Geophysical Research Abstracts
Vol. 14, EGU2012-1621-2, 2012
EGU General Assembly 2012

Recognition of Intermediate Crust (IC), its construction and its distinctive epeirogenic behaviour: an exciting new tool for plate kinematic analysis (PKA) of the Arctic margins and western Siberia

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

Identification of a microcontinental block within or near a continental margin raises two questions, addressed in this talk - How did it get there? What is the nature of the intervening crust? I will then illustrate briefly how, in the Arctic, the answers, although by no means restricted to that region, do seem to help us a lot to begin unravelling the ancient plate kinematics of its wide margins.

The plate tectonics paradigm currently posits that the Earth has only two kinds of crust - continental and oceanic - and that the former may be stretched to form sedimentary basins or the latter may be modified by arc or collision until it looks continental. But global analysis of the dynamics of actual plate motions for the past 150 Ma indicates [1, 2, 3] that continental tectospheres must be immensely thicker than previously thought and almost certainly too thick to be stretched with the forces available. In the extreme case of cratons, these tectospheric keels may commonly extend to 600 km or more [3]. This thick-plate behaviour is attributable, not to cooling but to a petrological 'stiffening' effect, associated with a loss of water-weakening, which also applies to the LVZ below MORs [4, 5, 6]. The corresponding thick-plate version of the MOR process [1, 6] has a deep, narrow wall-accreting axial crack which inherently brings two outstanding additional benefits:- (i) why, at medium to fast spreading rates, MOR axes become straight and orthogonally segmented [7], (ii) not being driven by body forces, it can achieve the sudden jumps of axis, spreading-rate and direction widely recorded in mid-ocean and are necessary after generating the limited separations of microplates near margins.

So in seeking the 'continent-ocean boundary' (COB) along passive margins, a site where stretching has often been invoked, we need instead to consider how this MOR process would be affected by the heavy *concurrent* sedimentation to be expected when splitting a continent. I reason that, by blocking the hydrothermal cooling, this must inhibit magnetic anomaly formation and prolong magmagenesis to give a thicker-than-oceanic mafic crust, which I have called Intermediate Crust (IC) [8, 9], to distinguish it from Mature Continental Crust (MCC). Seismologically, IC basement must look deceptively like that assigned to stretched MCC. For thermodynamic reasons [8, 9] the hydrous content of deep MCC and of deeply subducted UHP crustal slices gives them a big thermal epeirogenic sensitivity which IC lacks.

The NE Atlantic offers an example of this distinction. Structurally, the MCC of Greenland and Norway must have been intimately juxtaposed by the Scandian collision, so it was concluded [9] that the crust of the Greenland-Norway continental shelves must mostly be IC of post-Scandian (early Devonian?) age, a character confirmed by their lack of epeirogenic response to laterally conducted heat from the opening N Atlantic, although drainage systems in Norway proper clearly show it. Geometrically, this separation appears to have changed direction sharply, the second and bigger stage also involving separation of Svalbard from near Tromsø, where it had provided northward continuation of a complete Caledonian transect, so it has an IC implication for much of the Barents Sea area (bar the Bjørnøya block).

Moving quickly round to the NE side of Baltica, we can begin to trace the separative motions of the Novaya Zemlya - Pay Khoy (NZPK) strip of less-mature MCC, transverse to the Timanian belt, and the associated evolution of the Pechora basin system. In places, faulted IC/MCC epeirogenic contrasts seem to define the size and direction of the IC-generating separation with remarkable precision. A crucial opening-up of this analysis is provided by realizing that the Polar Ural stretch is not MCC, but is merely the huge 585 Ma Voykar-Synya ophiolite, with its metamorphics, resting on a now-crumpled boundary between IC of very different ages. For further understanding we need briefly to extend the analysis, first to the formation of the West Siberian Basin, the IC nature of whose crust (but not its low thermal epeirogenic sensitivity) has been obscured by Permo-Triassic addition of the Siberian flood basalts, and thence to the complicated MCC distribution seen in Khazakhstan. The pattern of the older elements of the latter appears to be a further, but more ancient, example of the plate dynamics evidence [1, 2, 3] for 'deepkeeled' cratons, in that, when they separate, horizontal inflows of mantle are induced which impinge on the lesser keels of MCC blocks in the region, potentially generating IC-floored basins in between them.

In this way the geology which now lies between the Baltica and East Siberia cratons can in principle provide powerful constraints on the freedom with which palaeomagnetic data for them has been interpreted. A key element in this is that otherwise-missing components of the Timanian orogen are apparently to be found on the western edge of the Siberian platform. This means that the NZPK strip and Pechora Basin area were formed as part of the Timanian interplay between the then-roughly-parallel sides of the Baltica and Siberian cratons. A final step in this limited analysis suggests that the clockwise bending of northern Novaya Zemlya was the dextral consequence of the final ($\sim$2000 km) northwestward cratonic separation of Baltica plus NZPK etc. to form the IC of the West Siberian Basin during the 580-535 Ma interval. This may be older than any of the NZ rocks suitable for palaeomagnetic determination.

Resolution of the conflict between this geologically and geometrically secured reconstruction and that prescribed palaeomagnetically for 'Rodinia' appears to lie in the possibility that at some point on the APWP there has been an inadvertent switch between following the N and the S pole, due to the habitual choosing of the lesser of two plate motion speeds during the interval between points on the curve. In that case some of the supposed assemblage will be geographically upside down in relation to the rest.

Finally, a quick visit to the Chukchi-Bering-Alaska sector of the Arctic margin. Here, too, recognition of IC may provide a key. I suggest that northward emplacement of the Brooks Range Ophiolite at close to 170 Ma was swiftly followed by the (now) westward extraction of the Seward-Chukchi MCC assemblage to form, as IC, both the extensive Koyukuk basin system which lies south of Brooks Range and, ultimately, the Bering gap in the Pacific rim of cratonic keels, through which mantle to put at depth under the widening Eurasian Basin ocean floor has been drawn, initiating the Aleutian arc in the Palaeocene, trapping OC/IC behind it. I discuss a global reason for the initiation of the Bering gap, and its timing, in another session (GD6.1) of this meeting.

[1] 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*, Proc. ICAM IV 2003* (ed. R. Scott & D. Thurston). OCS Study MMS 2006-003, pp.105-124: Also published on: http://www.mms.gov/alaska/icam

[2] 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. *XXIV IUGG, Session JSS 011* Abstr #2105. http://www.iugg2007perugia.it/webbook/.

[3] Osmaston M. F. (2009) 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. *Geophys. Res. Abst.* **11**, EGU2009-6359 (Solicited).

[4] Karato S. (1986) Does partial melting reduce the creep strength of the upper mantle? *Nature* **319**, 309-310.

[5] Hirth G. & Kohlstedt D. L. (1996) Water in the oceanic upper mantle: implication for rheology, melt extraction, and the evolution of the lithosphere. *EPSL* **144**, 93-108.

[6] Osmaston M. F. (2010) On the actual variety of plate dynamical mechanisms and how mantle evolution affected them through time, from core formation to the Indian collision. *Geophys. Res. Abstr.* **12**, EGU2010-6101.

[7] Osmaston M. F. (1995) A straightness mechanism for MORs: a new view of ocean plate genesis and evolution. In *IUGG XXI Gen. Assy.* Abstracts p. A472.

[8] Osmaston M. F. (2011) An introduction to Intermediate Crust (IC): its formation, epeirogenic character, and plate tectonics significance. *TSG Ann.Mtg. 2011, Durham University*, Technical Programme p.45.

[9] 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. *Internat. Geol. Rev.* **50**(8), 685-754 DOI: 10.2747/00206814.50.8.685.