Questions about rifting processes from variations in magmatism and structure along eastern North America

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Some key questions about continental extension and rupture

• What is the relationship between the style of rifting and the volume and timing of magmatism?

• What is the nature of the transition between magma-rich and magma-poor rifting?

• How do magmatism and deformation vary within and between segments?

• When does mature seafloor spreading occur?
after Withjack et al., 1998
Tankard and Welsink, 1988
The crust thins relatively abruptly, and the outer part of the margin primarily comprises new magmatic material.

Off the eastern US: magma is abundant...

Holbrook et al., 1994

Tréhu et al, 1989
High-velocity bodies at magmatic margins interpreted as mafic synrift underplates…

…although debate continues about volumes of new magma versus pre-existing crust

White et al., 2008

Hopper et al., 2003
after Withjack et al., 1998
Tankard and Welsink, 1988
The outer parts of the margin comprise wide regions of highly thinned crust and exposed, serpentinized subcontinental mantle.
“Wide” versus “narrow” rifting?

Gernigon et al., 2006
“Wide” versus “narrow” rifting?

- Common observation: magma-poor rifts are wider than magma-rich rifts

- Many magma-poor and magma-rich margins defy simple characterization as ‘wide’ or ‘narrow’

- Areas of the ENAM with comparable volumes of magmatism have variable thinning profiles and modes of deformation
Off Nova Scotia: a transition in magmatism
Off Nova Scotia: a transition in magmatism

...but the nature of this transition is not well-constrained by existing geophysical data.

Keen & Potter, Tectonophysics, 1988

Funck et al., JGR, 2004
Keen & Potter, Tectonophysics, 1988
Along-rift changes in magmatism can be abrupt.

Sharp along-strike change in magmatism over ~20 km

Eastern Black Sea, Cretaceous back-arc basin

Shillington et al., Geology, 2009
Emergence and evolution of tectonic and magmatic segmentation

Mid-ocean ridges

Rifts

Keranen et al., 2004
How does segmentation evolve from the initiation of rifting to the formation of a mature mid-ocean ridge?
Segmentation of the magmatic margin off the eastern US

Behn and Lin, JGR, 2000
In other highly magmatic settings, magmatism may overwhelm melt focusing mechanisms.
Segmentation of the magma-poor margin off Newfoundland

Van Avendonk et al., JGR, 2006

Van Avendonk et al. (2006); Chian et al. (1999)

Lau et al. (2006); Dean et al. (2000)
Are we there yet?
When does mature seafloor spreading begin?

• The most seaward mantle and/or magmatic rocks recovered off Newfoundland and Iberia show evidence for inheritance.

• Dating of magmatic rocks shows alternating alkaline and MOR magmatism at least 10 m.y. after first magnetic anomalies (Jagoutz et al., 2007)

• Wide-spread postrift magmatism until ~105-95 Ma
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Abrupt thinning of the crust with wide zone of thinned continental crust seaward

Van Avendonk et al., 2009
Examples of along-strike variability

**Gulf of California**

Lizarralde et al., *Nature*, 2007

**Newfoundland-Iberia**

Van Avendonk et al., *JGR*, 2006

Keen and Barrett (1981); Funck et al. (2003); Whitmarsh et al. (1996)

Van Avendonk et al. (2006); Chian et al. (1999)

Lau et al. (2006); Dean et al. (2000)
Tomographic inversion of seismic refraction data on SCREECH 2

Continental crust thinned to 25-27 km beneath Beothuk Knoll / Flemish Pass

Seismic velocity 7.0-7.5 km/s in lower crust beneath continental slope
Seismic velocity 5.5-6.5 km/s in crust of deep margin
Seismic velocity > 8.0 km/s in mantle of deep margin
Off the eastern US: magma is abundant...

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Tréhu et al, 1989