The lithosphere of the Appalachian orogen and the Atlantic passive margin: A seismological perspective

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van de Schootbrugge et al. (2009)
The big picture...

Yuan et al. (GJI, 2011)

Bedle and van der Lee (JGR, 2009)
Constraining the lithosphere-asthenosphere boundary

Combined inversions of Ps and Sp converted waves:

- 5.3-7.4%
- 6.0-9.6%
- < 5-11 km

Rychert et al. (Nature, 2005 & JGR, 2007)
North America
Sp Discontinuity Depth
Abt et al. (JGR, 2010)
Ford et al. (in prep)
North America

- Dominant Sp period ~ 10 s
- Sharp LAB beneath younger continent:
  \( H < 30-40 \text{ km} \)
  Best fits <= 20 km
  Volatiles or melt in asthenosphere
- No cratonic LAB phase:
  \( H > 50-60 \text{ km} \)
  Consistent with purely thermal gradient
Orogenic processes

- What expression of collisional processes exists in the mantle lithosphere beneath the Appalachians?
- Are crustal terranes and sutures connected to mantle features?
- How do these relationships constrain models of lithospheric deformation during collision?
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Laurentia

Iapetan

Peri-Gondwana

(Cook and Vasudevan, 2006)

(Cook and Vasudevan, 2006)

(Hibbard et al., 2010)

(Hibbard, 2009 EarthScope Science Plan Workshop)
Example from Canadian Shield

Bostock (1998)
Cook et al. (1997)
Orogenic processes

- What expression of collisional processes exists in the mantle lithosphere beneath the Appalachians?

- Look for:
  - Dipping reflectors
  - Lateral changes in velocity, attenuation
  - Gradients in anisotropy
  - Offsets in LAB depth
Rifting/Passive margin processes

- What expressions of rifting processes remain in the mantle?
- Reactivation of orogenic structures?
- Given Mesozoic mafic magmatism, does a corresponding region of depleted, dehydrated, high viscosity mantle lithosphere exist?
- How do rifted continental and oceanic lithosphere compare?

Edge-driven convection? Offshore experiments needed!

van de Schootbrugge et al. (2009)
Southern California

Sp CCP Stack
Lekic et al. (Science, 2011)

• ~30 km of lithospheric thinning beneath Salton Trough and Inner Borderlands

• Lithospheric and crustal thinning very well-correlated with surface geology/deformation; vary over small length-scales

• High viscosity mantle lithosphere and localized strain
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NHSC
LAB 55 ± 6 km
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GOGA from NNW LAB 101 ± 18 km

GOGA from SSE LAB 64 ± 10 km

NHSC LAB 55 ± 6 km
South Georgia Rift Basin

101 ± 18 km
55 ± 6 km
64 ± 10 km

Knapp et al. White Paper
Longterm evolution of surface topography

- What are the relative roles of lithospheric buoyancy (crust and mantle) and sub-lithospheric density anomalies and flow?
- How have they evolved over time? Need record of erosion and uplift combined with geodynamic modeling.

Forte et al. (2010)
Forte et al. (2010)

Yuan et al. (2011)

(b) Depth = 220 km

(d) Depth = 670 km

Forte et al. (2010)
French et al. (2009)  
Fischer (2002)