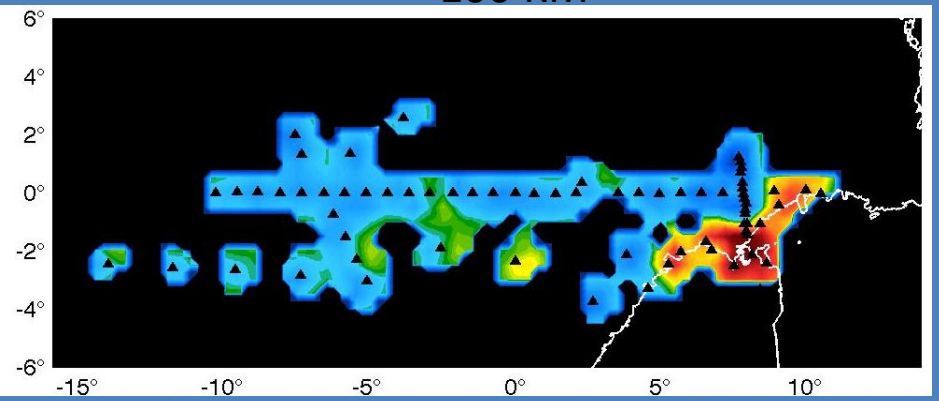
Hansen et al., EPSL (*In Review*)



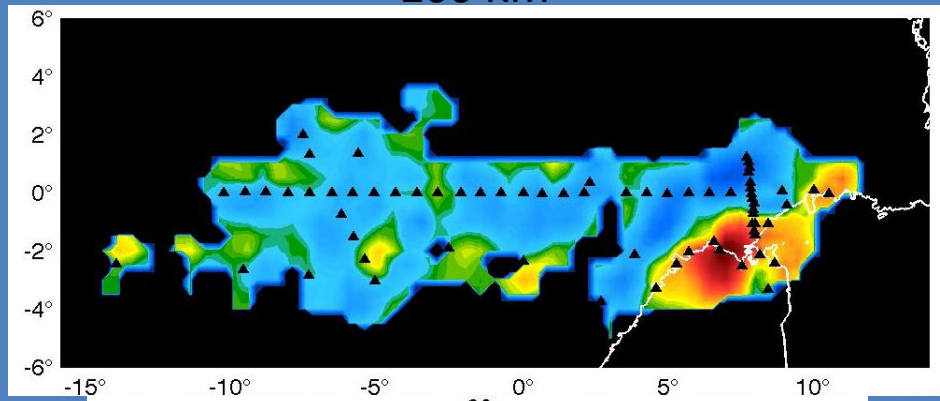
Hansen et al., 2009

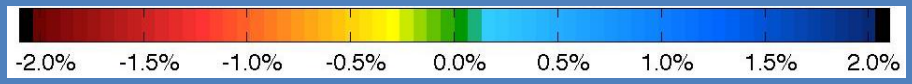
Mantle Structure from P wave Tomography

100 KM



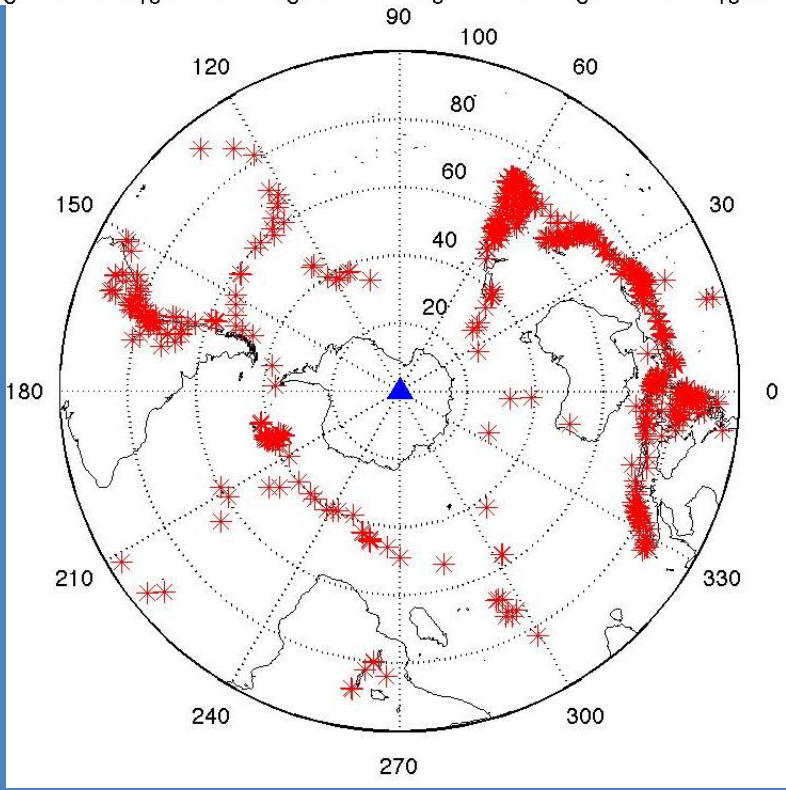
200 KM





77 Stations are used from TAMSEIS, GAMSEIS, POLENET, & GSN Seismic Arrays

752 Events with 8,523 Ray Paths are Inverted for P Velocity Perturbations

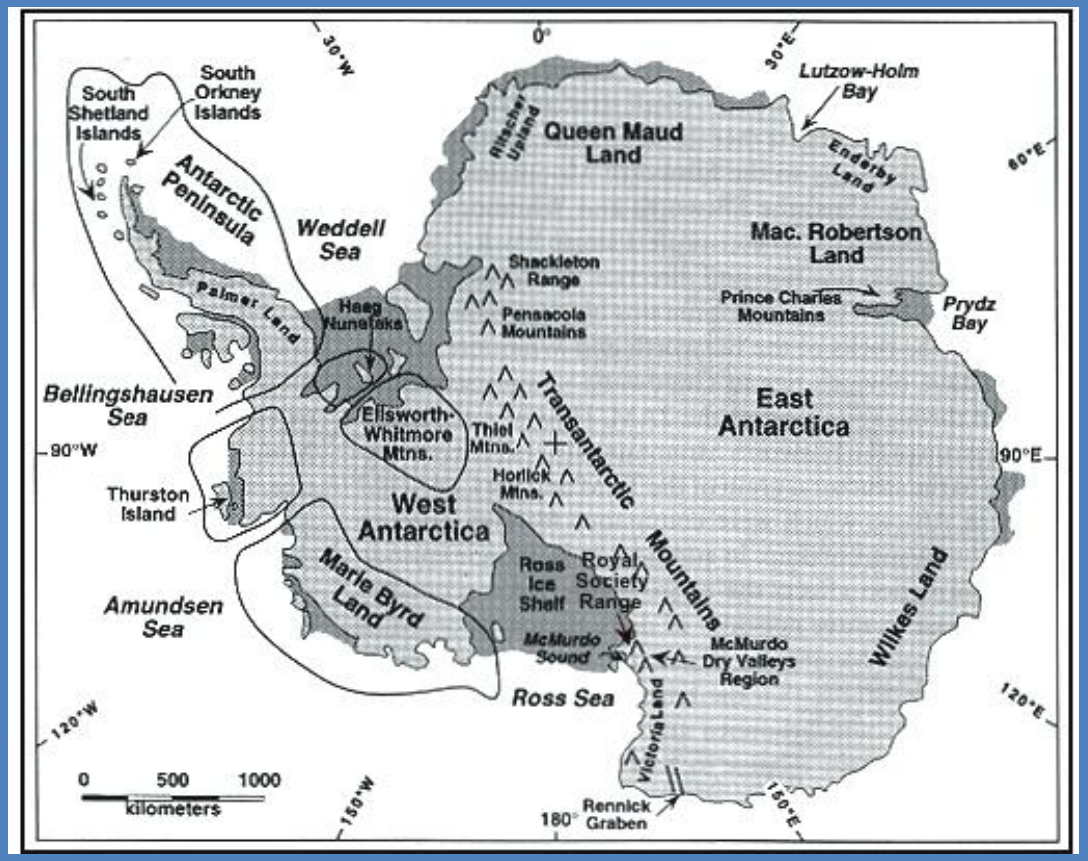


A. Lloyd, Work in Progress

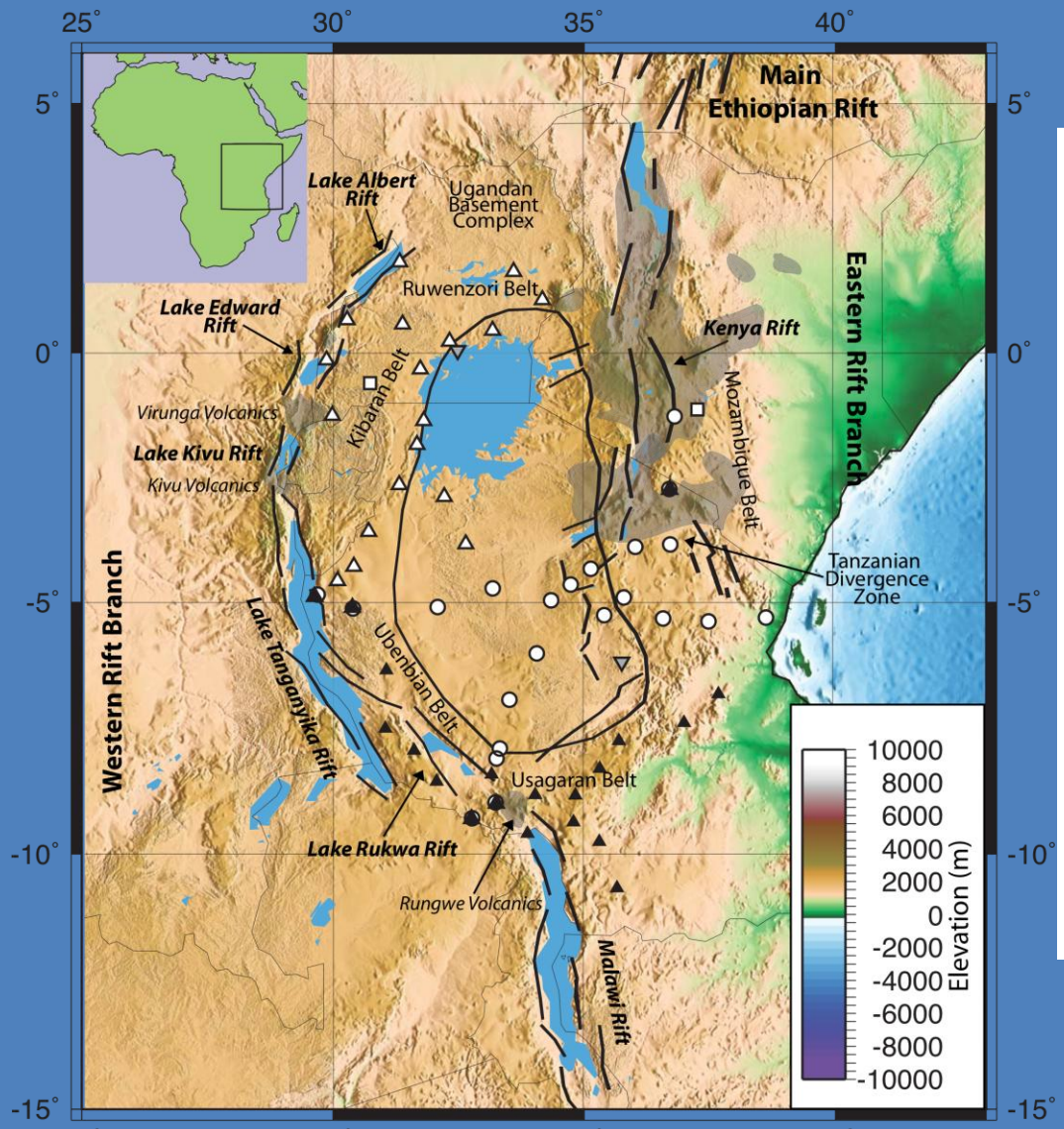
Science Questions

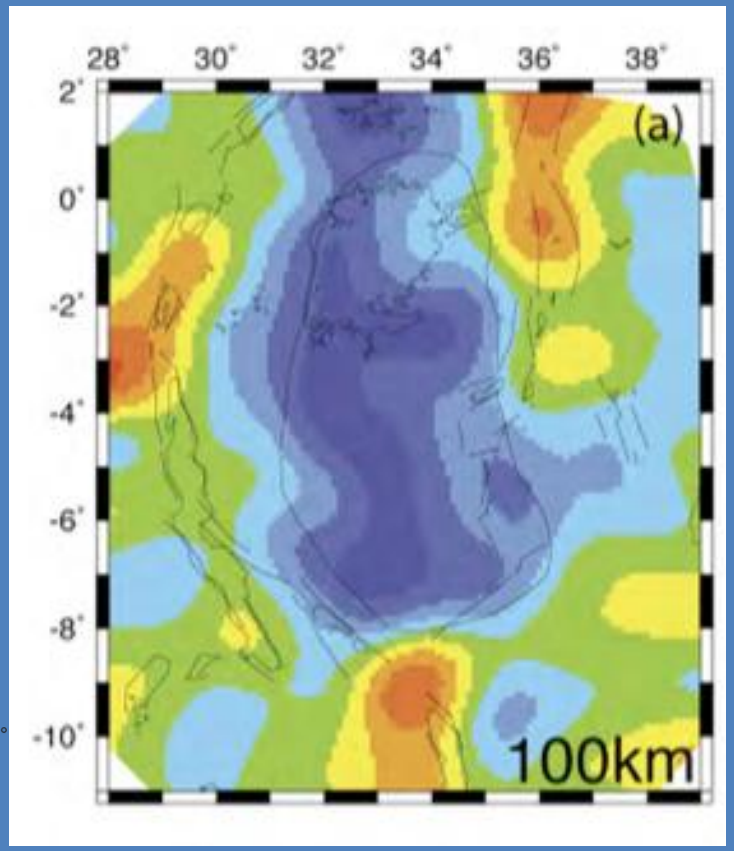
What is the thermal structure of the crust and mantle?

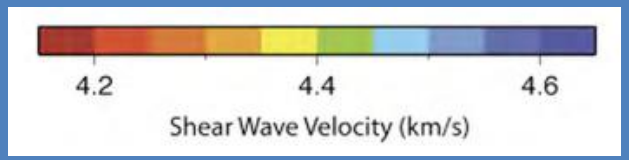
- **Implications for ice sheet models**



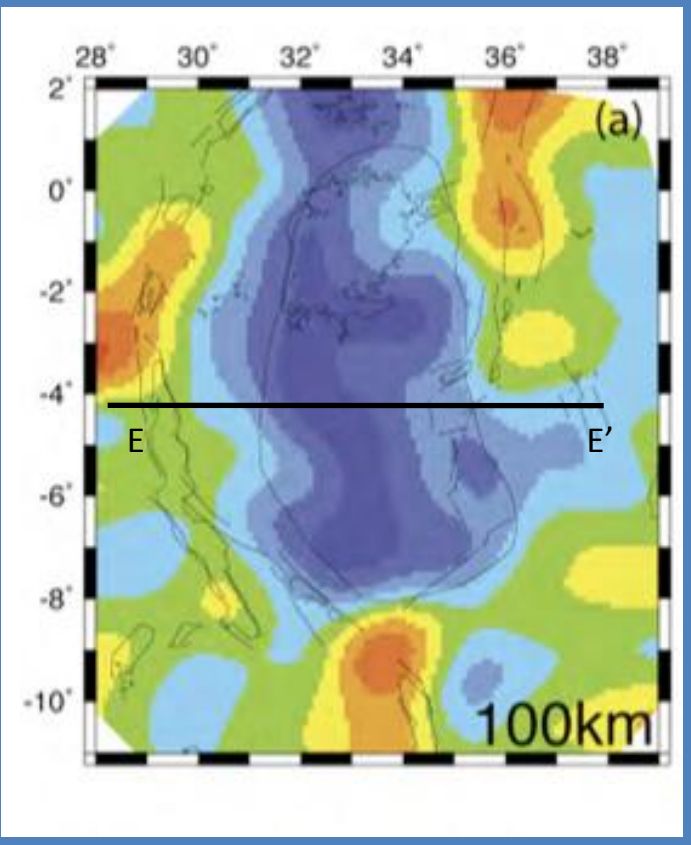
An African Example- Heat Flow across East Africa

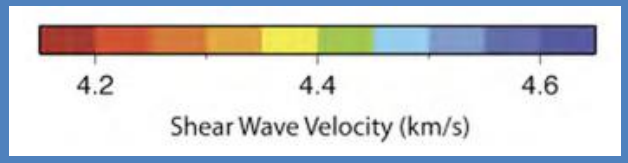


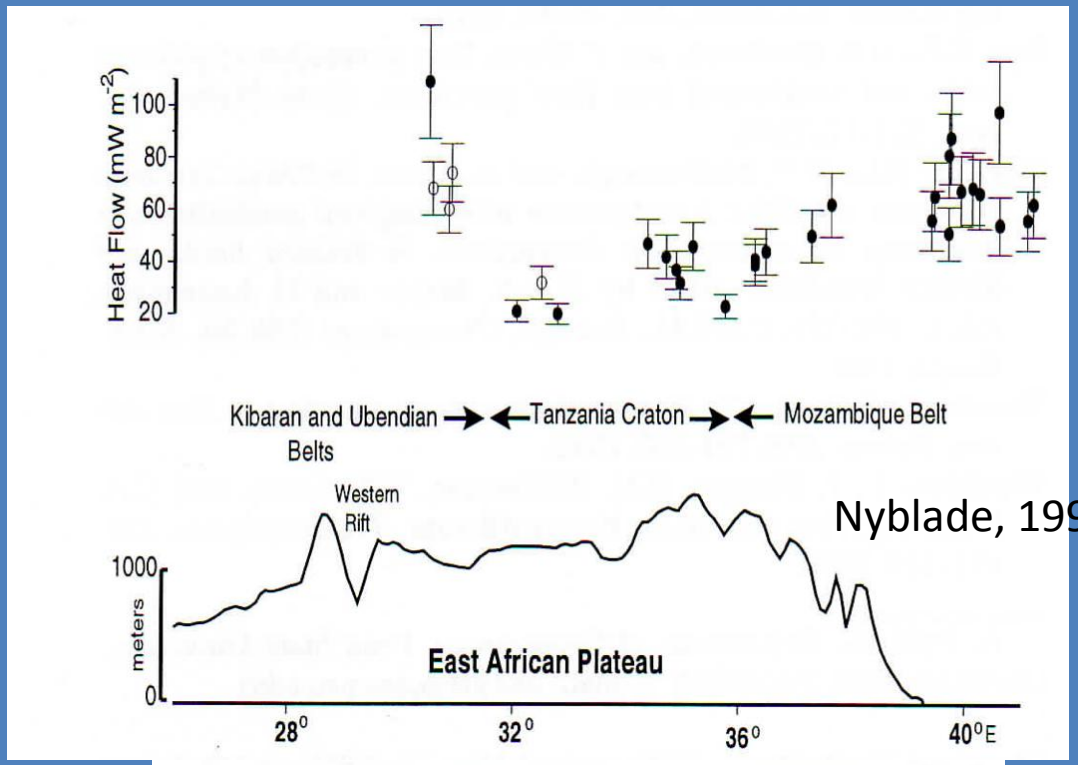




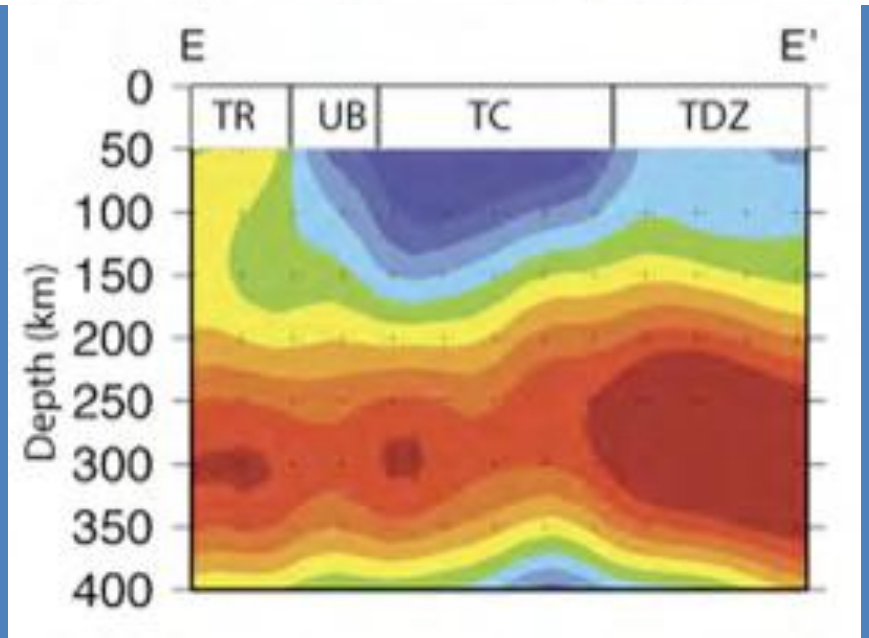
Adams, PhD Thesis - 2010







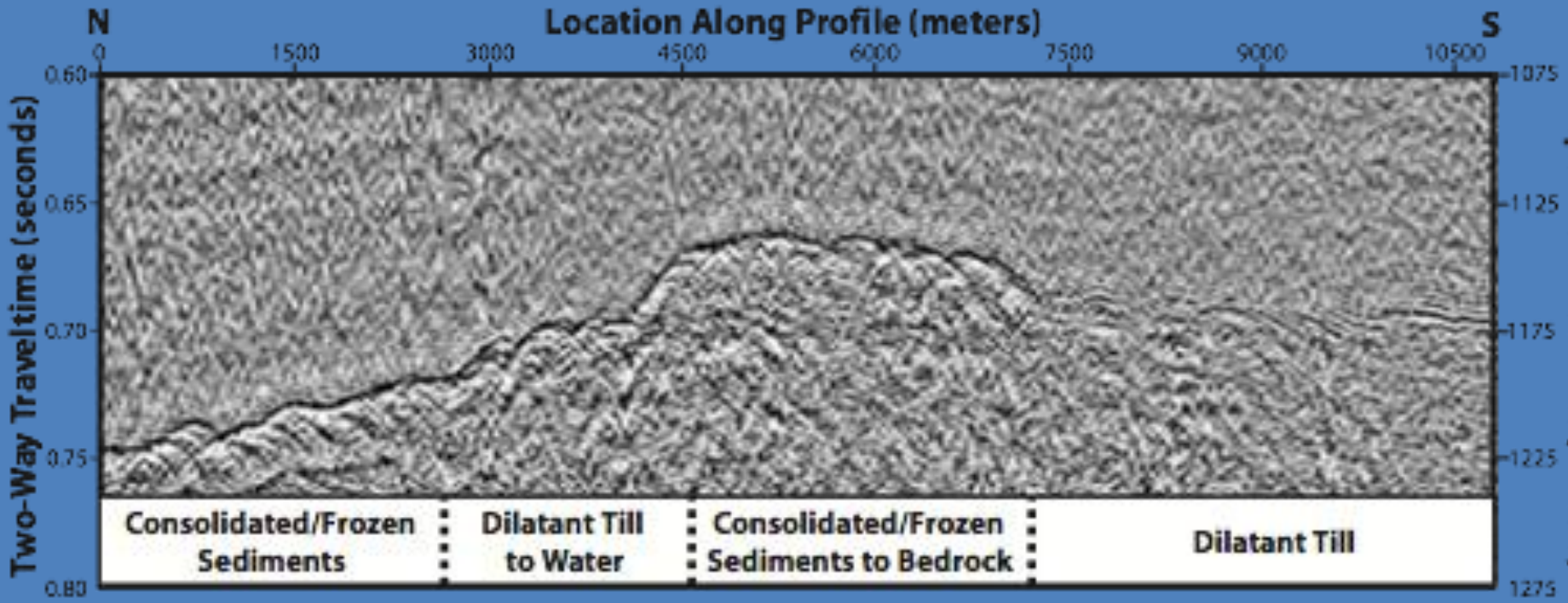
Nyblade, 1997



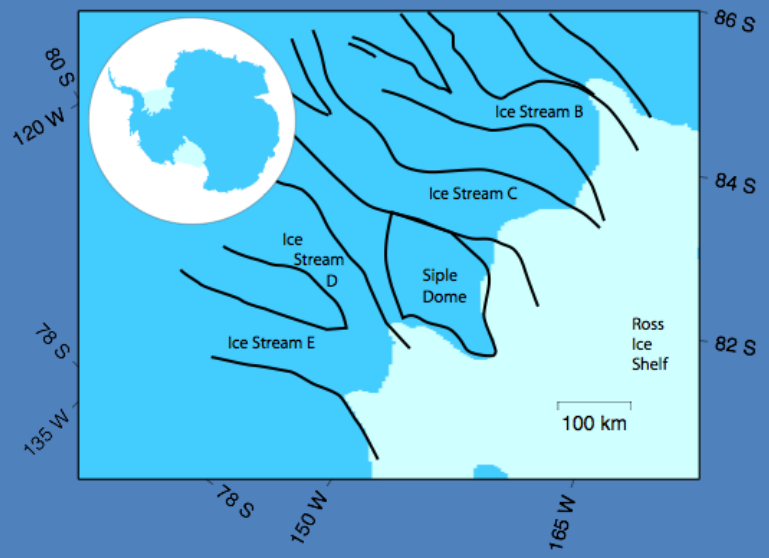
Science Questions

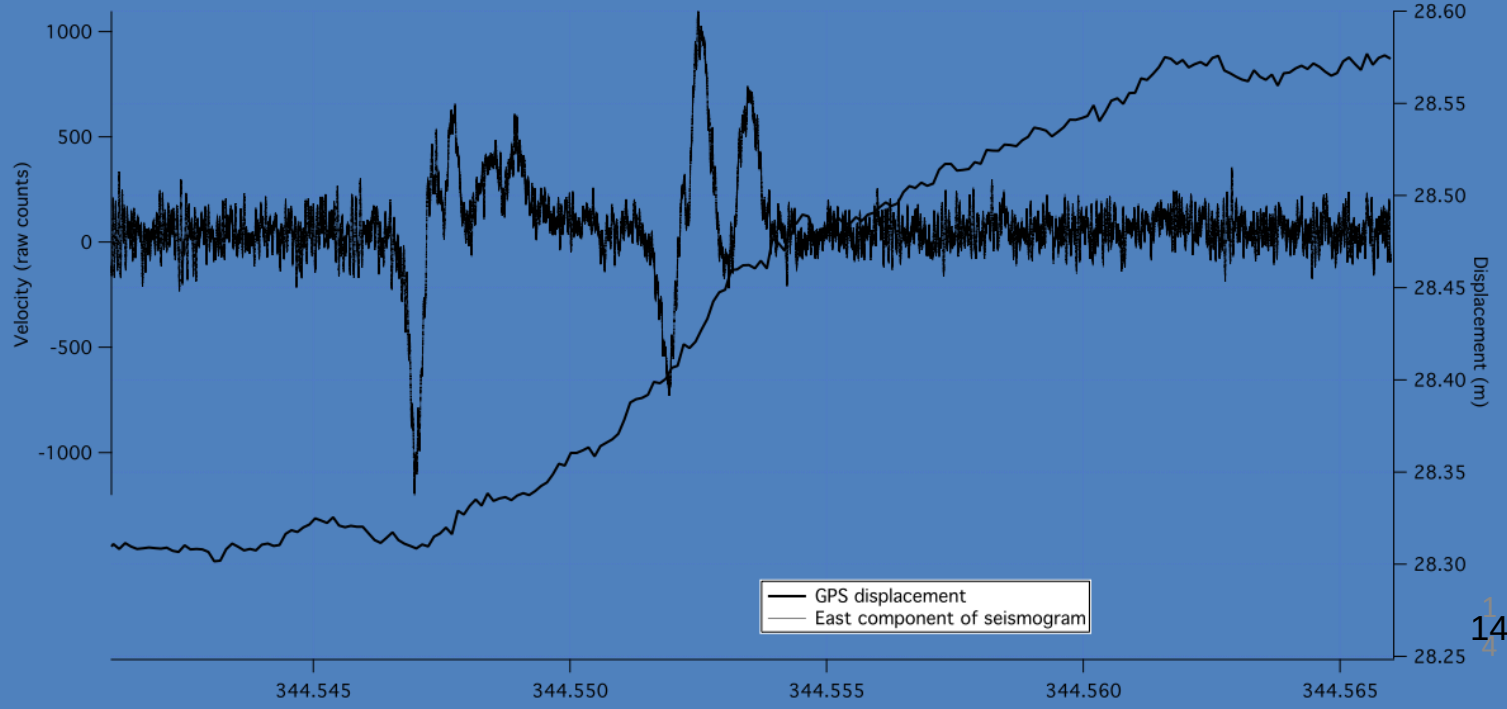
Glacial Seismology

- What are the response times and spatial gradients in ice sheet movements?
- What is under the ice?



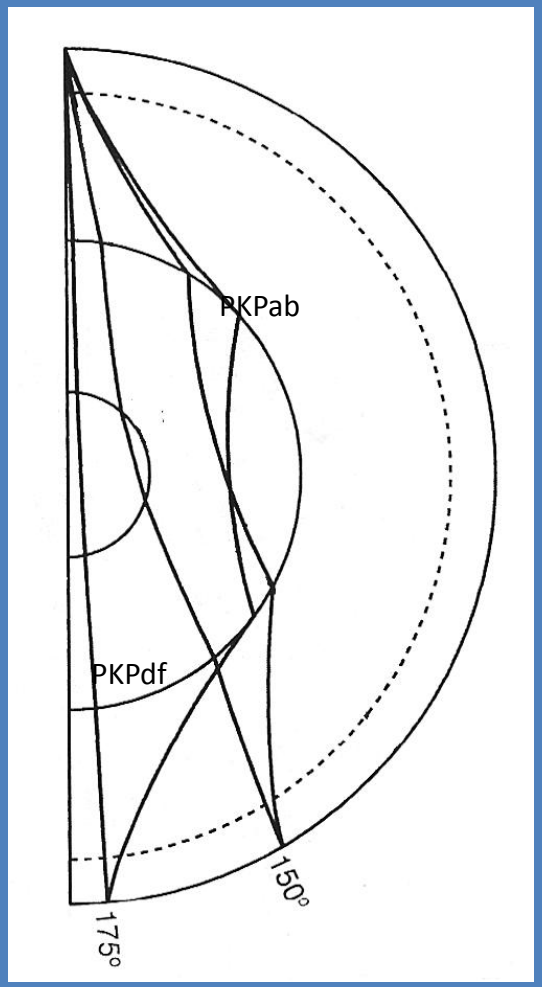
Combined GPS & Seismic





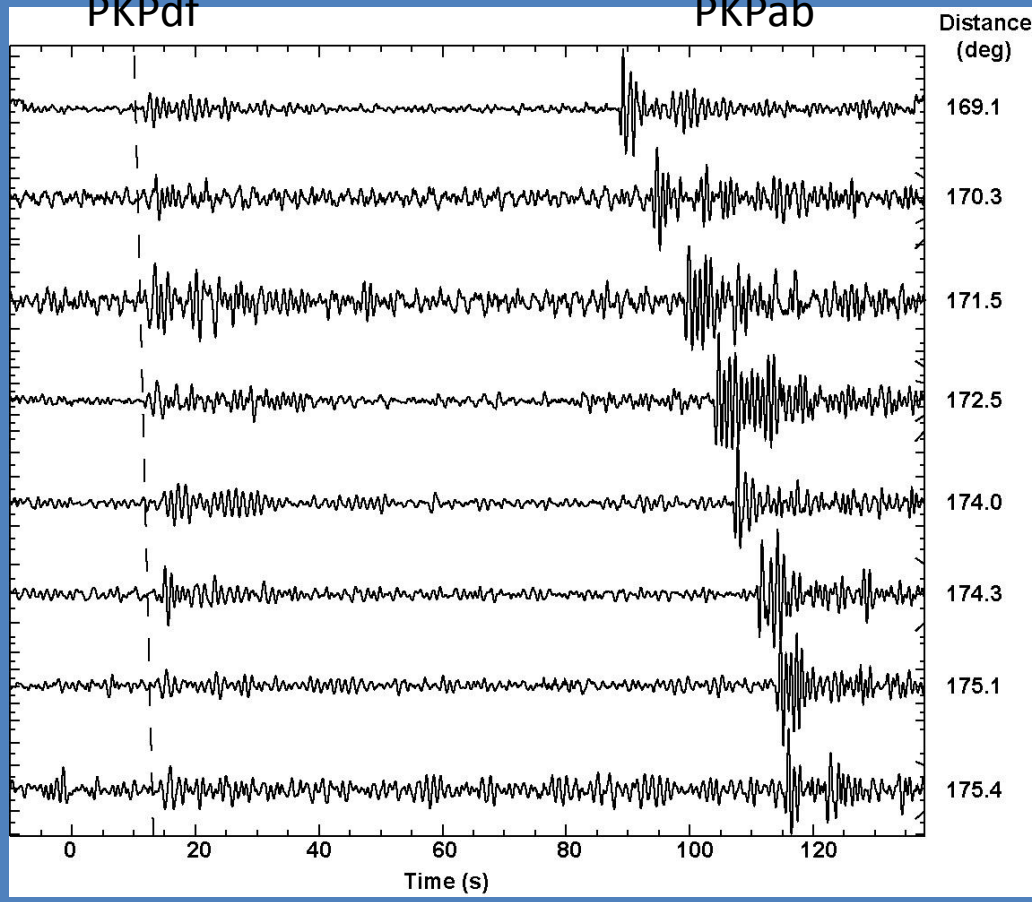
Science Questions

Ray Paths



Nearly Antipodal PKPdf arrivals

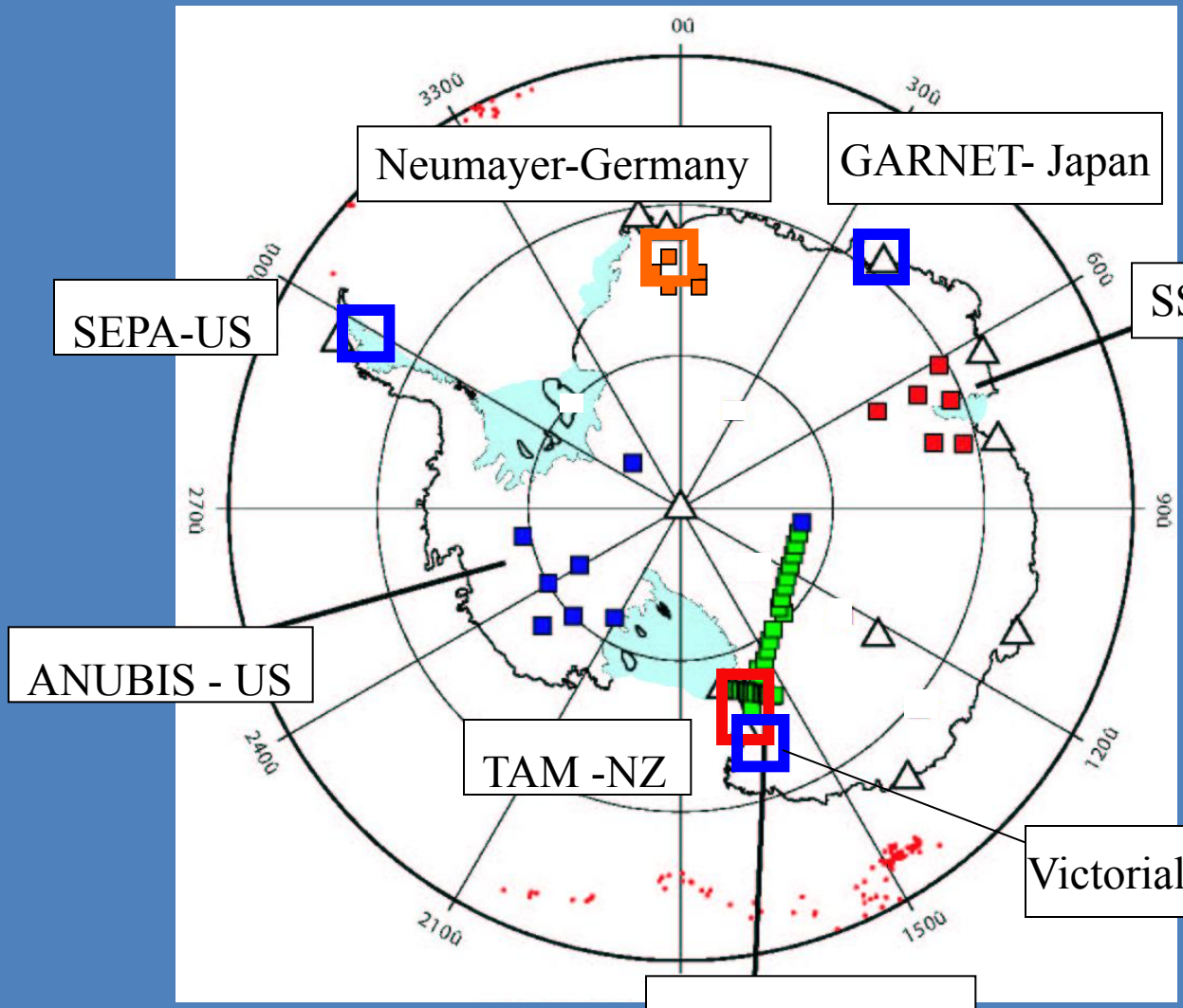
Dec 8, 2001 - 81ºN, 1ºE (Arctic Ridge) , 5.2 Mw



PKP (ab-df) anomaly = 3.2 to 6.1 s

Inner Core Anisotropy

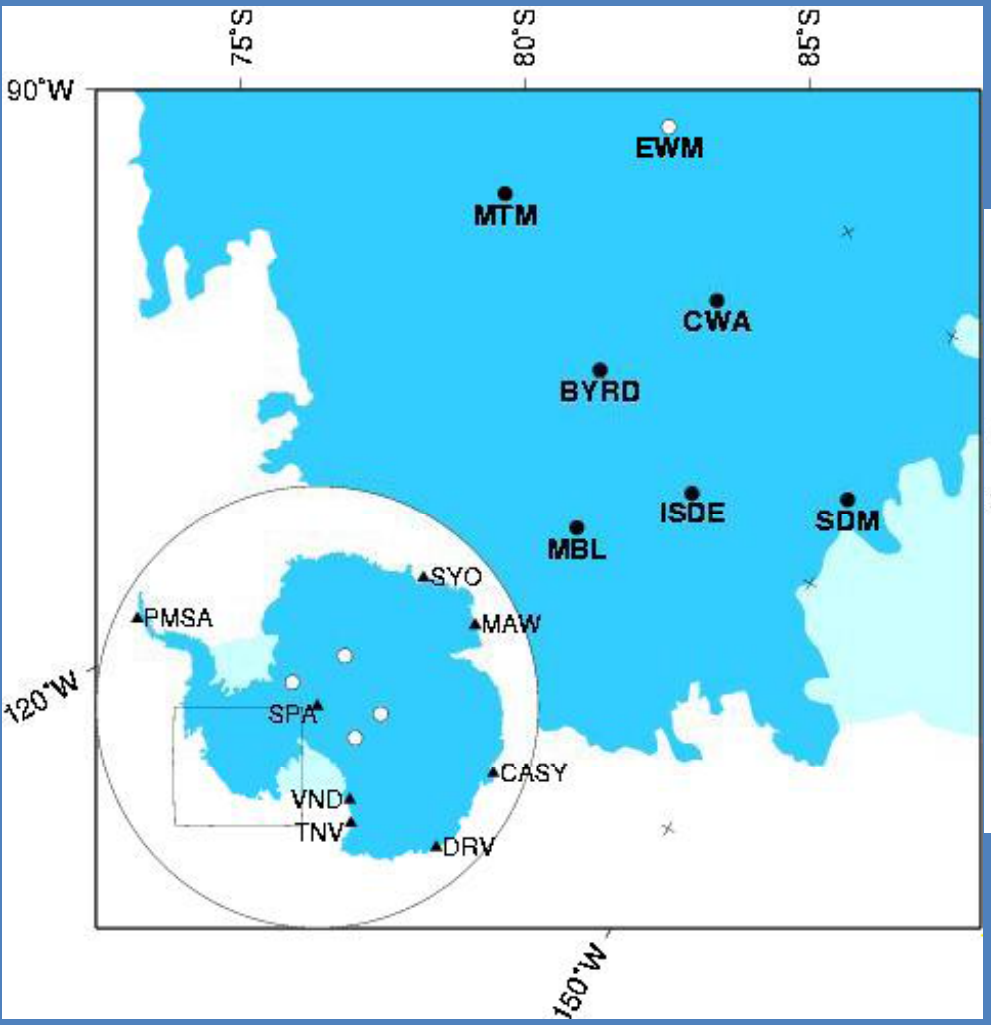
Broadband seismic stations in Antarctica and initial temporary broadband networks

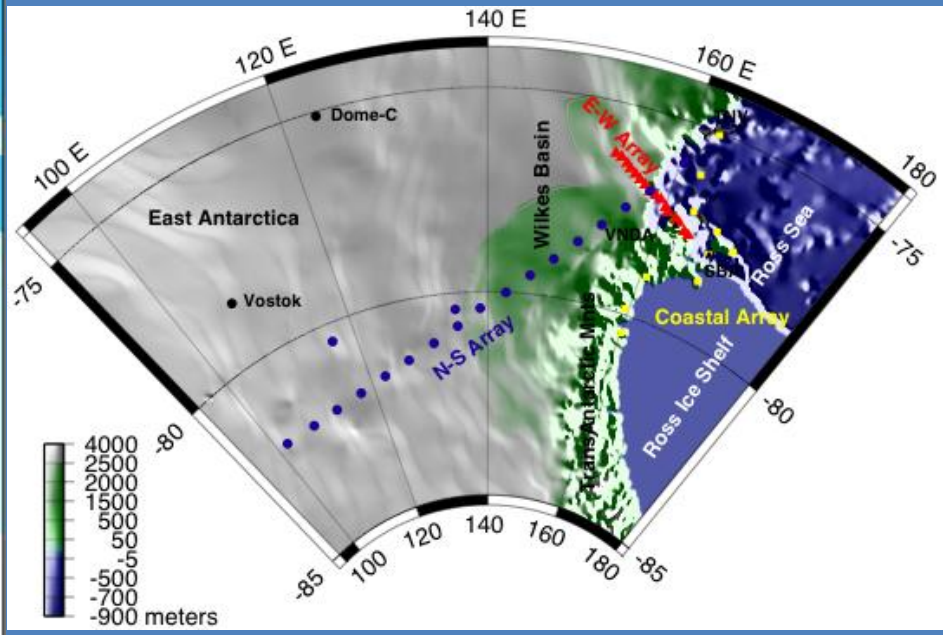


ANUBIS & TAMSEIS Deployments

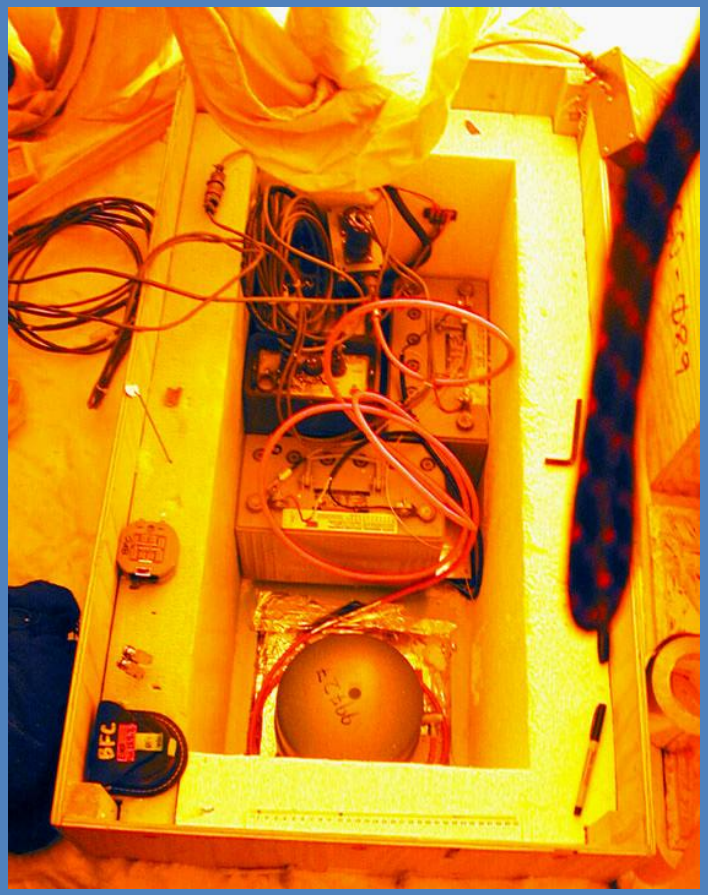
S. Anandakrishnan: 1999-2001

D. Wiens, A. Nyblade & S. Anandakrishnan: 2001-2003





ANUBIS & TAMSEIS Deployments

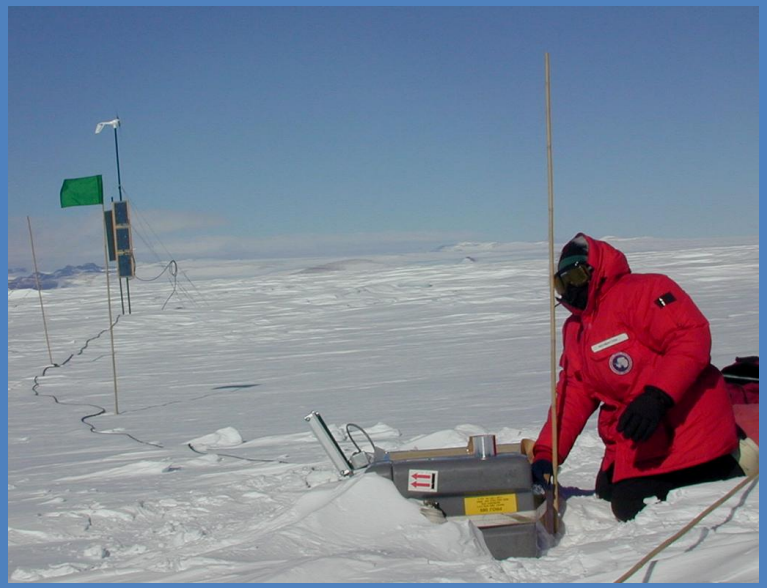


28 stations are on the ice plateau

- Installed and serviced by twin otter
- 10 stations serviced from a field camp
- Established by C-130

Ice installations:

- sensor and DAS are in a heated box
- all stations have 6 30 W panels
- about 20 stations have windmills
- sensor placed on wood block about 1 m below surface
- generally operate from Nov-March



Antarctic Seismology - where do we go from here?
Structure and Evolution of the Antarctic Plate (SEAP) Workshop

March, 2003 in Boulder CO
Organized by Mike Ritzwoller
~ 80 participants

Recommendations:

- International Program
- Establishment of permanent seismic stations on the interior
- Systematic coverage of Antarctica with a moving array
- Focused experiments in key regions

Proposed Antarctic Backbone stations and Moving Array (Pinwheel)

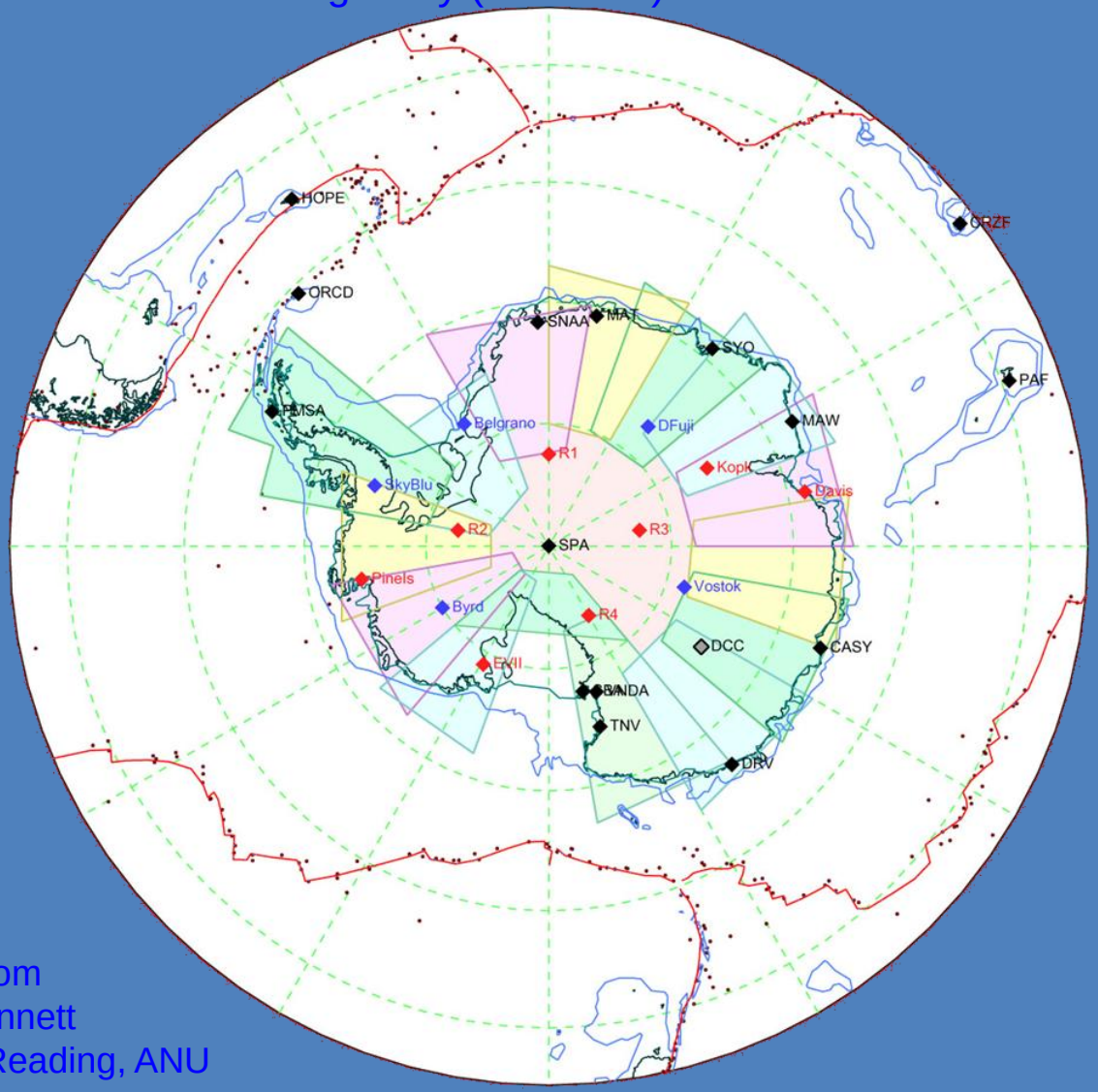
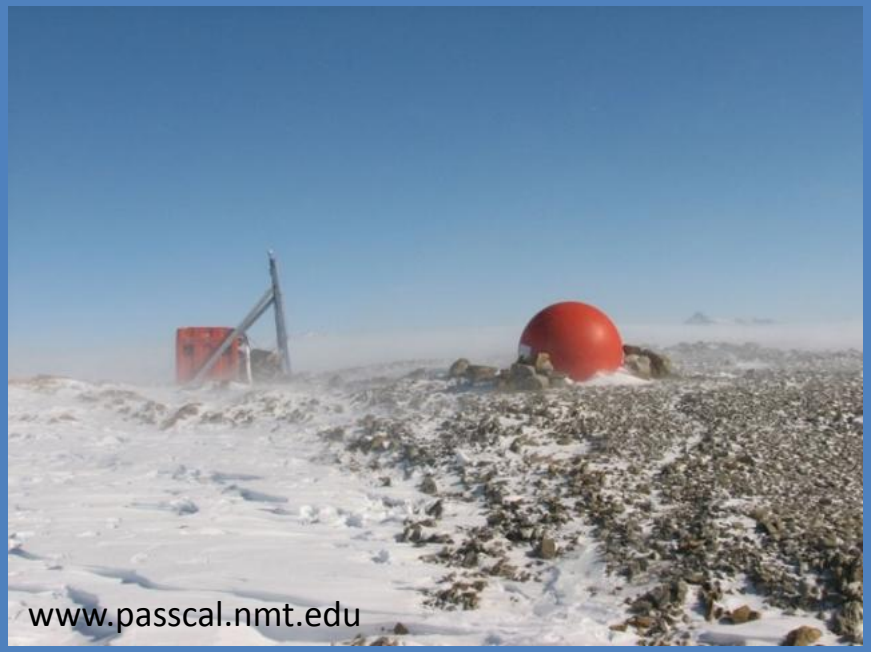


Figure from
Brian Kennett
& Anya Reading, ANU

NSF investments in polar seismology

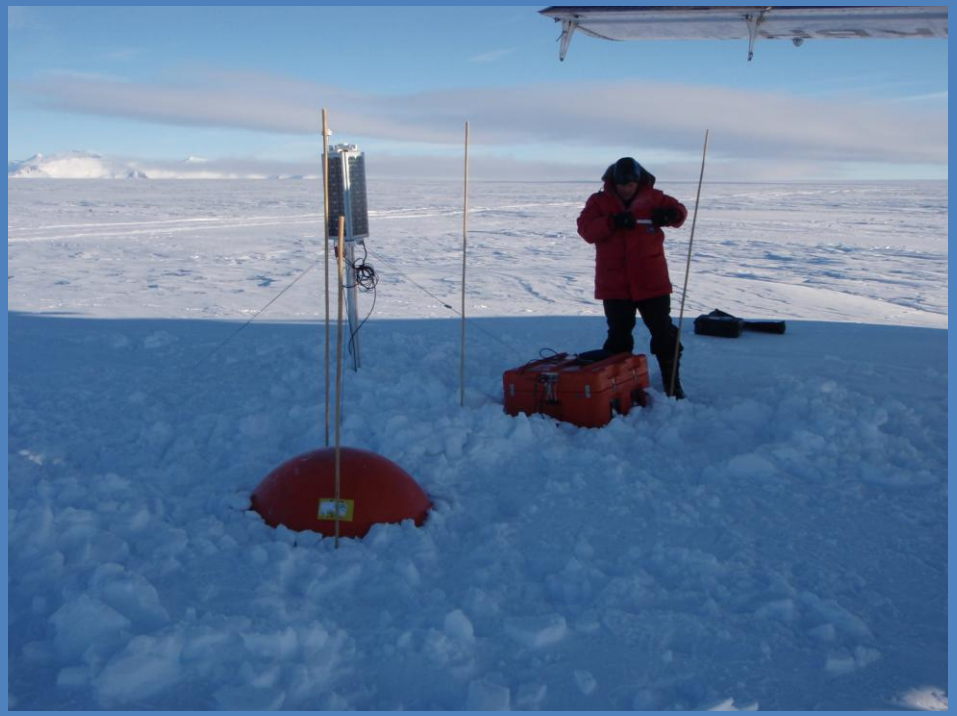
- MRI I – to develop the next generation of power and communication system for seismic and GPS stations – Jan 2006
- MRI II – to purchase cold-equipped seismic sensors and data loggers - Jan 2007
- Additional investments as supplemental awards – equipment, personnel
- MRI - GLISN

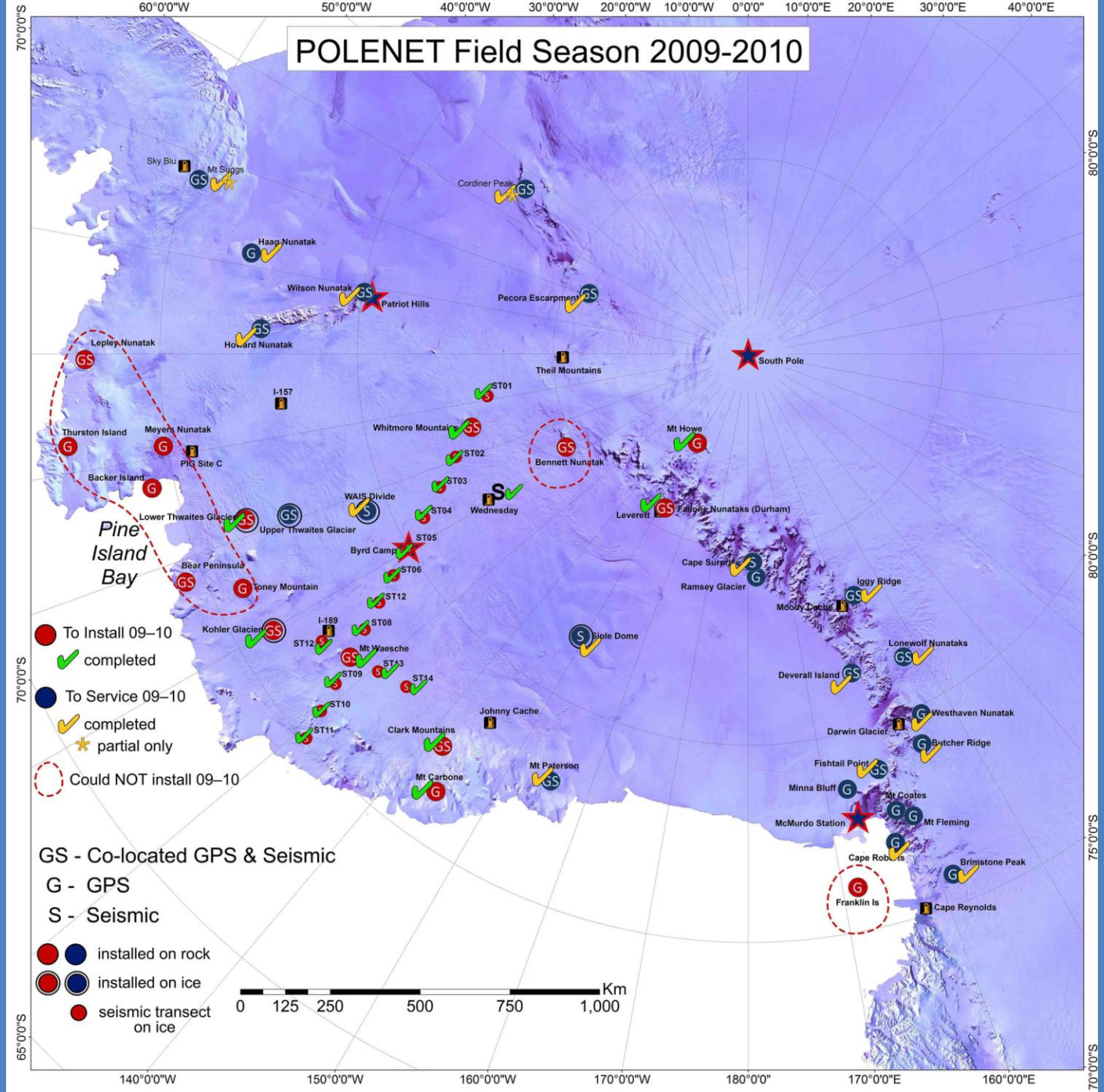
Seismic Stations



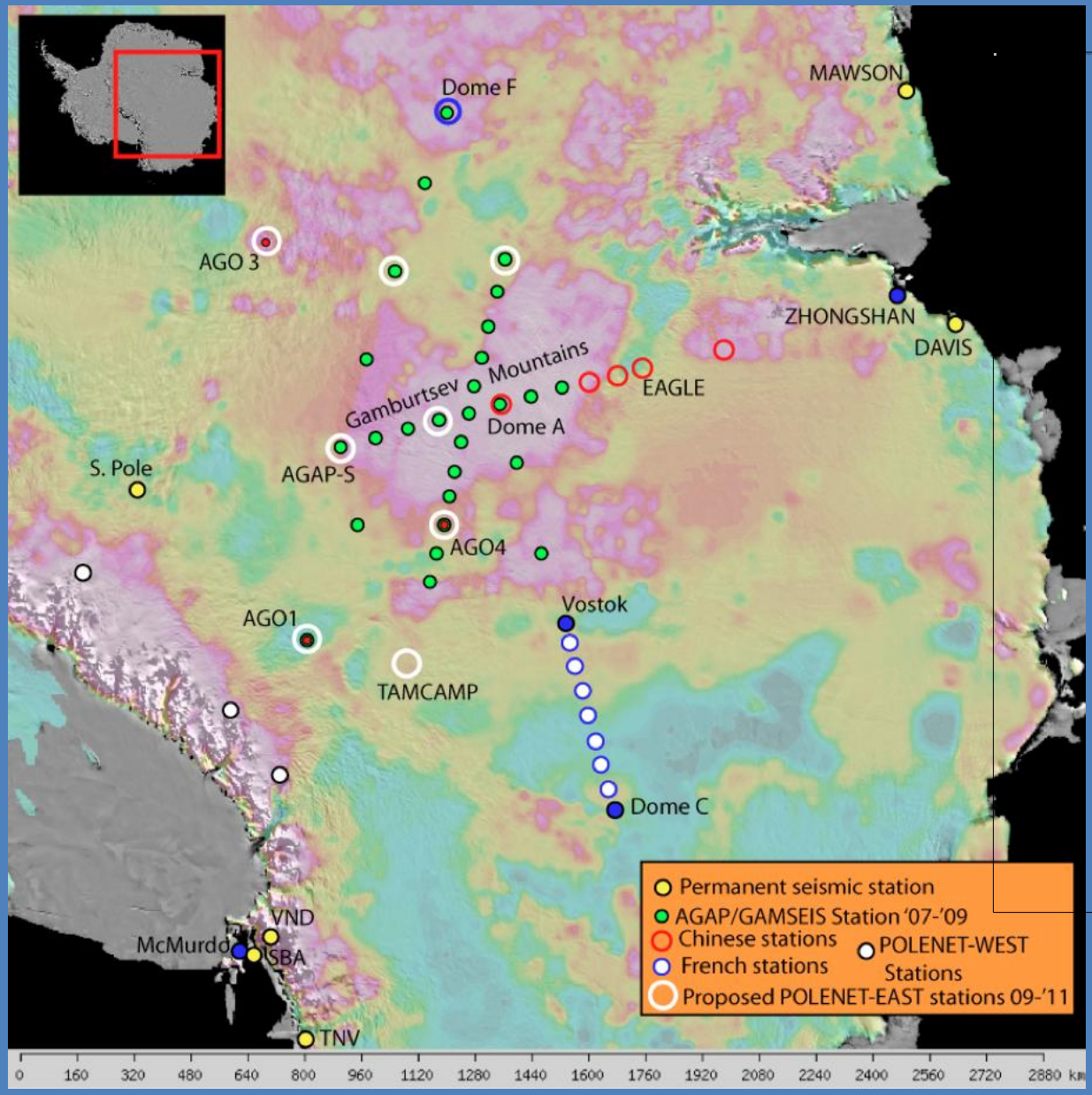
Rock Deployment: Backbone Station

Ice Deployment: Transect Station



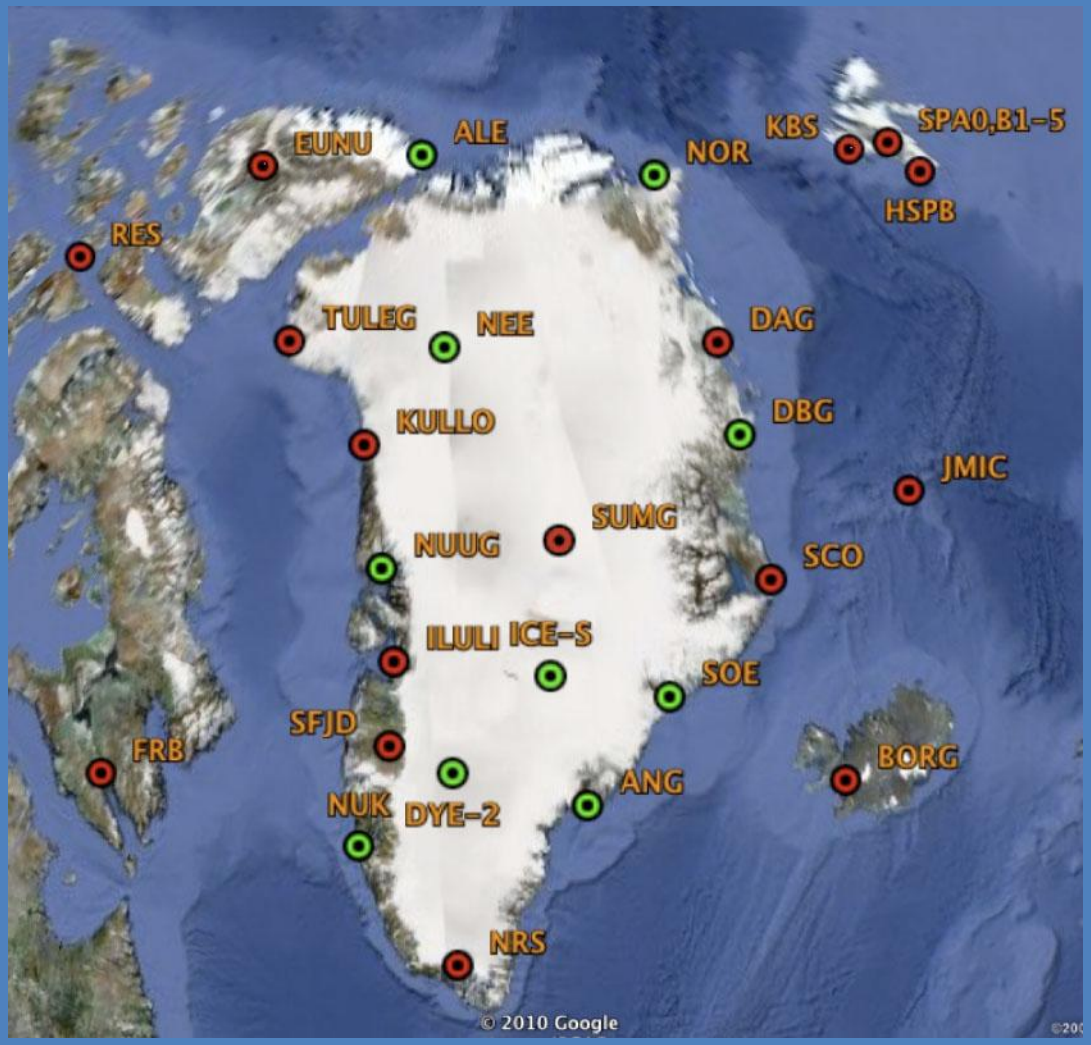

POLENET Field Season 2009-2010
60°0'0"W
50°0'0"W
40°0'0"W
30°0'0"W
20°0'0"W
10°0'0"W
0°0'0"
10°0'0"E
20°0'0"E
30°0'0"E
40°0'0"E
70°0'0"S
80°0'0"S
75°0'0"S
65°0'0"S
140°0'0"W
150°0'0"W
160°0'0"W
170°0'0"W
180°0'0"
170°0'0"E
160°0'0"E
Sky Blu
Mt Suggs
Cordiner Peak
Haag Nunatak
Wilson Nunatak
Patriot Hills
Pecora Escarpment
Howard Nunatak
Lepley Nunatak
Theil Mountains
South Pole
I-157
ST01
Thurston Island
Meyers Nunatak
PIG Site C
Whitmore Mountains
ST02
Bennett Nunatak
Mt Howe
Backer Island
ST03
WAIS Divide
Wednesday
Leverett
Tallorie Nunataks (Durham)
Lower Thwaites Glacier
Upper Thwaites Glacier
ST04
ST05
Byrd Camp
Pine Island Bay
Bear Peninsula
Toney Mountain
ST06
ST12
Cape Surprise
Ramsey Glacier
Iggy Ridge
Moody Cache
Kohler Glacier
I-189
ST08
ST12
Siple Dome
Lonewolf Nunataks
Mt Waesche
ST13
ST09
ST14
Deverall Island
ST10
Johnny Cache
Westhaven Nunatak
Darwin Glacier
ST11
Clark Mountains
Butcher Ridge
Fishtail Point
Mt Paterson
Mt Carbone
Minna Bluff
Mt Coates
McMurdo Station
Mt Fleming
Cape Roberts
Brimstone Peak
Franklin Is
Cape Reynolds
To Install 09–10
completed
To Service 09–10
completed
partial only
Could NOT install 09–10
GS - Co-located GPS & Seismic
G - GPS
S - Seismic
installed on rock
installed on ice
seismic transect on ice
0
125
250
500
750
1,000
Km

Remaining AGAP Stations



GLISN – Greenland Ice Sheet Monitoring Network

The GLISN project will establish a real-time sensor array of 25 stations to enhance and upgrade the performance of the scarce existing Greenland seismic infrastructure for detecting, locating, and characterizing glacial earthquakes and other cryo-seismic phenomena, and contribute to our understanding of Ice Sheet dynamics. [http://glisn.info/]



Polar Seismology - where do we go from here?

Proposed Antarctic Backbone stations and
Moving Array (Pinwheel)

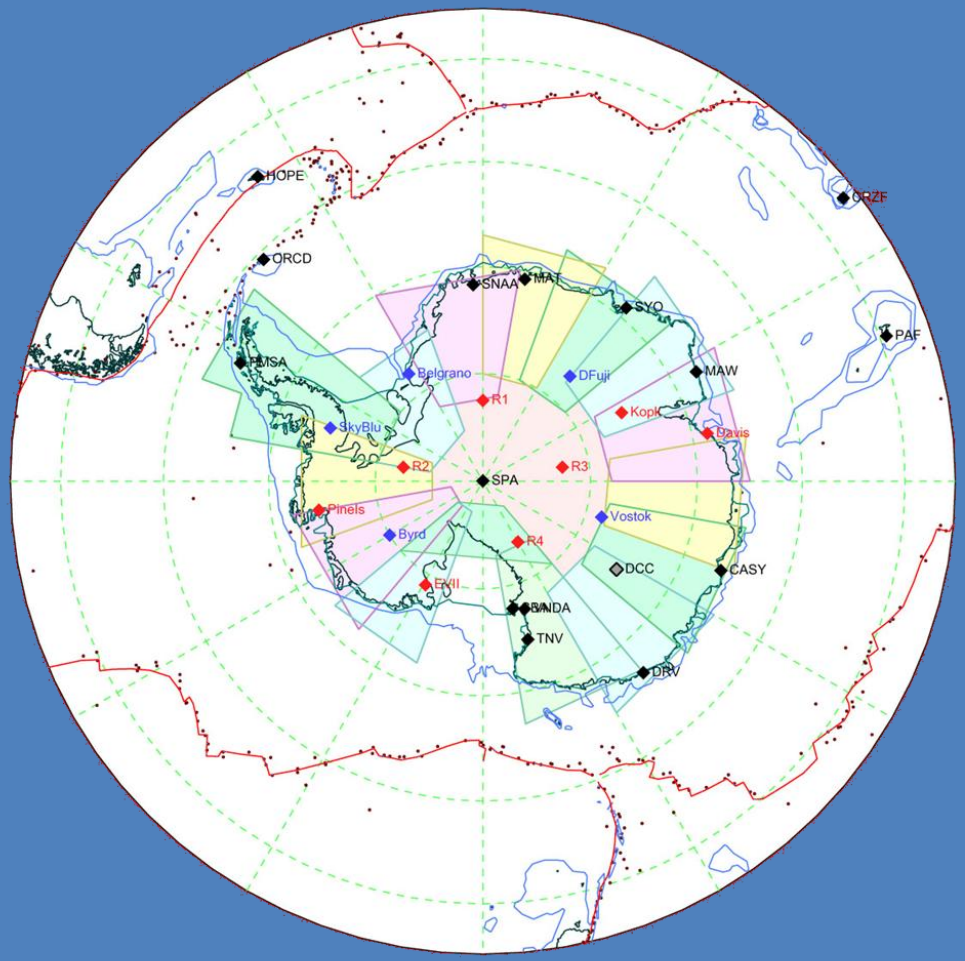
Recommendations:

- International Program
- Establishment of many permanent seismic stations
  - Polenet & AGAP&GLISN
  - Long-term O&M?
- Focused experiments in key regions

– dedicated equipment pool

a) broadband seismometers

b) active source systems



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