Geophysical Research Abstracts,
Vol. 11, EGU6359-6, 2009
21.4.09
EGU General Assembly 2009

Session SM 6.2 (Solicited) 8.30 Tues

Conveners: Alan G. Jones, Irina Artemieva

Deep cratonic keels and a 2-layer mantle? Tectonic basis for some far-reaching new insights on the dynamical properties of the Earth´ s mantle: example motions from Mediterranean, Atlantic-Arctic and India

M.F. Osmaston
The White Cottage, Sendmarsh, Ripley, Surrey GU23 6JT, UK (miles@osmaston.demon.co.uk)

Two of the most controversial questions concerning mantle behaviour concern the great depth of cratonic tecto- spheric keels (e.g. [1, 2]) and whether the base of the upper mantle is a substantial barrier to flow [3]. Individually the arguments for each are indecisive and have hitherto been regarded as the province of seismologists and mantle modellers. But if both are true we can by-pass these physical arguments because there should be major dynamical consequences for plate motions, susceptible to direct observation [4]. We will here develop further the author´ s recent contention [4-7] that both are true.

The point is that if the 660 is indeed a barrier to mantle flow and keels extend nearly that far we need to ask: (a) Where does the mantle come from to put beneath a widening ocean? and (b) Where does it go as two cratons approach one another? Here we seek observation-anchored answers to each.

In an Atlantic-Arctic context we find three examples of (a). First, the widely-evident eastward motions of the Caribbean and Scotia Sea plates appears to record the eastward flow, at depth, of mantle to put beneath the widening S Atlantic. Second, the intra-Eocene Eureka folding from Ellesmere Island to Svalbard, across northern Greenland, is seen [4] as due to drag upon Greenland´ s keel by mantle being drawn to put under the widening Eurasia Basin. Significantly the compression began at the moment Greenland became detached on both sides and ended when the NE Atlantic offered a sufficient gap for the flow. Third, before this gap appeared, mantle flow had to use the West Siberian gap between cratonic keels, assisting India´ s northward flight to Himalayan collision. This drag/suction has compressed Asia as never before and is still evident around southern India as by far the deepest dent in the geoid (>100m) and much N-S compressive seismicity there.

In an Alpide belt setting we have a complex example of (b). My recent studies [8, 9] show that the Western Alps were primarily the result of up to 250km westward motion of northern Adria/Italy in the early Oligocene, using a formerly-straight Insubric-Pusteria-Gailtal fault-Line, before differential compression of the Eastern Alps caused the Giudicaria offset. This dextral motion is recorded in a shear zone extending all the way to the Black Sea in the Danube delta area, north of the probably Neo-Archaean Moesian block, long known for its mysterious westward índenter behaviour. Westward flow of mantle from between the converging Arabian and Russian tectospheres in the Caucasus has evidently driven this motion by impinging upon the cratonic keel of Moesia, opening the western Black Sea, and it may explain the present deep seismicity below the SE Carpathians (Vrancea). This westward motion, ultimately of the entire Balkan Peninsula, appears first (mid-K) to have built the N-S volcanic and granitic arc on the W side of Moesia, progressing westward to the Dinarides and finally (Oligocene) to the Western Alps and Apennines. Thus the dominantly N-S closure of Africa and Eurasia now yields a mechanism for the broadly concurrent E-W components of compression in the Alpide belt.

Answers to three questions raised by these findings will be briefly outlined.

A. How is the implied mantle ´ suction´ generated by the MOR process?

B. What is the character and origin of the evidently immobile subcratonic mantle beyond ˜ 200km depth which has such deceptive seismic properties?

C. If the Earth now has a 2-layer mantle, when and how did it change from the whole-mantle convective pattern surely driven by the high heat generation in the early Earth? The answer is highly significant for us all. The interval 2.49-2.2Ga marks the convective hiatus during the changeover. MOR collapse and sea-level fall led to lower atmospheric CO_2, glaciations during 2.45-2.3Ga and the Great Oxygenation Event at ˜ 2.3Ga when oxgenic life had finally won its battle against the reducing chemical action of MORs. In this sense, therefore, we all are the living proof of that changeover.

[1] Gu, Dziewonski & Agee (1998) EPSL. 157, 57-67.

[2] Agee (1998) Reviews in Mineralogy. 37, 165-203.

[3] Osmaston, M. F. (2003) What drives plate tectonics? Slab pull, ridge push or geomagnetic torque from the CMB? A new look at the old players vis-a-vis an exciting new one. XXIII IUGG 2003, Sapporo, Japan. Abstracts CD, p. B129, Abstr #016795-2.

[4] Osmaston, M., (2005) Interrelationships between large-scale plate motions as indicators of mantle structure: new constraints on mantle modelling and compositional layout. In 3rd Workshop on Ëarth´ s mantle composition, structure and phase transitions ¨ , St. Malo, France http://deep.earth.free.fr/participants.php

[5] Osmaston, M. F. (2006) Global tectonic actions emanating from Arctic opening in the circumstances of a two-layer mantle and a thick-plate paradigm involving deep cratonic tectospheres: the Eurekan (Eocene) compressive motion of Greenland and other examples. In ICAM IV, Proc. 4th Int. Conf. on Arctic Margins, 2003 (ed. R. Scott & D. Thurston). Dartmouth, NS, Canada: OCS Study MMS 2006-003, p.105-124: Also published on: http://www.mms.gov/alaska/icam

[6] Osmaston, M. F. (2007) Cratonic keels and a two-layer mantle tested: mantle expulsion during Arabia-Russia closure linked to westward enlargement of the Black Sea, formation of the Western Alps and subduction of the Tyrrhenian (not the Ionian) Sea (abstr). XXIV IUGG 2007, Perugia, Italy, July 2007. http://www.iugg2007perugia.it/webbook/ Session JSS 011 Earth Structure and Geodynamics. Abstr #2105.

[7] Osmaston, M. F. (2008) Cratonic keels and a two-layer mantle tested: plate motion examples of mantle expulsion during craton-to-craton convergence and of its lateral induction during their separation - Mediterranean, Atlantic-Arctic and India, in 33rd IGC, Oslo, Symp. EIL-01 General contributions to the lithosphere. Abstr #1339677.

[8] Osmaston, M. F., 2008, Basal subduction tectonic erosion (STE), butter mélanges and the construction and exhumation of HP-UHP belts: the Alps example and some comparisons: International Geology Review, 50 (8) 685-754: DOI: 10.2747/00206814.50.9.685.

[9] Osmaston, M. F., 2008, Basal subduction tectonic erosion (STE) and the construction of HP-UHP metamorphic belts: A new model for the Alps and its comparison with the Maksyutov Complex, southern Urals, in 33rd IGC, Oslo, Session UHP-05, Abstr #13399700