Diachronous Crustal Localization and Onset of Seafloor Spreading in the Central Atlantic: Application of Inverse Continuum-based Plate Reconstruction Methods

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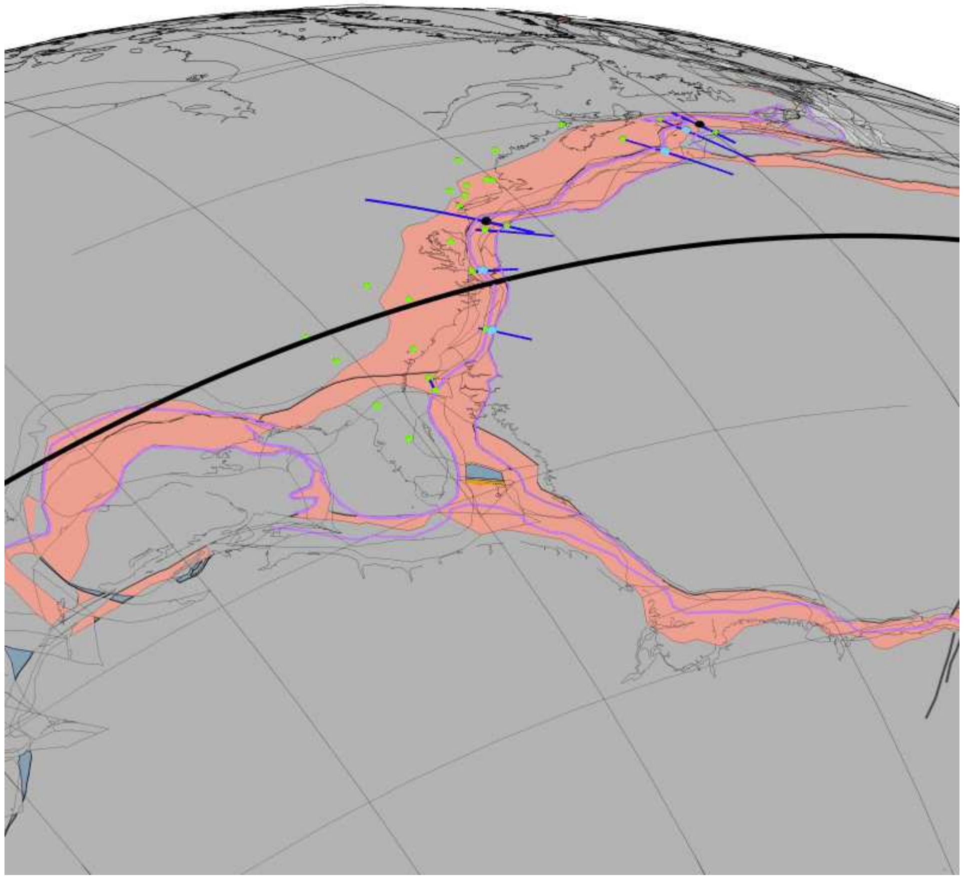
Summary

After decades of work, Central Atlantic plate reconstructions are still debated in the literature *(Schettino and Turco, 2009; Labails et al., 2010).*

The Central Atlantic imposes important boundary conditions on the Mesozoic evolution of the Gulf of Mexico

240.00 Ma Fixed Plate = 101



New Basement Type Maps

- Published reflection and refraction data, potential field data and field observations

Refined Tight-fit Pangaea Reconstruction

- Palinspastic restoration of crustal thickness grid constrained by refraction and receiver functions (e.g. Dunbar and Sawyer, 1989)

Rift to drift kinematics based on 3D non-rigid continuum plate models and linking ECMIP and CAMP events

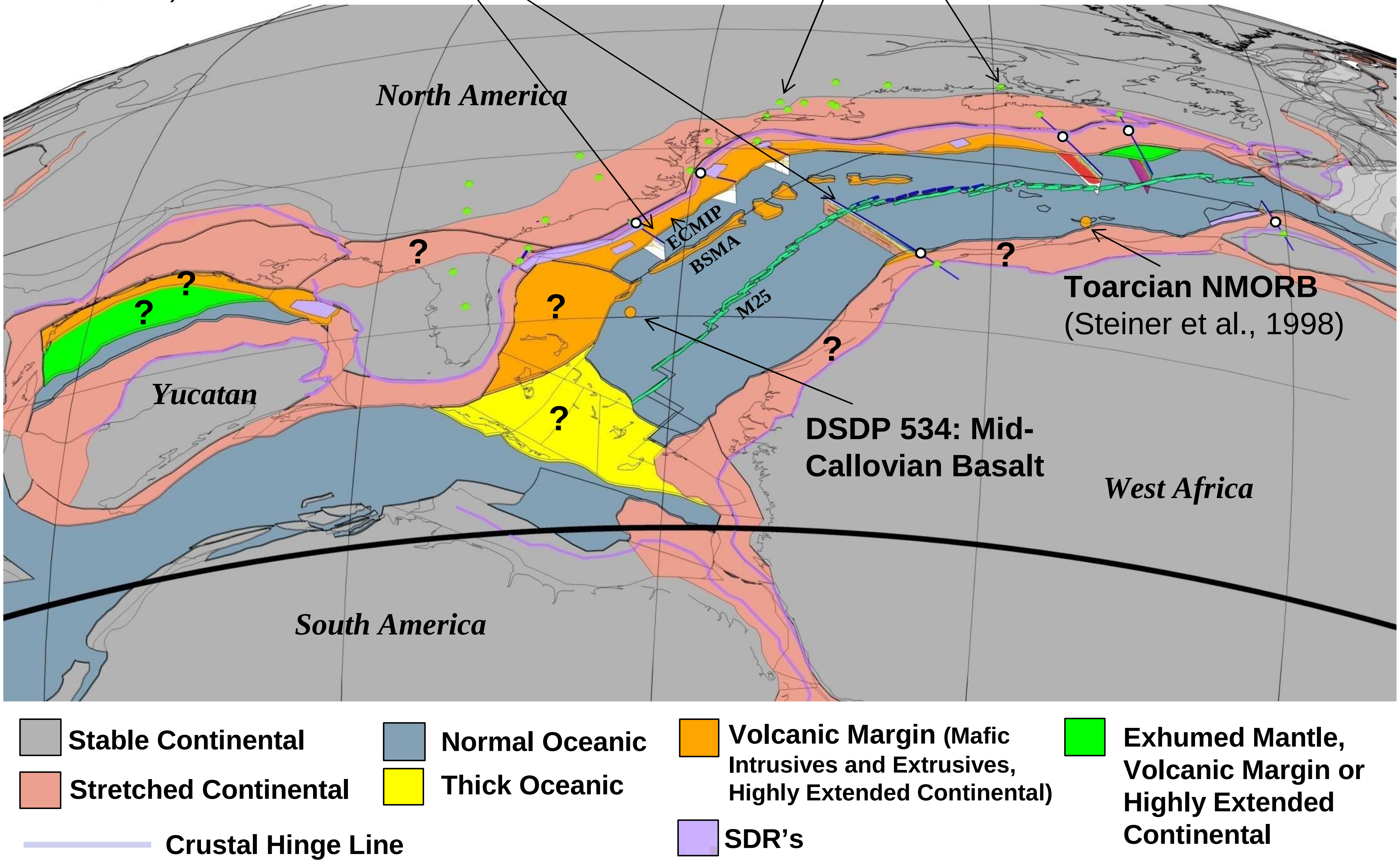
(Kneller et al., submitted to C&G)

Explore multiple scenarios for Jurassic seafloor spreading

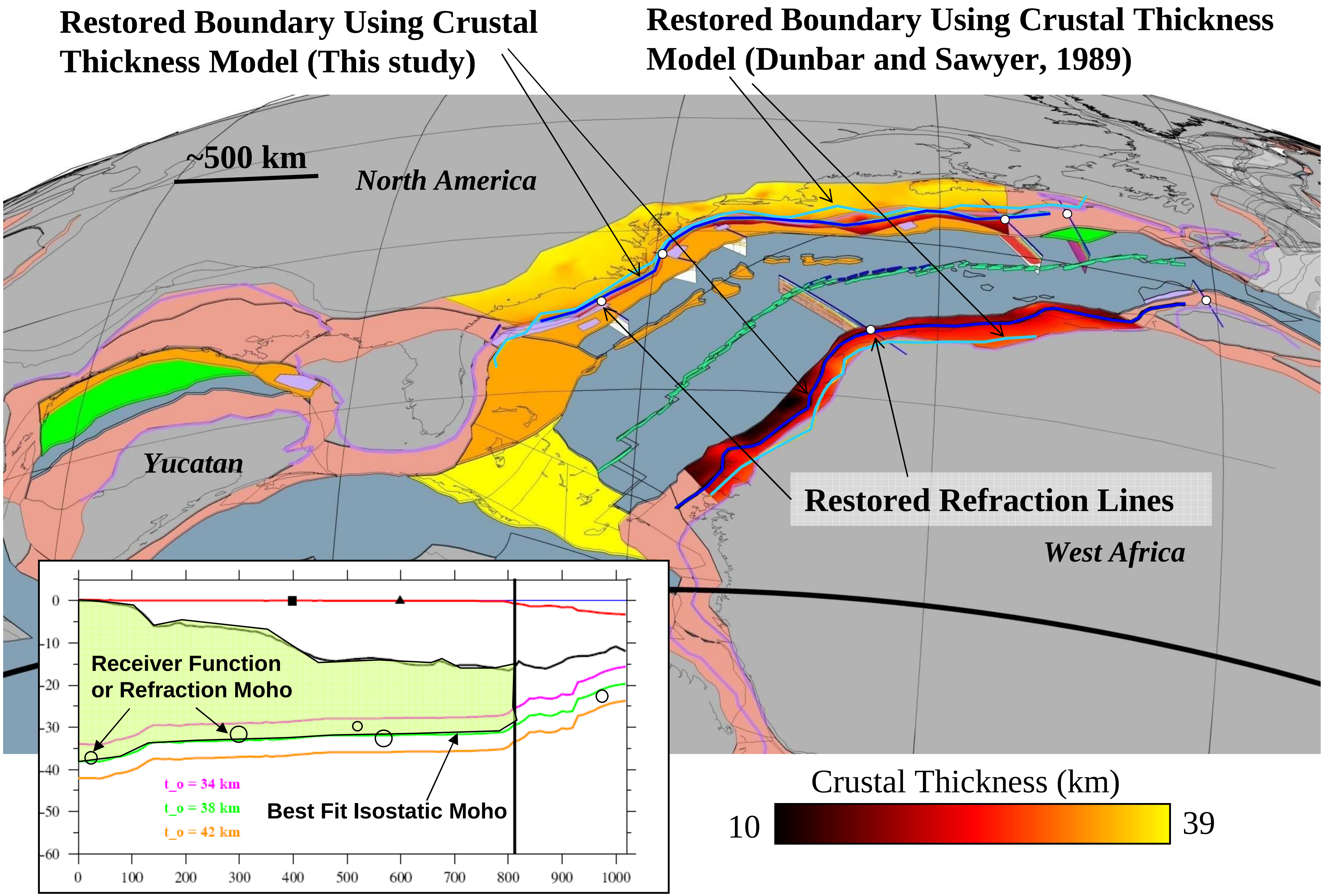
Characterizing the Lithosphere with Basement Type

Conjugate Refraction Lines (Talwani et al., 1995; Funk et al., 2004; Wu et al., 2006; Contrucci et al., 2004; Klingehoefer et al., 2009)

Receiver Functions (Li et al, 2002; Ramesh et al., 2002; Fnais, 2004)

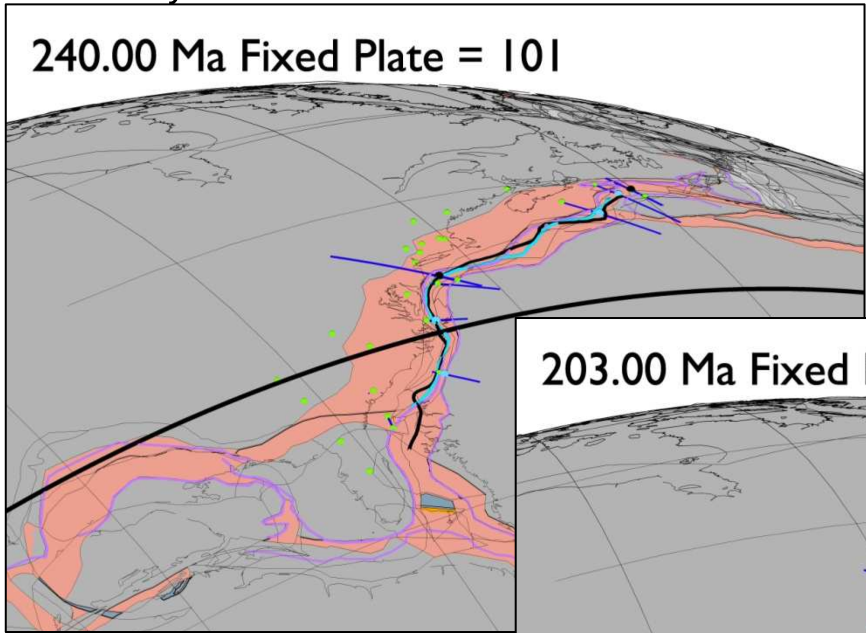


Crustal Thickness and Palinspastic Restorations

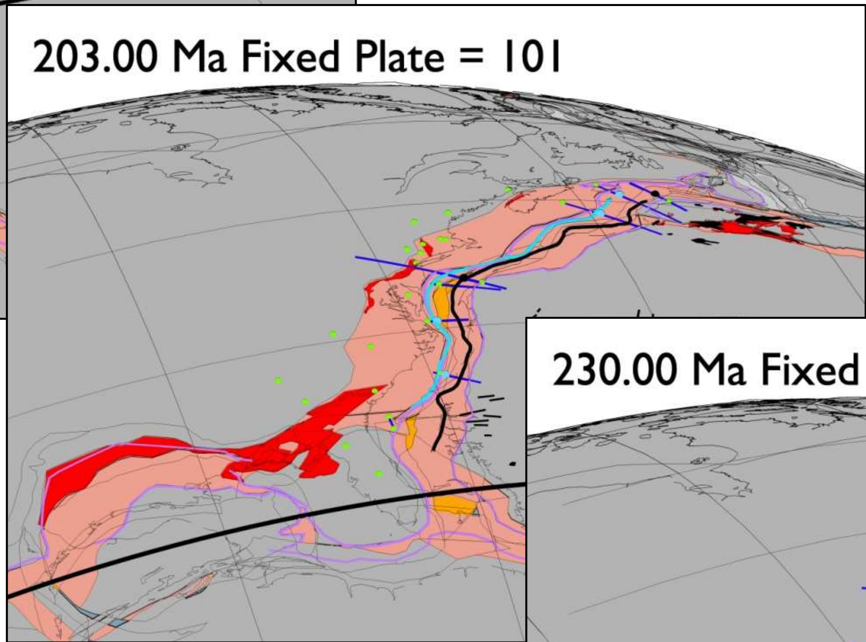


Comparison of Models at Maximum Closure

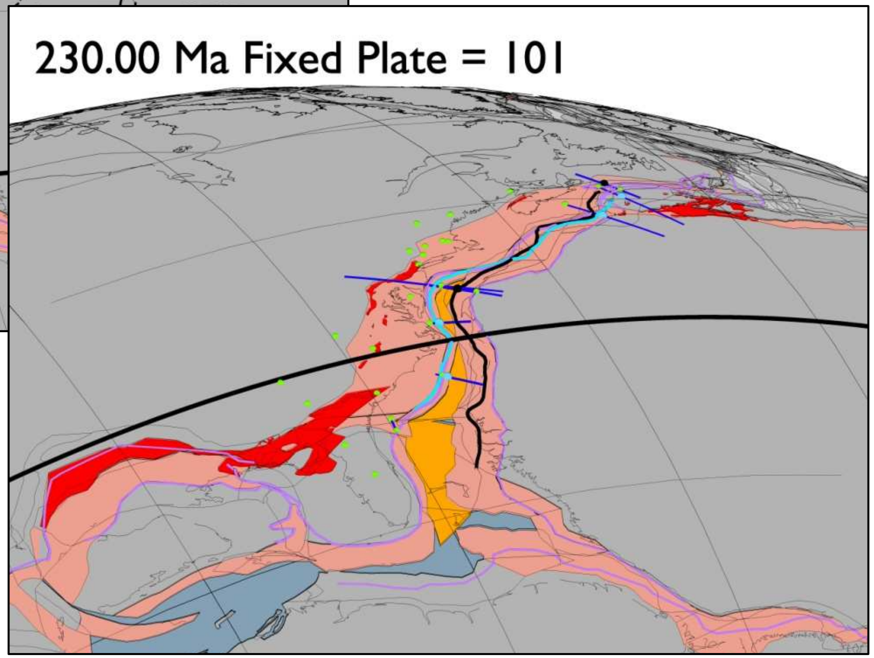
This Study



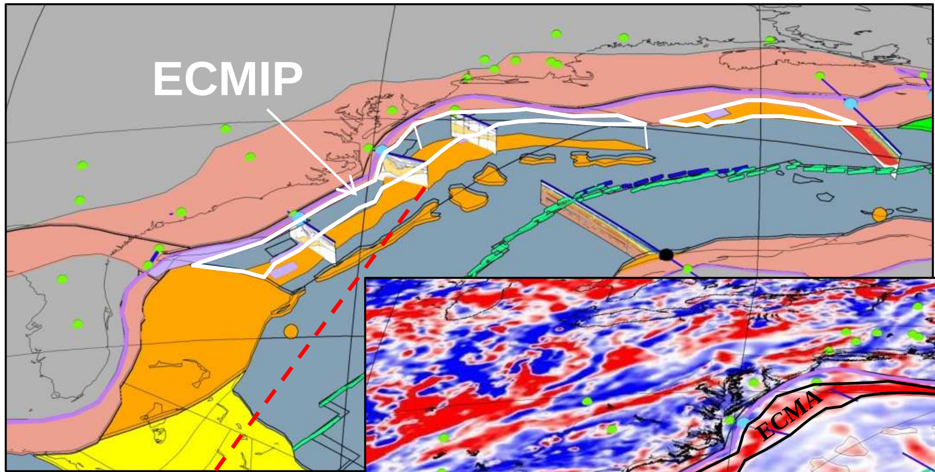
Labails et al., 2010

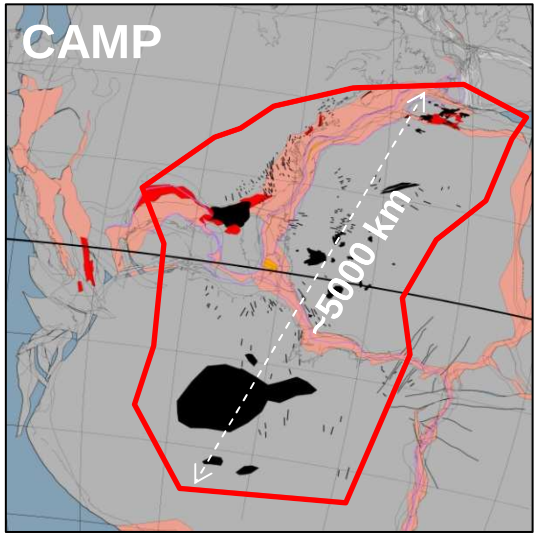


Schettino and Turco, 2009

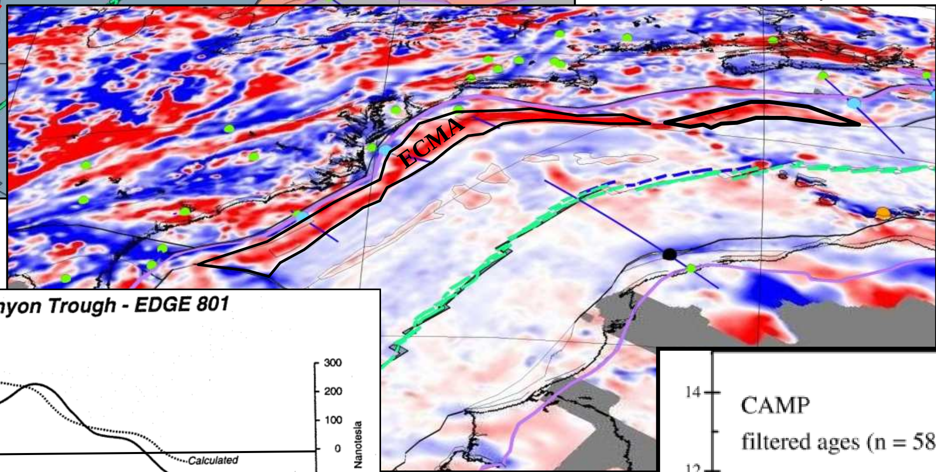


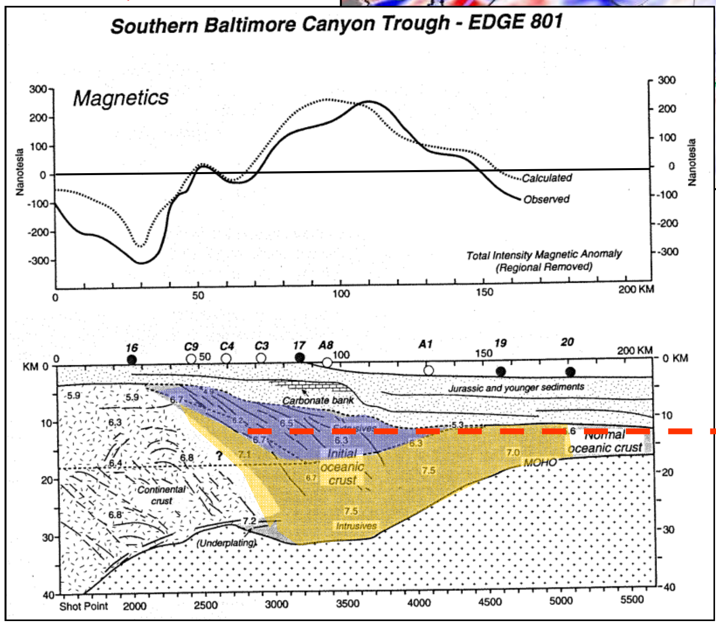
Hypothesis for Breakup Timing: Linking ECMIP and CAMP Events





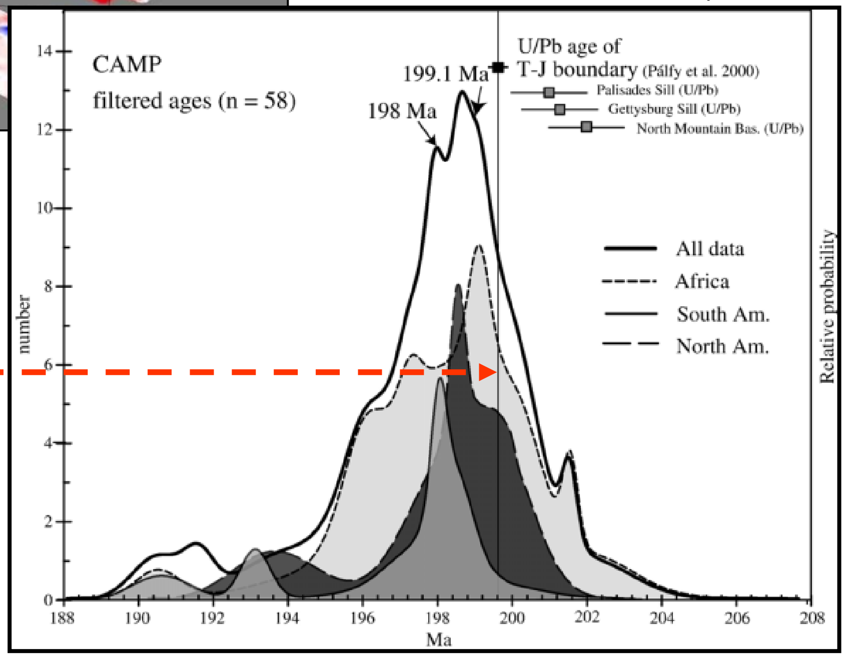
Maus et al., 2009





Holbrook et al., 1994; Talwani et al., 1995; Kelemen and Holbrook, 1995

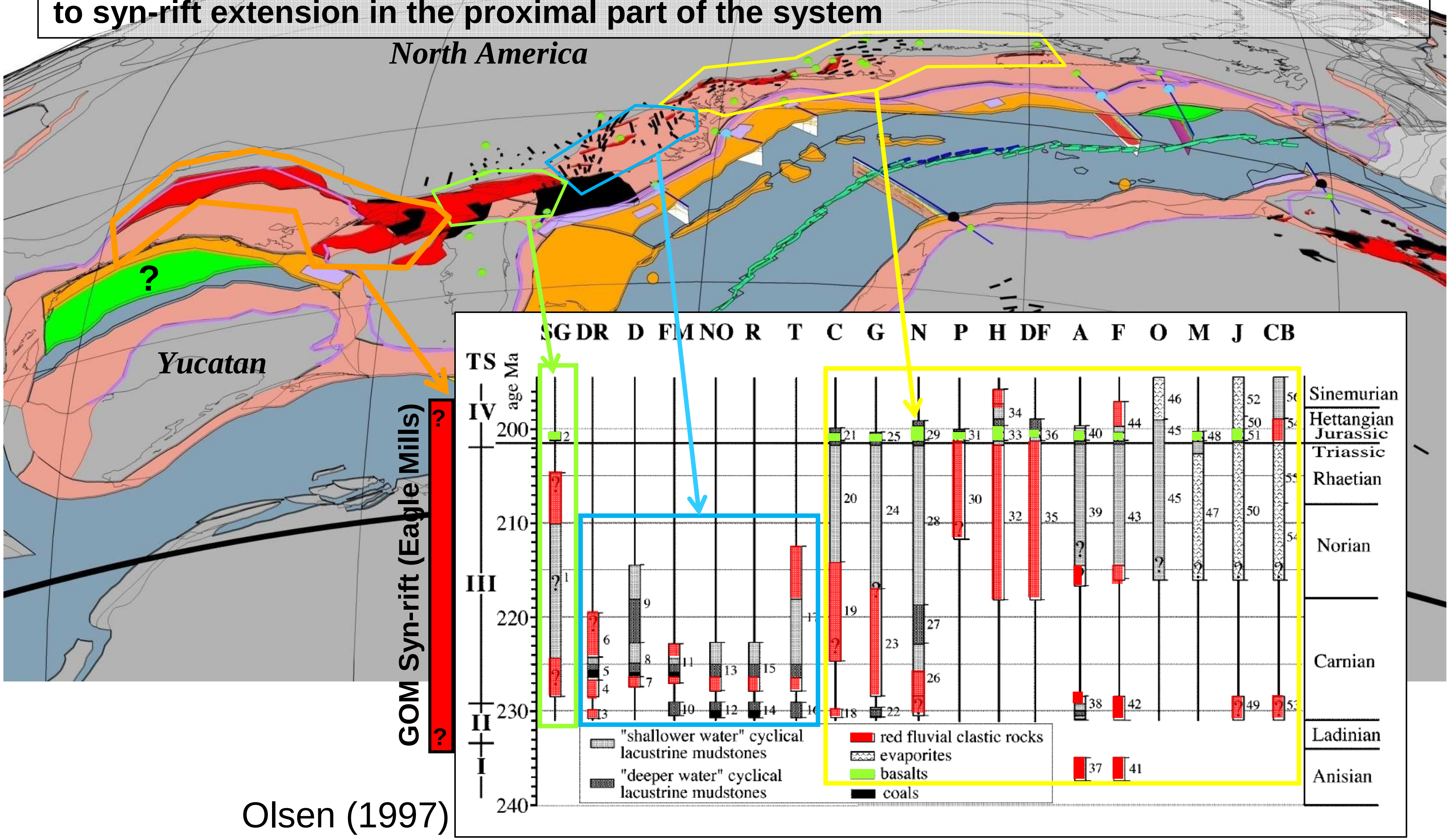
Nomade et al., 2007



Newark Supergroup and Rift to Drift Kinematics

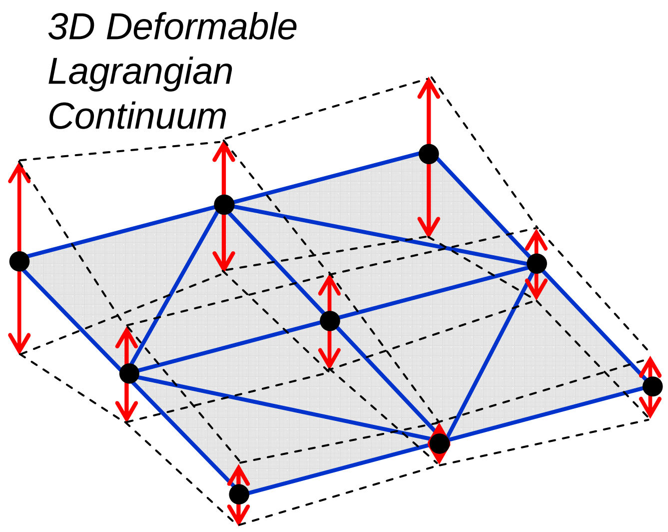
Diachronous initiation of seafloor spreading is inferred from Newark Supergroup stratigraphy (e.g. Withjack et al., 1998)**.**

Diachronous localization of extensional strain may also contribute to a diachronous end to syn-rift extension in the proximal part of the system

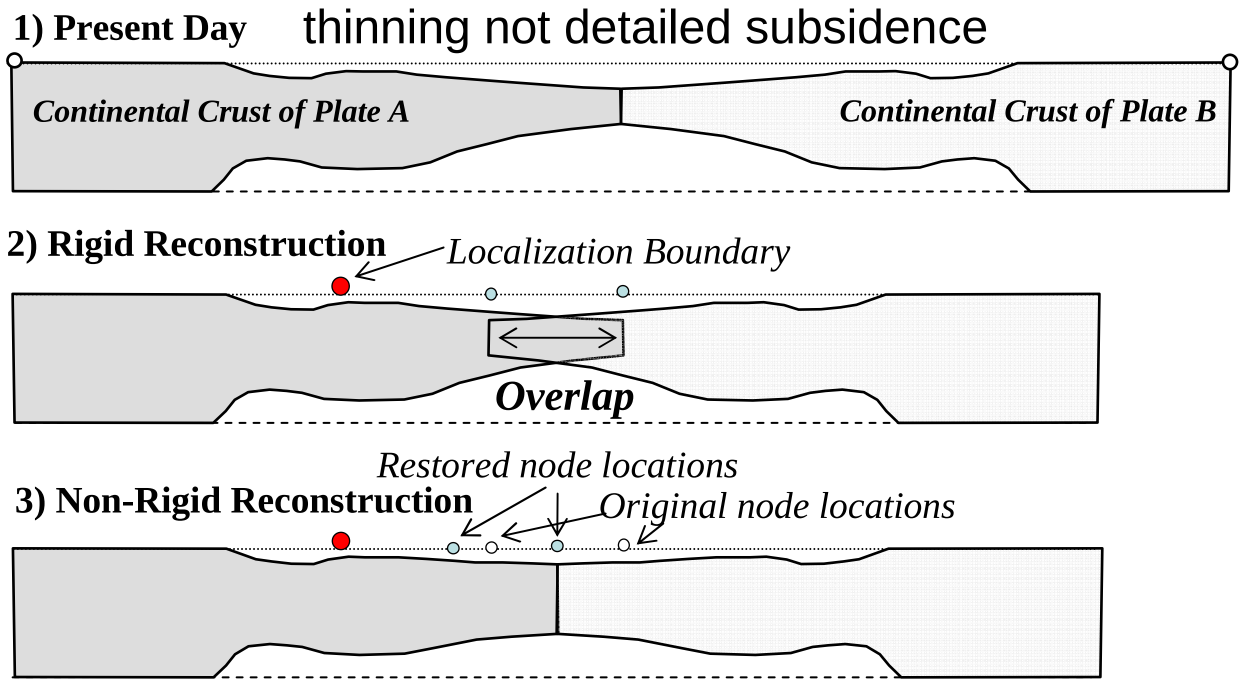


Olsen (1997)

Linking Plate Kinematics to 3D Crustal Deformation



- 3D Pure Shear Deformation with Mass Conservation
- Particle displacement is along Euler Pole Flow lines and is a function of overlap and integrated extension from both plates.
- Localization controlled with prescribed boundaries.
- Airy Isostasy (No Flexure), No Erosion, No Sedimentation
- The goal is capture plate-scale lateral strain and crustal thinning not detailed subsidence



Kneller et al., submitted to C&G

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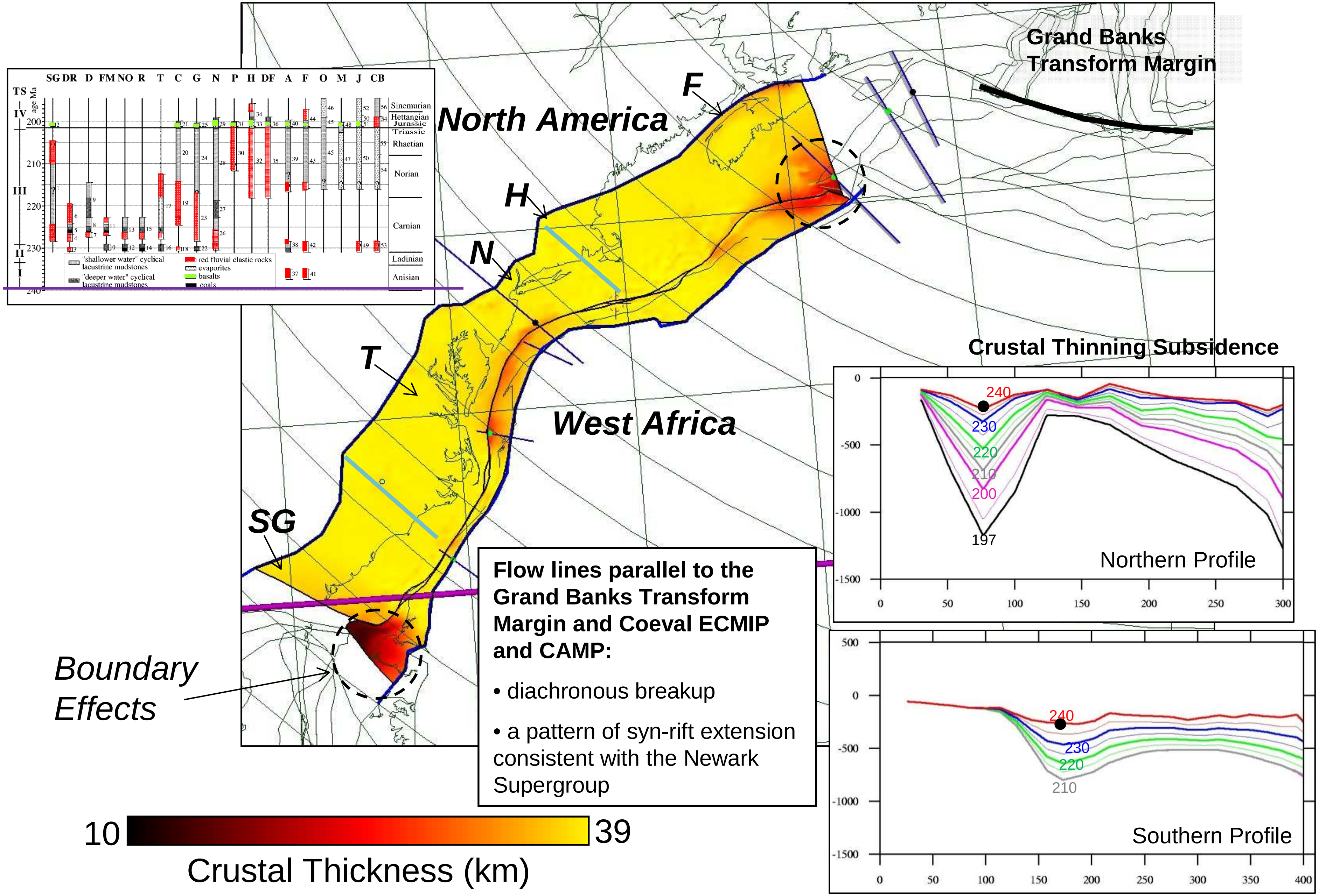
Testing Syn-extension Models with Deforming Continua

240 Ma



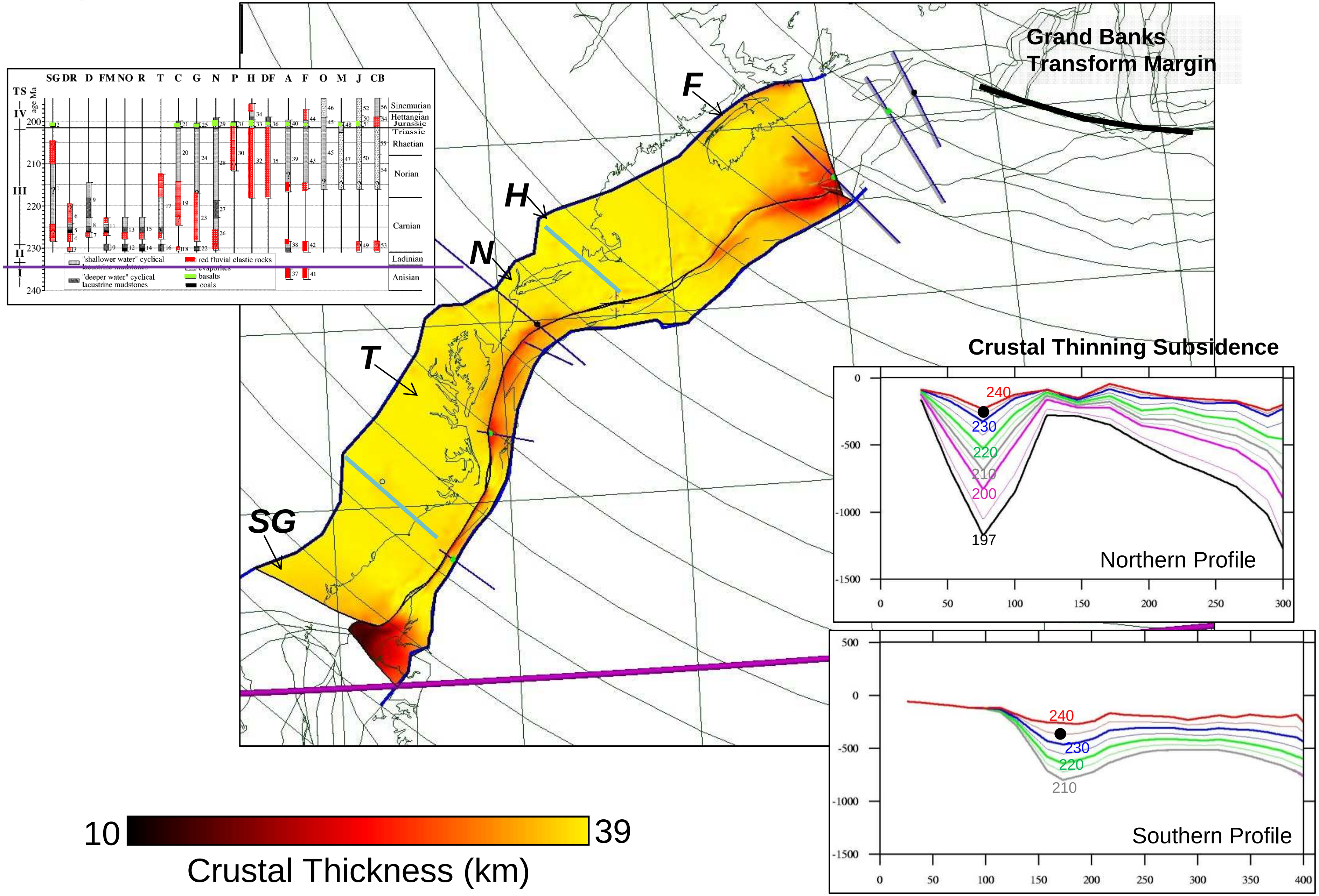
Flow lines parallel to the Grand Banks Transform Margin and Coeval ECMIP and CAMP:

- diachronous breakup
- a pattern of syn-rift extension consistent with the Newark Supergroup

Kneller et al., submitted to C&G

Testing Syn-extension Models with Deforming Continua

235 Ma



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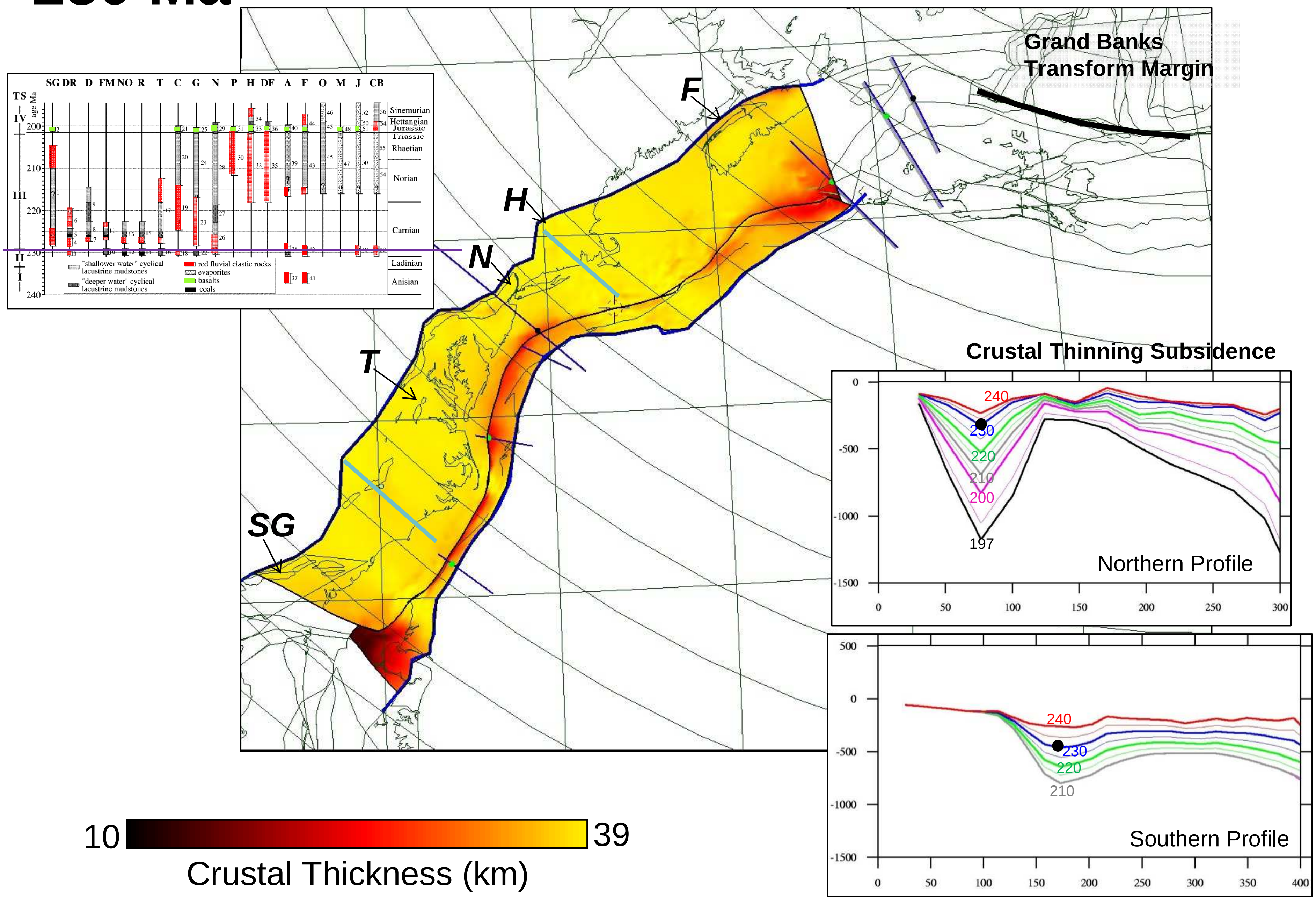
Testing Syn-extension Models with Deforming Continua

230 Ma



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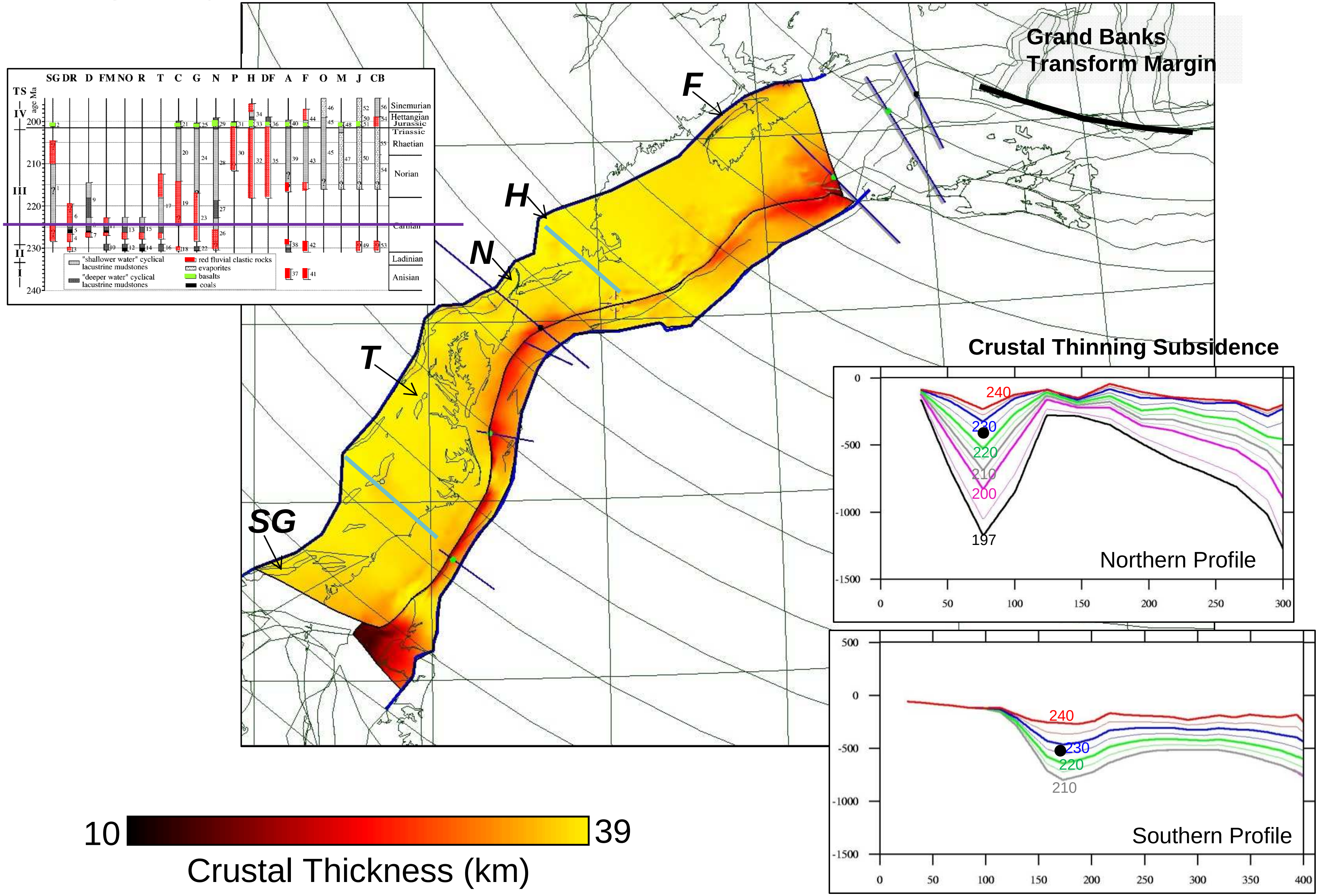
Testing Syn-extension Models with Deforming Continua

225 Ma



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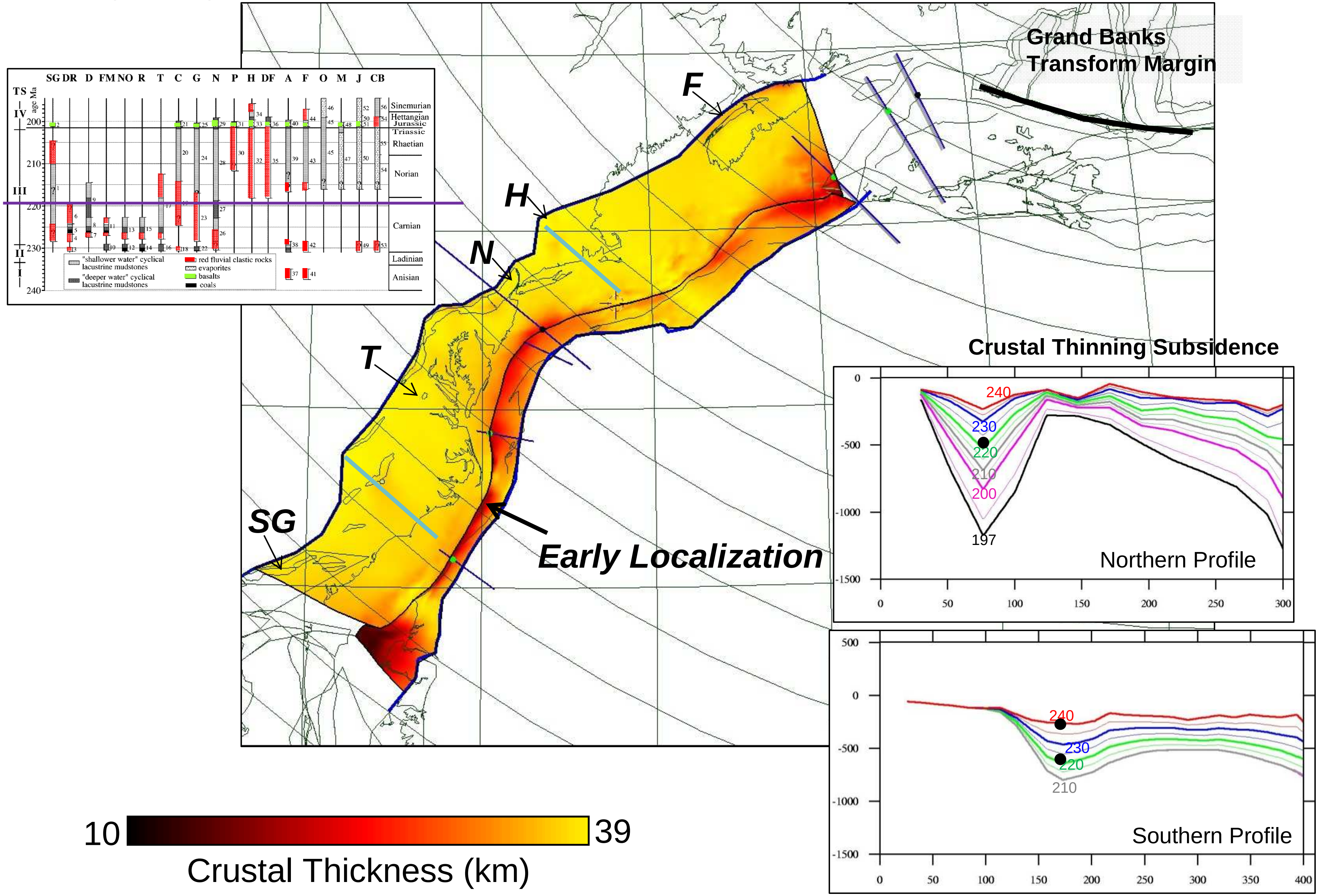
Testing Syn-extension Models with Deforming Continua

220 Ma



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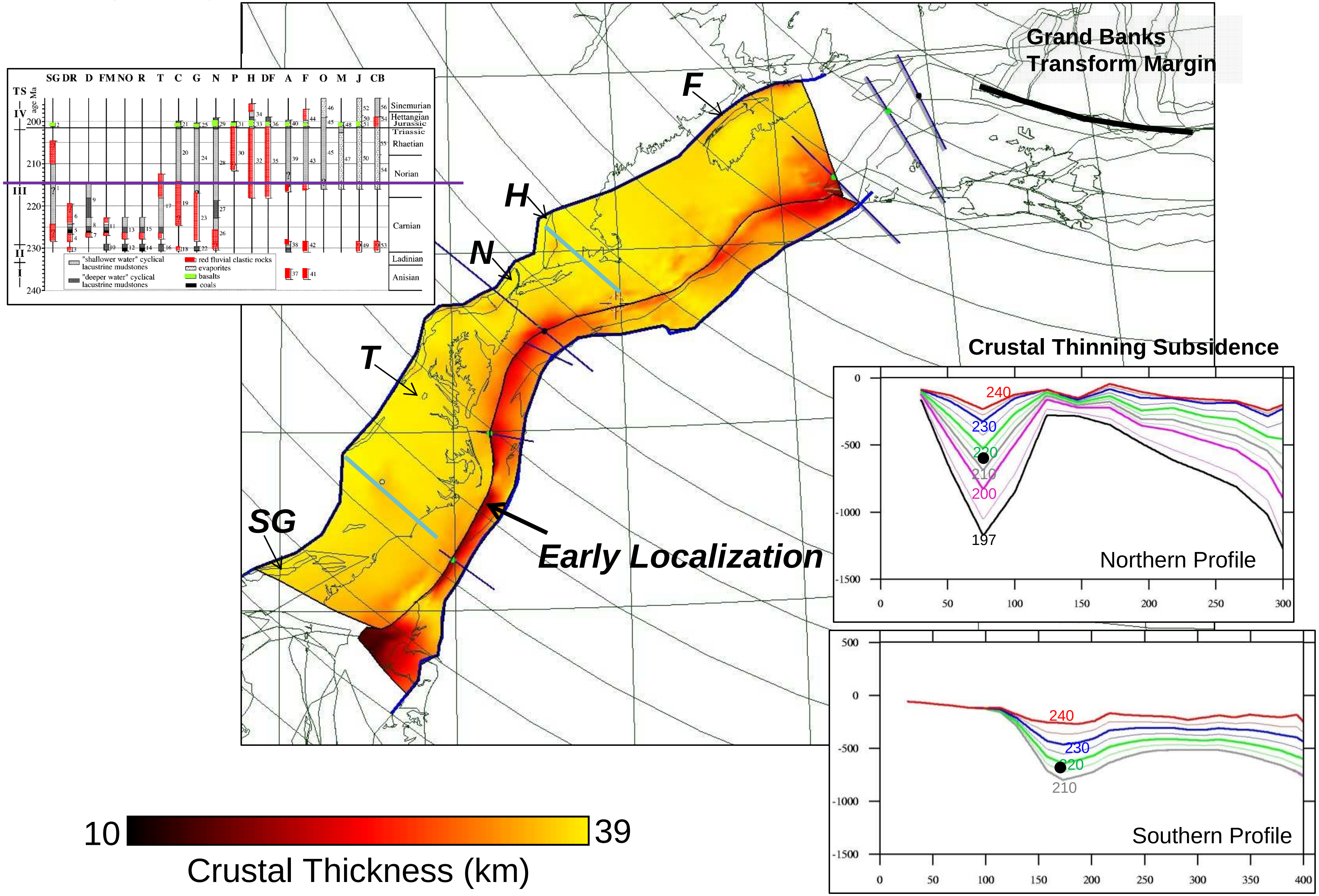
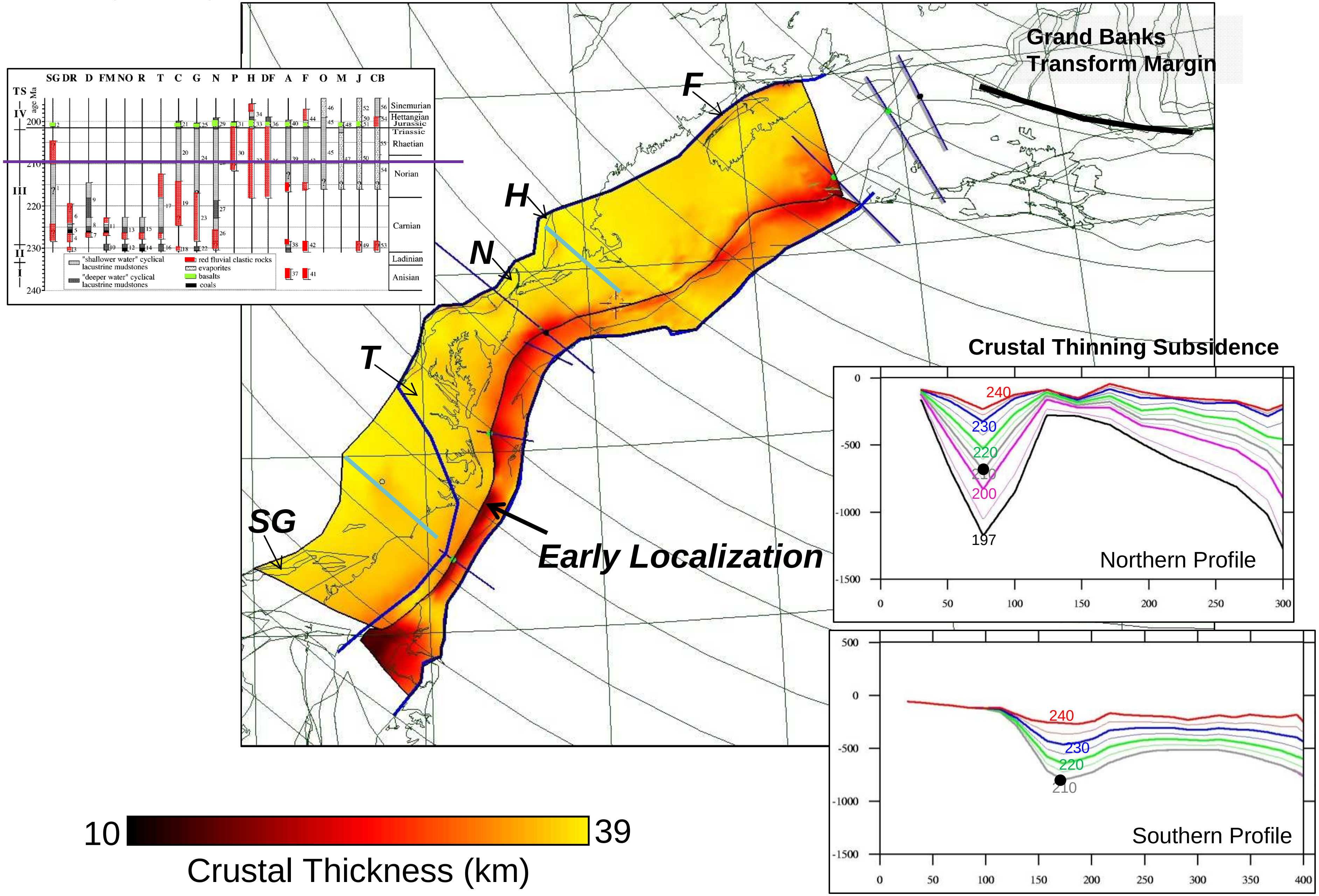
Testing Syn-extension Models with Deforming Continua

215 Ma



Testing Syn-extension Models with Deforming Continua

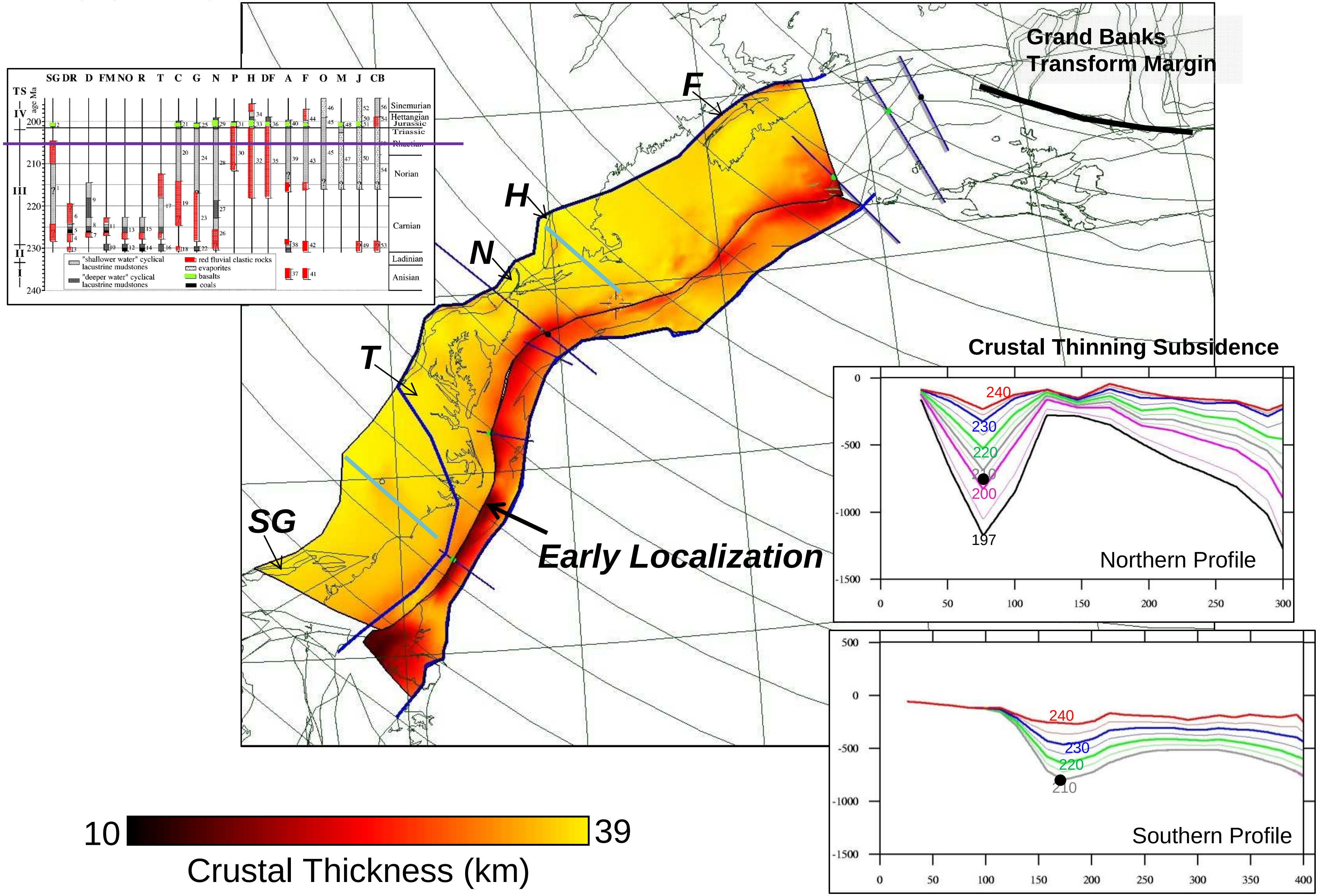
210 Ma



Kneller et al., submitted to C&G

Testing Syn-extension Models with Deforming Continua

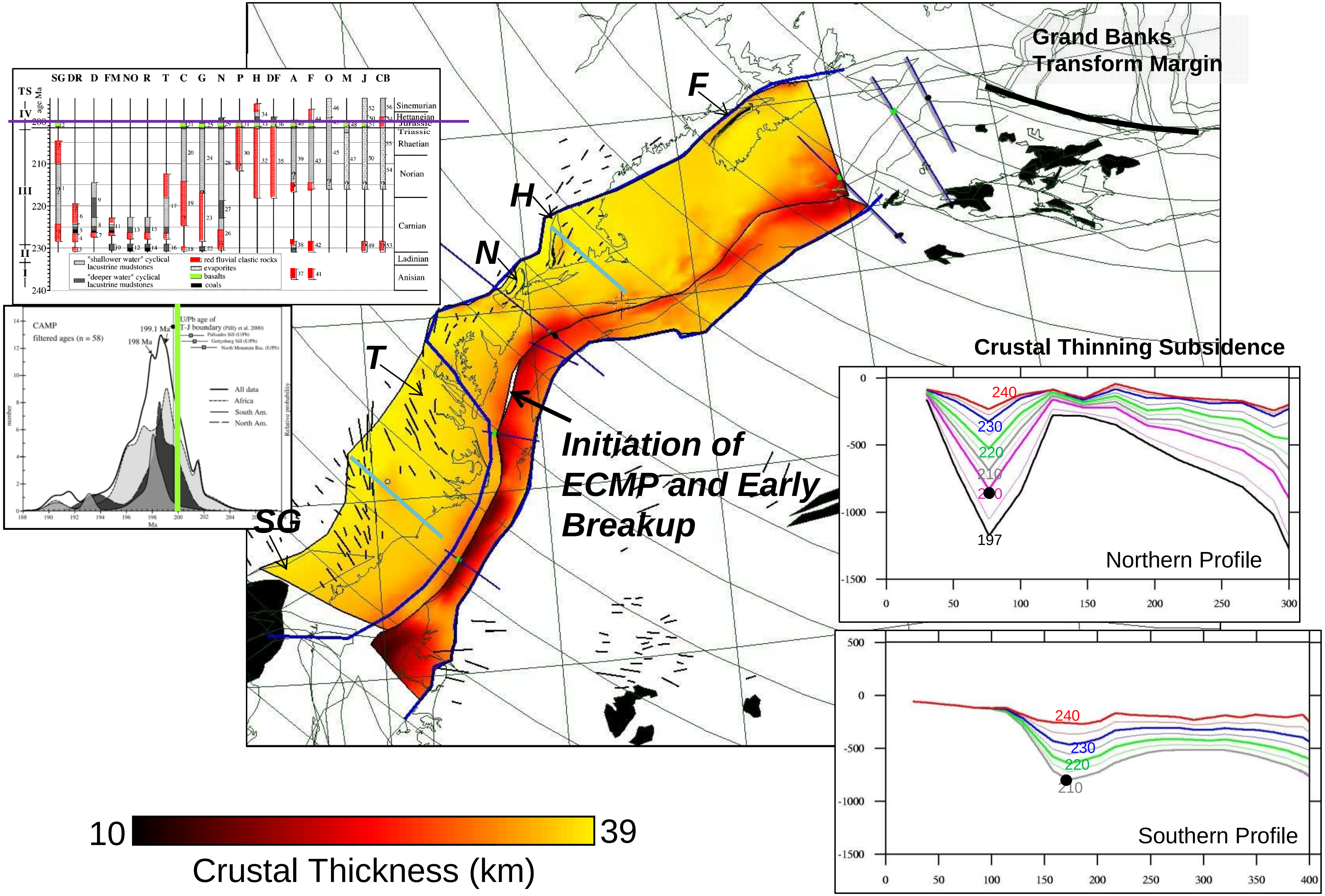
205 Ma



Kneller et al., submitted to C&G

Testing Syn-extension Models with Deforming Continua

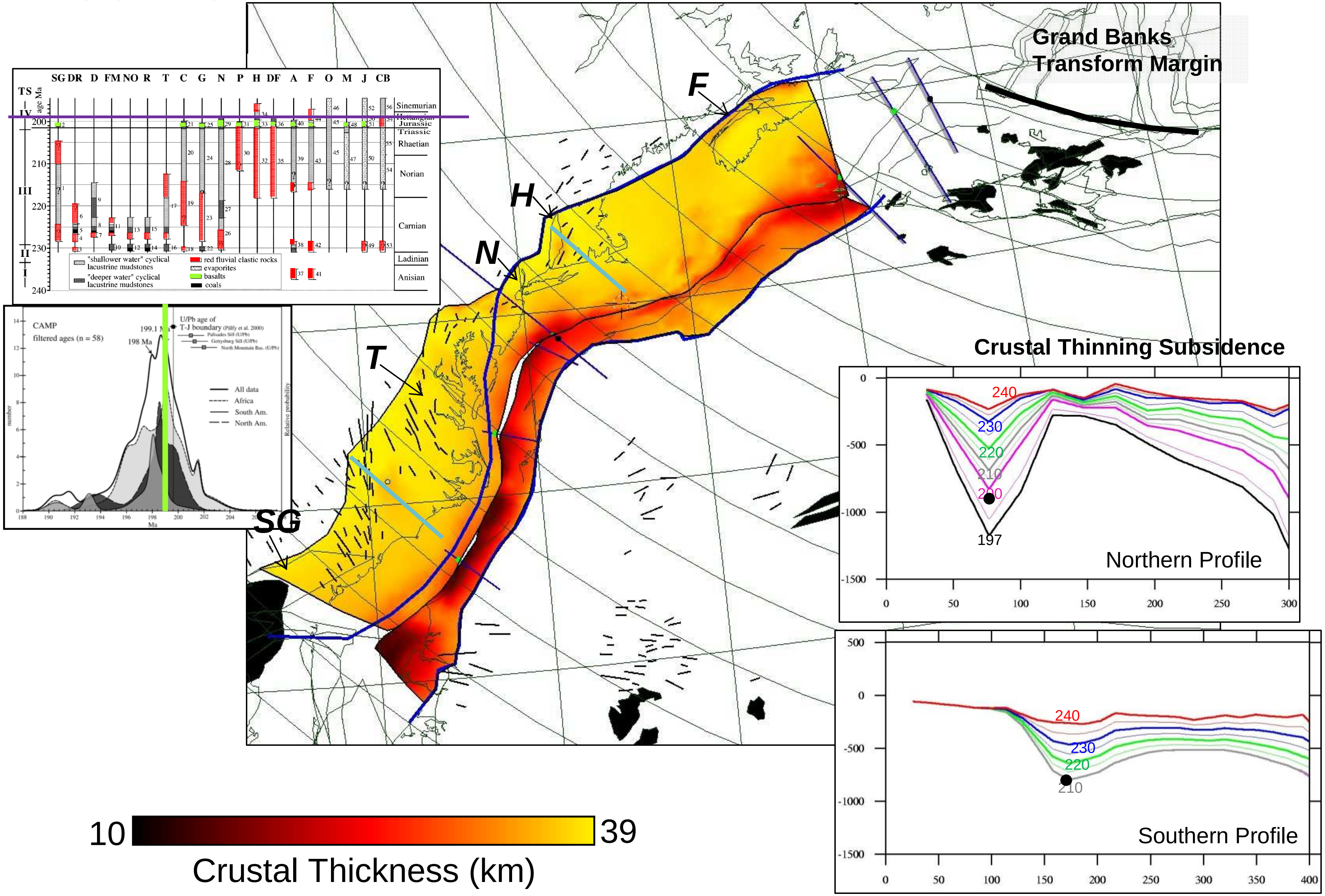
200 Ma



Kneller et al., submitted to C&G

Testing Syn-extension Models with Deforming Continua

199 Ma



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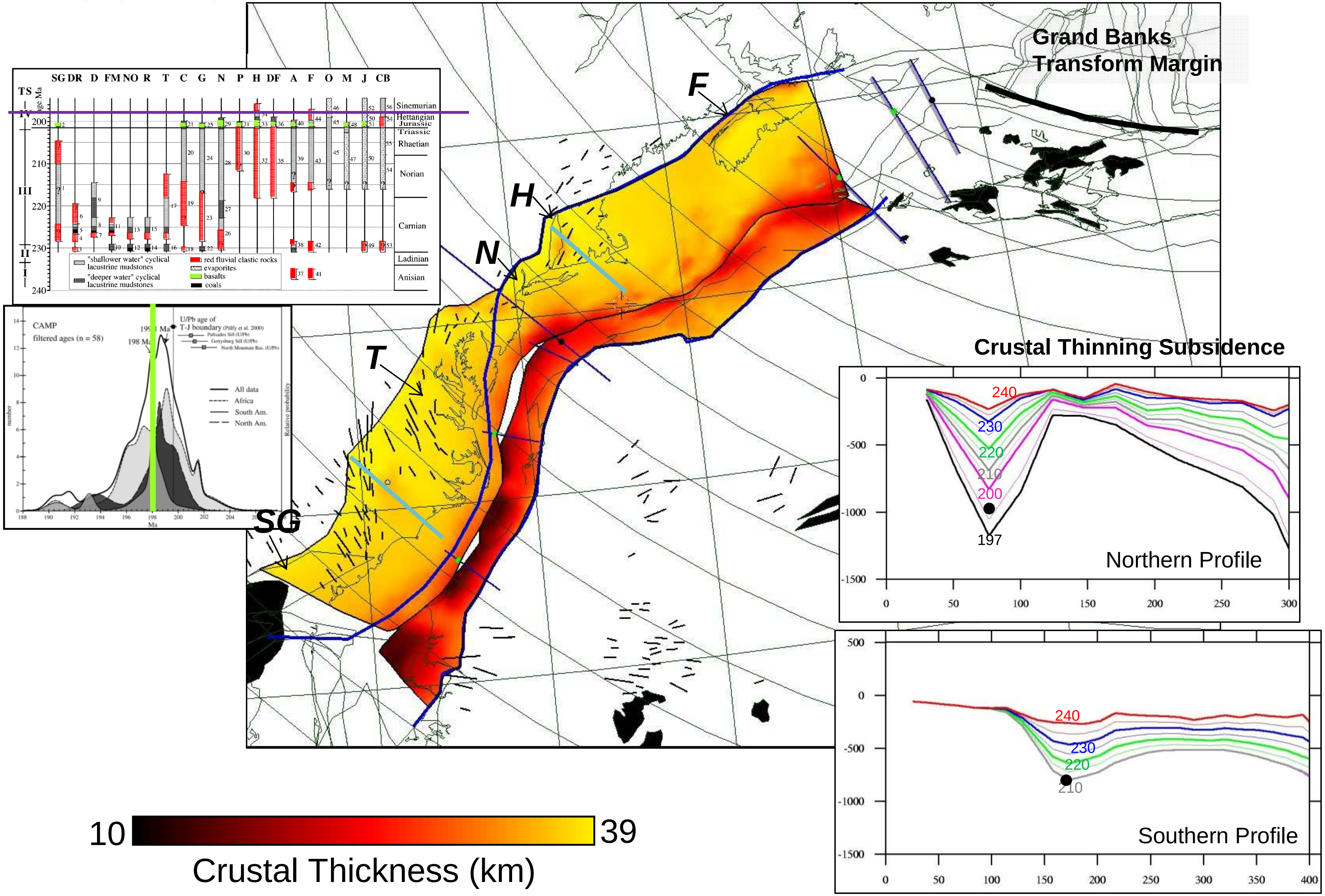
198 Ma



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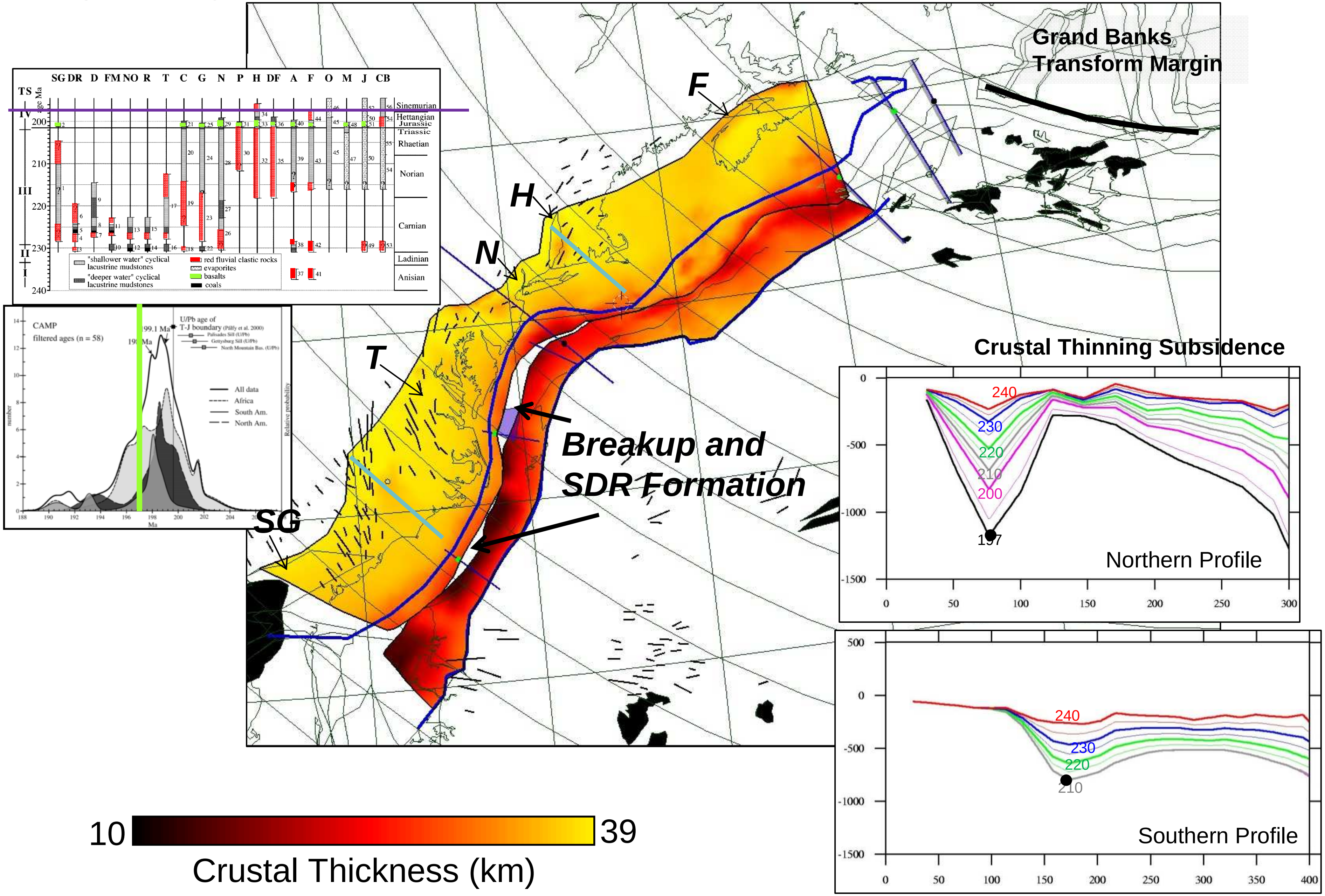
197 Ma



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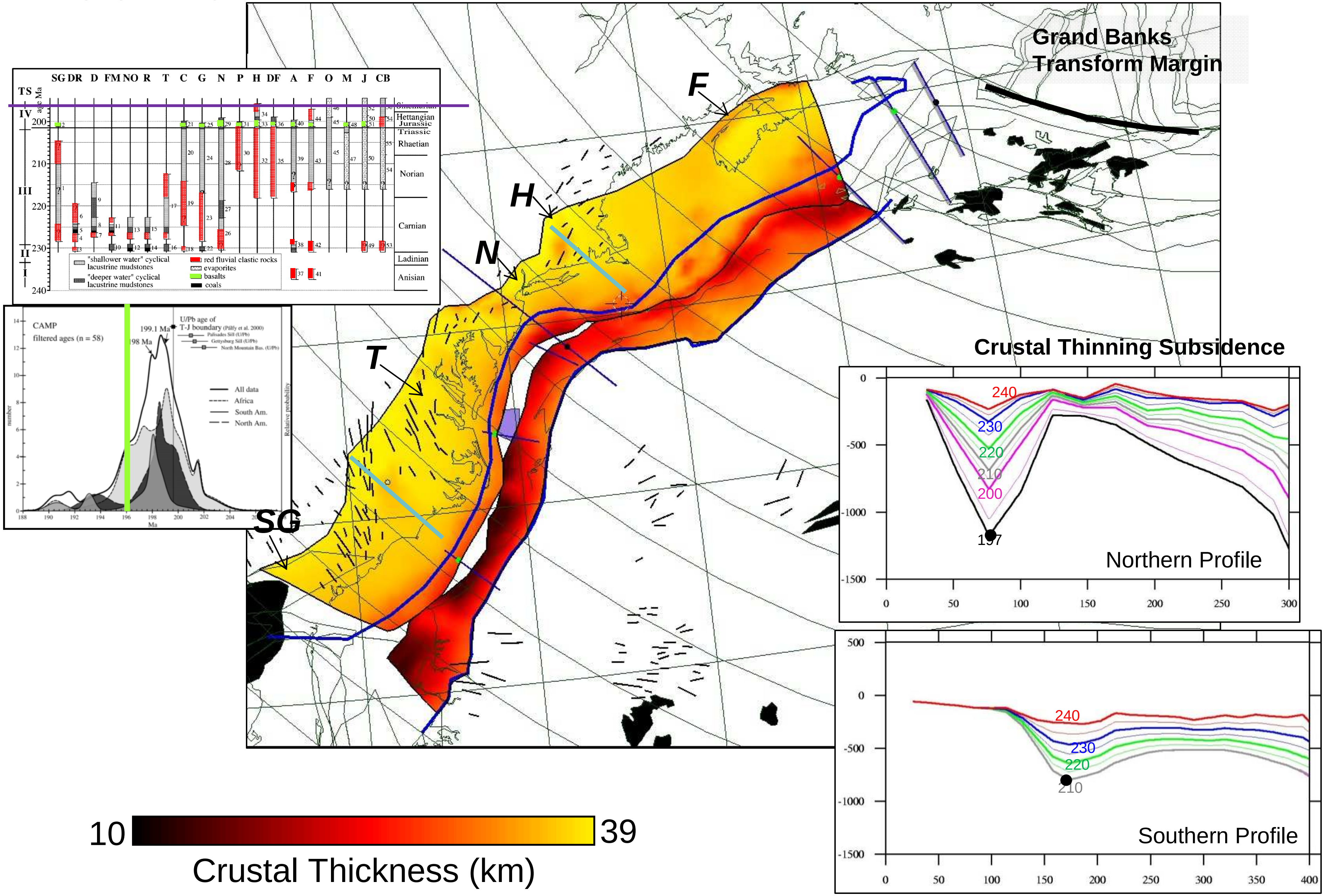
196 Ma



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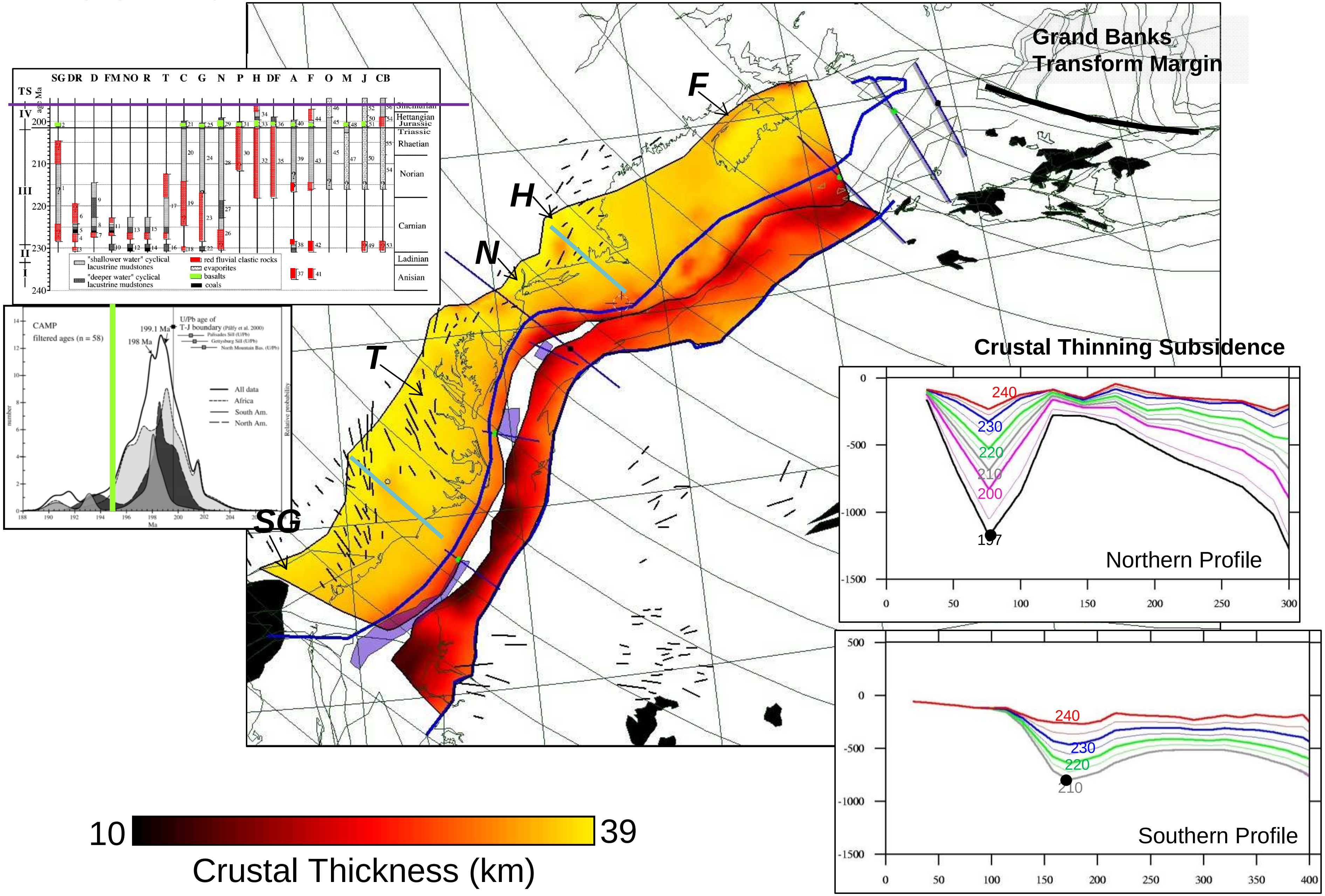
195 Ma



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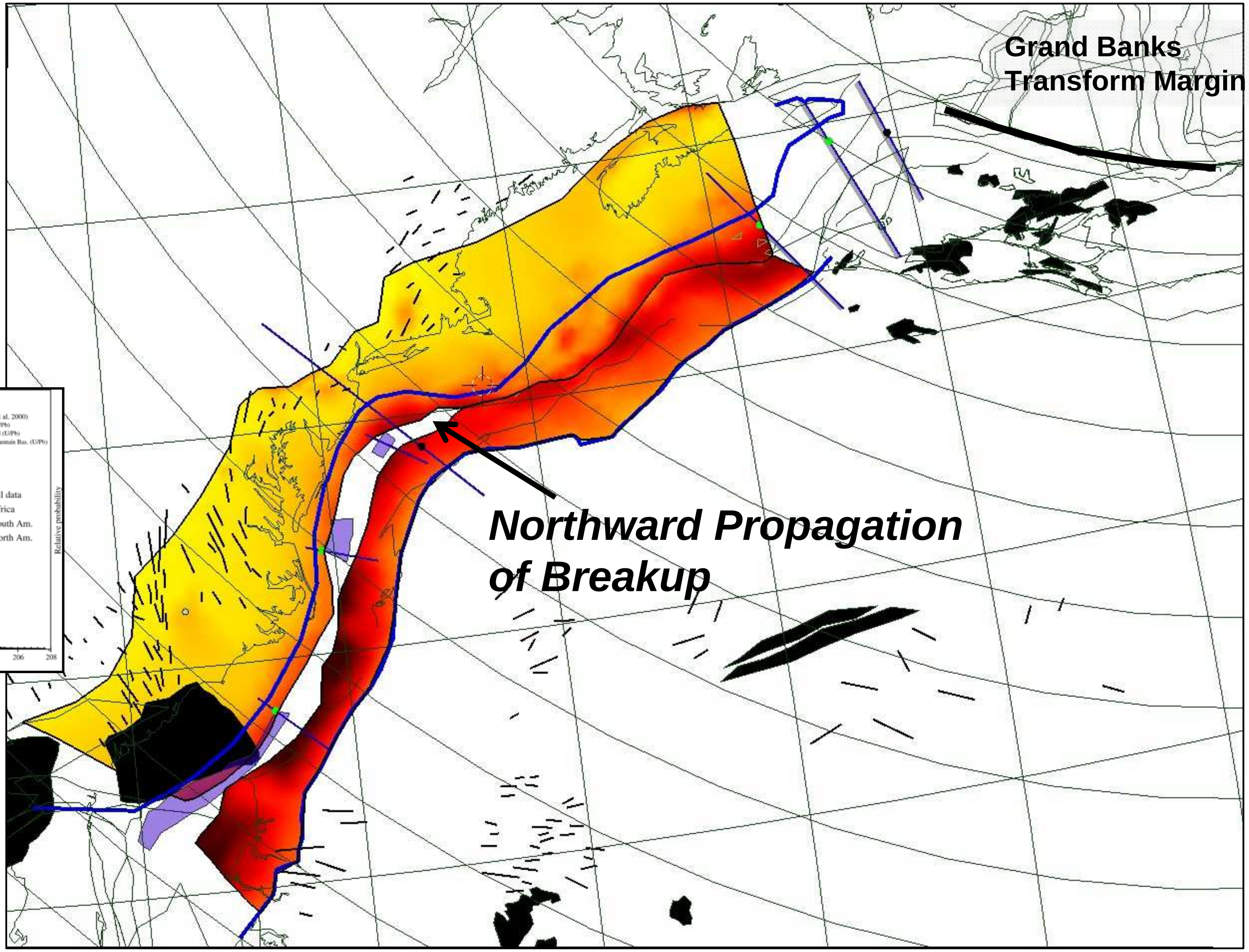
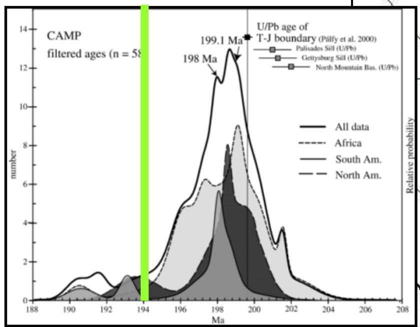
194 Ma





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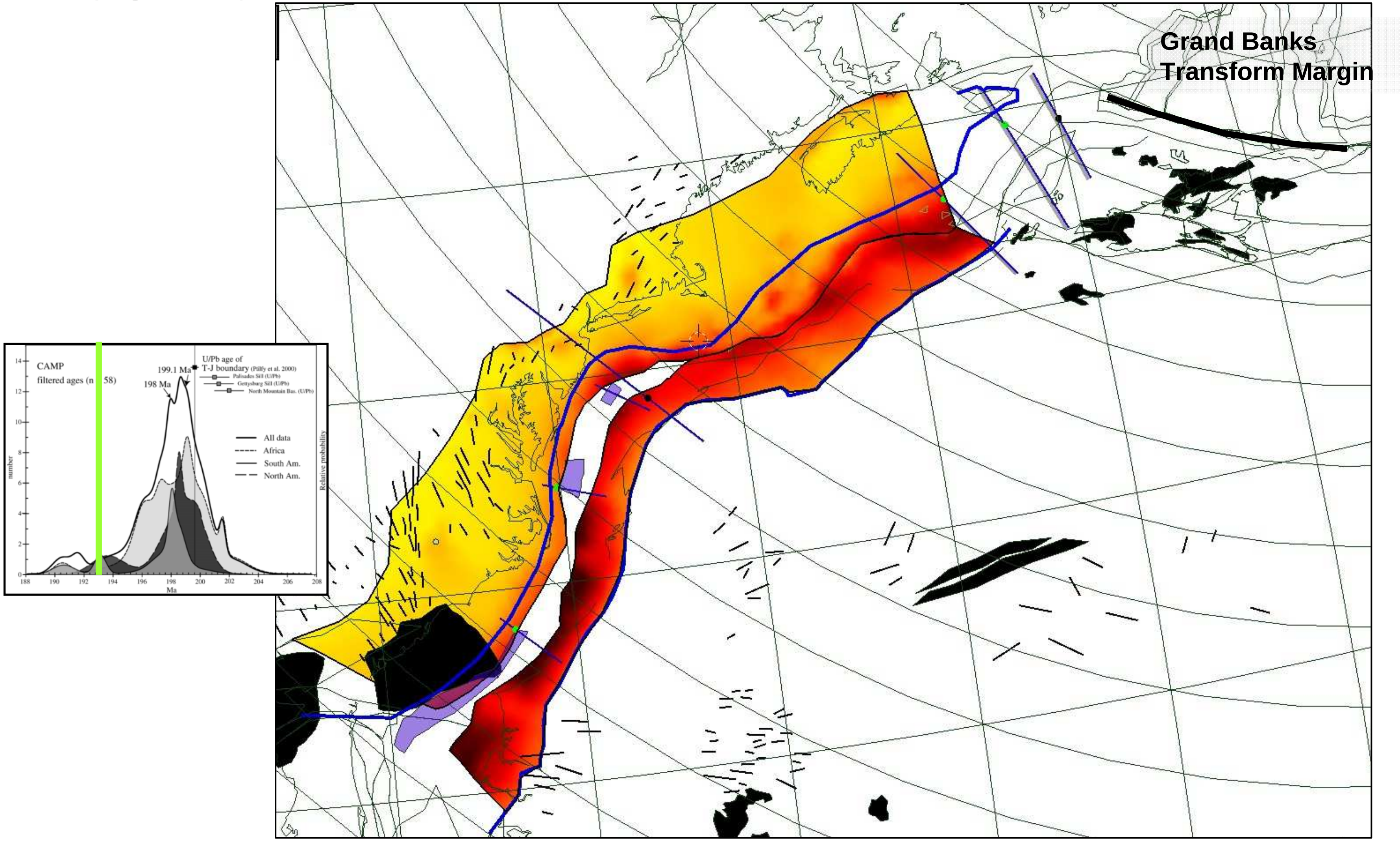
193 Ma



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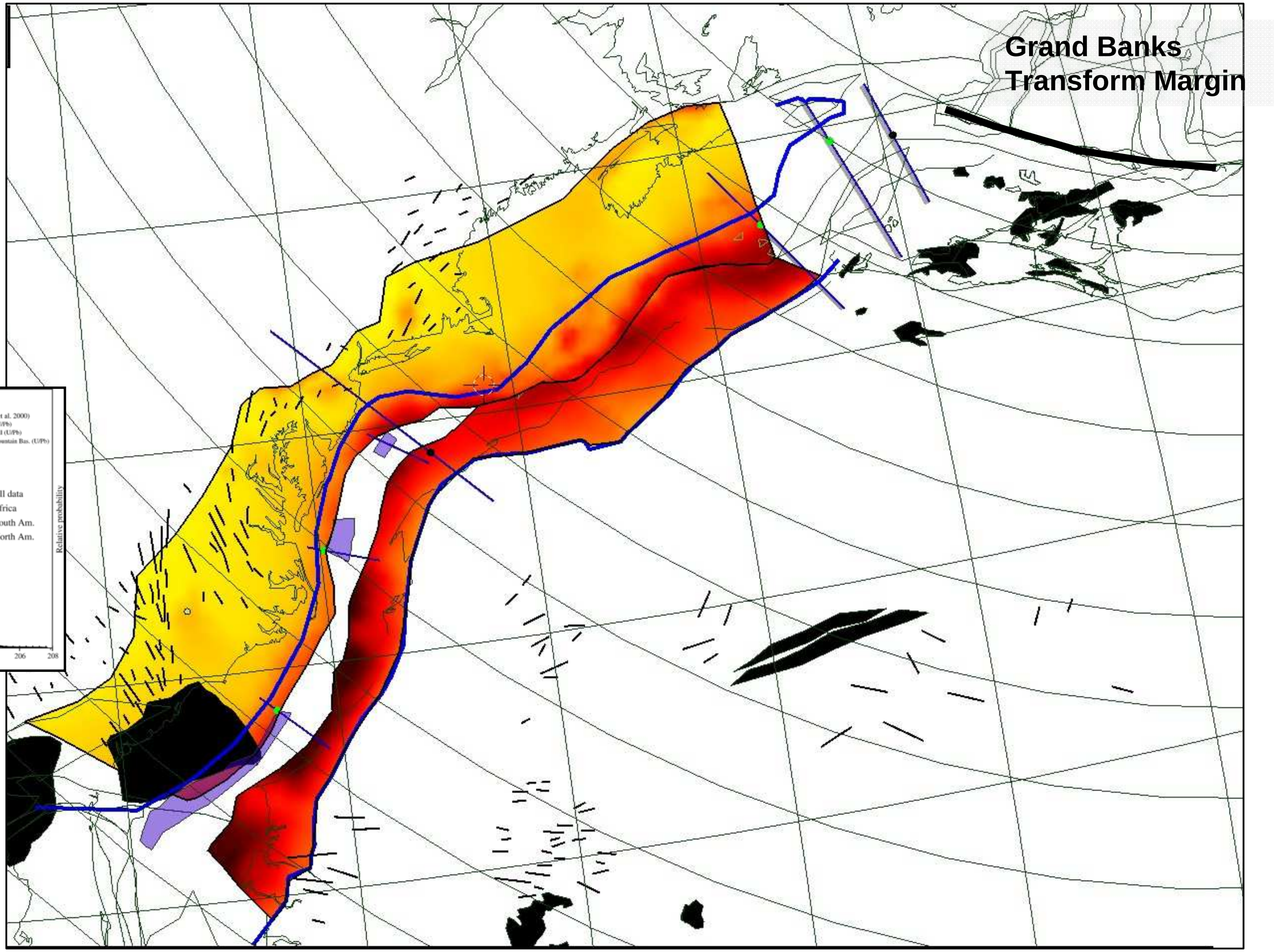

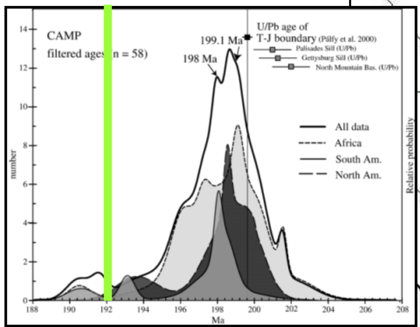

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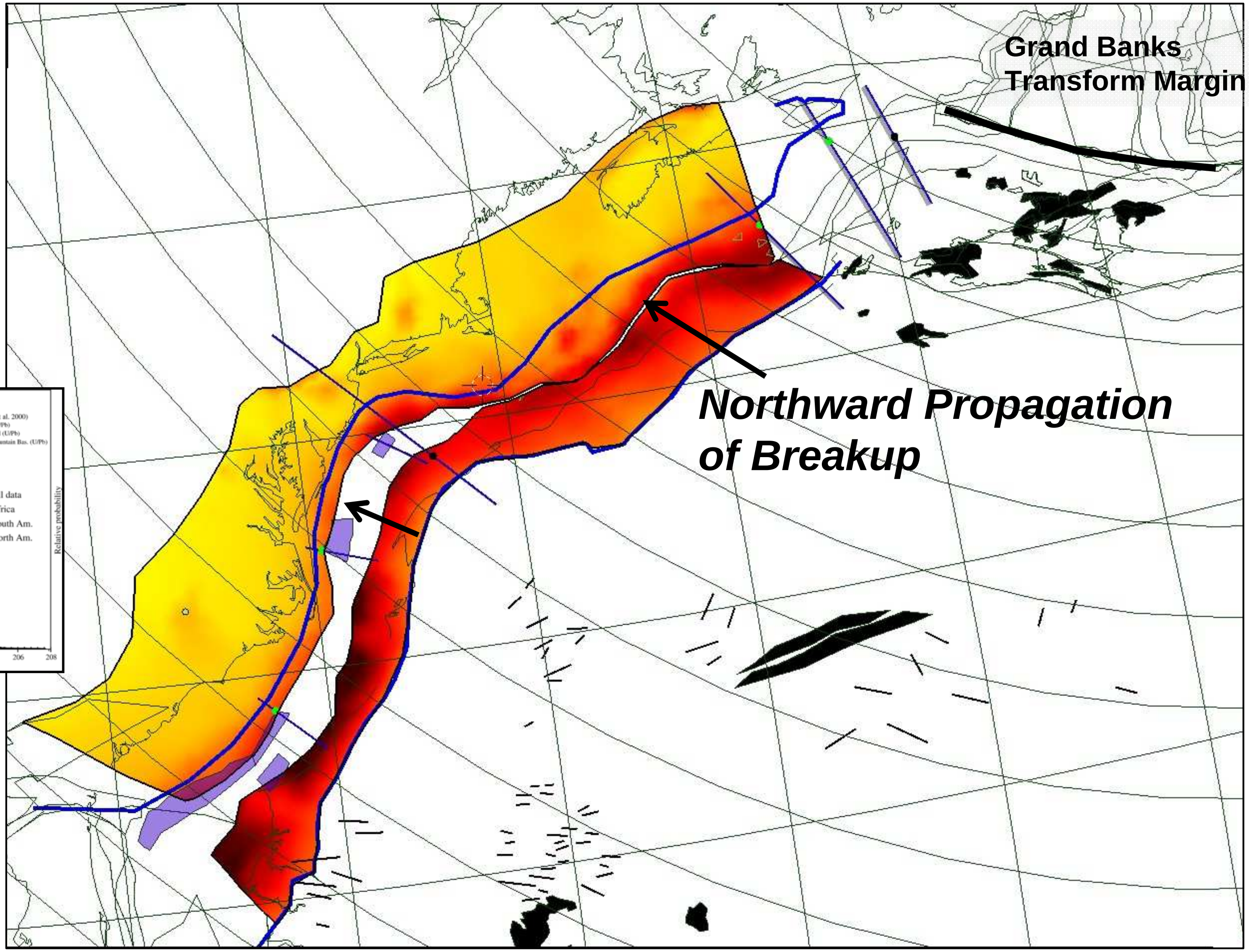
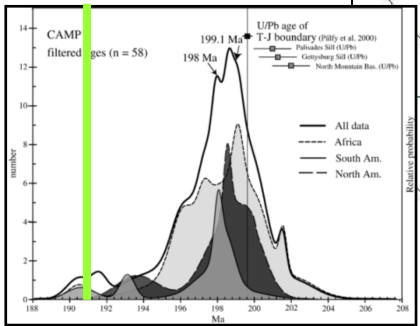
191 Ma





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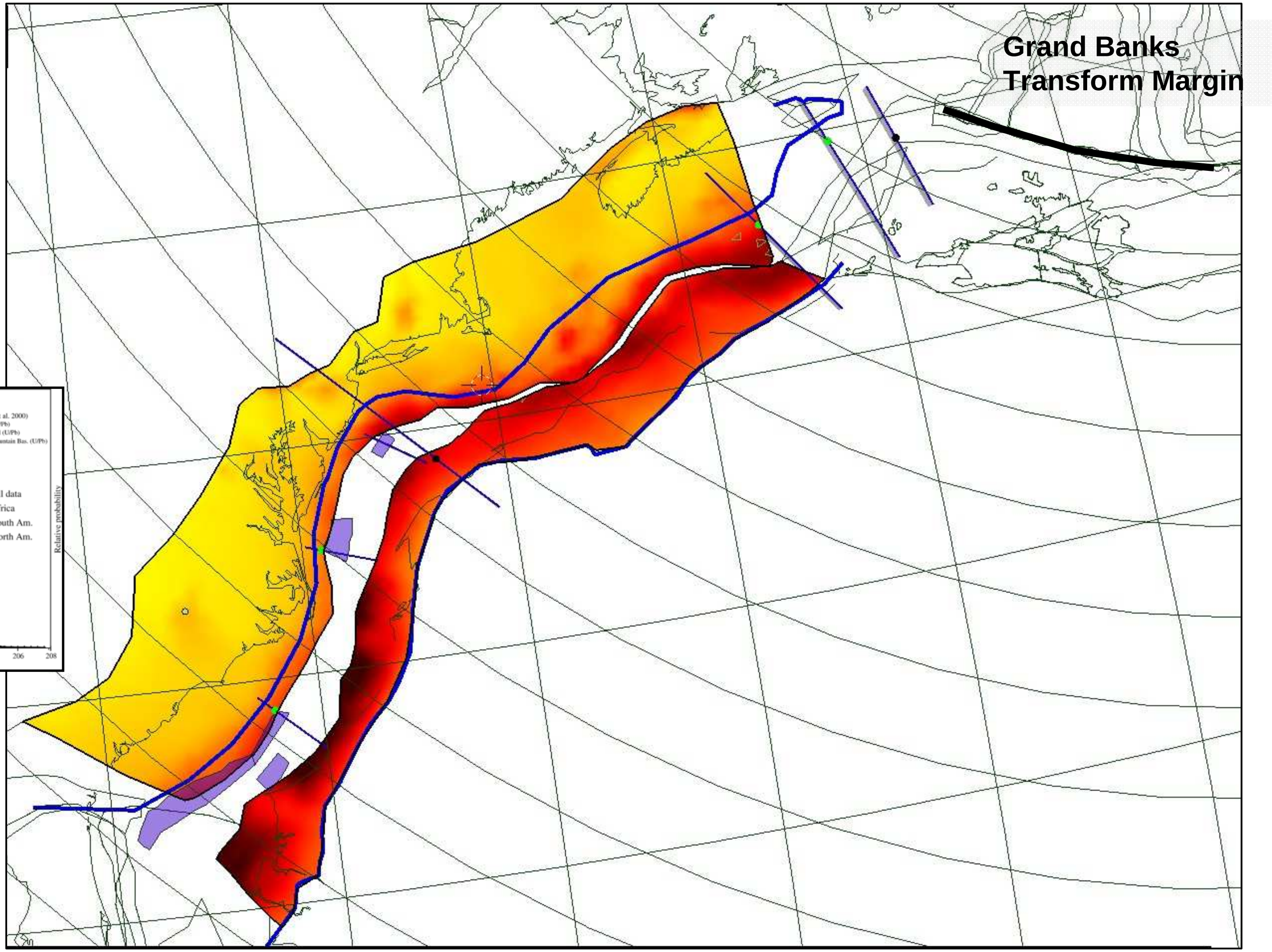
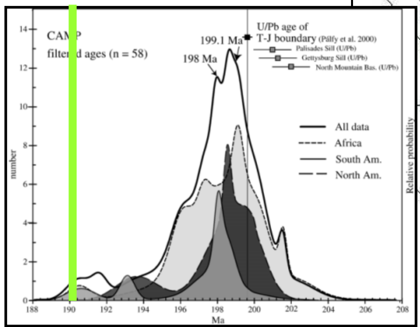
190 Ma



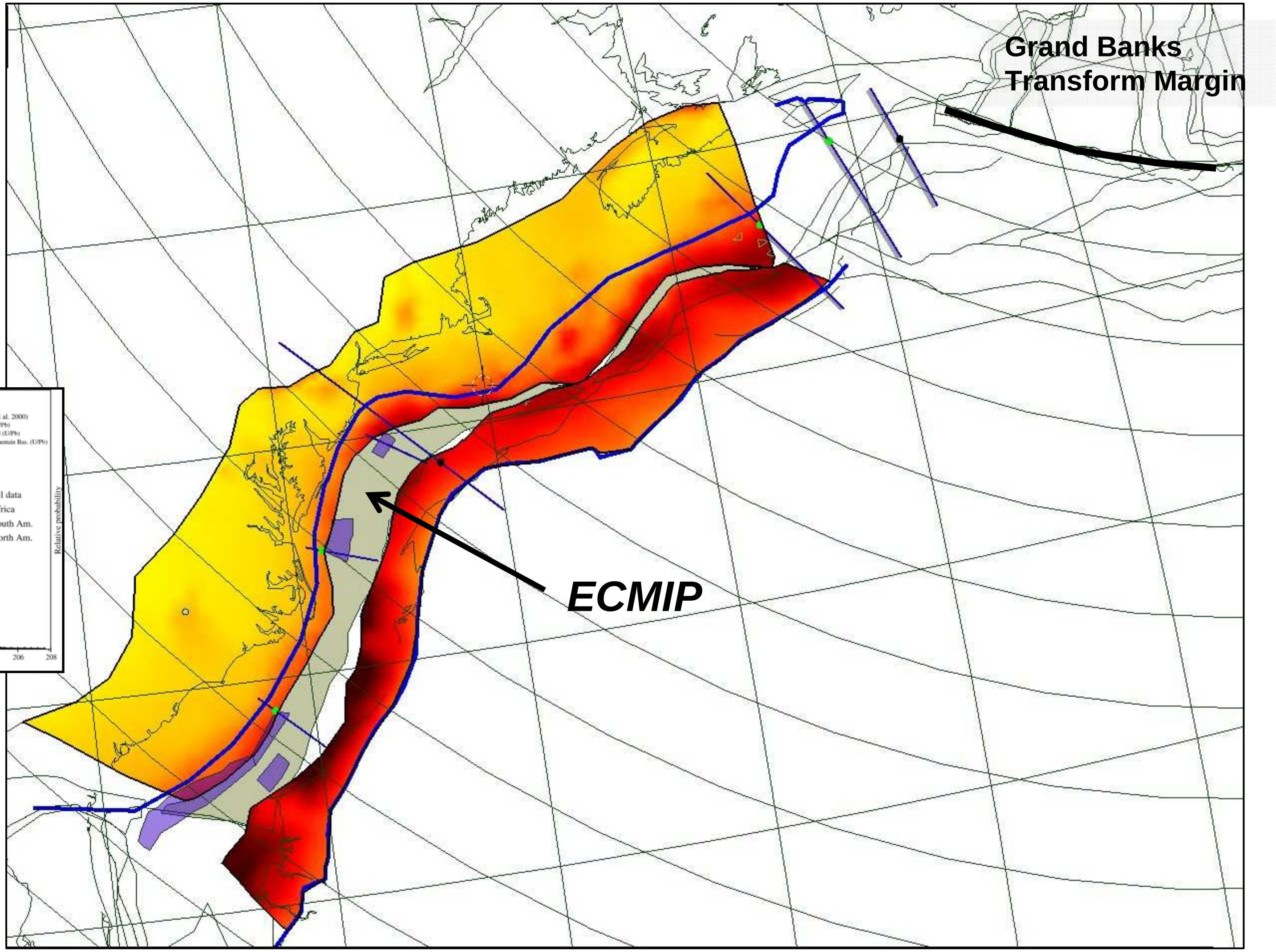


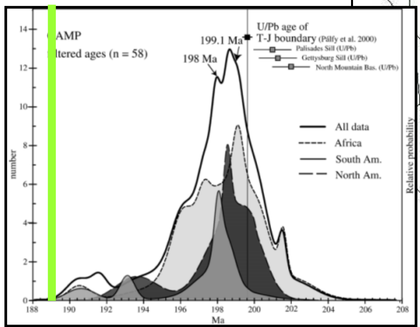
10 39
Crustal Thickness (km)

Kneller et al., submitted to C&G

Testing Syn-extension Models with Deforming Continua

189 Ma



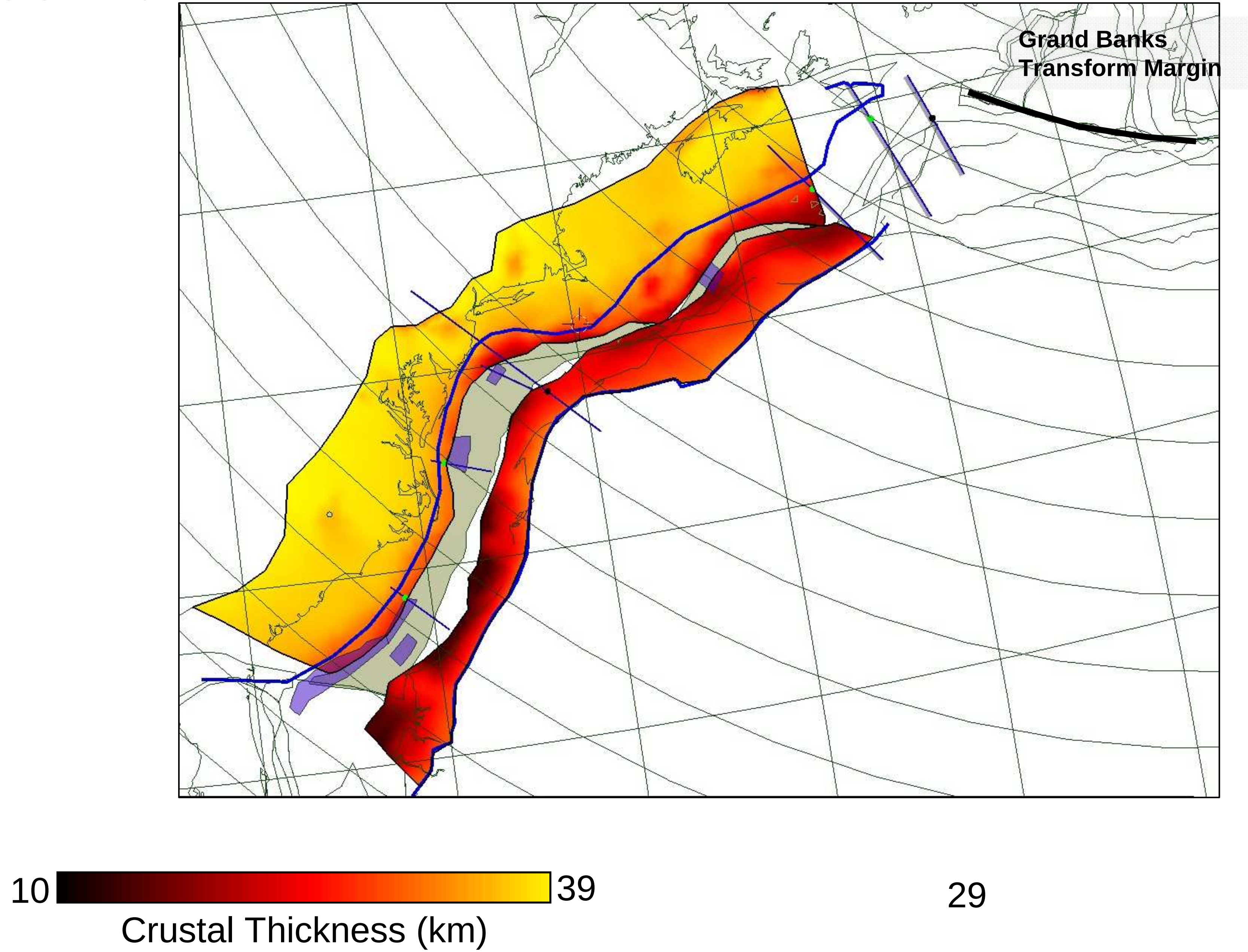


10 39

Crustal Thickness (km)

Testing Syn-extension Models with Deforming Continua

188 Ma



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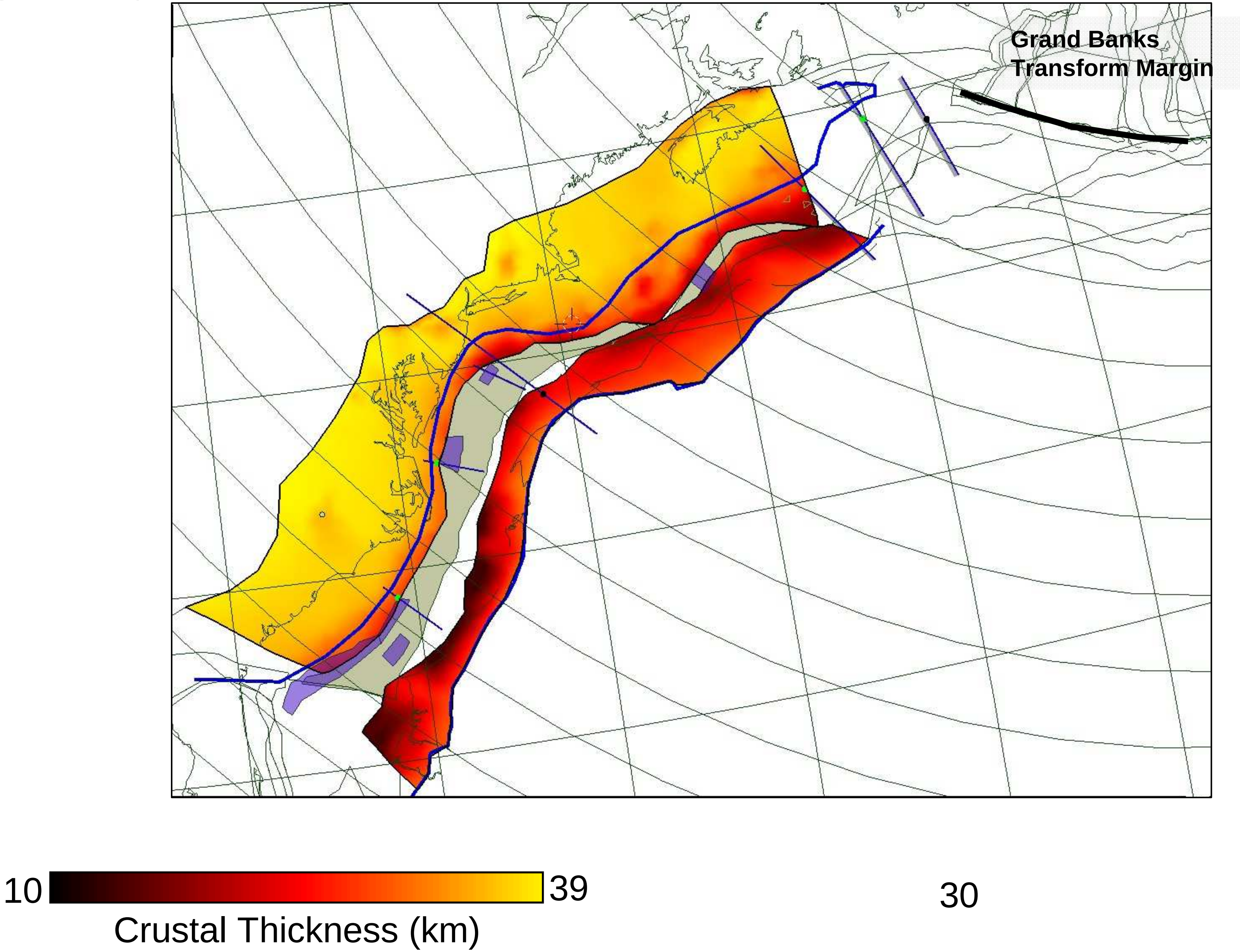
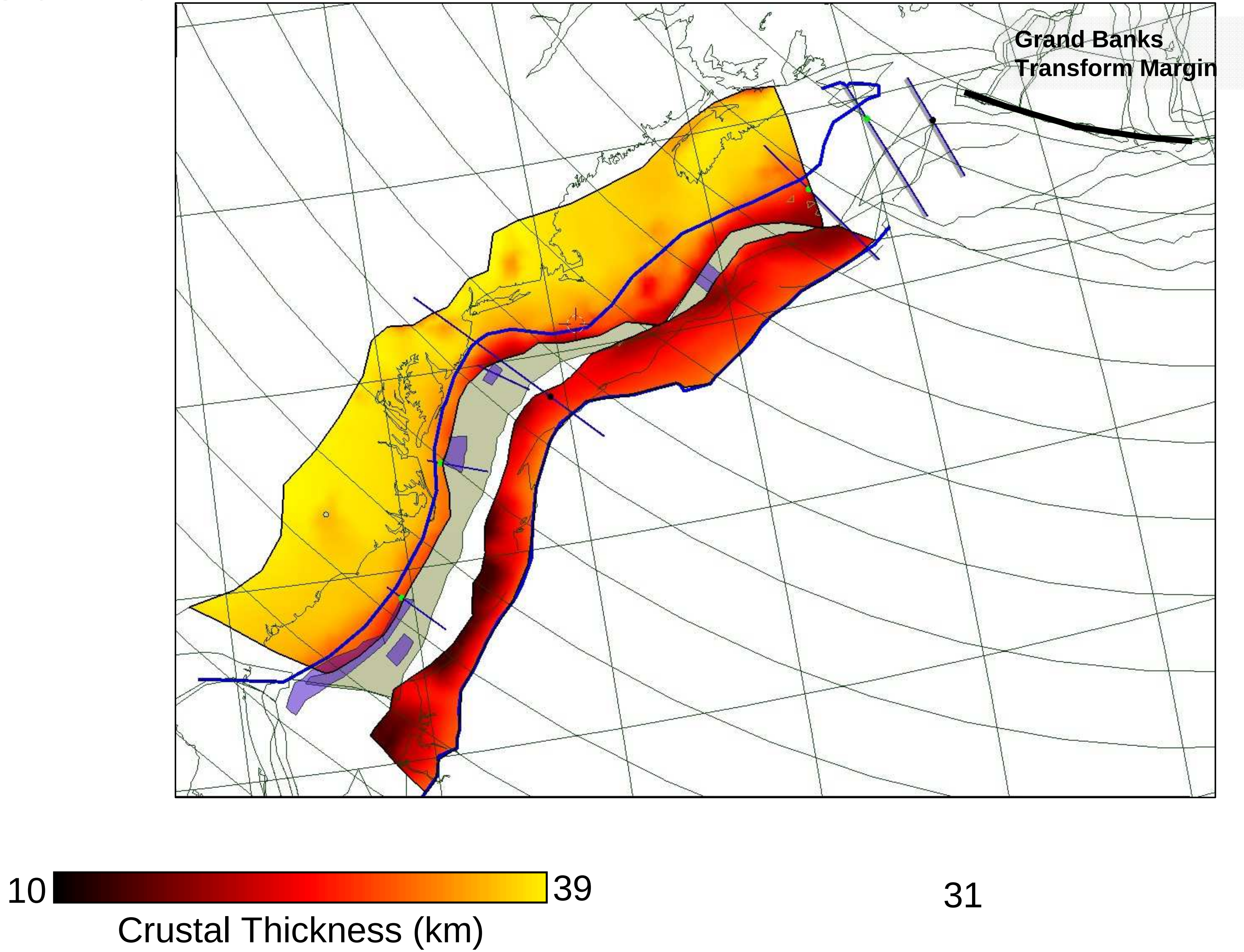
187 Ma



Testing Syn-extension Models with Deforming Continua

186 Ma



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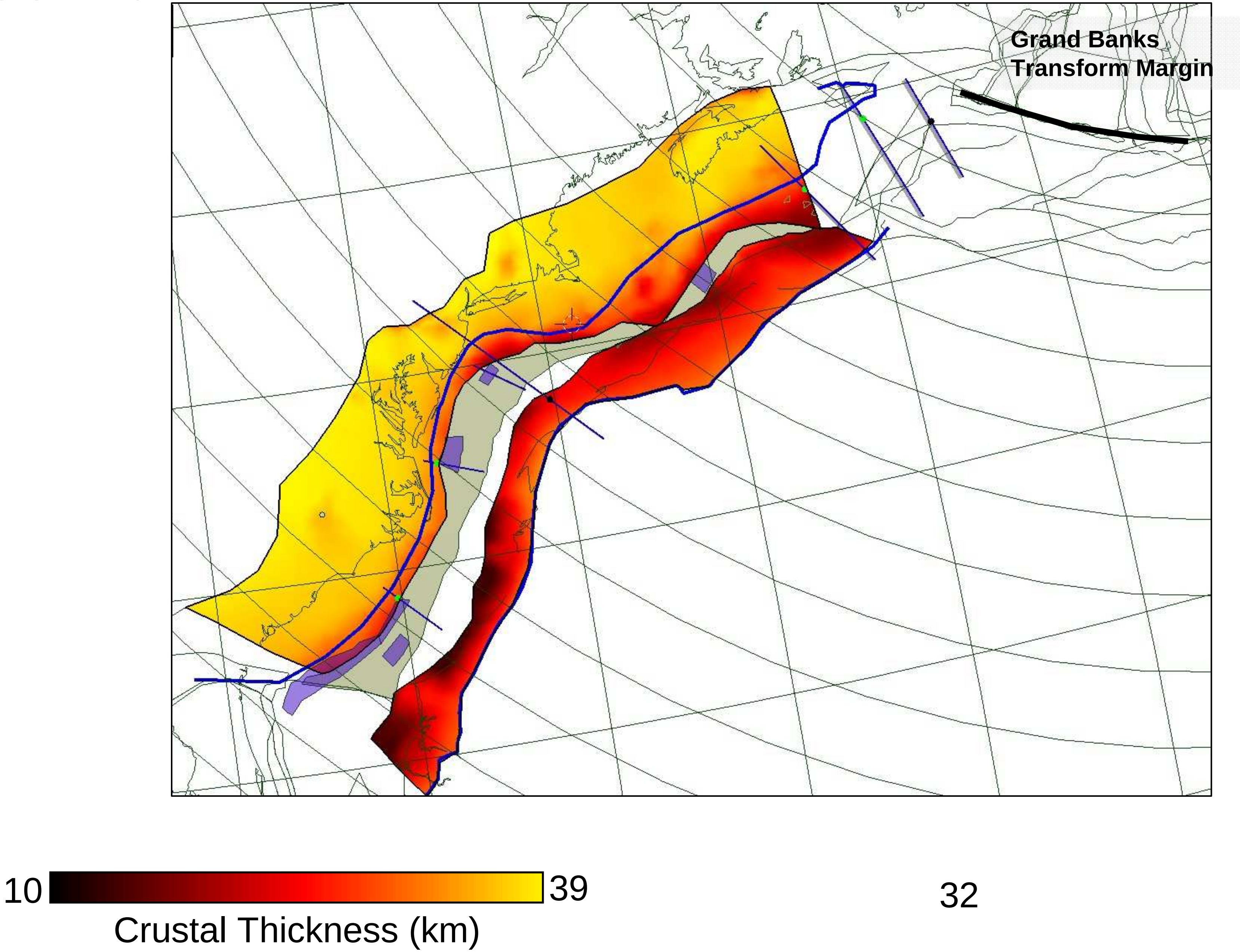
185 Ma



Central Atlantic Plate Model: Ridge Jump at 180 Ma

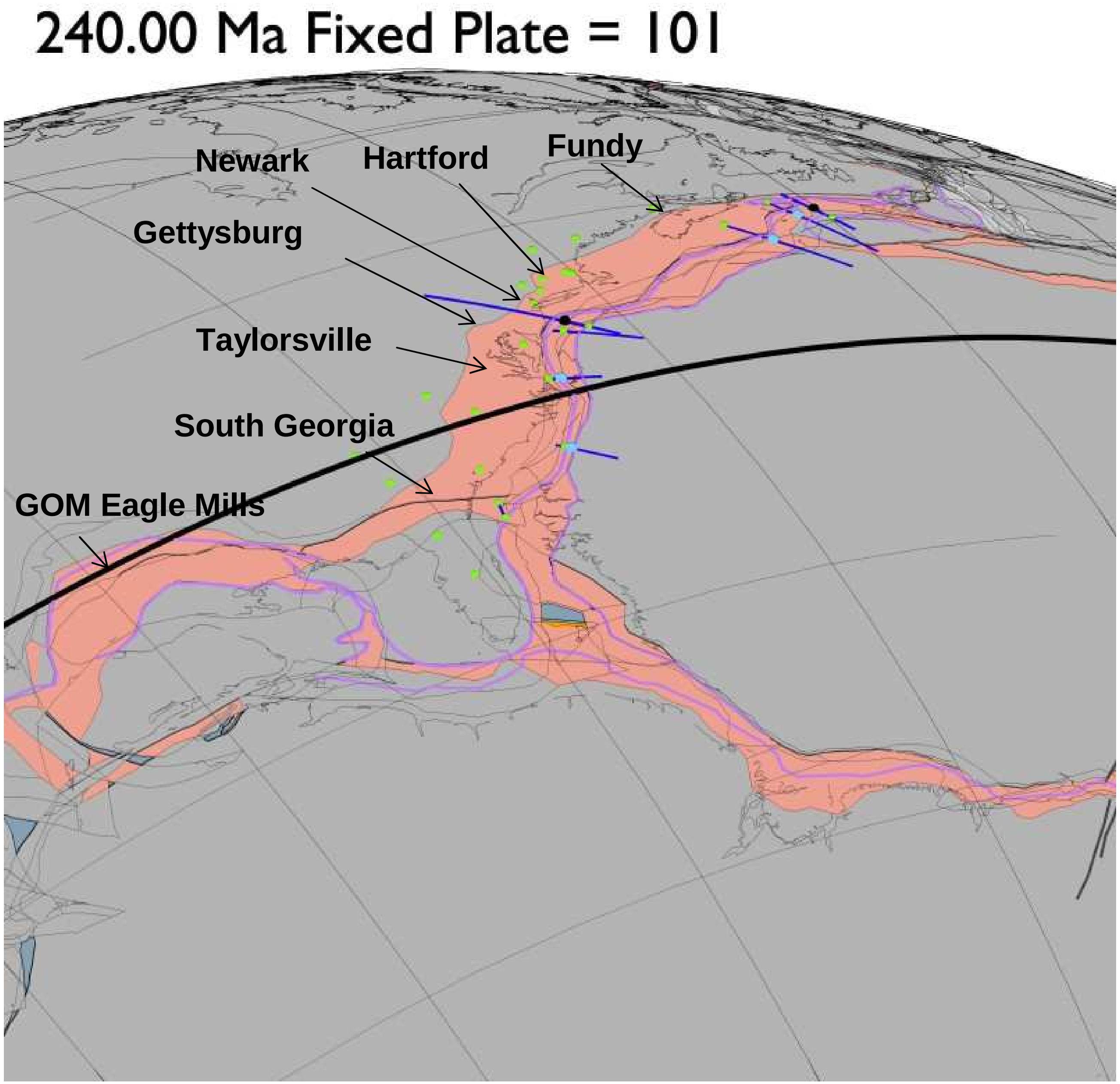
Syn-rift Basin (Costain and Coruh, 1989; Salvador, 1991; Olsen, 1997)

CAMP Flows (Nomade et al., 2007)

CAMP Dikes (Nomade et al., 2007)

Volcanic/Magmatic Margin

SDR's (Grow et al., 1993; Talwani et al., 1995; Oh et al., 1995)



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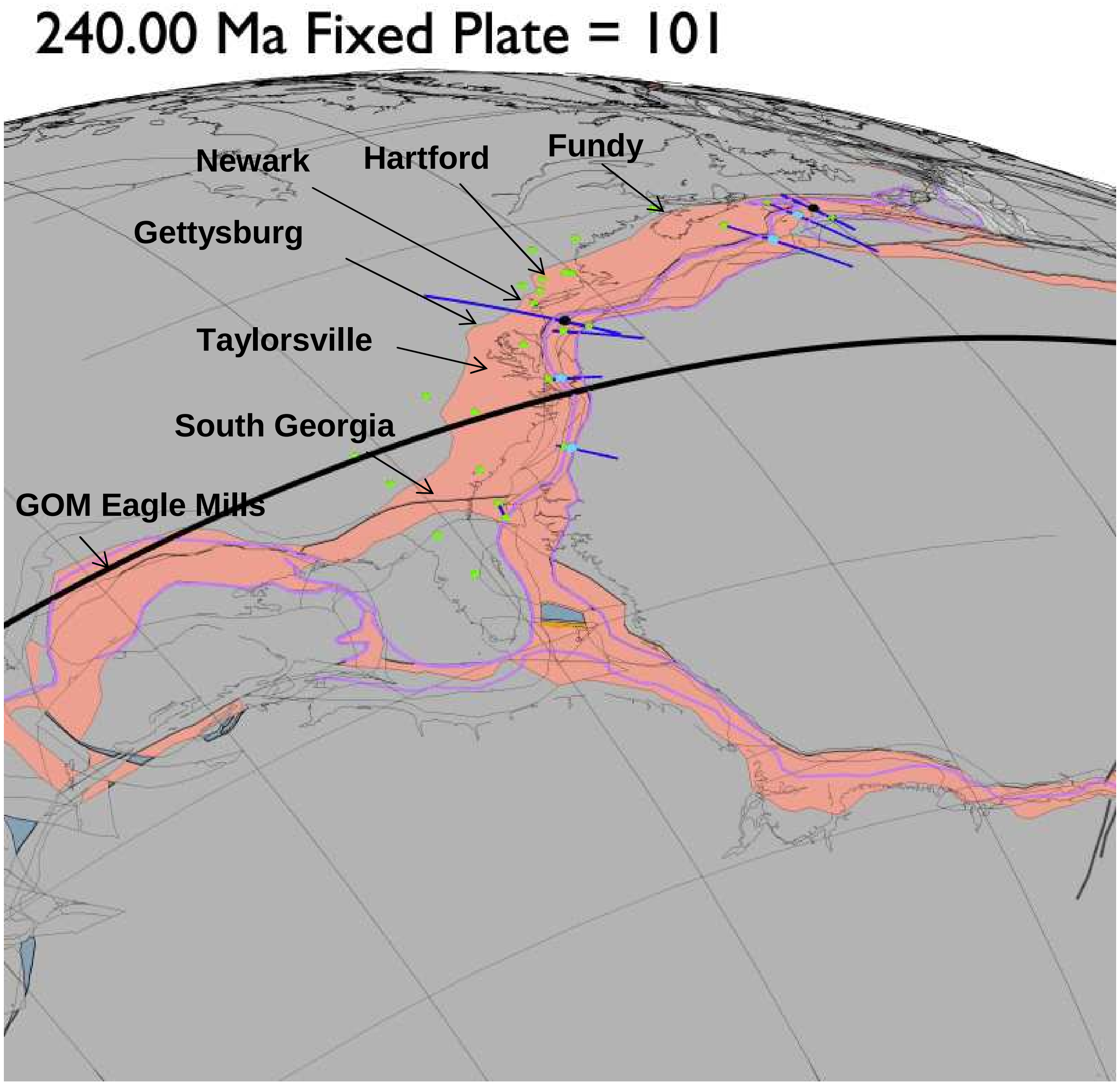
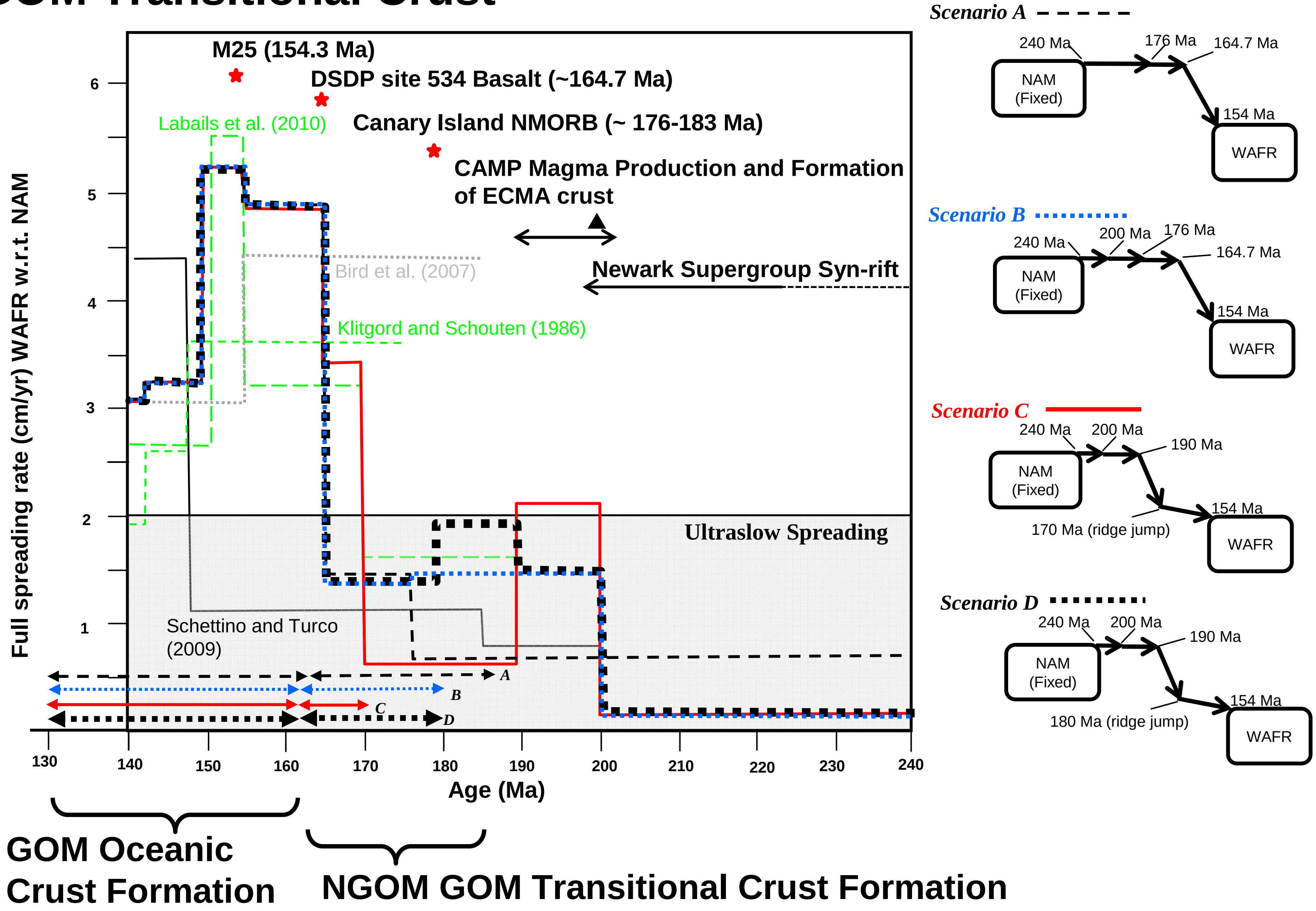


Multiple Scenarios and Implications for GOM Transitional Crust



Conclusions

Accurately mapping the distribution of magmatic crust is essential for constraining Central Atlantic plate kinematics.

Recently published plate models are inconsistent with geologic and geophysical observations, include unrealistic gaps and cannot restore extended crust to a reasonable initial thickness.

Palinspastic restorations constrained by receiver functions and refraction data closely match restored refraction lines and improve tight fit reconstructions.

Inverse continuum models linked to plate kinematics can restore extended crust to a reasonable initial thickness if extension initially occurs over a wide zone and then subsequently localizes in the distal part of the system

The occurrence and timing of diachronous breakup inferred from the Newark Supergroup can be produced with continuum models if

- **the ECMIP formation begins at peak CAMP time**
- **transform motion occurs between southern Grand Banks and West Africa**

The diachronous end to syn-rift extension in the south may be associated with early localization of extensional strain

A range of kinematic scenarios with different ridge jump timing are permissible during the Jurassic. Our preferred scenario involves a ridge jump at 180 Ma.