

Deep structure & tectonics of Pan-African belt, Dronning Maud Land, East Antarctica, derived from deep seismic surveys

SEAL-2000, -2002

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& SEAL Geo-transect Group

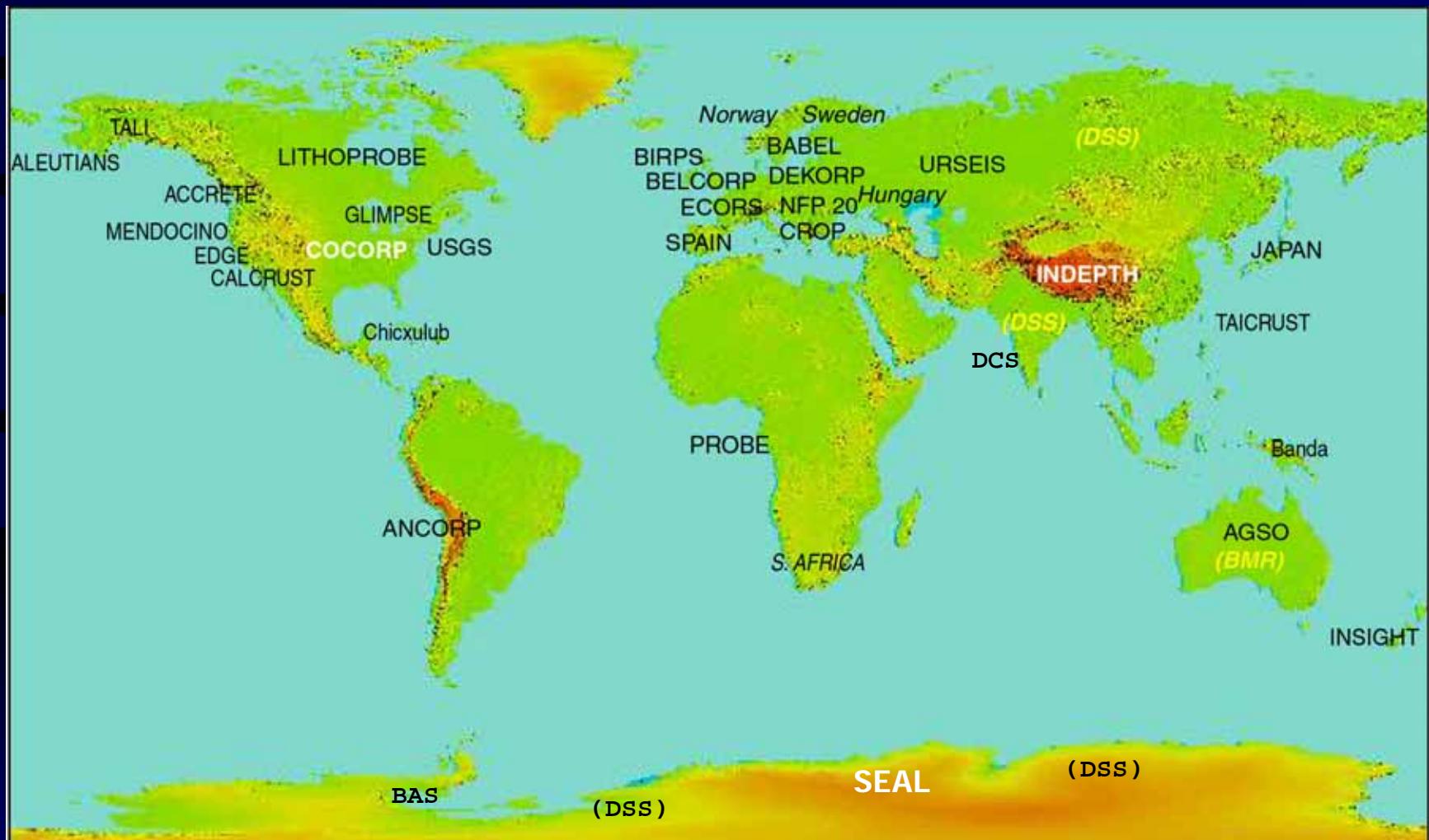


CONTENTS

- Outline of the **SEAL** program
- **SEAL-2000, -2002 seismic surveys**
 - geological setting
 - field operations
- Scientific results
 - ice sheet & bedrock
 - deep crustal structure
- Tectonic Interpretation
- Conclusion



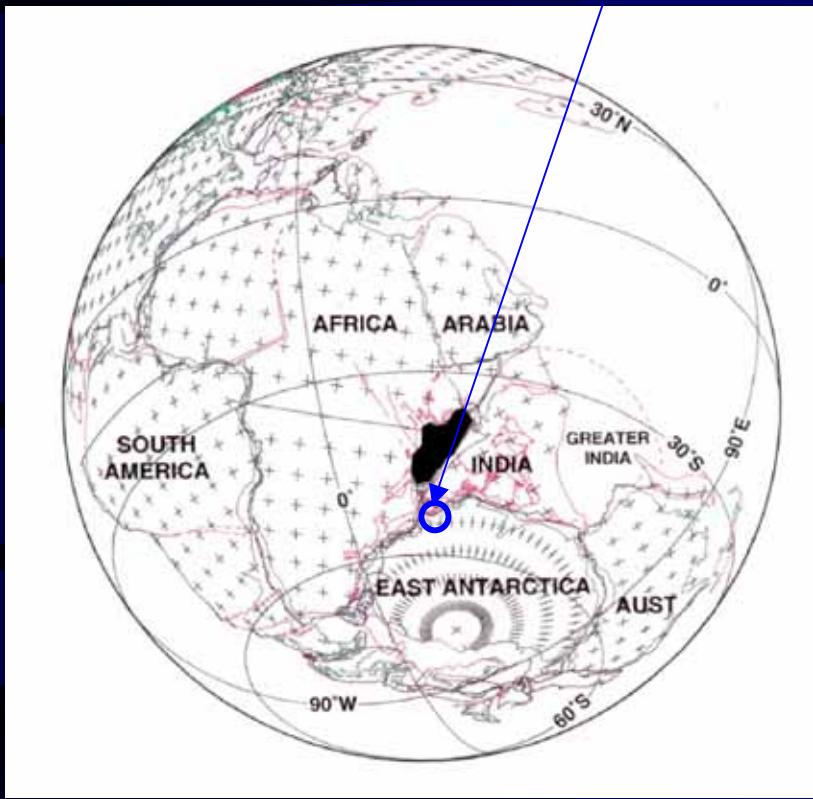
Continental Deep Seismic Profiling



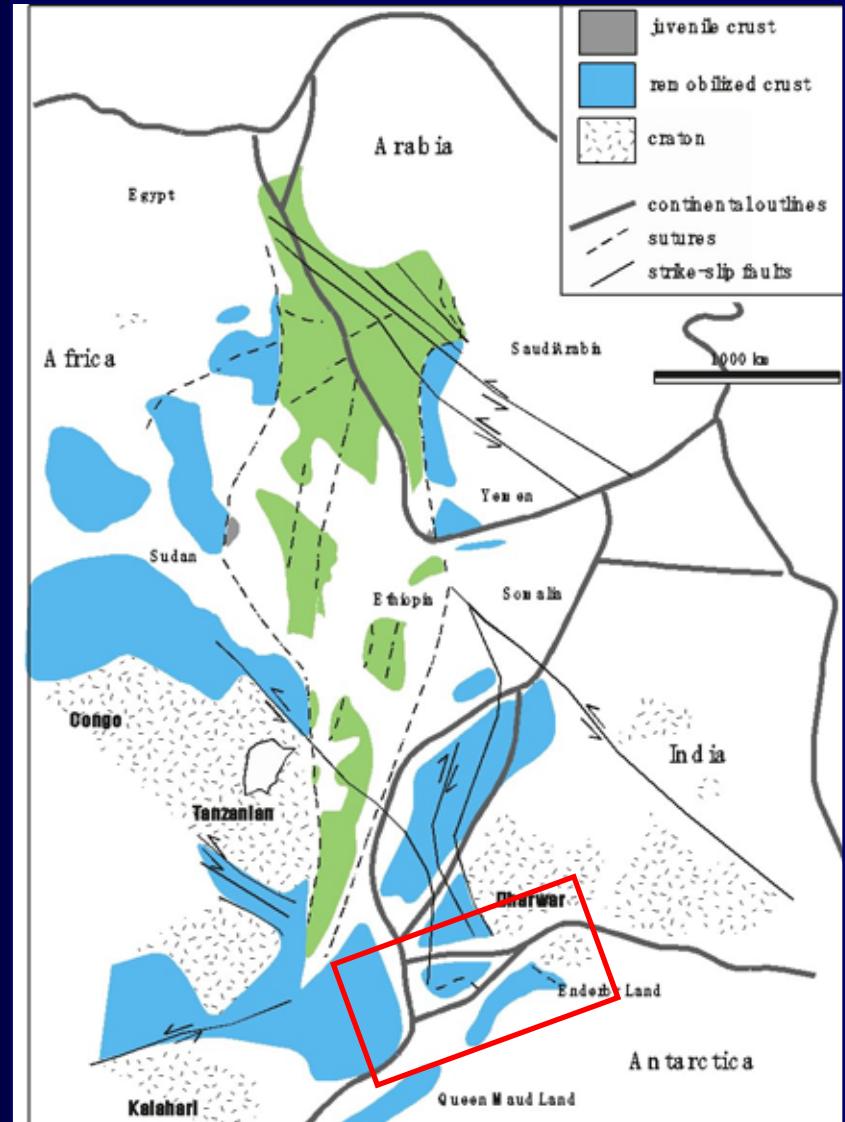
Courtesy from L. Brown

Amalgamation of Gondwana

Study area



Geological map showing the Pan-African Belt between East and West Gondwanaland (Stern, 1994).



Structure and Evolution of East Antarctic Lithosphere (SEAL)

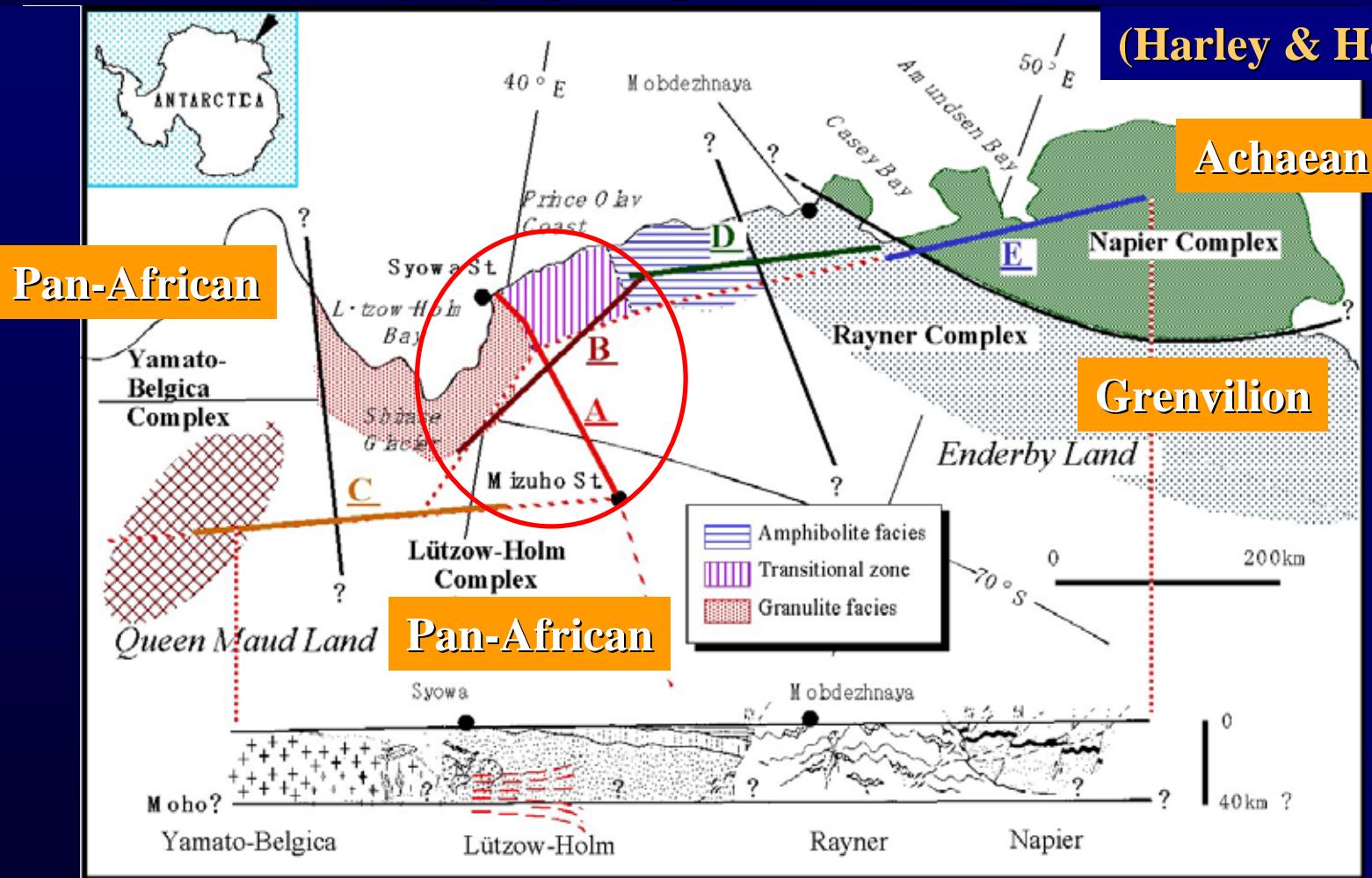
- Goescientific field works in the Western Enderby Land – Eastern Dronning Maud Land
 - Japanese Antarctic Research Expedition (JARE)
- The geoscientific themes:
 - **Structure and compositions of continental crust by DSS.**
 - Origin of ultra-high temperature metamorphism.
 - Tectonics and geochronology of the Napier Complexes.
 - Paleomagnetic, & sediment studies of East Antarctica.
 - Potential field data aquisition

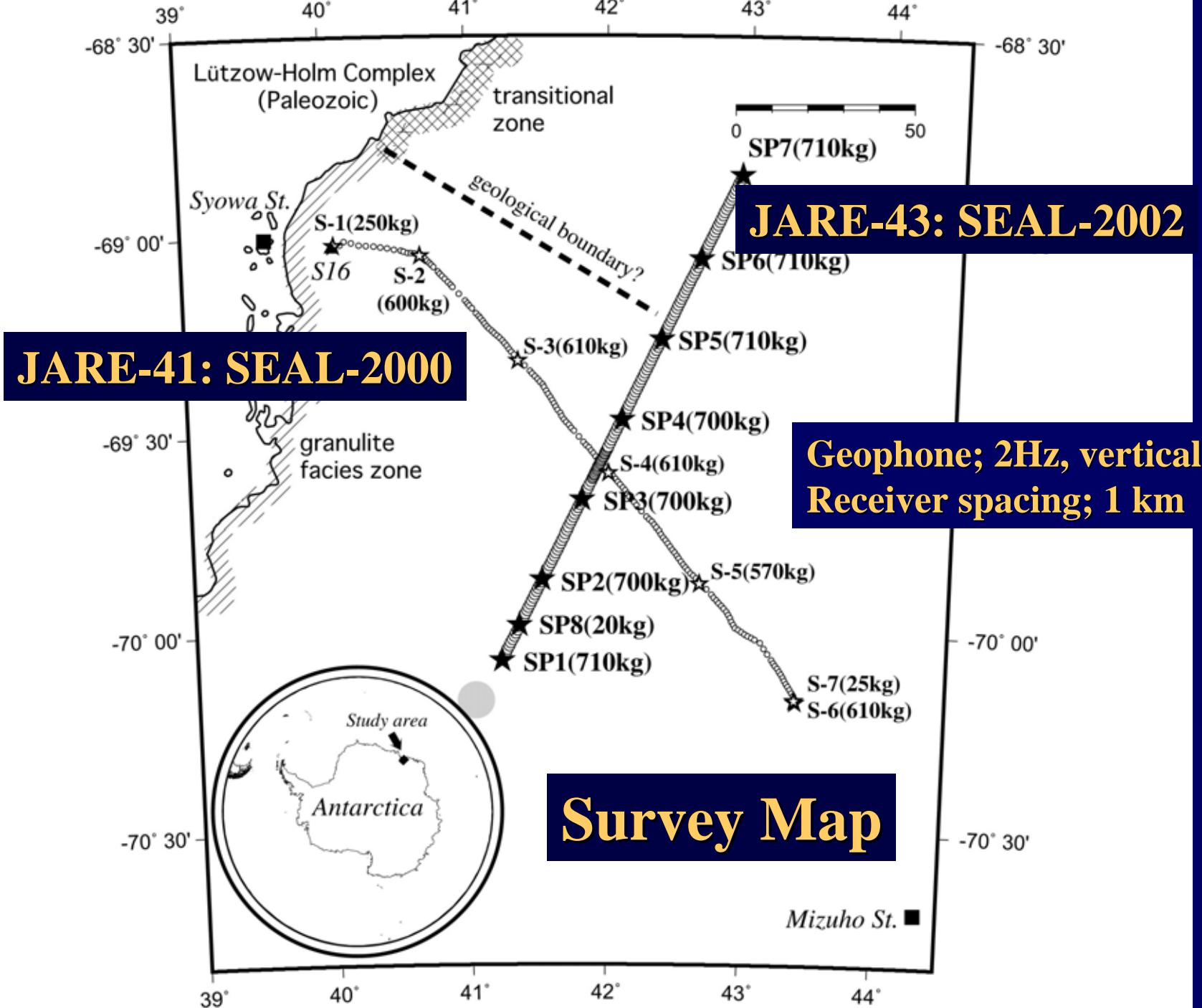


Geological Setting of East Antarctica

Tectonic setting & proposed profiles, with estimated crustal section

(Harley & Hensen, 1991)





JARE-41,-43 (SEAL-2000, -2002) Field operations

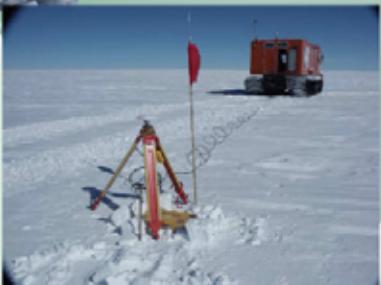
- Observation Line Team -



2Hz geophone
and data logger



Radio-echo sounder



Gravity and GPS

- Helicopter Team -



Type AS-355
helicopter



Antarctic penetrators

- Drilling and Explosion Team -

A total of 5,000kg
dynamites by 7
large explosions



Antarctic dynamites



Snow/ice drilling machine



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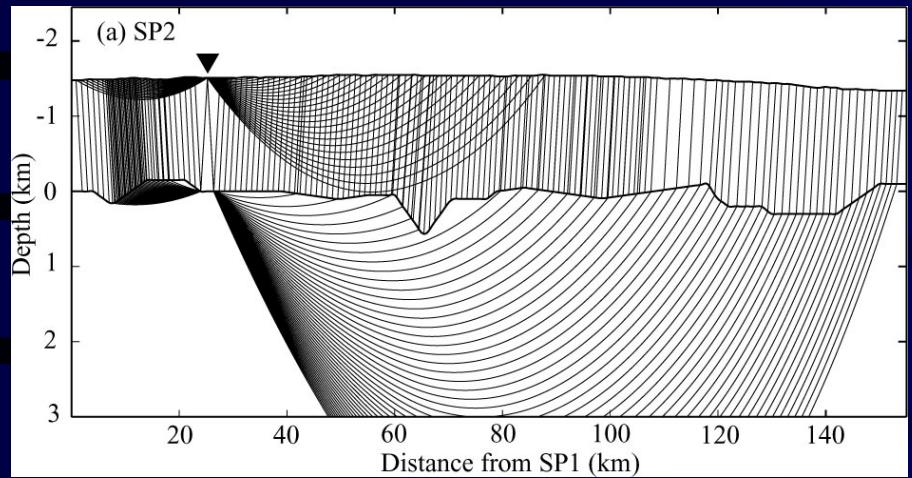
- Outline of the SEAL program
- SEAL-2000, -2002 seismic surveys

-Scientific results

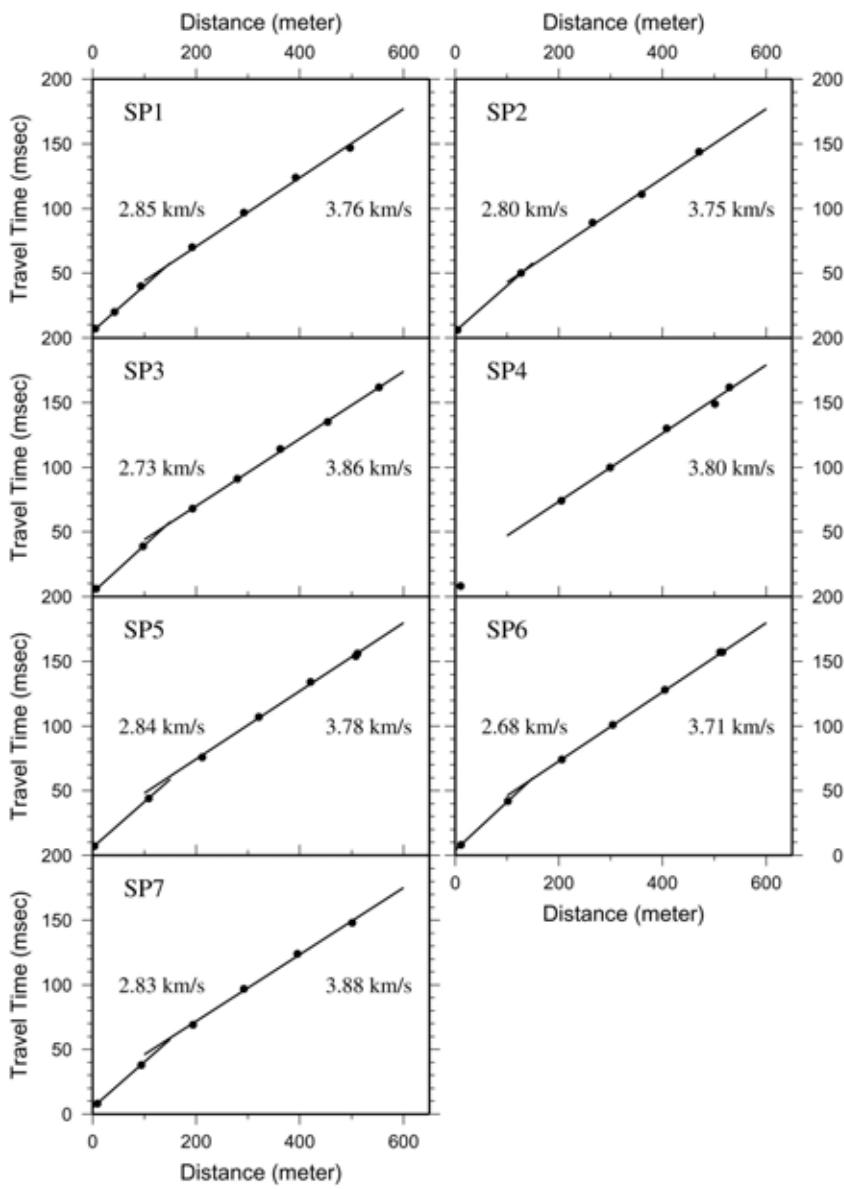
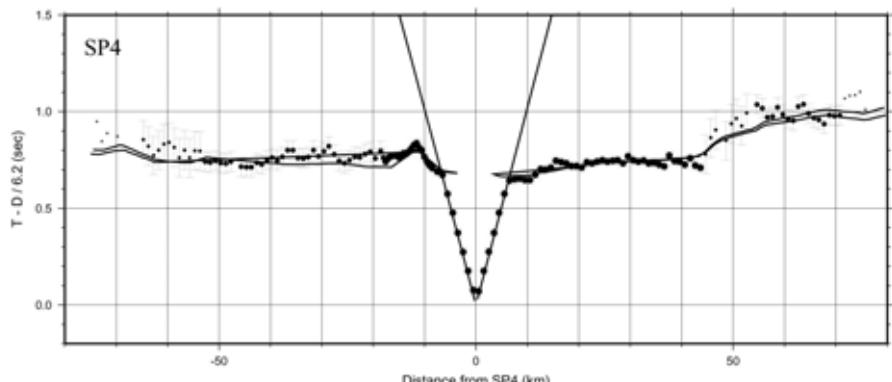
- ice sheet structure & bedrock topography
 - radio echo sounder, first arrivals
- shallow crustal structure
 - first arrivals, gravity
- deep crustal structure
- Tectonic Interpretation
- Conclusion



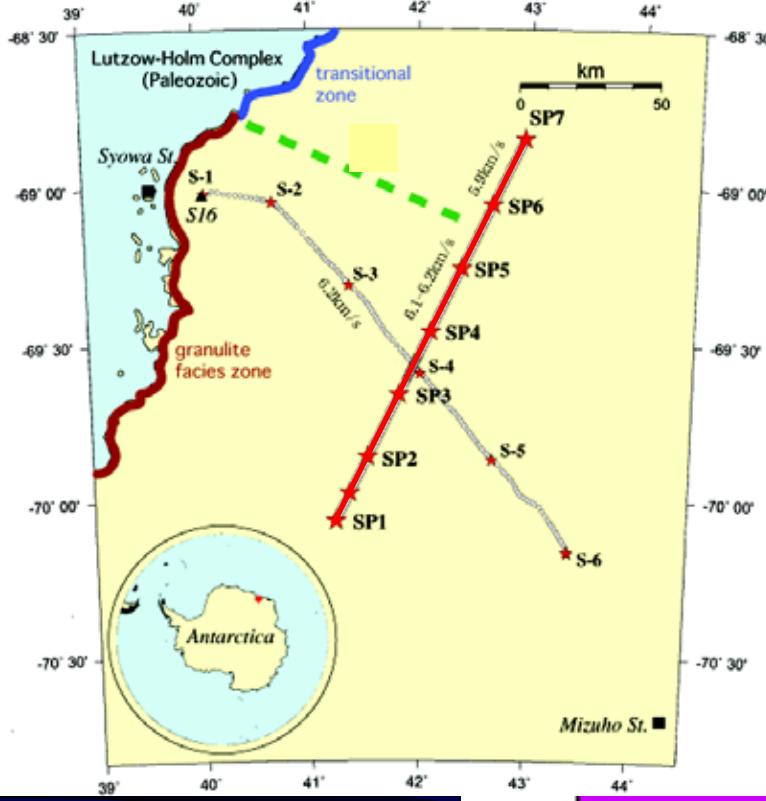
First arrival analyses (SEAL-2002)



Miyamachi et al. 2003

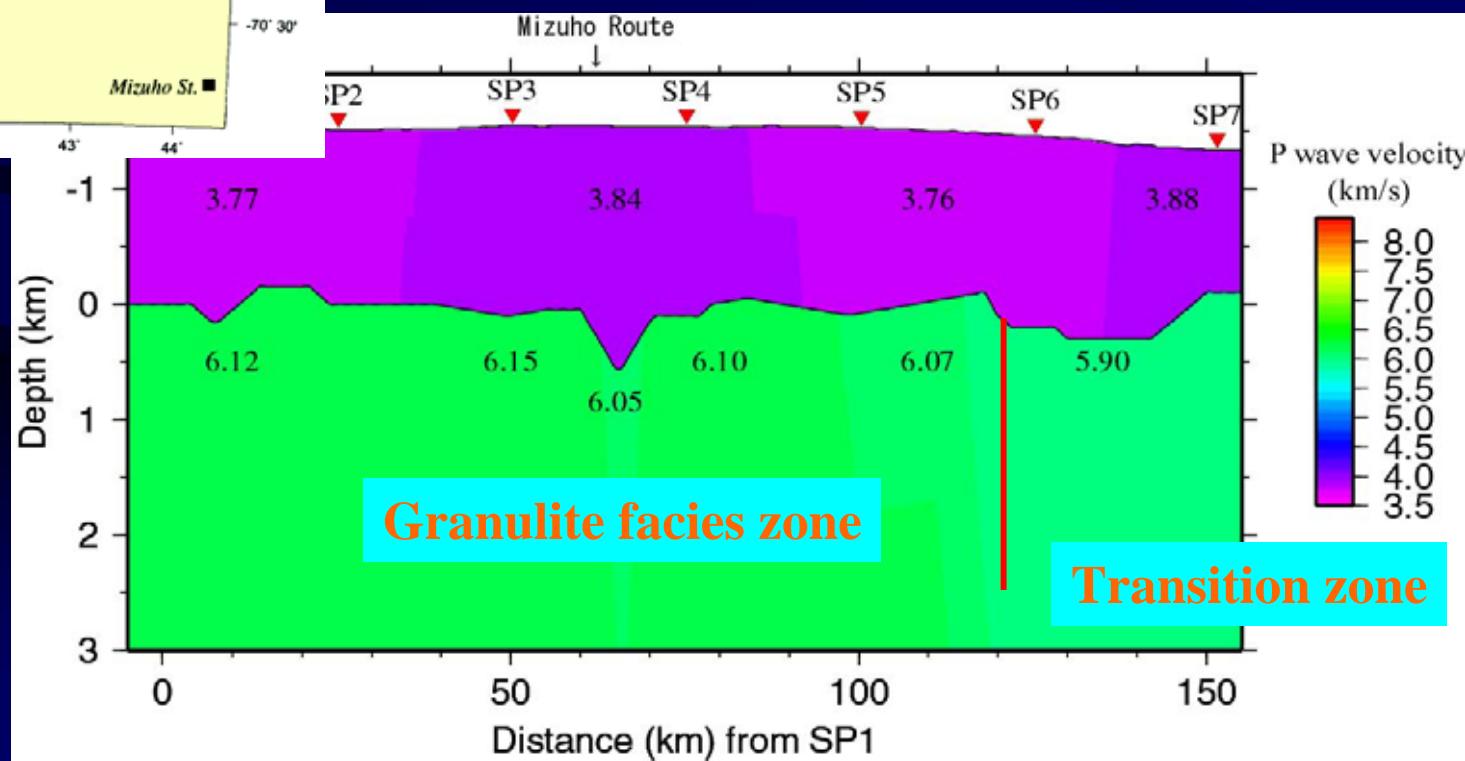


Ice sheet velocities

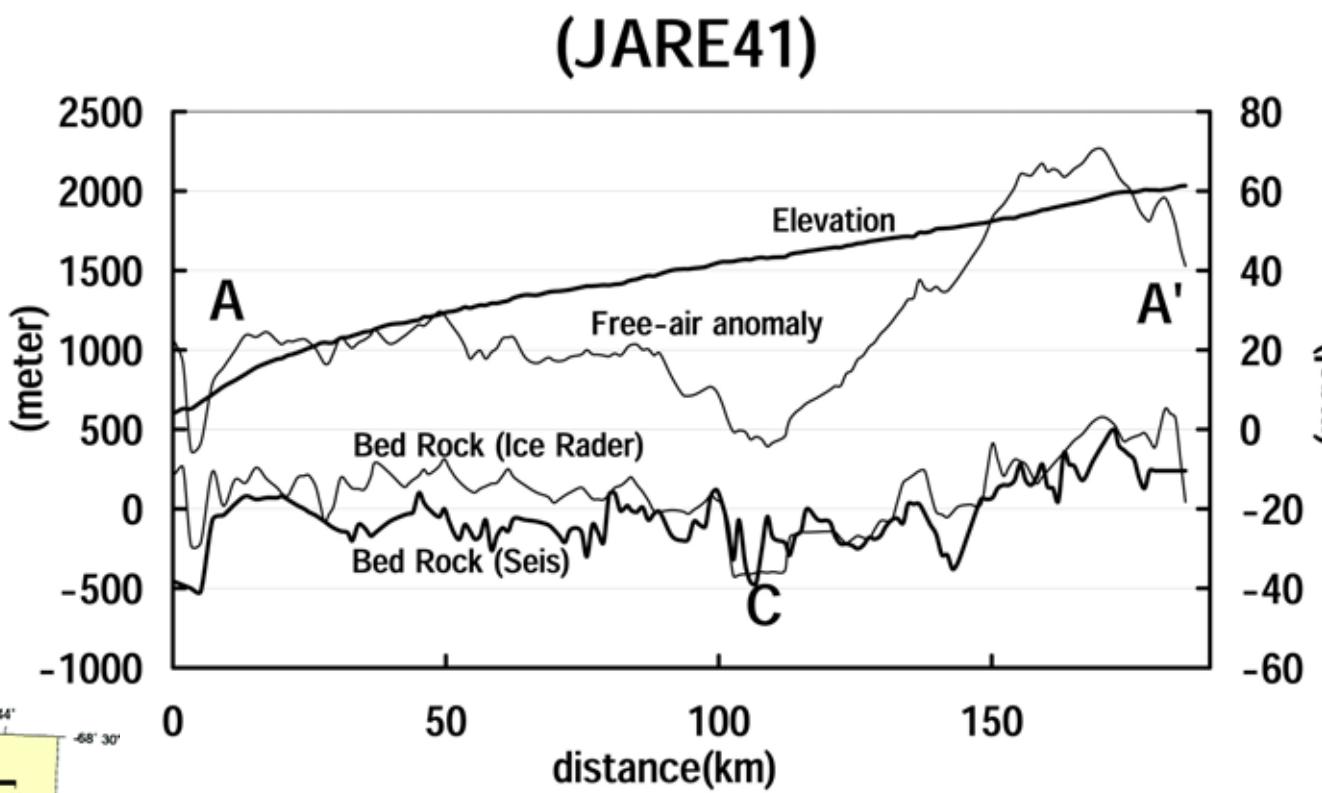
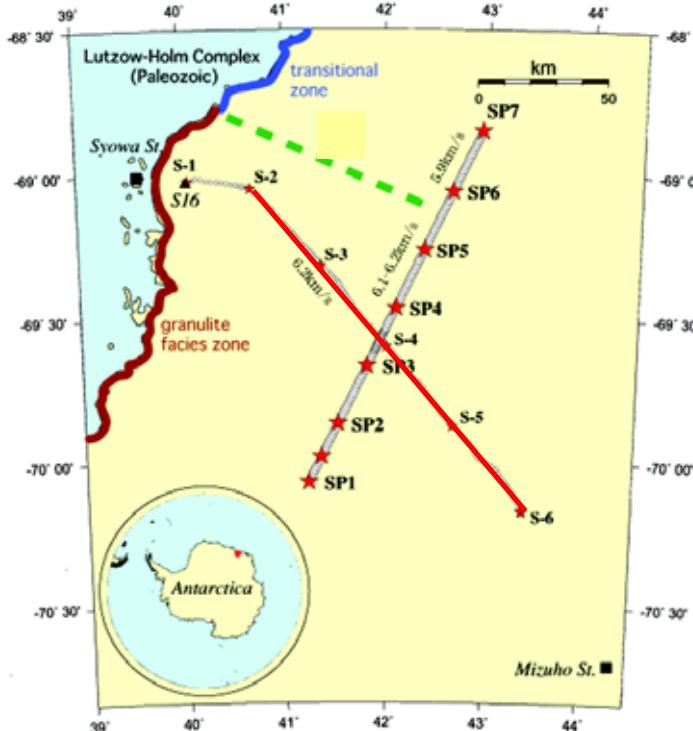


Velocities of ice sheet & topmost crust (SEAL-2002)

Miyamachi et al. 2003

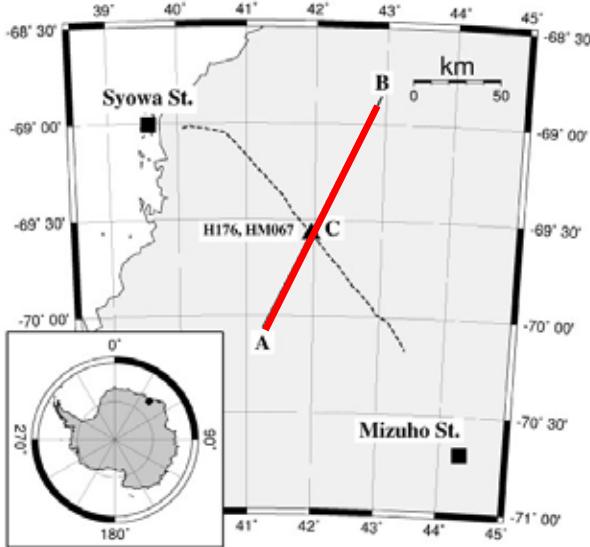


Bedrock topography

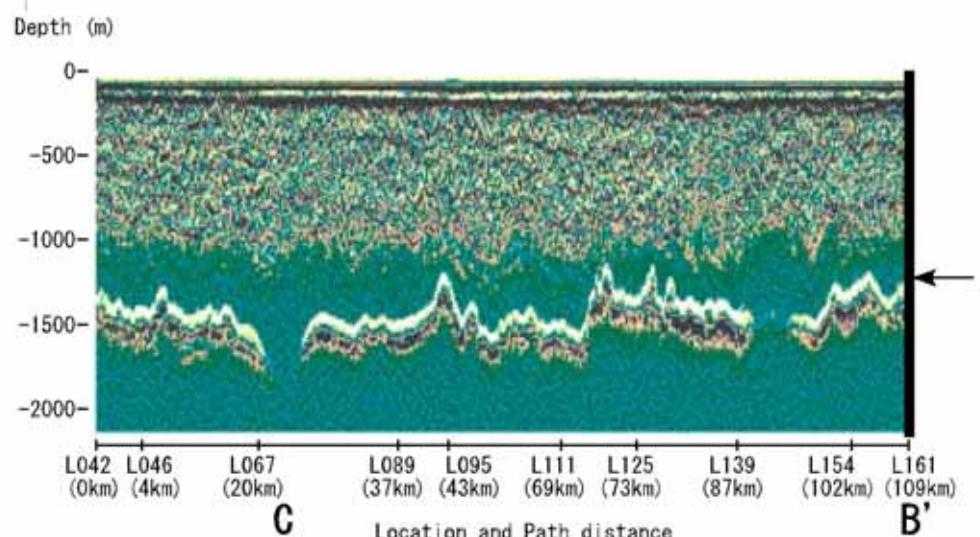


Toda et al. 2003

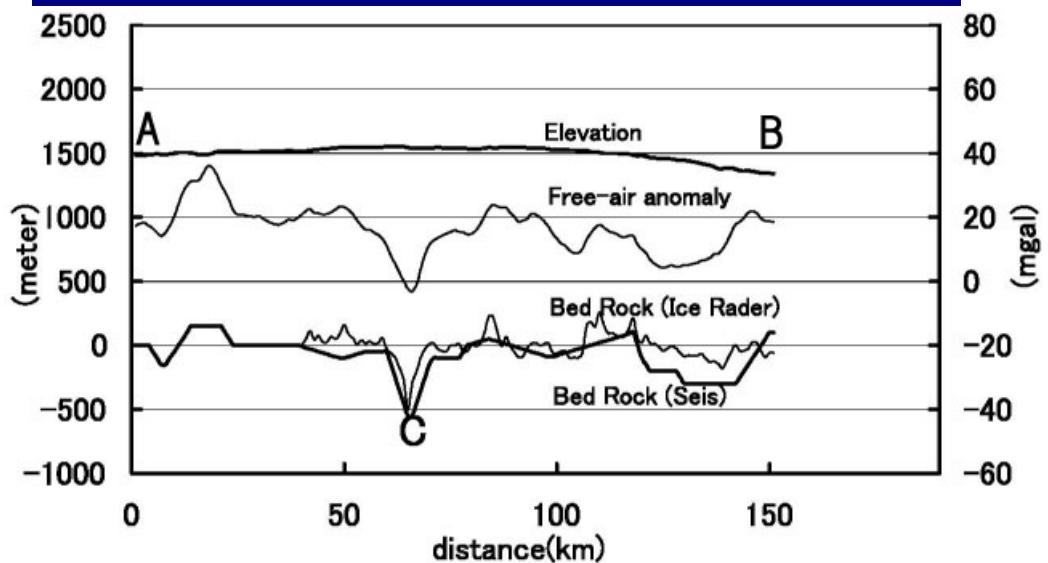
Radio echo soundings + Gravity
(SEAL-2000)



Bedrock topography (SEAL-2002)



Radio echo soundings + Gravity



Takada et al. 2003, Toda et al., 2004

Response from valley structure

(SEAL-2002)

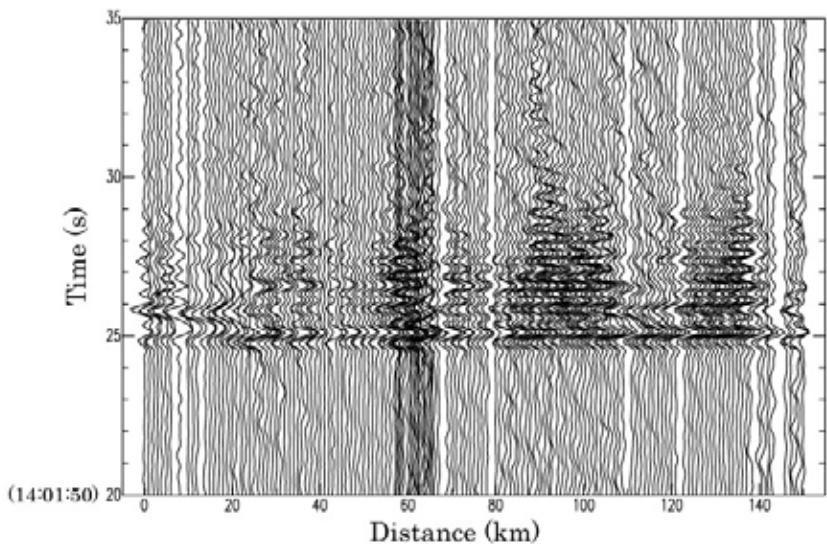


Fig. 7a Yamada, Kanao & Yamashita

*Kermadec Is. Earthquake
Depth=437*

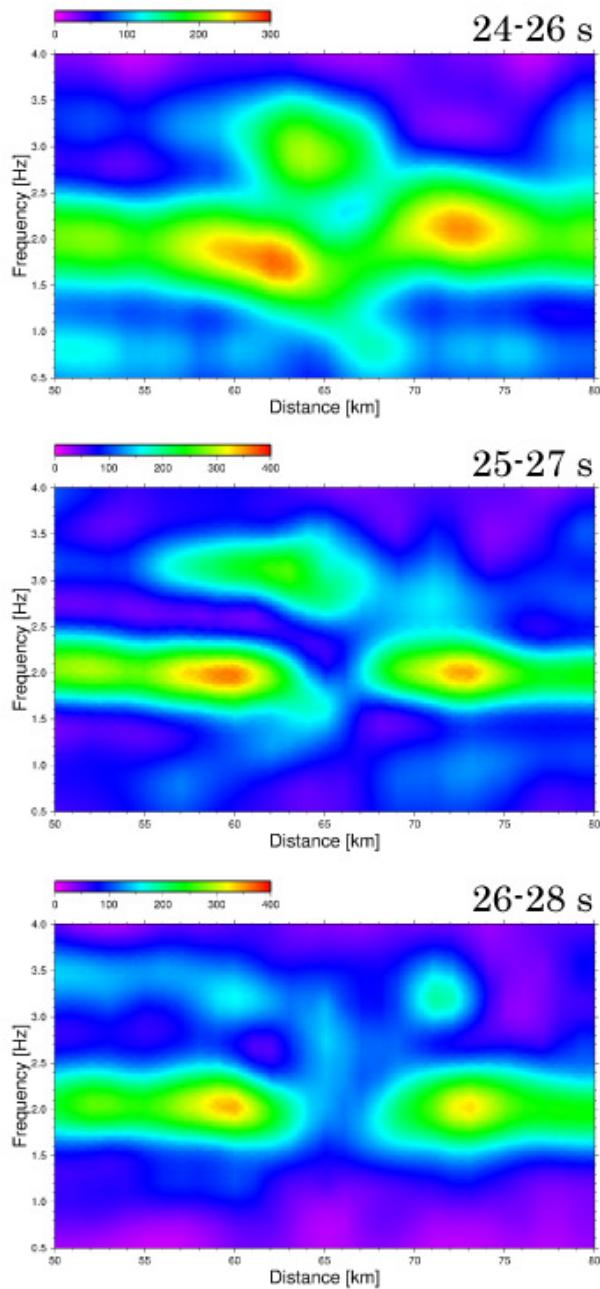


Fig. Yamada et al. 2004

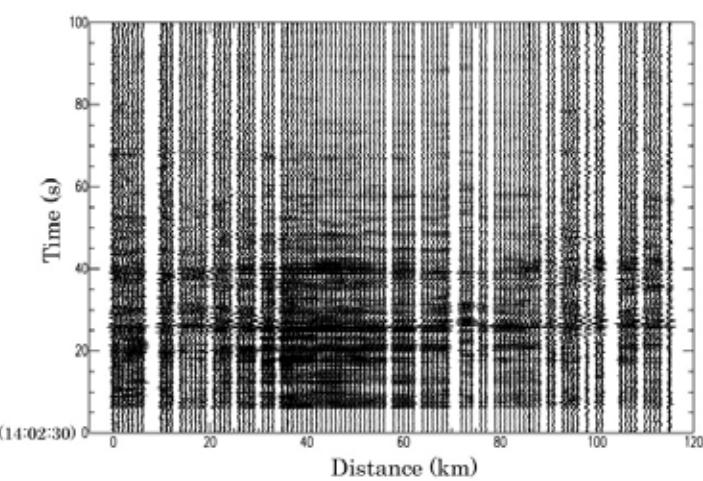


Fig. 5 Yamada, Kanao & Yamashita

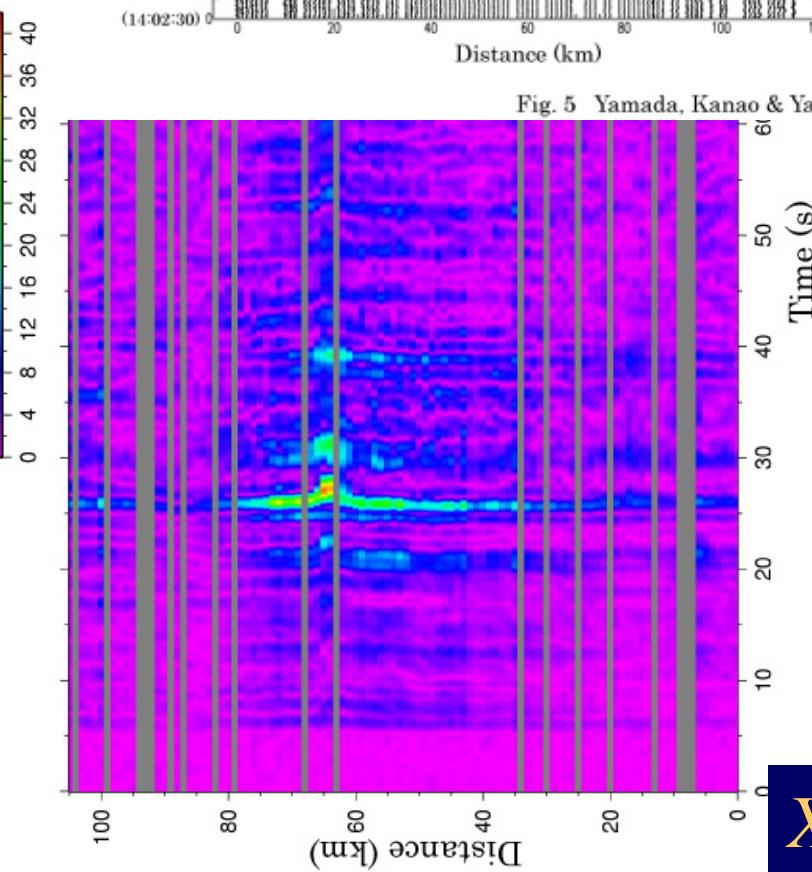
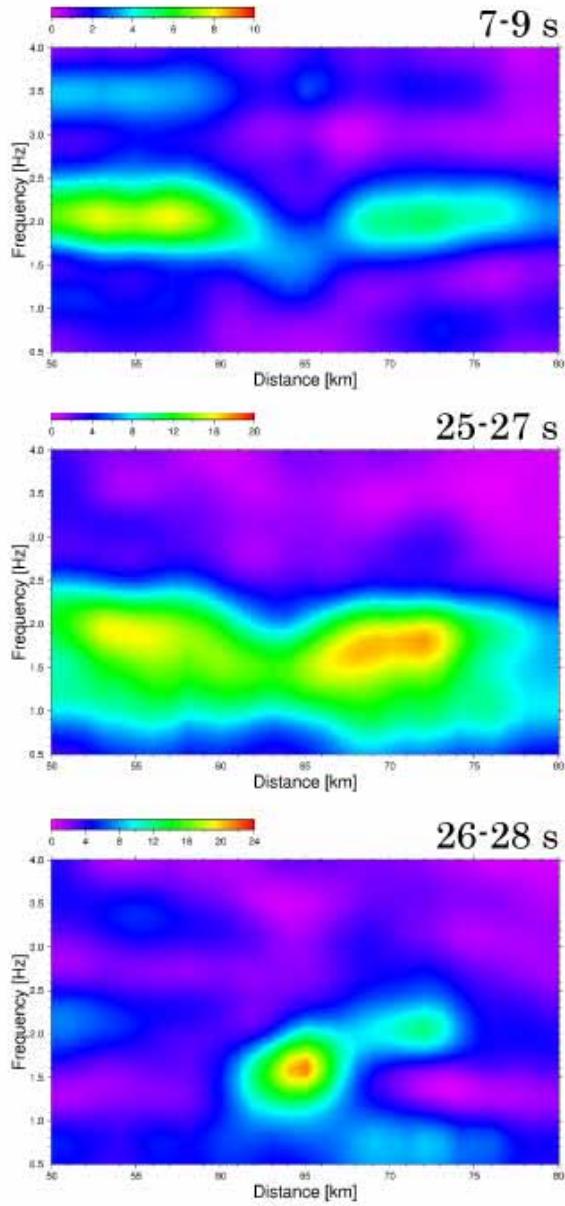


Fig. 6



X-phases, Around Antarctic event ?

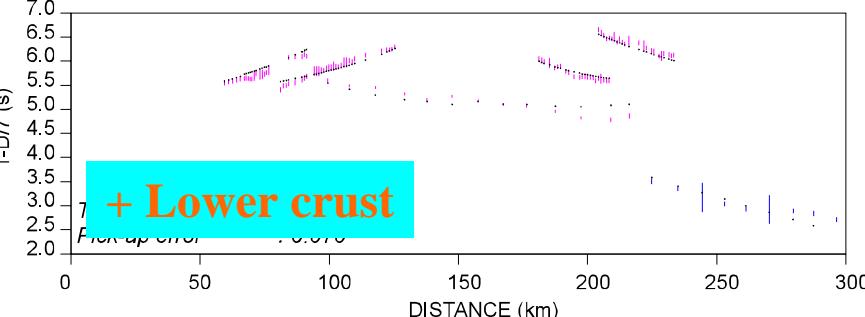
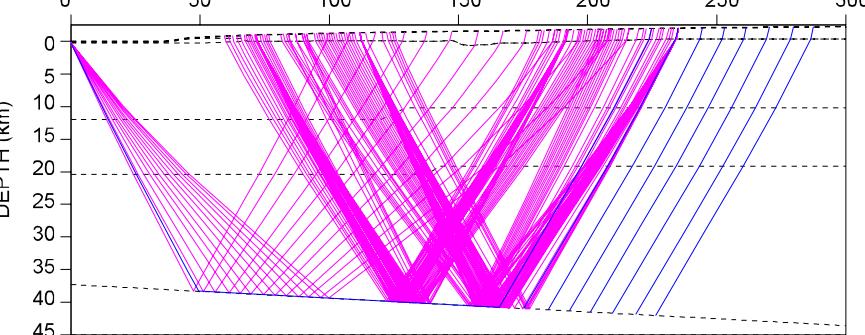
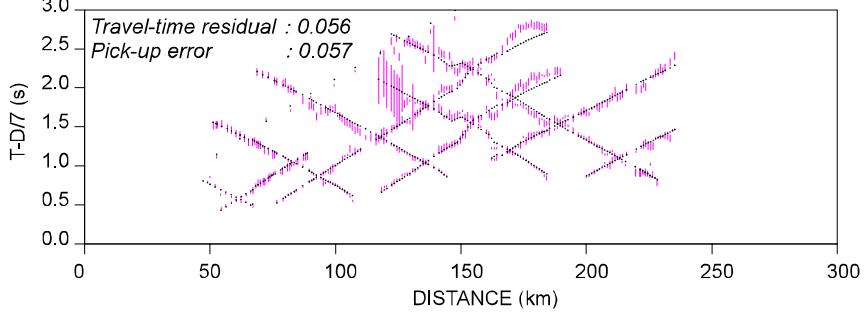
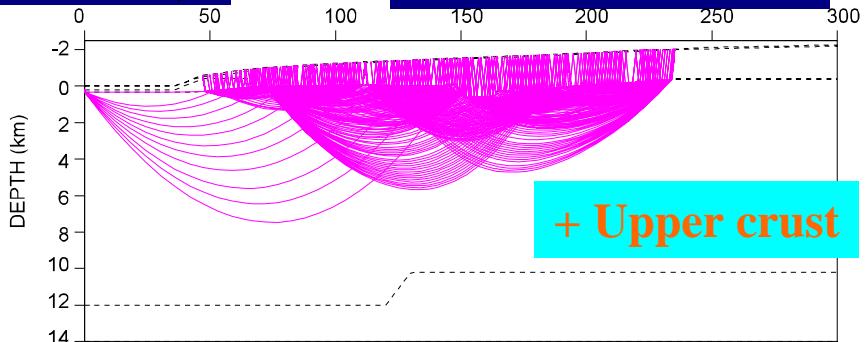
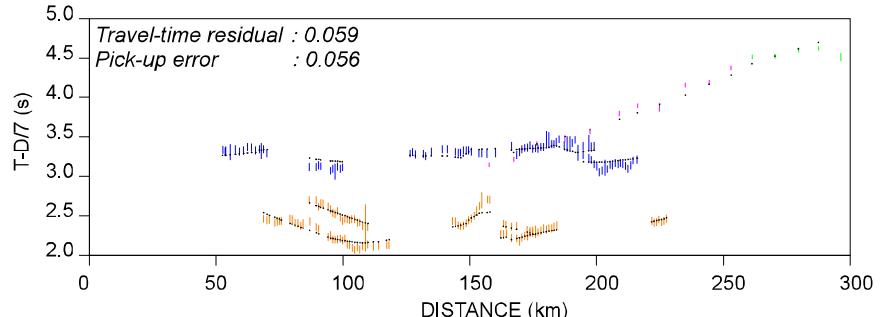
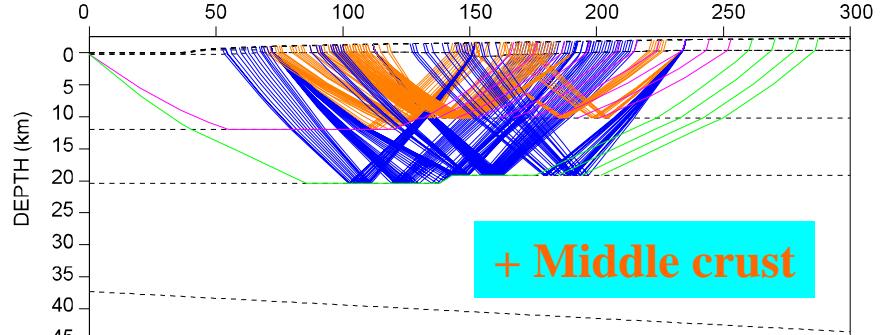
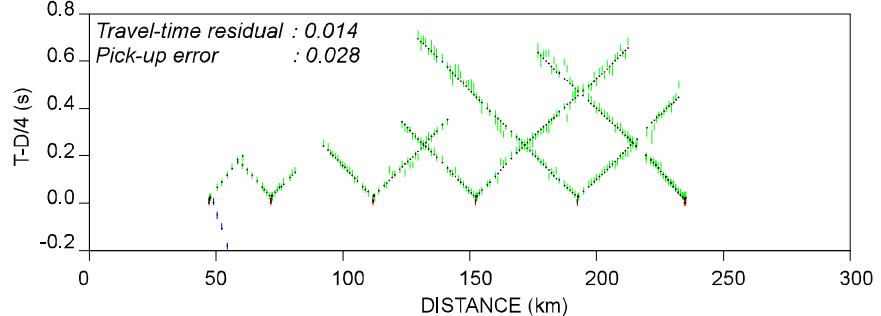
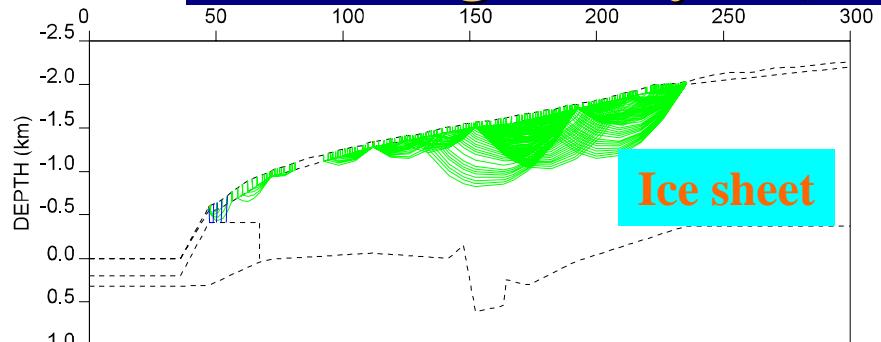
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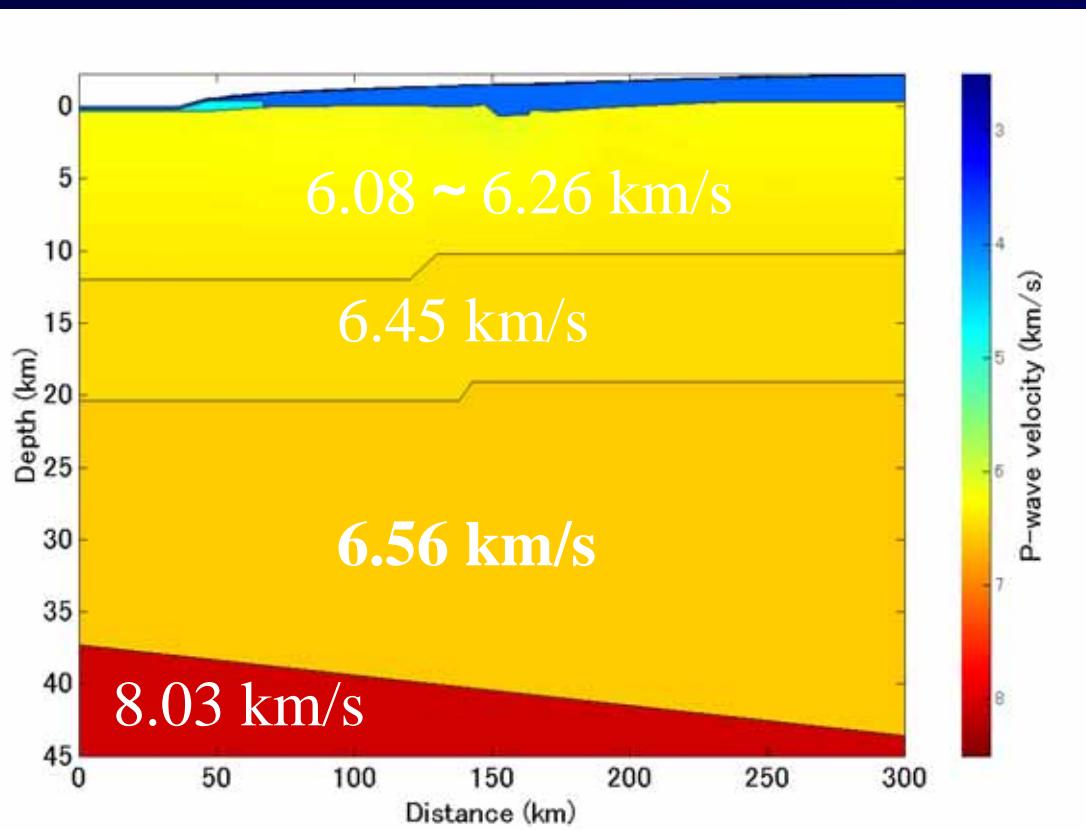
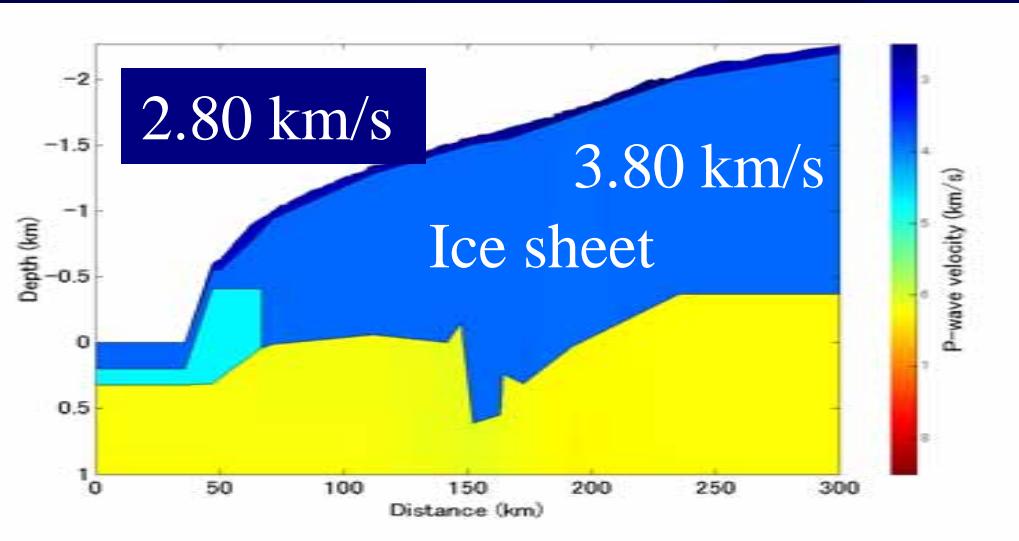
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 - wide-angle, reflection, gravity
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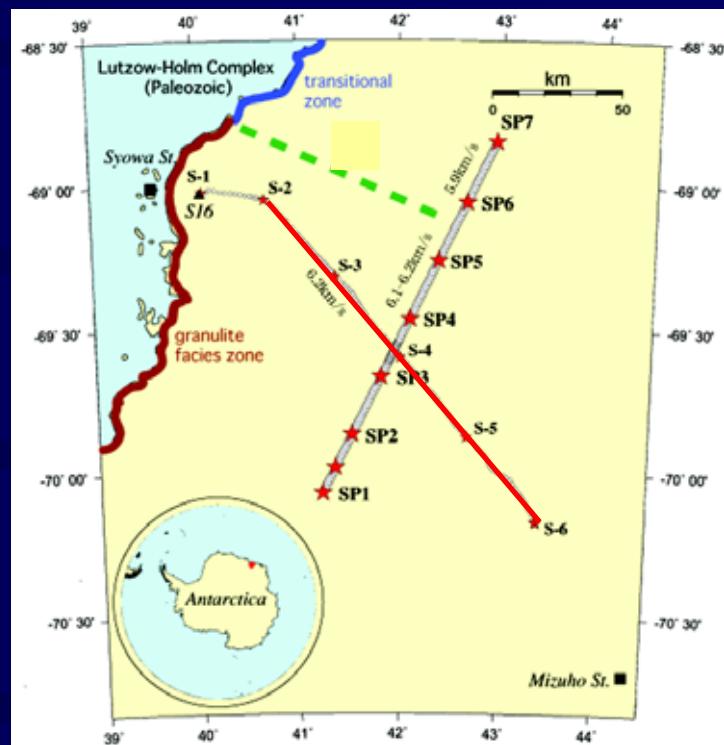
Wide-angle analysis (SEAL-2000)

Yoshii et al., 2004



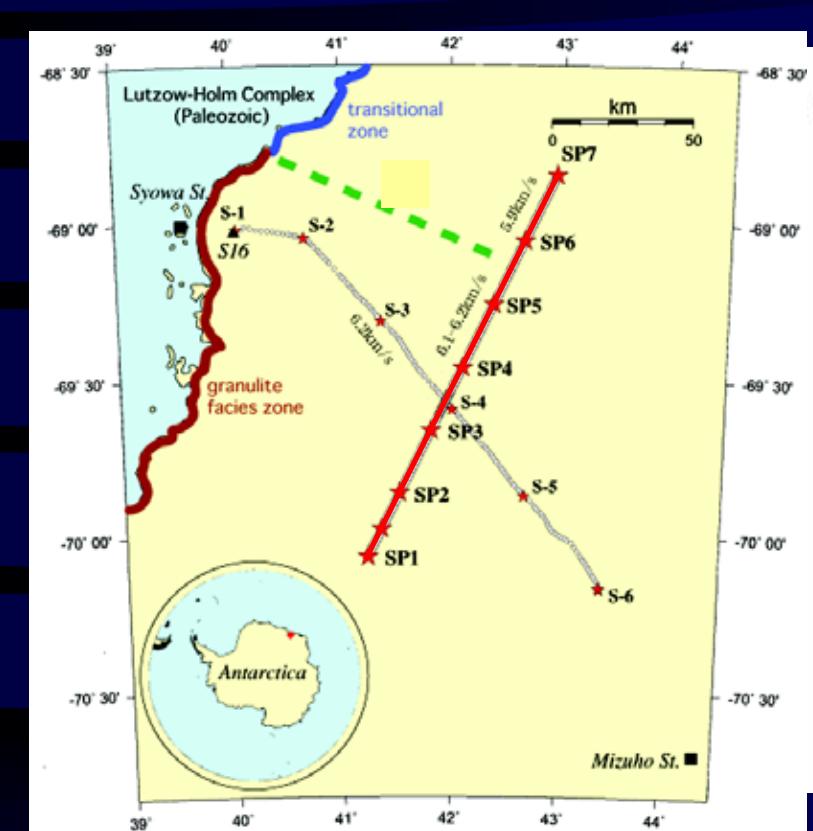


SEAL-2000, Mizuho routes

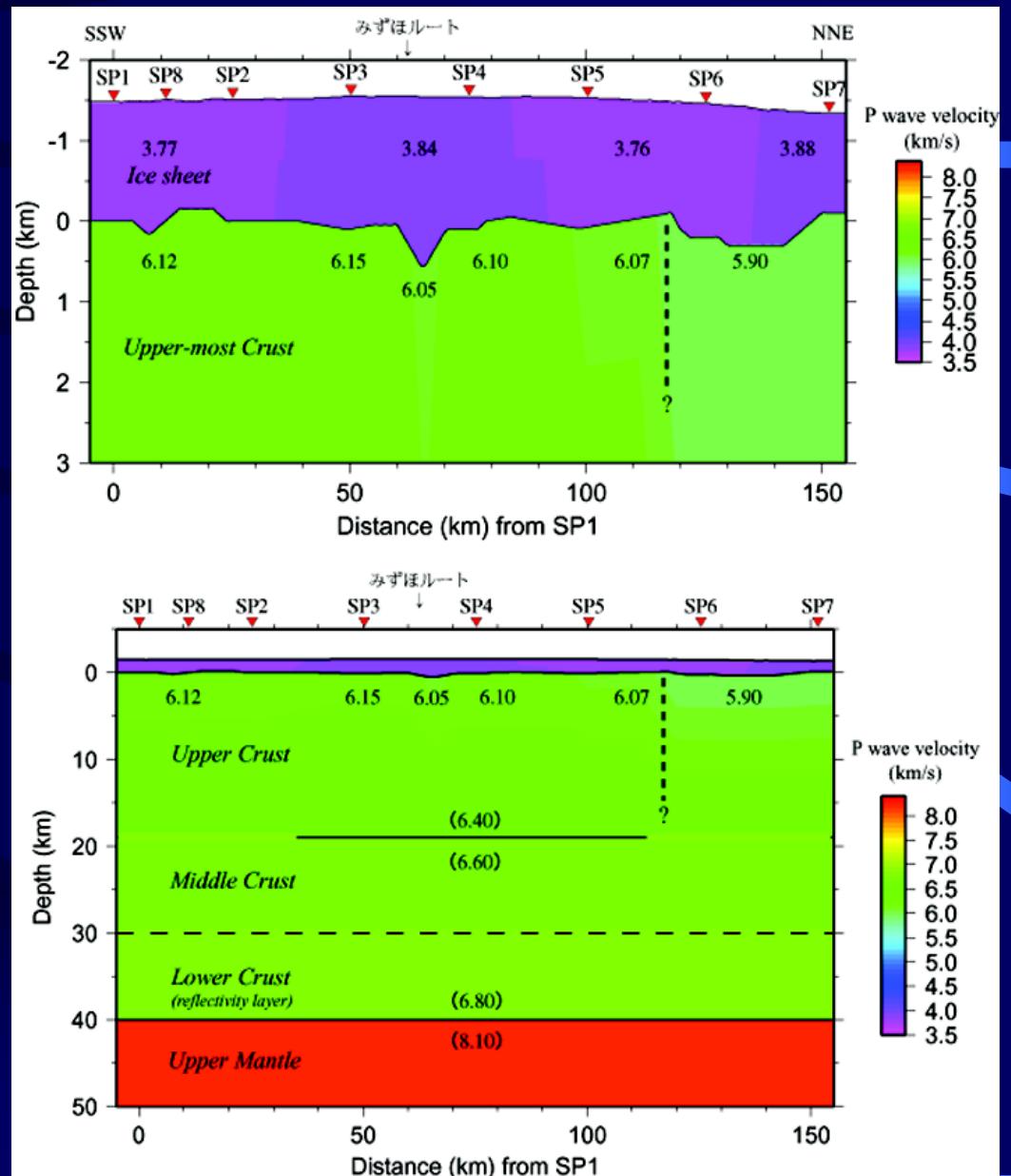


Crustal velocity model
DSS wide-angle
(Yoshii et al., 2004)

Wide angle analysis (SEAL-2002)

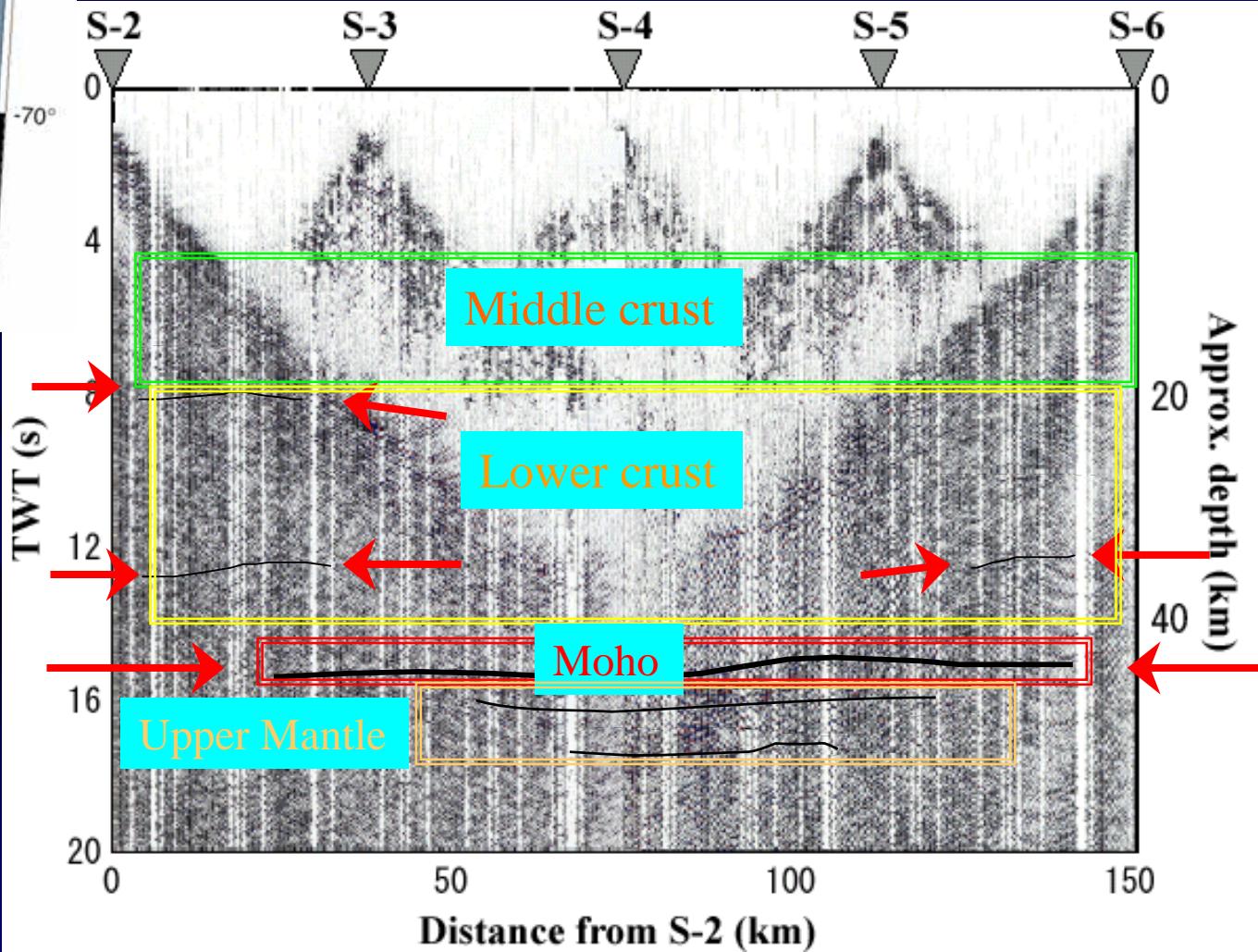
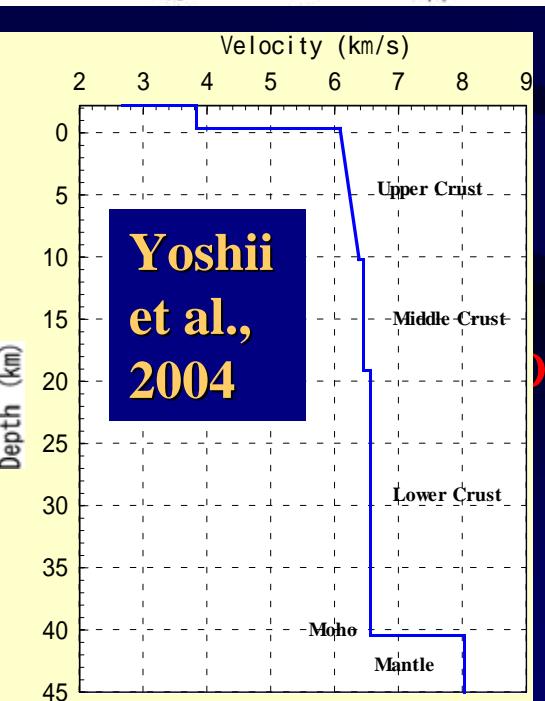
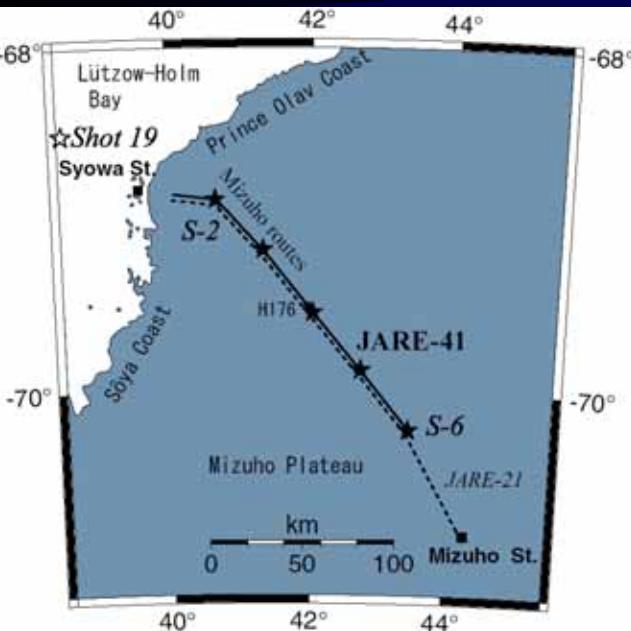


Miyamachi et al. 2003

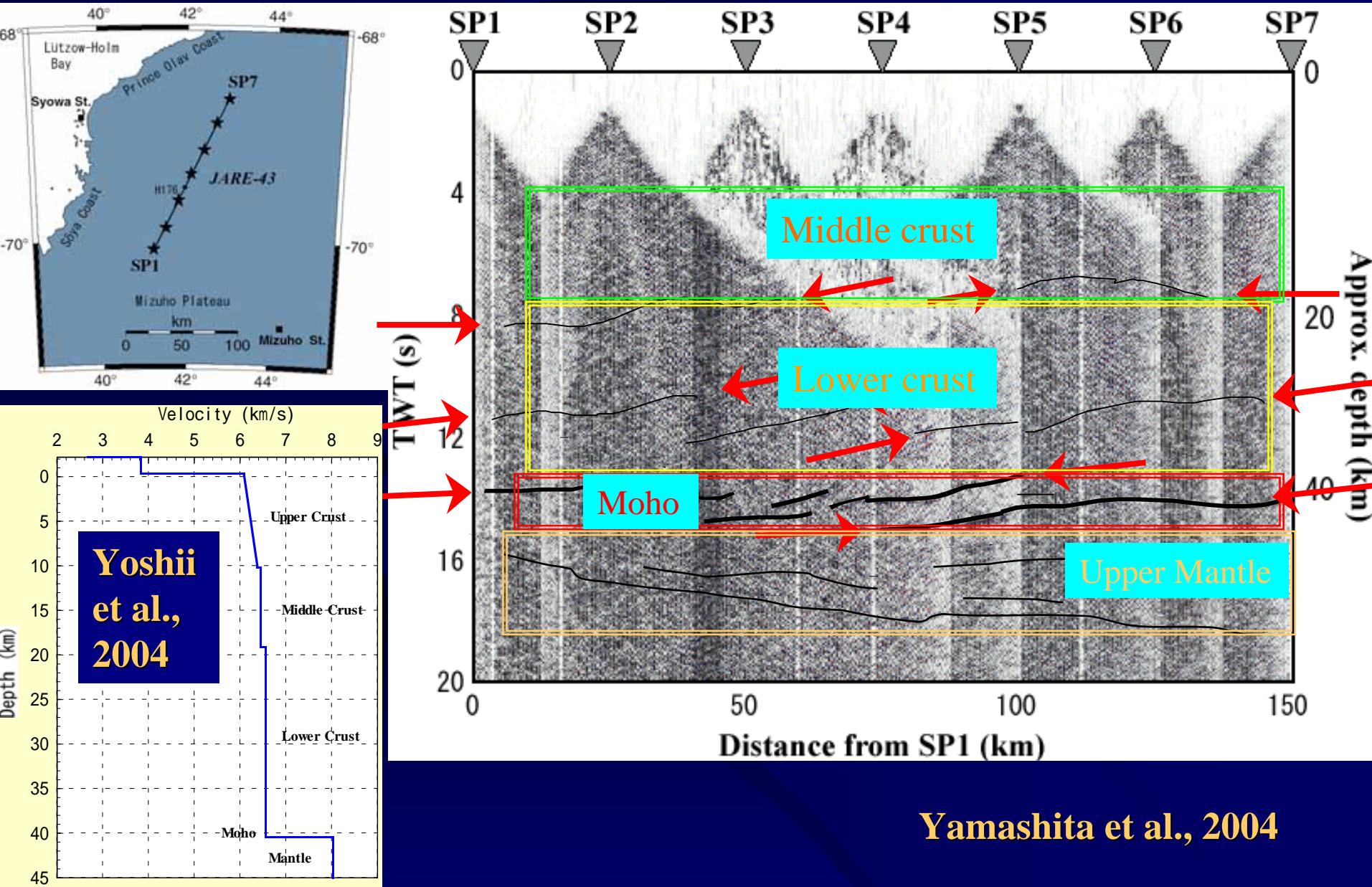


Migrated Reflection Section (SEAL-2000)

Yamashita et al., 2004



Migrated Reflection Section (SEAL-2002)



Yamashita et al., 2004

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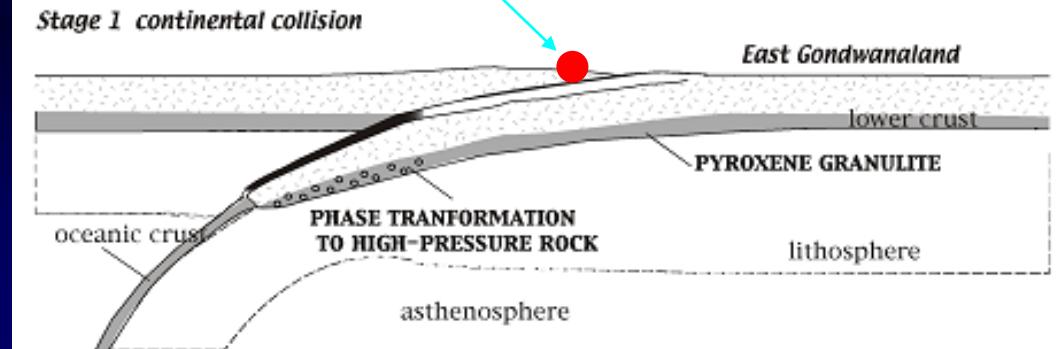
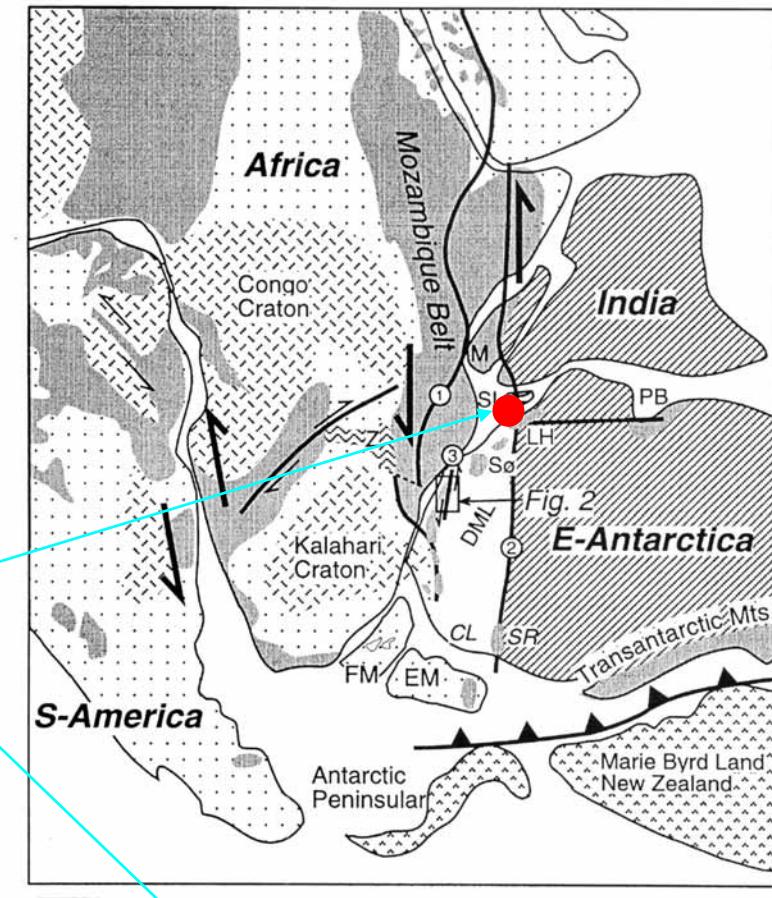
Tectonic evolution of Pan-African orogeny (550 Ma)

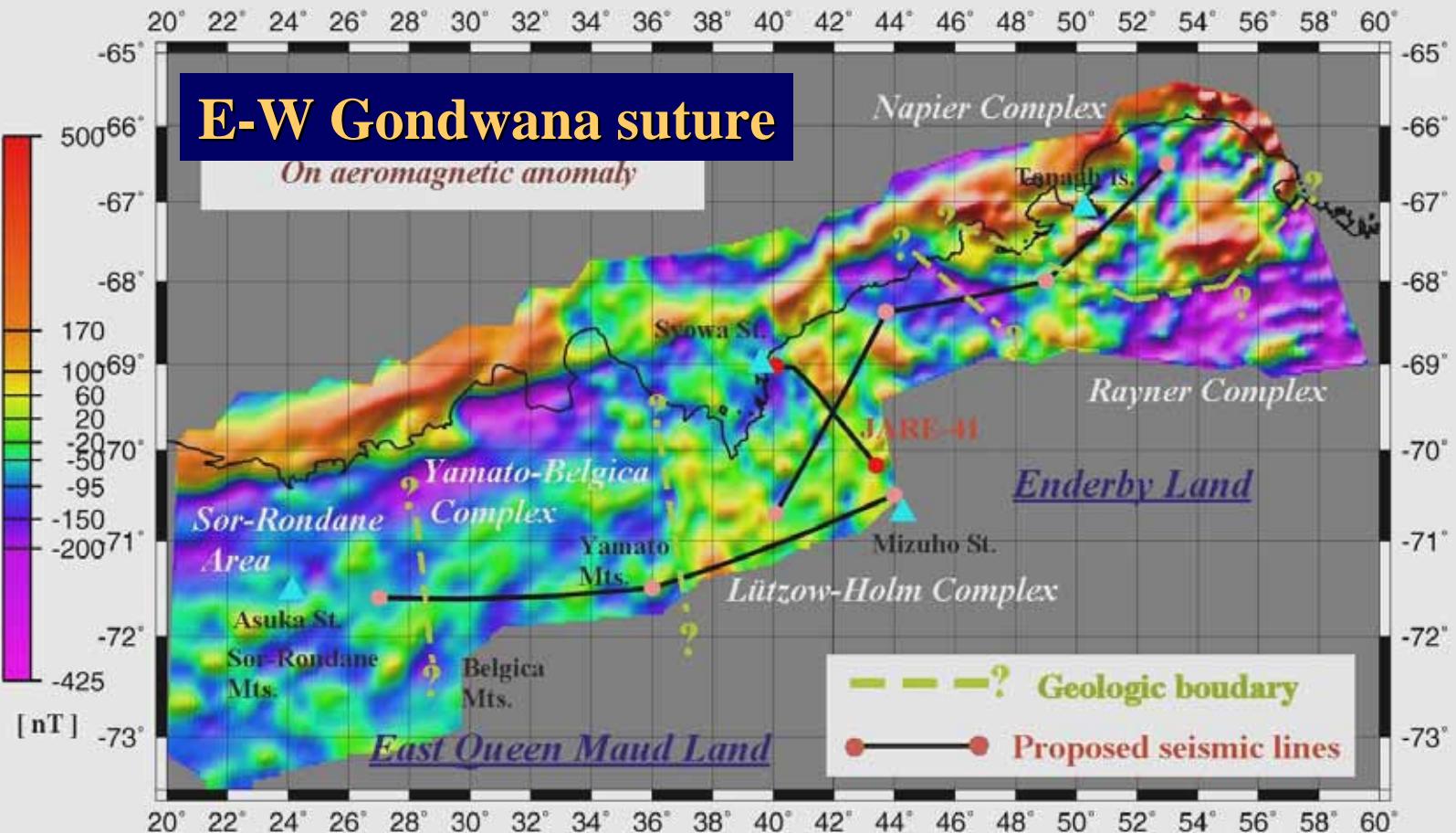
E-W Gondwana suture

Jacob (2002)

Ishikawa and Kanao (2002)

LHC



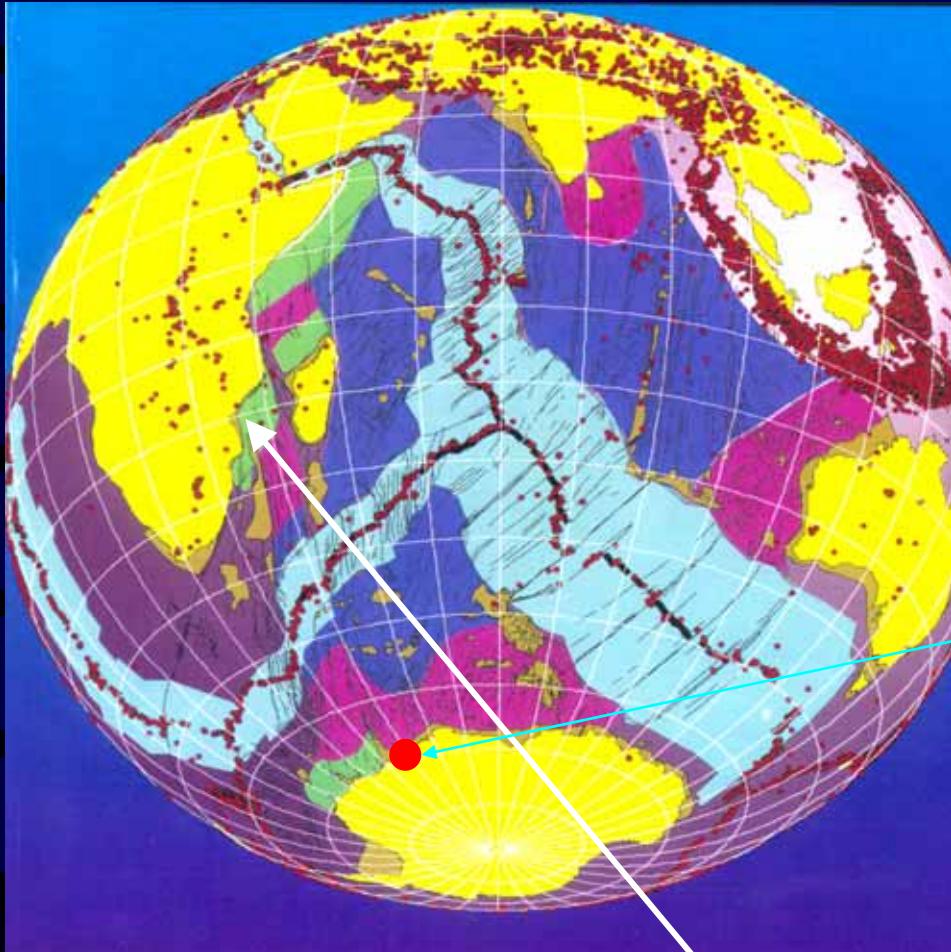


Geological setting and proposed seismic lines in Eastern Dronning Maud Land - Western Enderby Land, on aeromagnetic anomalies (Golynsky et al., 1996).

Breakup of Gondwana (150 Ma)

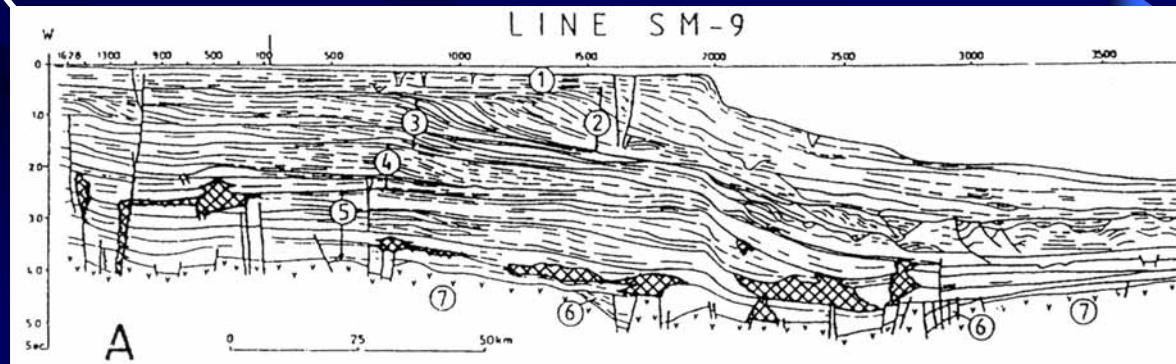
LHC

Mozambique Basin

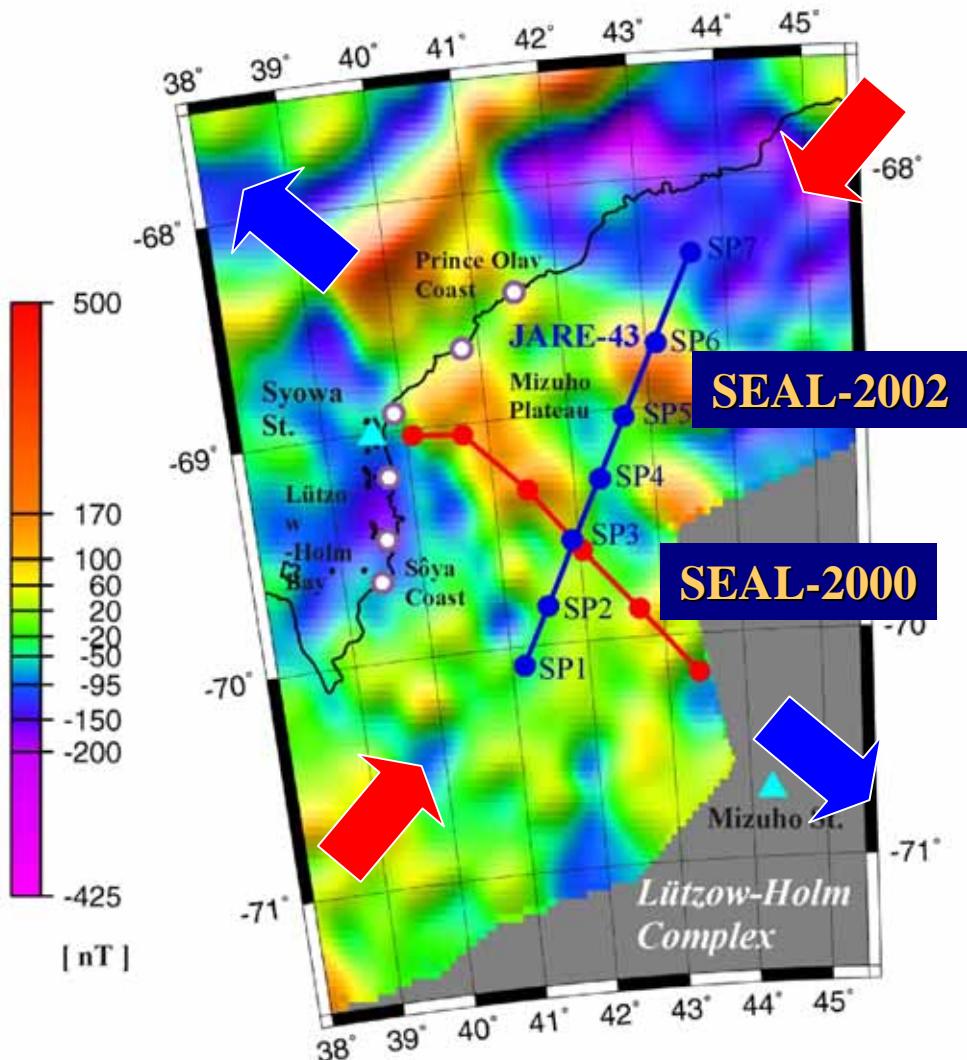


Reeves and DeWitt (2000)

Salman and Abdula (1995)

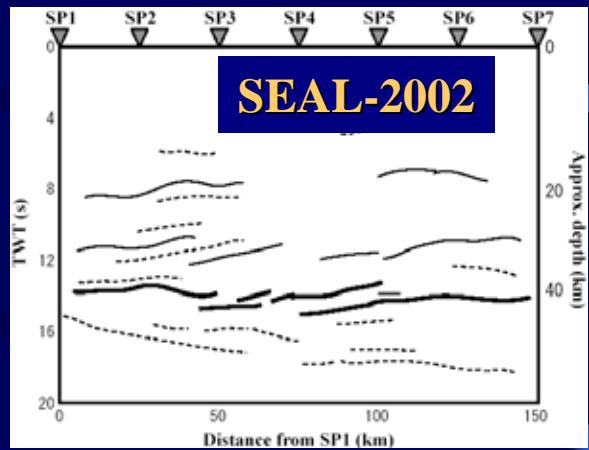


Tectonic interpretation for the reflectivity in LHC

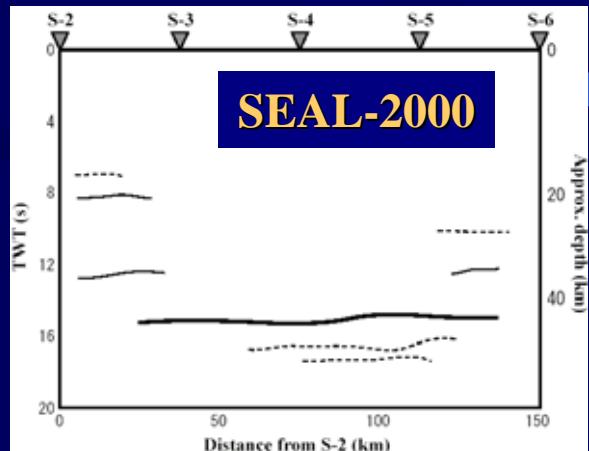


on aeromagnetic anomalies (Golynsky et al., 1996)

NE-SW compression
At Pan-African ?



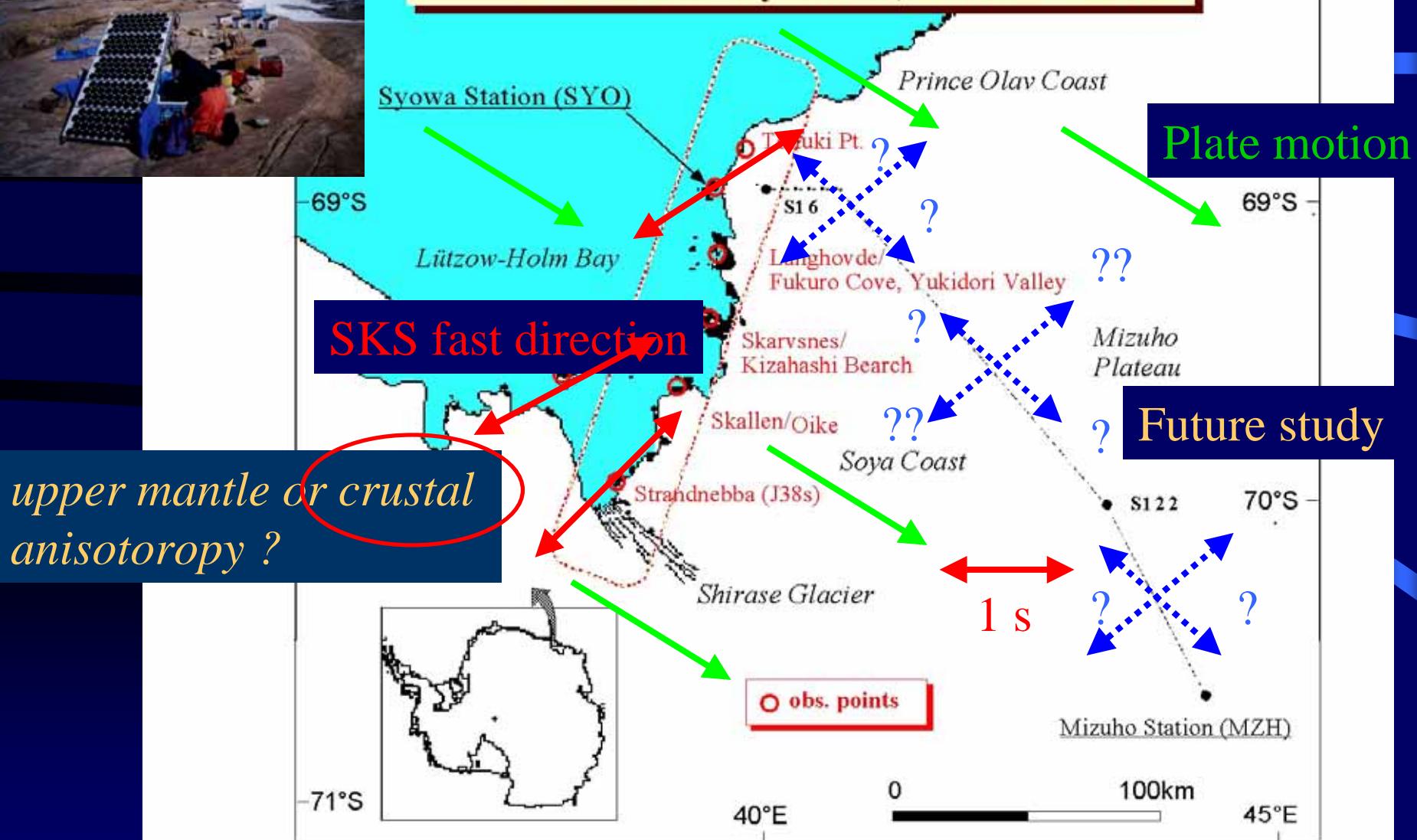
NW-SE extension
At Breakup ?



Shear wave (SKS) splitting

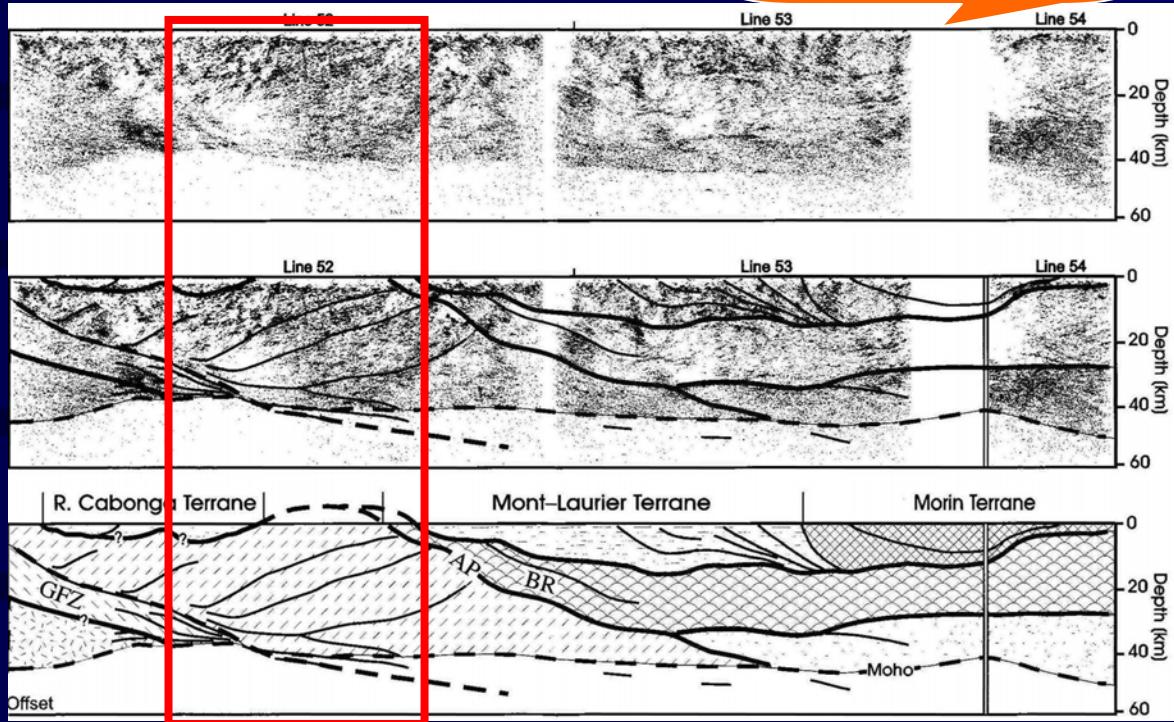
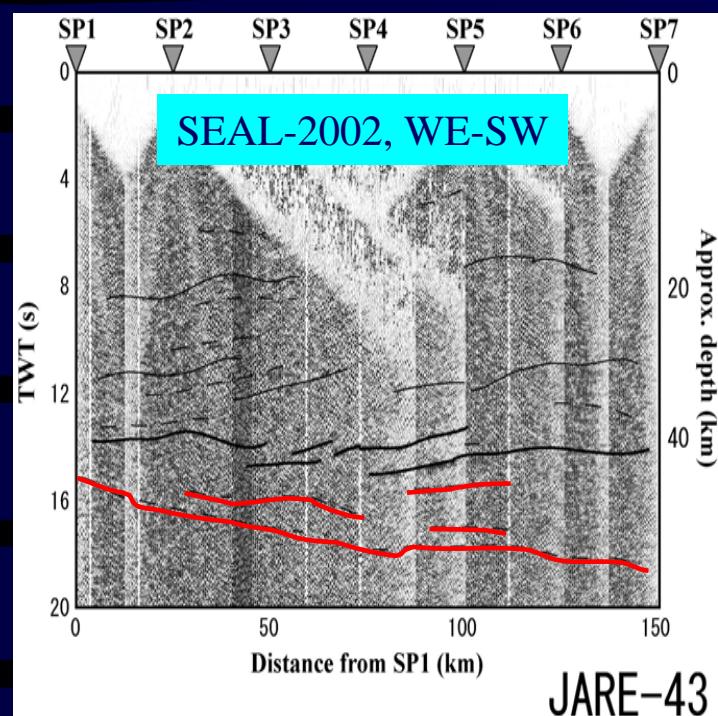


Large-span broadband seismic array observations around the Soya Coast, East Antarctica



Reflectors in the upper mantle ?

Mont-Tremblant



LHC, East Antarctica

When the reflectors have low velocities;

- Delaminated continental lower crust (Pan-African collision, W-block)
- Shear zones in the continental lithosphere (maybe Pan-African age ?)

When the reflectors have high velocities;

- Subducted fragments of eclogitic oceanic crust (Pan-African, early stage)
- Underplated mantle materials (Breakup in mid-Mesozoic, or Pan-African)

CONCLUSIONS

Deep structure and tectonic evolution of the Pan-African belt, the LHC were investigated by active seismic surveys on continental ice sheet by SEAL program.

Wide-angle travel-time analyses revealed Moho depths ranging in 38-42 km, with velocities of upper, middle, lower crust and uppermost mantle, as 6.2, 6.4, 6.5 and 8.0 km/s, respectively. (Not so high in the lower crust -> felsic granulites ?)

Travel-time analyses along the SEAL-2002 profile obtained a gradual increase in velocities from 5.9-6.2 km/s on the topmost crust: which agree with the metamorphic grade along the coast (NE amphibolite to SW granulite facies).

Complicated crustal structure by reflection section of SEAL-2002 indicate the influence of compression stress in NE-SW direction during Pan-African event; when the last stage of continent-continent collision between E-W Gondwana.

On the contrary, fairly flatter structure derived by SEAL-2000 suggests the existence of extensional stress in NW-SE direction presumably associated with breakup of Gondwana around 150 Ma.

Acknowledgements

- All members of Antarctic Expedition (JARE-40, -41, -42, -43)
- All crews of Icebreaker “Shirase”
- All staffs of Polar Institute, & related Seismologists
- Ministry of the Environment
- Ministry of Land, Infrastructure and Transport