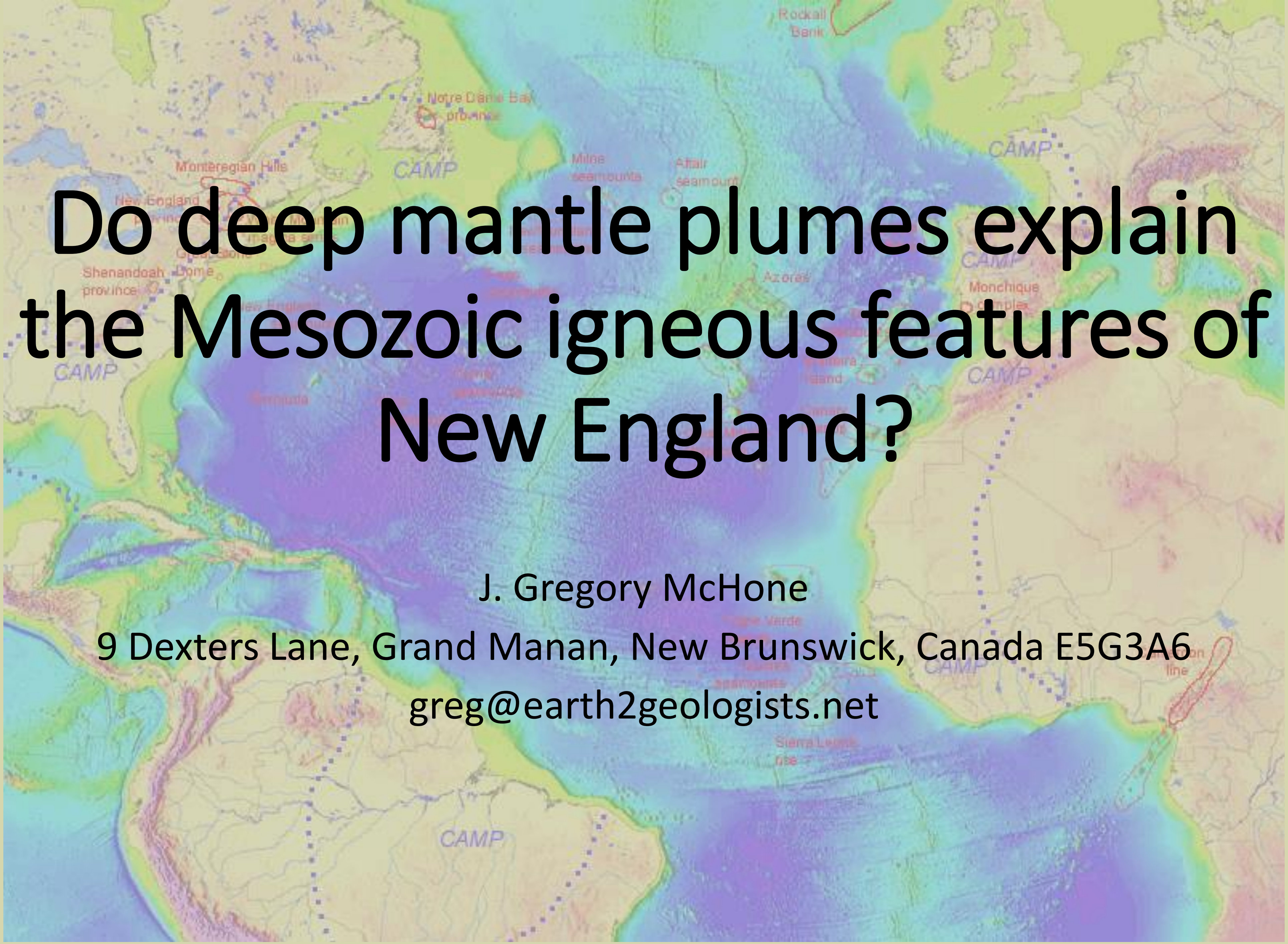
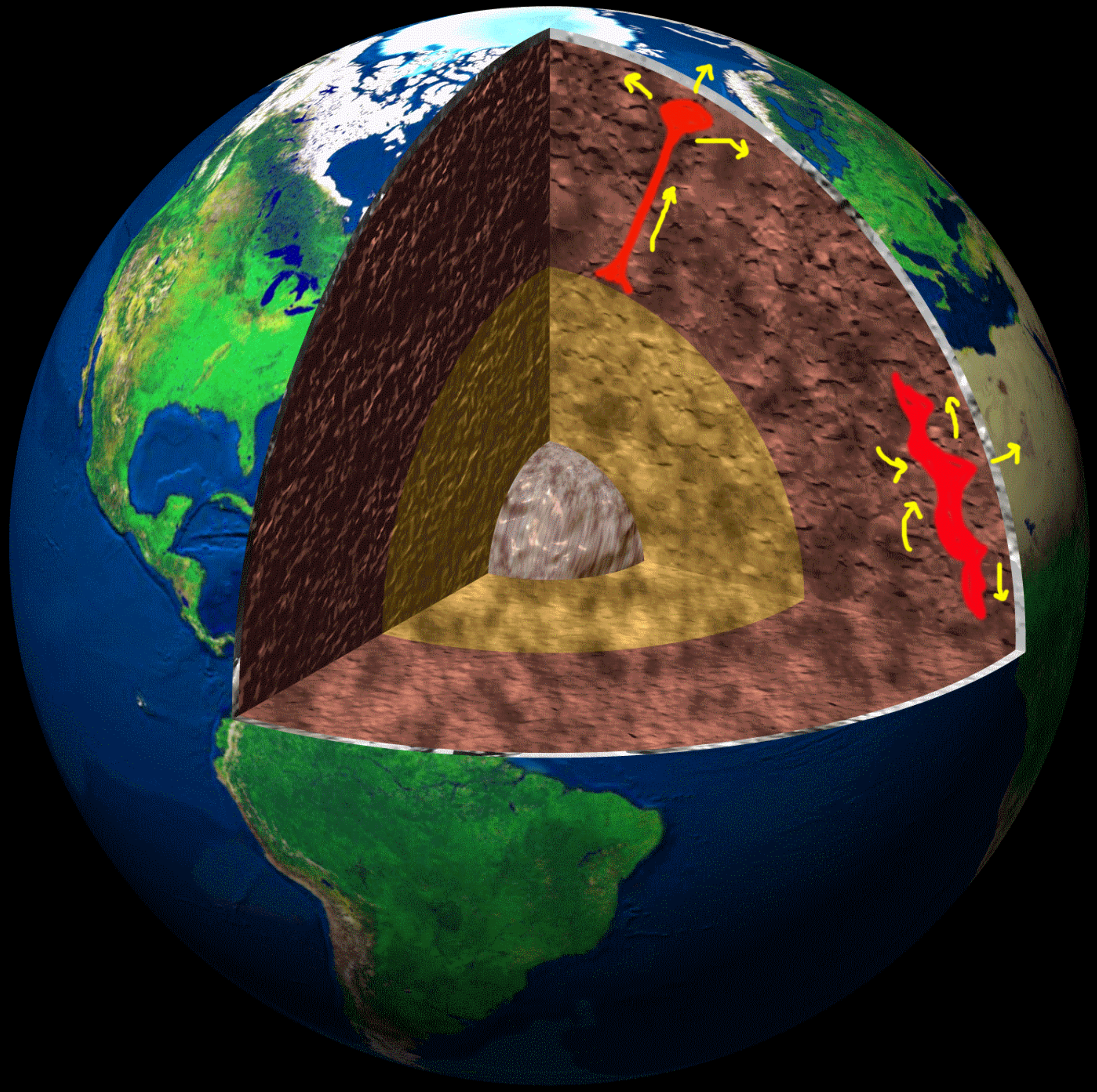
Do deep mantle plumes explain the Mesozoic igneous features of New England?

J. Gregory McHone

9 Dexters Lane, Grand Manan, New Brunswick, Canada E5G3A6

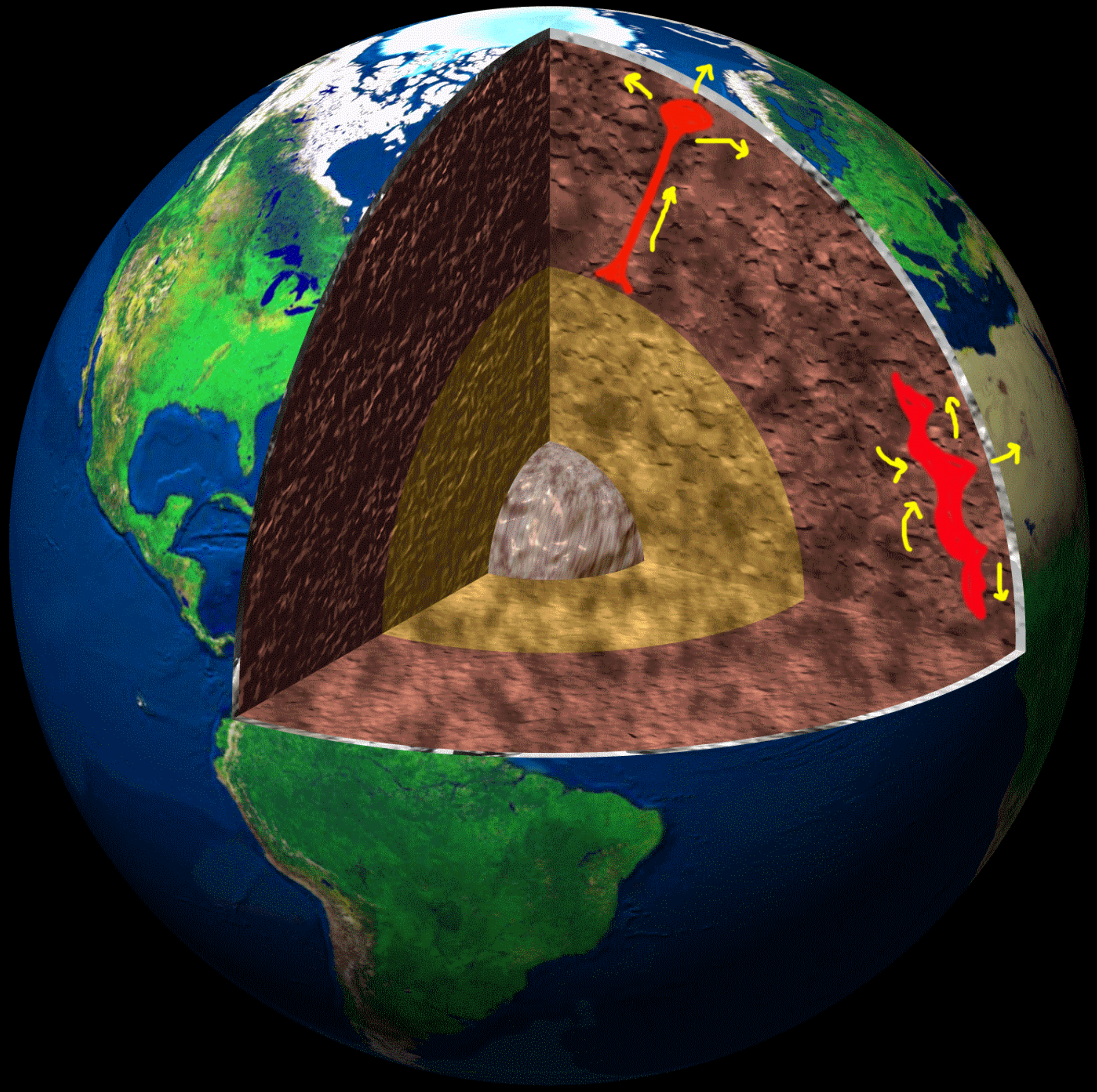
greg@earth2geologists.net





“Hotspots” are regions of anomalous volcanism that appear to be unrelated to plate boundary processes (Tuzo Wilson, 1963). So the term “hotspot” was originally defined purely as a surface feature with an unknown cause of volcanism.

Jason Morgan (1971) and others proposed that hotspots and linear chains of intraplate volcanoes are made by narrow plumes of hot material rising from the deepest mantle.



Many now think of the terms “hotspot” and “mantle plume” as near-synonyms, and the term “hotspot” is sometimes used even where there is no surface volcanism.

Direct evidence that deep-mantle plumes actually exist and are the cause of all or most hotspots remains inconclusive, unlike robust evidence that plate boundary processes produce most volcanoes.

Tectonic processes within plates and related upper-mantle convection should also be considered as mechanisms for volcanoes that are isolated from plate boundaries.

Fig 1.2 from “Plates vs Plumes: A Geological Controversy” by Gillian Foulger

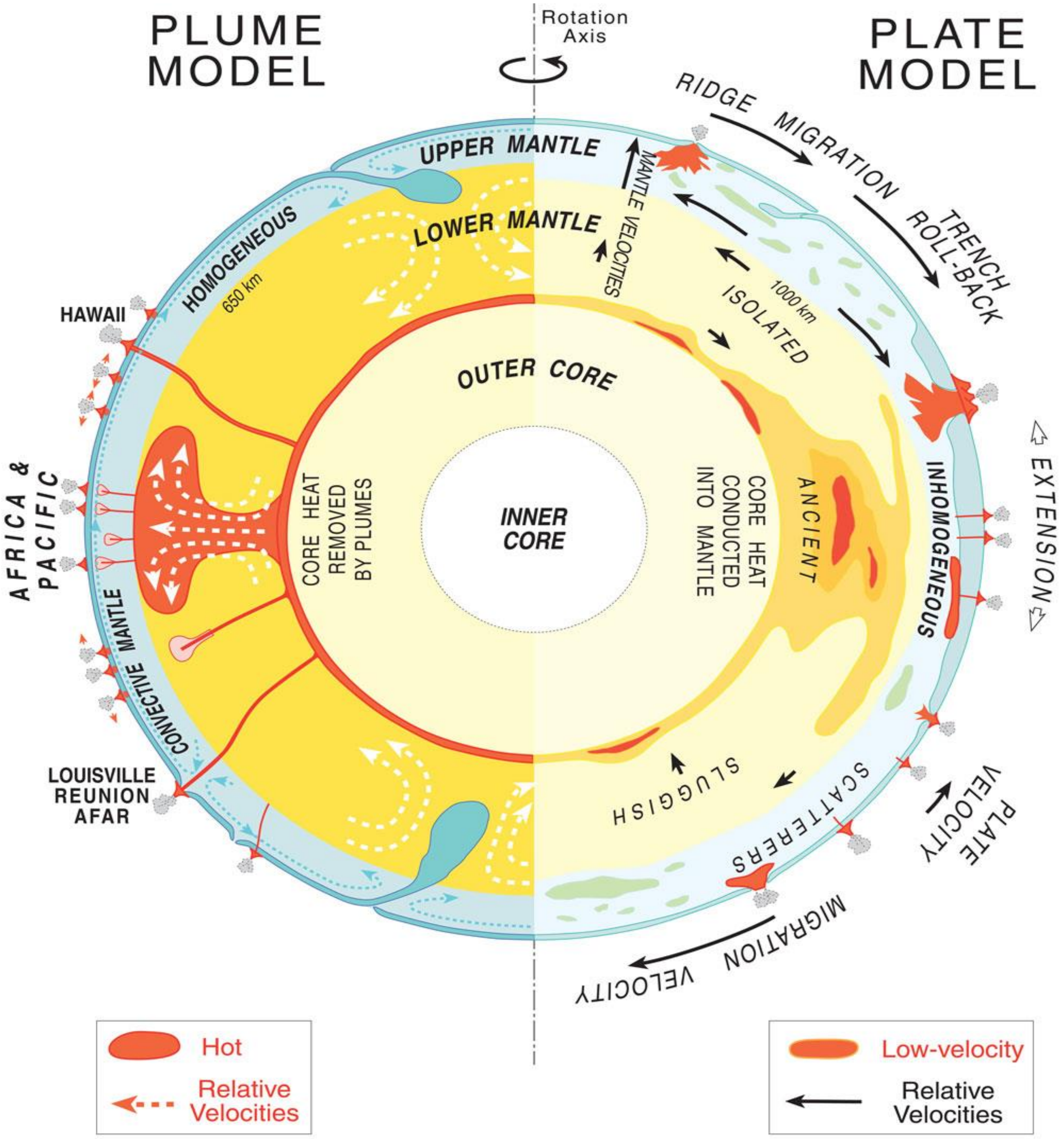
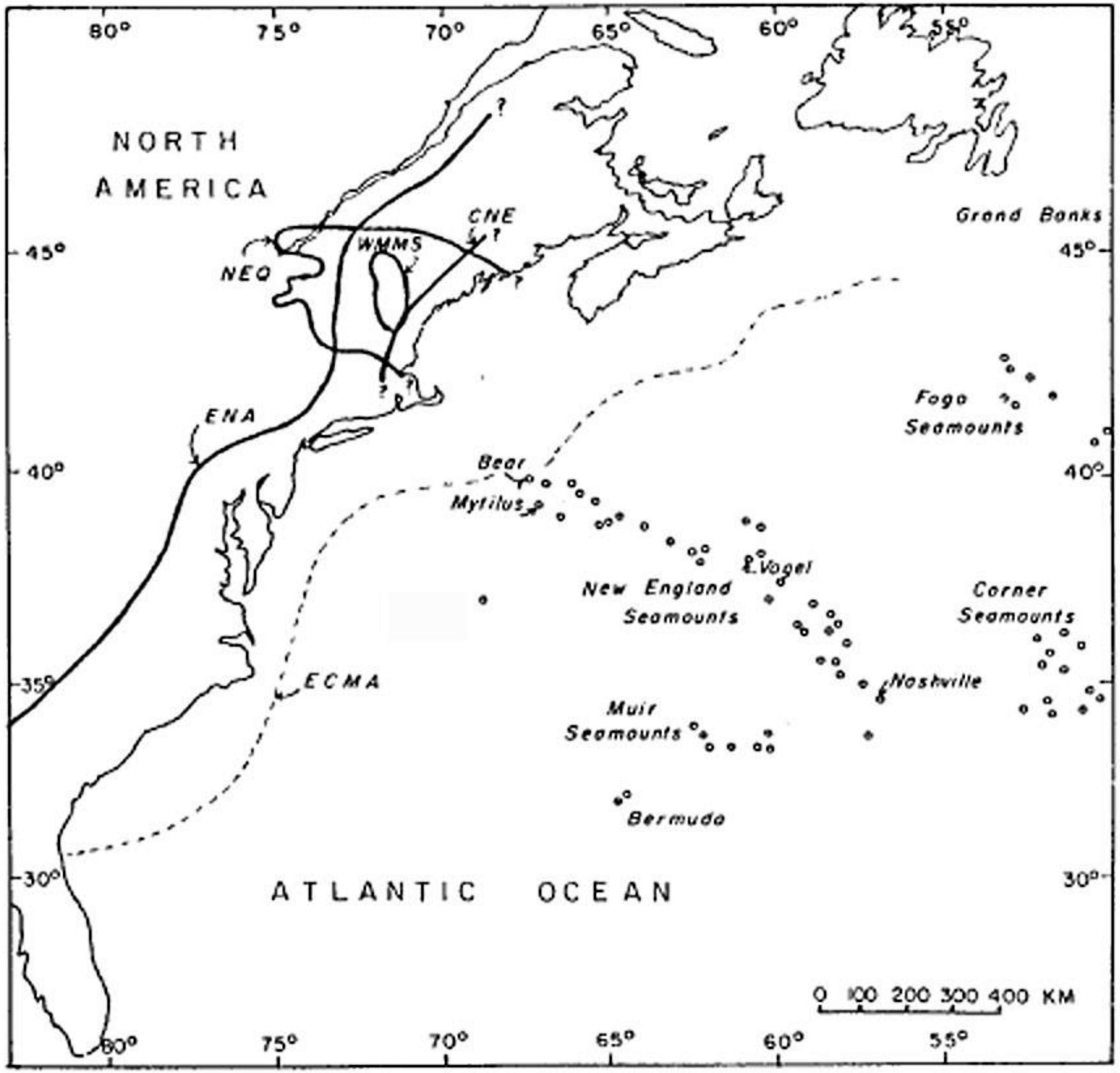


Fig. 8 from McHone & Butler, 1984, "Mesozoic igneous provinces of New England and the opening of the North Atlantic Ocean:" GSA Bulletin, v. 95. p. 757-765.



Mesozoic igneous provinces overlap in New England:

- Early Triassic = Coastal New England subalkaline dikes and plutons
- Early Jurassic = tholeiitic CAMP dikes and basalts of eastern North America
- Jurassic = alkali plutons of the White Mountain Magma Series
- Early Cretaceous = alkali dikes and plutons of New England-Quebec
- Cretaceous-Tertiary chains and clusters of seamounts (alkalic submarine volcanoes) are offshore.

Do deep mantle plumes explain these features?

Fig. 1 from
"Mesozoic hotspot epeirogeny
in eastern North America:"
S. Thomas Crough, 1981, Geology,
v. 9, p.2-6.

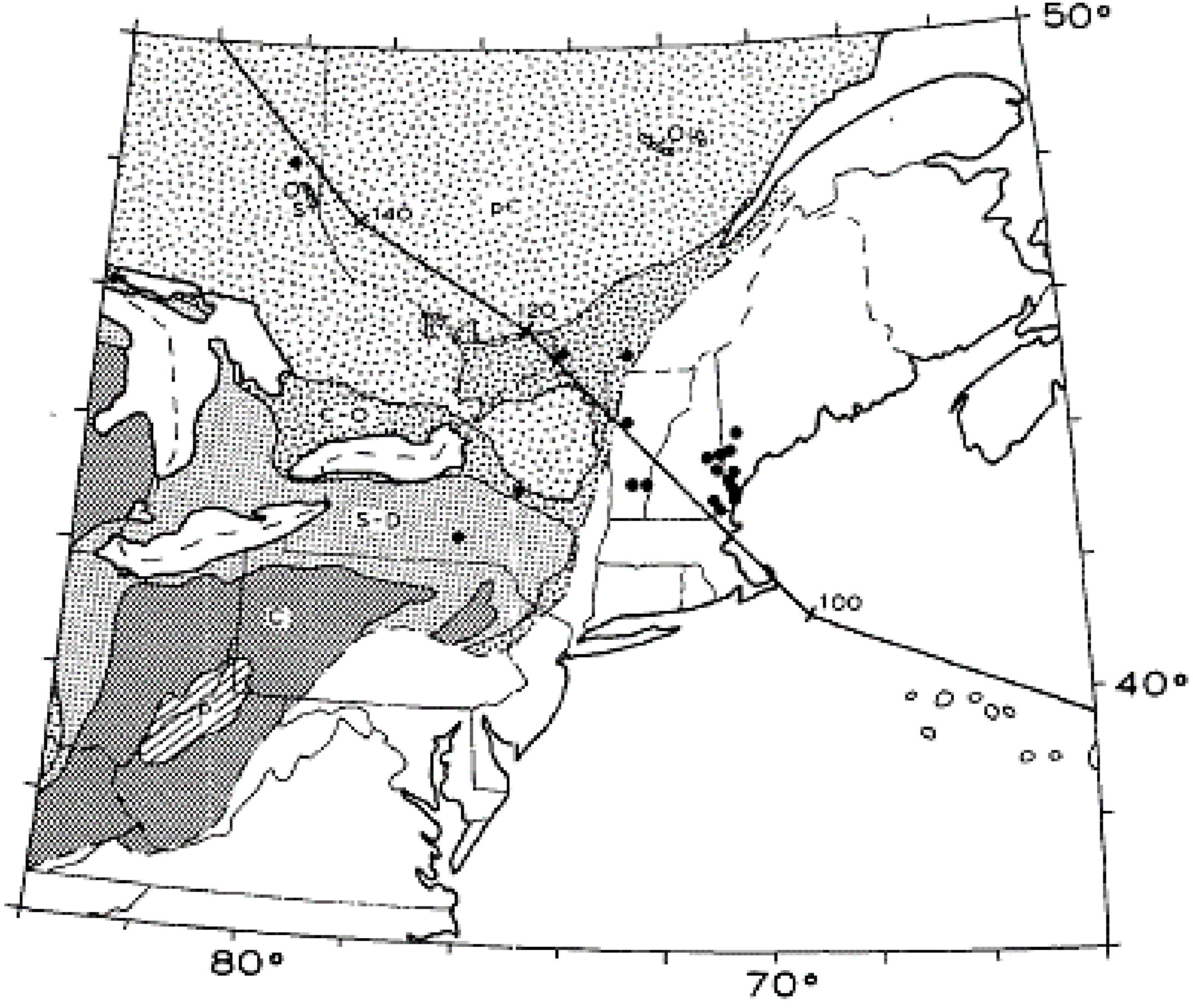
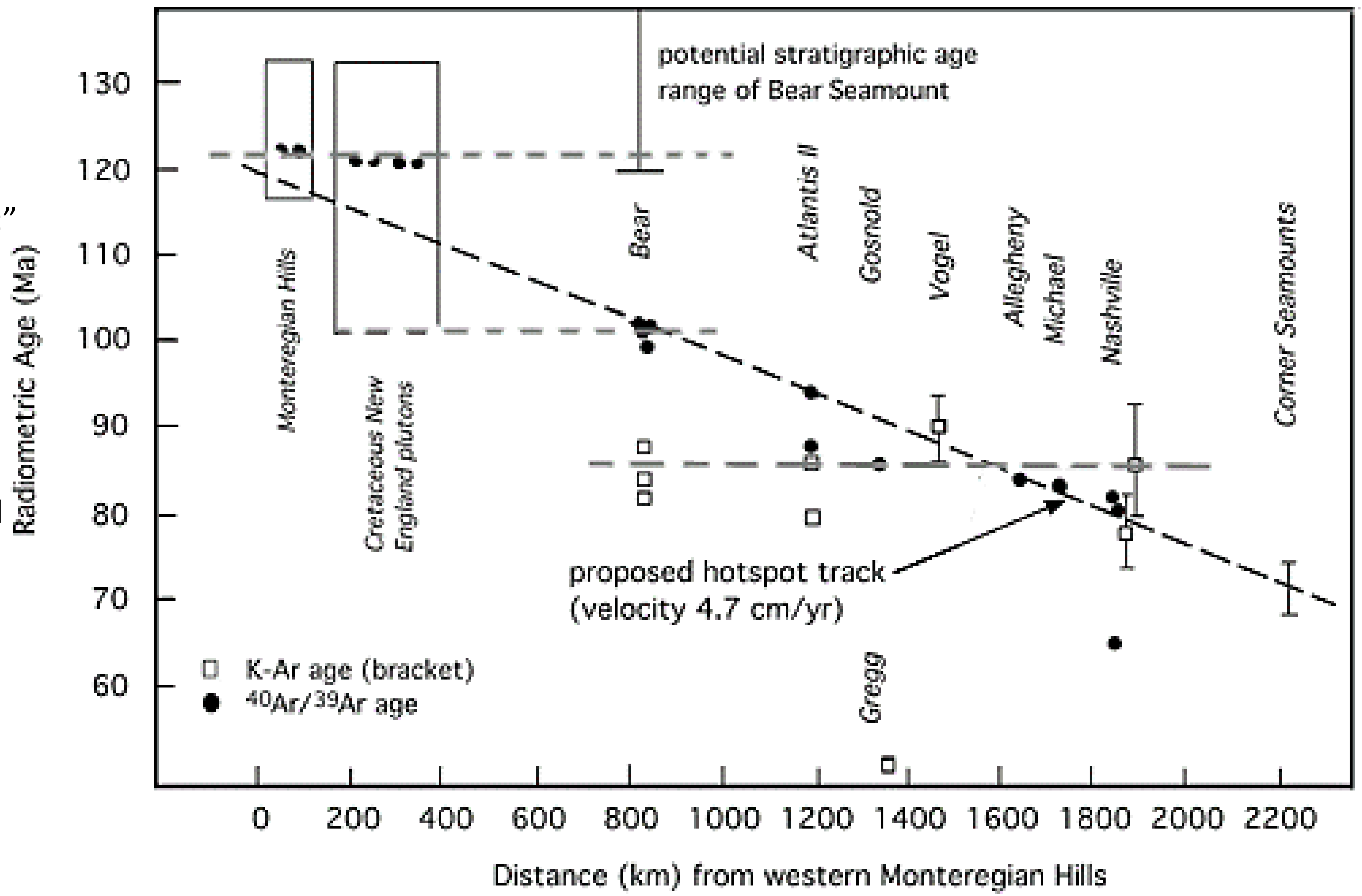


Figure 1. Predicted track of Great Meteor hotspot from about 160 to 80 m.y. B.P., superposed on generalized geologic map of craton in eastern North America. Solid dots are radiometrically dated igneous intrusions which track explains (see text). Trace marks southern limit of Canadian Shield, suggesting that hotspot swell caused present structural relief.

Fig. 2 from McHone, J.G., 1996, “Constraints on the mantle plume model for Mesozoic alkaline intrusions in northeastern North America:” Canadian Mineralogist, v. 34 pp 325-334.

Seamount ages are by Duncan, R.A., 1984: “Age-progressive volcanism in the New England seamounts and the opening of the central Atlantic Ocean. J. Geophys. Res. V. 89, pp. 9980-9990.



Morgan, W.J., 1983: “Hotspot tracks and the early rifting of the Atlantic:” Tectonophysics 94, pp. 123-139.

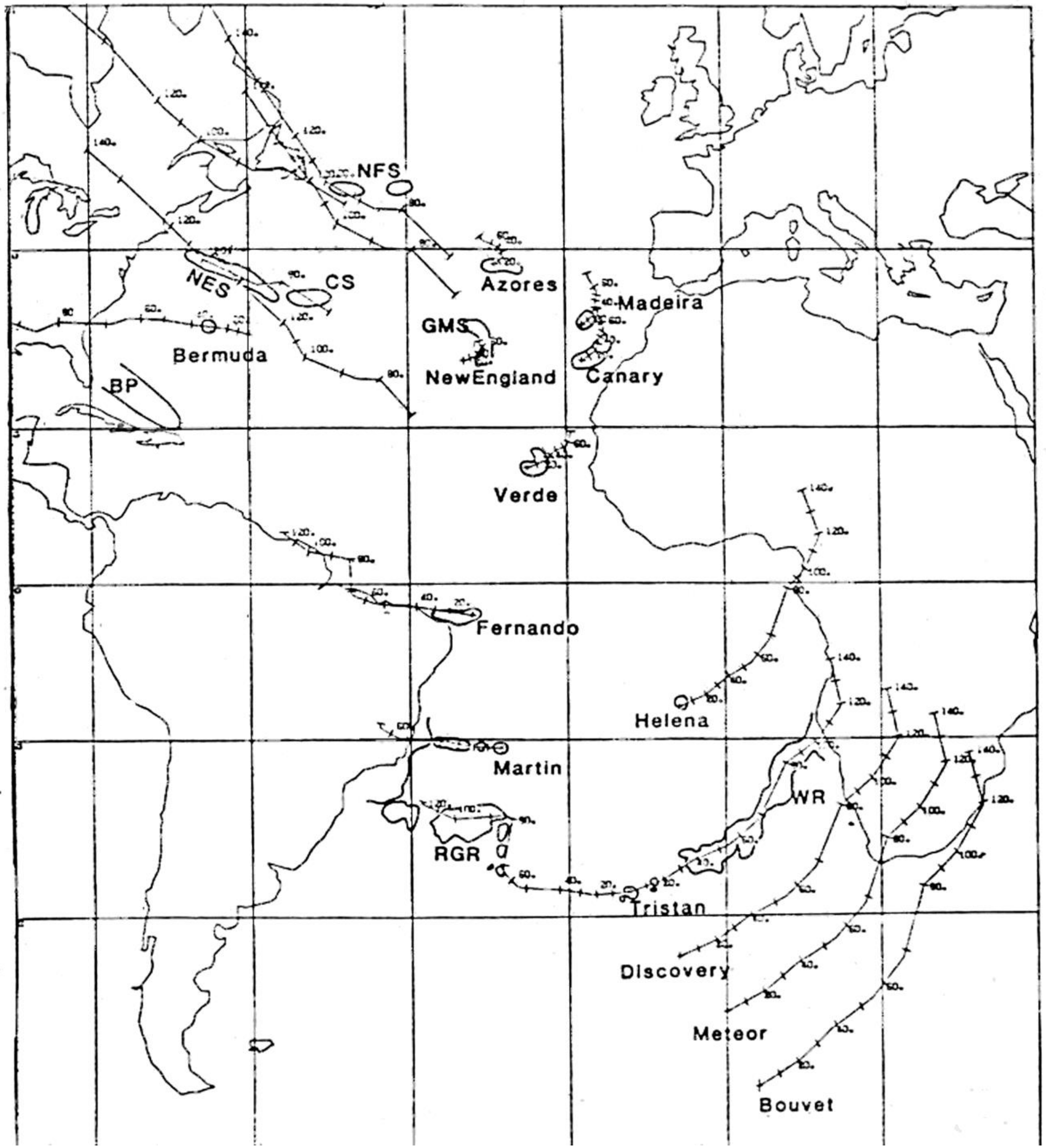


Fig. 1 from
McHone, J.G., 1996,
“Constraints on the mantle plume model for Mesozoic alkaline intrusions in northeastern North America:” Canadian Mineralogist, v. 34 pp 325-334.

Eastern North American kimberlites are distributed by structural controls proposed by Parrish, J.B. & Lavin, P.M. 1982, “Tectonic model for kimberlite emplacement in the Appalachian plateau of Pennsylvania.” Geology v. 10, pp. 344-347.

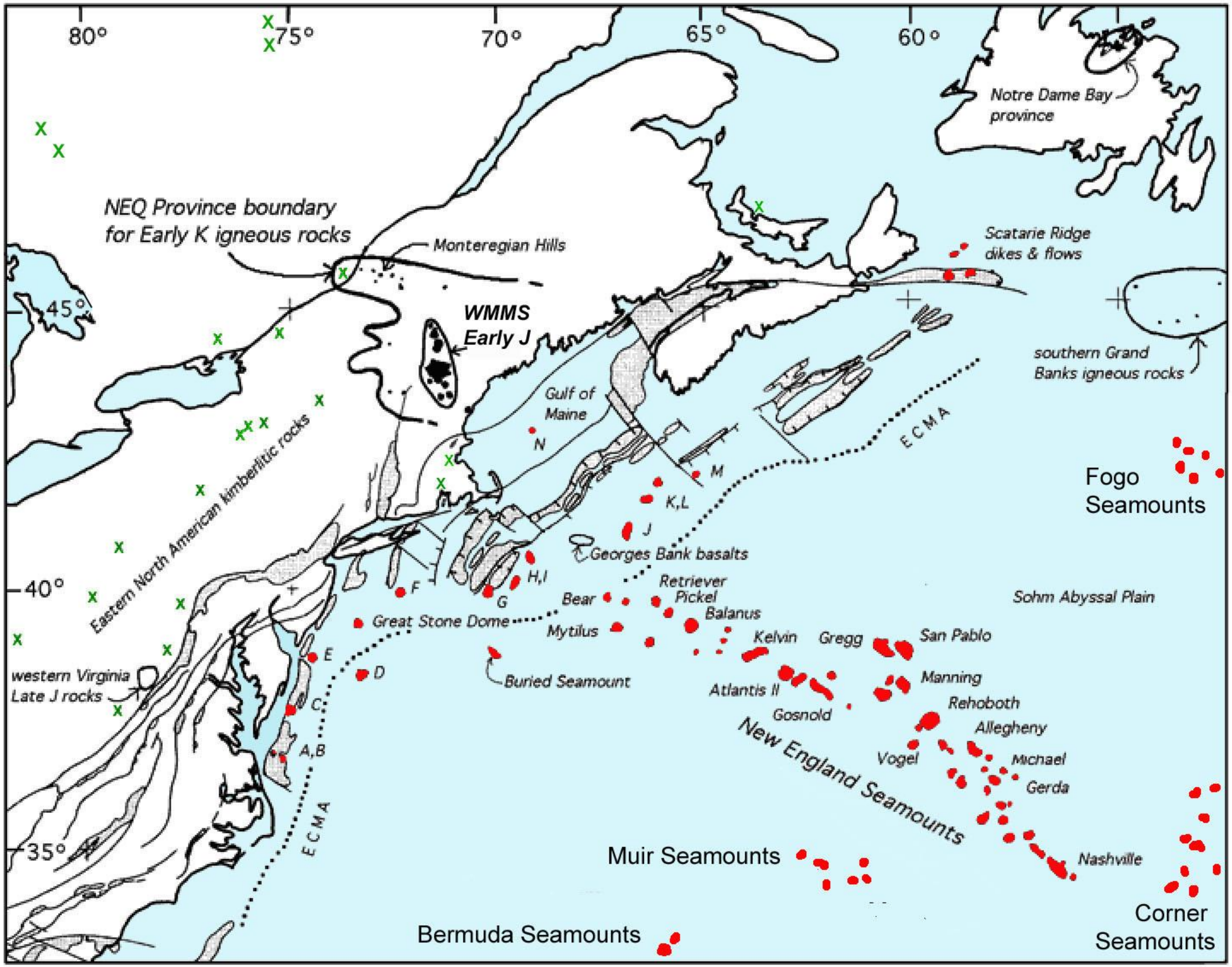
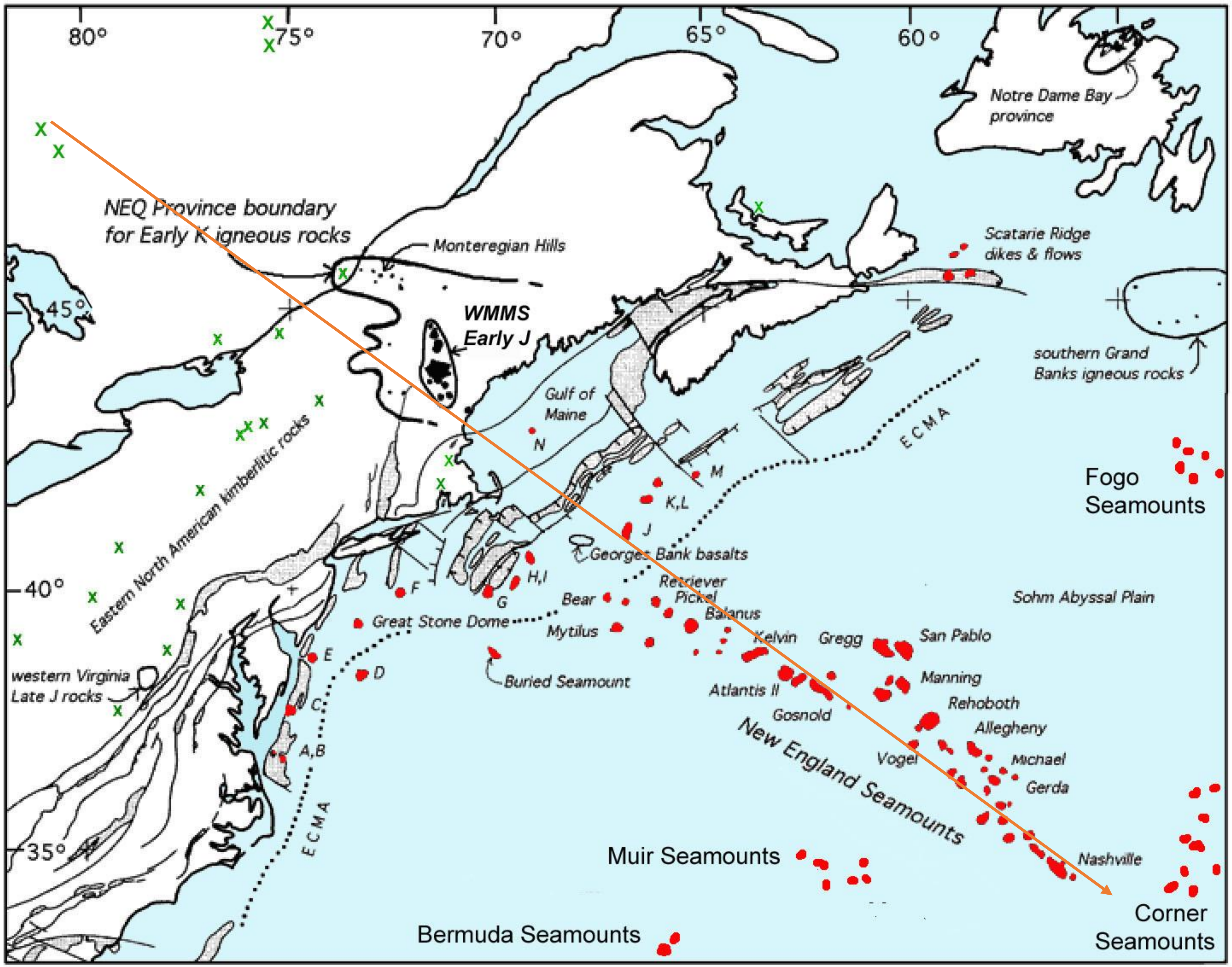


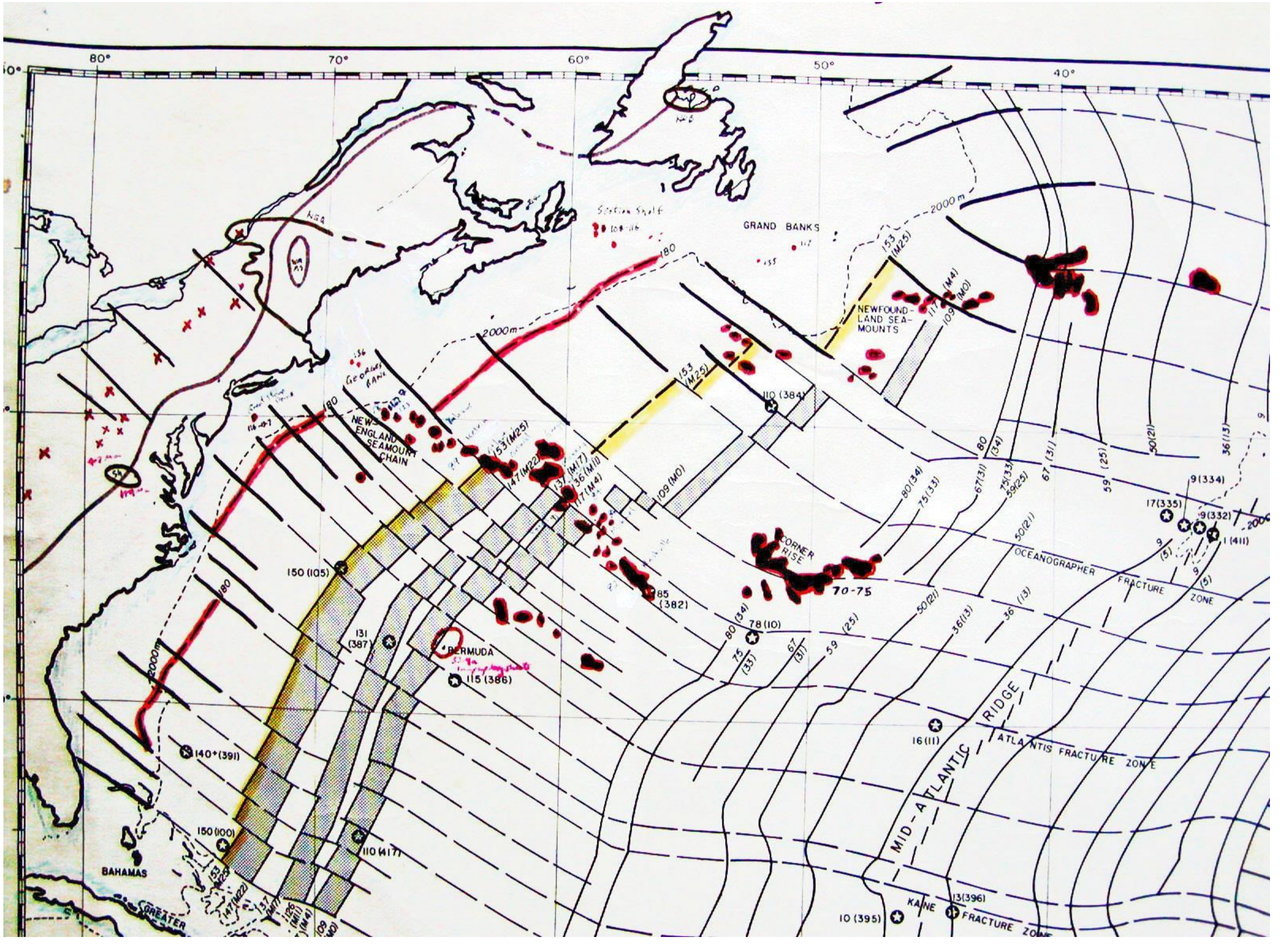
Fig. 1 from
McHone, J.G., 1996, "Constraints on the mantle plume model for Mesozoic alkaline intrusions in northeastern North America:" Canadian Mineralogist, v. 34 pp 325-334.

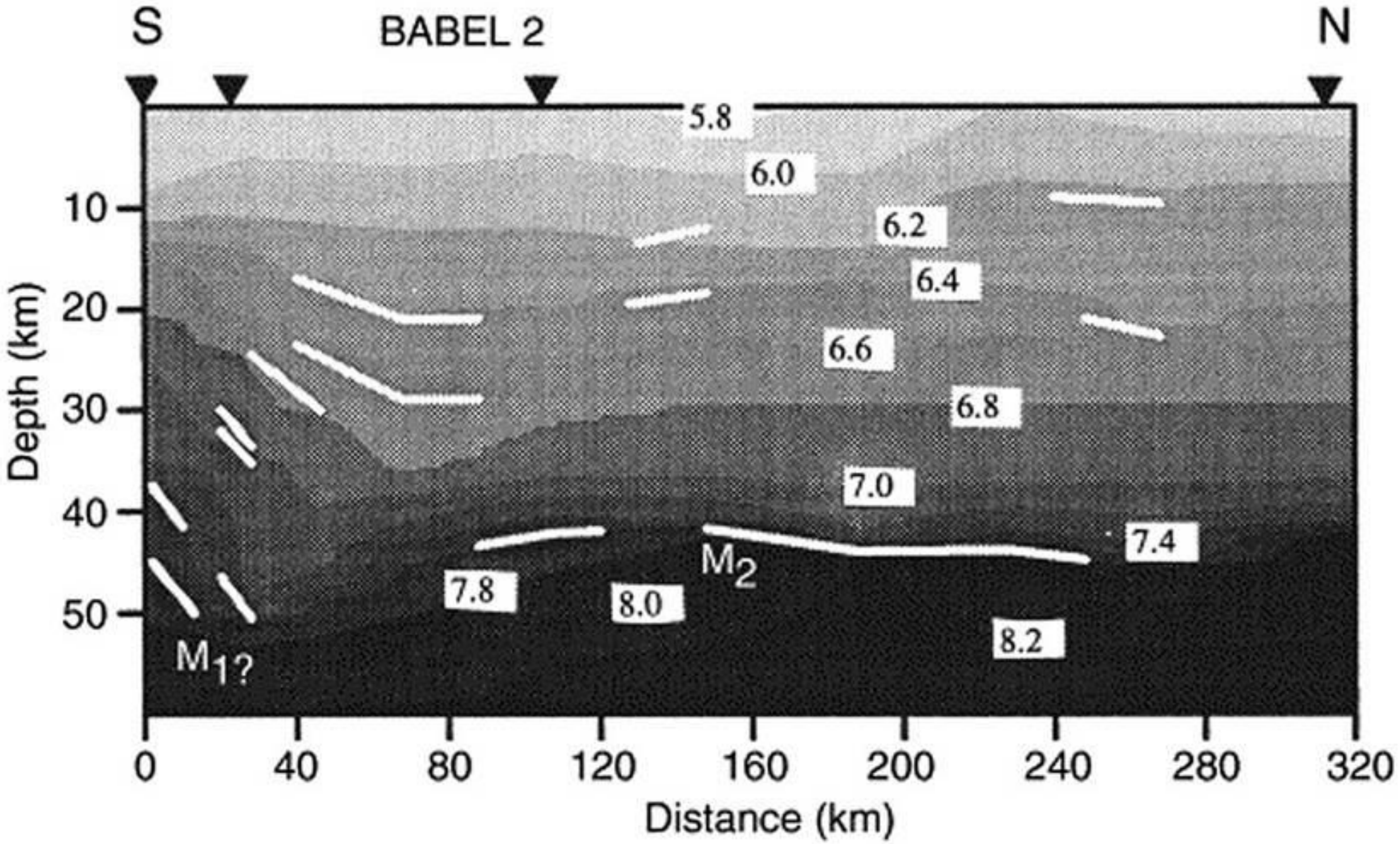
Eastern North American kimberlites are distributed by structural controls proposed by Parrish, J.B. & Lavin, P.M. 1982, "Tectonic model for kimberlite emplacement in the Appalachian plateau of Pennsylvania." Geology v. 10, pp. 344-347.



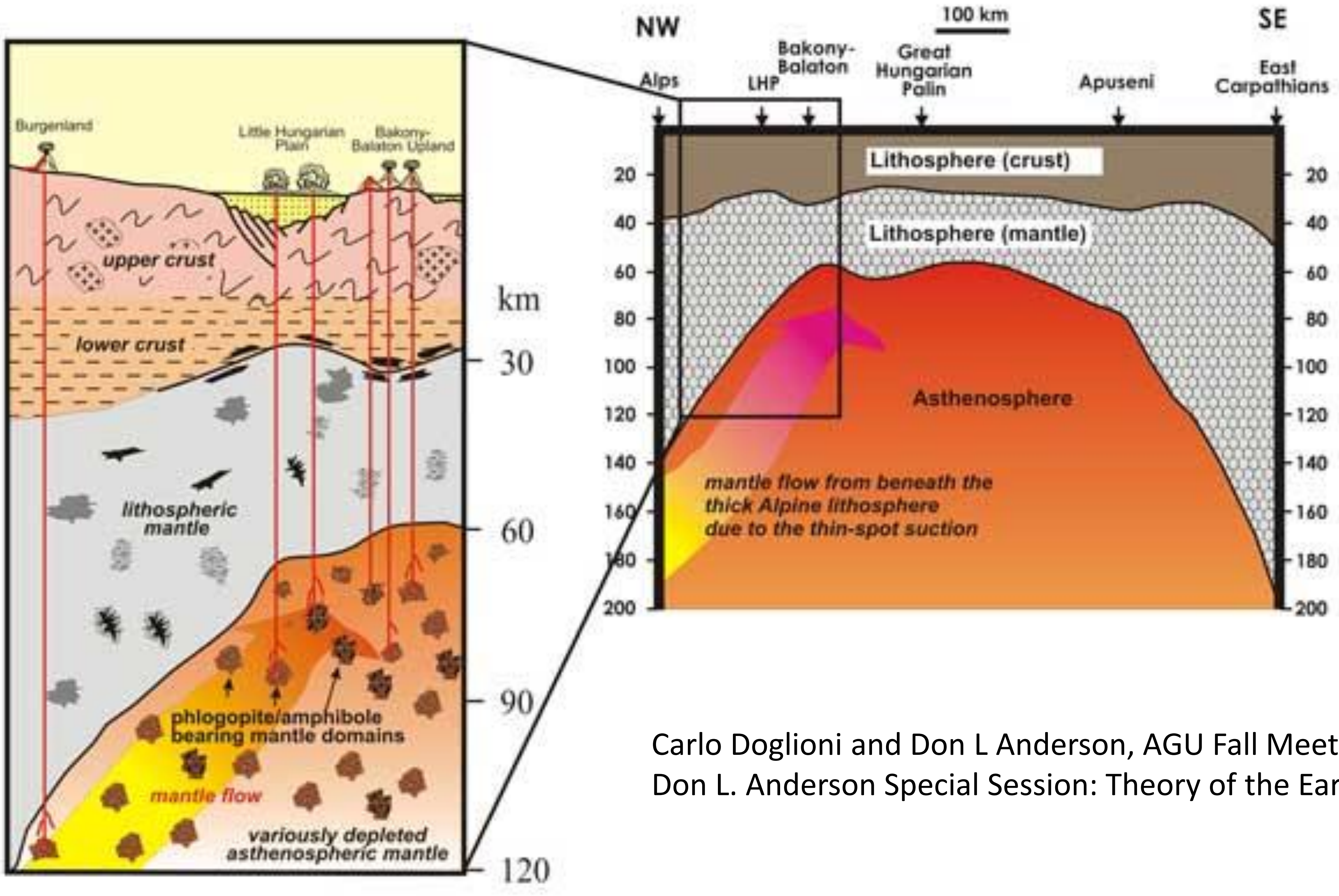
Fracture zones of the western Atlantic Ocean with distribution of seamounts.

Eastern North American kimberlites are distributed by structural controls proposed by Parrish, J.B. & Lavin, P.M. 1982, “Tectonic model for kimberlite emplacement in the Appalachian plateau of Pennsylvania.” Geology v. 10, p.344-347.

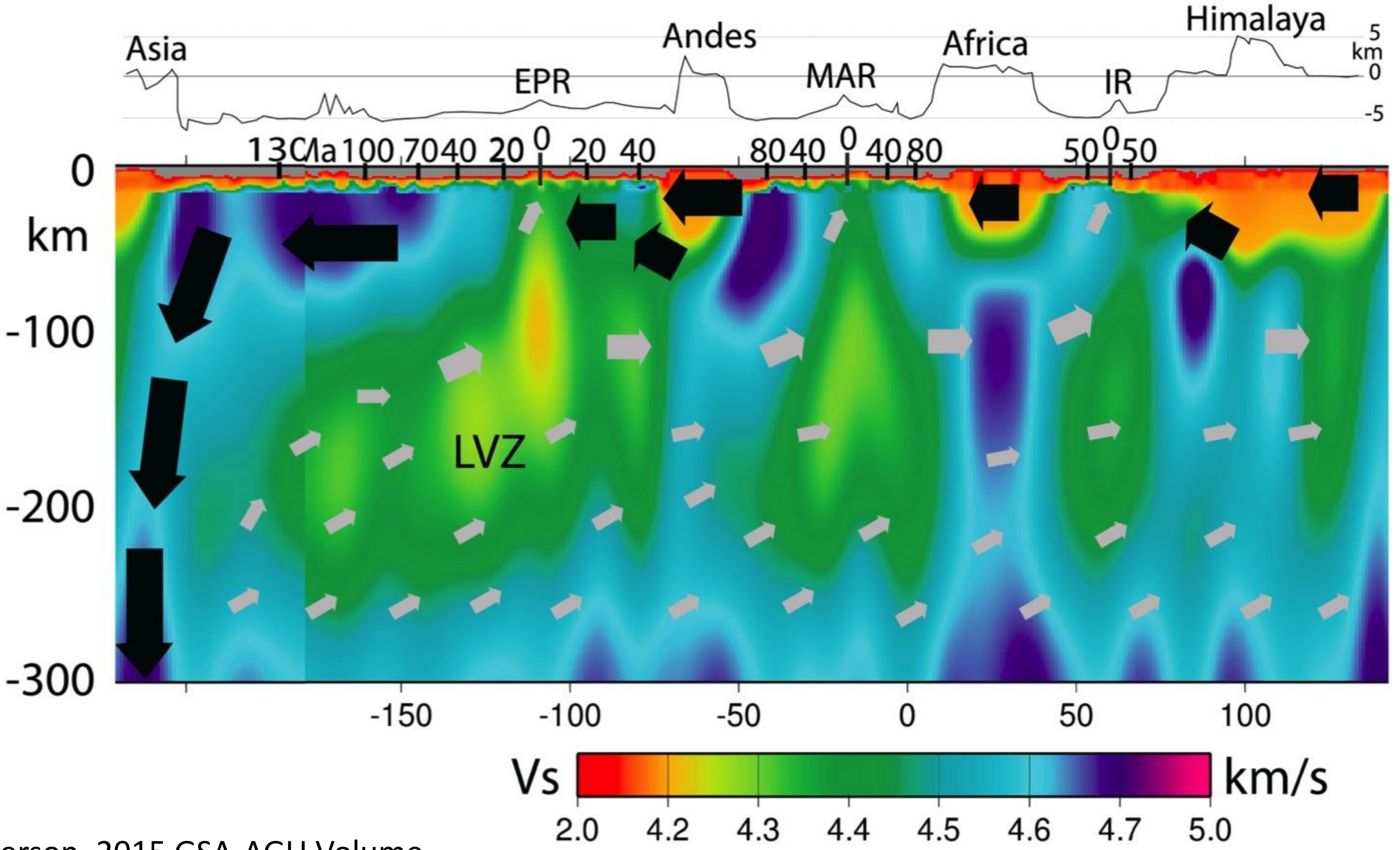




Balling, N., 2000, Deep seismic reflection evidence for ancient subduction and collision zones within the continental lithosphere of northwestern Europe: Tectonophysics, v. 329, p. 269-300.



Carlo Doglioni and Don L Anderson, AGU Fall Meeting 2014,
Don L. Anderson Special Session: Theory of the Earth



Doglioni & Anderson, 2015 GSA-AGU Volume

Most kimberlites, alkali plutons, and seamount volcanoes of Jurassic and Cretaceous ages in eastern North America are NOT on mantle plume tracks.

Lithospheric structures may control where mantle melts rise through the crust.

Oceanic fracture zone propagate along plate movement directions, providing pathways for chains and clusters of seamount volcanoes.

Warm sections of a layered upper mantle can cause local convection and zones of melting, influenced by plate rifting events

Epeirogeny and doming may be caused by local mantle convection and heating.

There is no need for, or strong evidence for, narrow plumes of material that rise from the base of the mantle. Hotspots are better related to plate tectonic processes.

Deep Mantle Plume	Upper Mantle Convection
Melts include lower mantle materials	Melts are derived from upper mantle “marble cake” components
Very local “point” source beneath plates can make a “hotspot track”	Large sources within upper mantle can make isolated “hotspots” and volcanic chains along fractures
Large dikes must flow horizontally over great distances	Dikes rise vertically from wide mantle sources, follow fractures as they open
Domal uplift from buoyant plume top, heating	Epirogenic uplift from buoyant shallow convection, heating

Fig. 6 from
"Graphic solutions to problems of plumacy:"
Holden, J.E. & P.R. Vogt, EOS Trans. AGU, 56, 573-580, 1977.

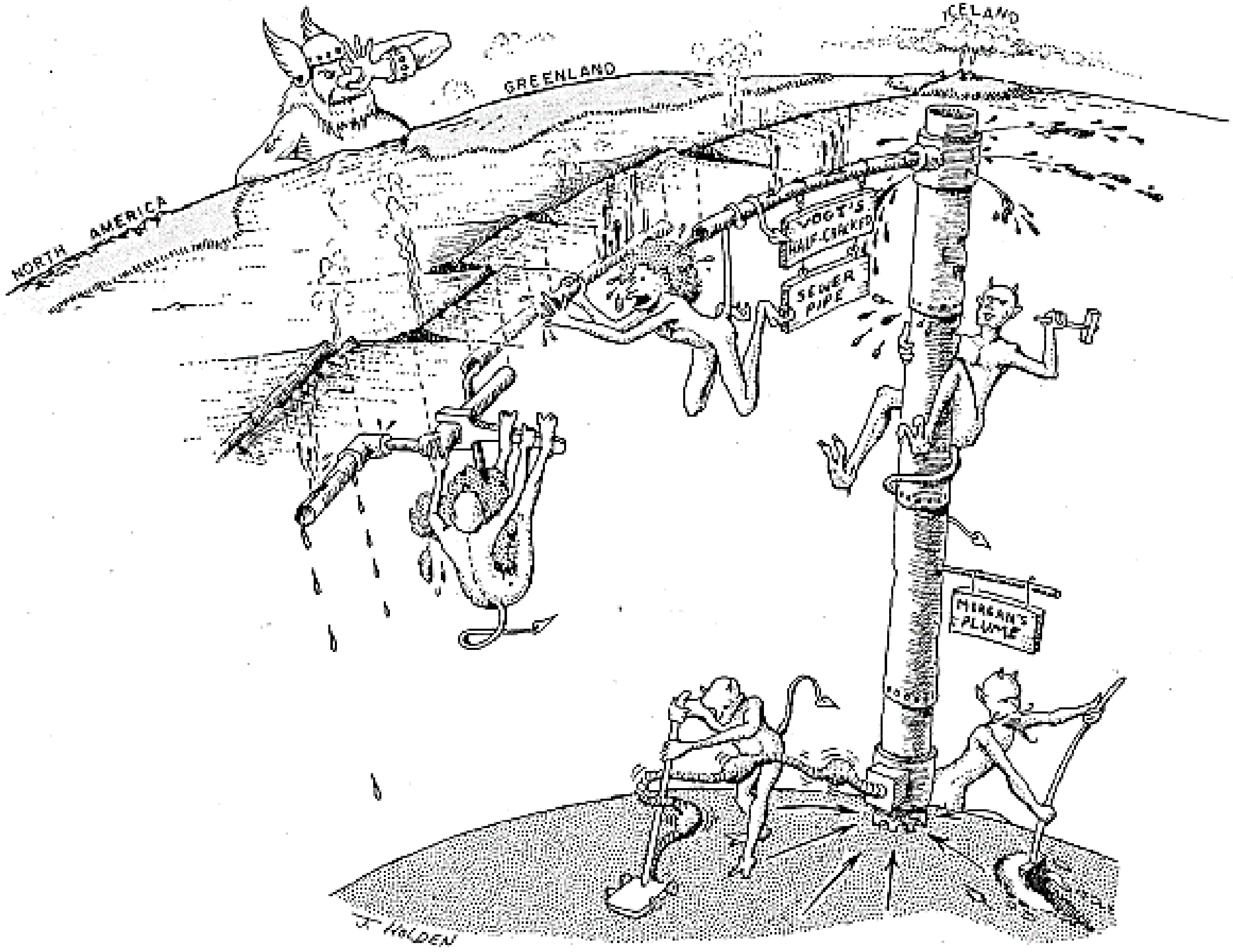


Fig. 6. Mantle plume materials transported by faulty plumbing system from the lower regions to the midoceanic ridge. (Devils not to scale.)