Rifting and Drifting in Eastern North America, et al.

ENAM - GeoPRISMS
Paul E. Olsen, October 27, 2011
1) History of Continental Rifting.

2) The CAMP LIP.

3) Earliest Atlantic Ocean Crust and Drifting.
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Pangea Rifting and CAMP
New York TriCarb Seismic  Line 1
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Tectonostratigraphic sequences in CAM basins
(modified after Olsen, 1997)
1) Most remnant ENA rifts are half graben, but prior to erosion they were much broader and probably interconnected over giant rift zone.

2) Oldest syn-rift strata Late Permian (post Variscan), verified in ENA only in Fundy rift. But no apparent age progression in onset of rifting evident.

3) There is a trend in termination, with youngest synrift strata being Late Triassic and pre-CAMP.
What We Don’t Know

1) Mechanism for initiating rifting and geometry of initial conditions.

2) How big and interconnected were the actual basins and sediments.

3) Why no rift volcanism for the entire stretch in Permo-Triassic.

4) What controls the tectonstratigraphic sequences.

5) Relation to the New England Coastal Province and White Mountain magmatism.

6) Why rifting turns off in southern rifting area.

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CAMP

Central Atlantic Magmatic Province

Massive exchange of materials among magma, the oceans and atmosphere.
Pangea Rifting and CAMP

- Continental Rift Zone without CAMP
- Continental Rift Zone with CAMP
- CAMP Outside Rift Zone
North Mountain Basalt, Fundy Basin, Nova Scotia, Canada
LIPs  **Large Igneous Provinces**
Areas and Volumes

McHone (2002)

Area $\sim 11 \times 10^6 \text{ km}^2$

Assuming half of the continental CAMP area was originally covered by 200 m of lava, the total volume of CAMP and ECMIP basalt exceeded $2.4 \times 10^6 \text{ km}^3$

Marzoli (1999)

Area $7 \times 10^6 \text{ km}^2$

Assuming that preserved volcanic sections averaging 200 to 300 m thick in distal portions of the CAMP are representative, an original volume of $2 \times 10^6 \text{ km}^3$ is implied.
Jourdan et al., 2009

- $^{40}$Ar/$^{39}$Ar ages; n=69 (corrected from $^{40}$K bias)
- ID-TIMS U/Pb age of the T-J limit
- ~1% $^{40}$K bias correction
- Late magmatic event
$^{206}\text{Pb}/^{238}\text{U}$

201.38$\pm$0.02

Schoene et al., 2010
Blackburn et al., 2011
McHone, 2002 adapted from Palais and Sigurdsson [1989].
Mantle Plumes

- Plume head
- Lithosphere
- Plume tail
- LIPs
- Upper mantle 670 km
- Lower mantle 2,900 km
- Outer core
- Inner core
CAMP IGNEOUS ROCKS

- Mafic Dike
- Continental Margin
- Basalt Wedge
- Province Boundary (?)

Area of Present-Day Basaltic Lavas or Sills

Approximate Hettangian Equator

Kilometers

0 250 500 750
Distribution of Mafic Dikes in the Southeastern US

NB: Newark Basin
GB: Gettysburg Basin
DB: Durham Basin
P: Pageland Dike
CC: Clubhouse Crossroads

from Ragland et al., 1983
Magellan Synthetic Aperture Radar (SAR) mosaics

Irnini Mons

Sapas Mons

50 km

http://www.geology.pomona.edu/research/Faculty/Grosfils/Venus/Volcano/large_volcanoes.htm
1) CAMP is most areally extensive continental LIP.

2) Duration of extrusion < 1 m.y. beginning at 201.4 Ma.

3) CAMP fed by giant radial dike swarm.

4) CAMP likely produced many short-lived massive S aerosol coolings and apparently fewer but much more prolonged CO$_2$-driven global warmings resulting in end-Triassic mass extinction.

5) Geometry and chemistry consistent with localized source in Florida-Bahama region – Dietz’s Bahama Nexus, plausibly a plume
What We Don’t Know

1) Its real origin: plume or non-plume.
2) Vertical or lateral feeding.
3) Concomitant geodynamic processes – uplift?
4) Mechanism of increased accommodation in rifts.
5) Continuity and duration of plumbing system and effects on heat flow.
6) Relation to cessation of rifting and inversion.
7) Relationship to Atlantic seafloor.
8) Present crustal and mantle inheritance.
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Blackburn et al, in prep
Trace Element Correlations (Deenen, 2010)

Dates from Blackburn et al. In prep.
Austin et al. 1990
Southeast US, Continental Margin

no vertical exaggeration at 4 km/s

Scottsville basin Richmond/Taylorsville basins

Hylas fault zone - border fault

Ordovician Taconic suture zone (?)

Baltimore Canyon trough

SDRs (Volcanic wedge?) near continent-ocean boundary

Branchville/Jedburg basins

Jurassic basalts

Post-rift unconformity

Continental crust

Oceanic crust

Salt, syn-rift or post-rift

Syn-rift

Modified from Withjack & Schlische, 2005
Age of initial Atlantic Ocean Crust and SDRs

TIME SCALES

- Gradstein et al., 1994
- Palfy et al., 2000

Modified from Benson, 2003 and Sheridan, 1980
Sierra Leone
Hot Spot

Schettino and Turco, 2009
1) Age of oldest Atlantic seafloor and SDRs unknown.

2) Chemistry of CAMP trends very rapidly, and exponentially, to ocean basalt.

3) Non-rifted basalt flows on South Georgia Rift may be related to SDRs even if j-reflector not reliable.

4) SDRs are plausible part of CAMP.

5) Both ECMA and BSMA may be conjugate sdrss, stranded by ridge jump.
What We Don’t Know

1) All of the above.