INTERMEDIATE CRUST (IC); ITS CONSTRUCTION AND SIGNIFICANCE FOR PLATE KINEMATIC ANALYSIS (PKA) OF ITS DISTINCTIVE EPEIROGENIC BEHAVIOUR: ONE OF A FAMILY OF CRUST AND MANTLE METAMORPHIC PROCESSES RESPONSIBLE FOR THE VERTICAL AND HORIZONTAL MOTIVATION OF PLATES

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Most metamorphic changes, whether in the crust or in the mantle, involve overall changes in volume large compared with the normal expansivity effect of the heat in or out. I will argue that this under-regarded parameter is important not only in the mechanisms that drive plate motions but in providing the basis for remarkably detailed and precise analysis (PKA) of the region-scale crustal record of past plate relative motions. These insights would now benefit from precisely related quantifications of this parameter and of the forces potentially developed.

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 or the latter modified by arc/collision until it looks continental. But analysis of the dynamics of actual plate motions for the past 150Ma indicates [1,2] that continental tectospheres must be immensely thicker than previously thought and almost certainly too thick to be stretched with the forces available, slab pull being problematic also [2]. So in seeking the 'continent-ocean boundary' (COB) along passive margins, a site where stretching has often been invoked, we will instead think of how the MOR process there would have been affected by heavy concurrent sedimentation. The evidence is that this, by blocking the hydrothermal cooling, inhibits magnetic anomaly formation and prolongs magmagenesis to give a much thicker mafic crust, here called IC, to distinguish it from Mature Continental Crust (MCC). I have shown [3] that the hydrous content of deep MCC and of deeply subducted UHP crustal slices gives them a big thermal epeirogenic sensitivity which IC lacks. My global analyses of block-and-basin (B&B) layouts within continents, begun in 1966, have shown, remarkably, that their MCC, identified by uplift and often by exposed geology, can be geometrically reconstructed by reversing a sequence of two or more very precise (locally <5km) IC-generating separations, commonly in differing directions, such that the second was only made kinematically viable by the first. Clearly not a matter of chance!

Vital final steps in this interpretation are to explain the remarkable tightness dictated by the geometries, and the evident spreading of thermal rejuvenation to up to hundreds of km from the present COBs. My analyses [1,2] indicate that it is for a petrological/metamorphic reason [4] that mantle LVZ material is actually very stiff and that tectospheres reach >600km below cratons and even to >100km at MORs. Such great thickness means that any new splitting, as when starting to make an ocean, induces hot mantle against cooler tectosphere at a great depth and the resulting lateral heat input can spread to a correspondingly great distance. Alternatively, differential thermal epeirogenic rejuvenation of MCC blocks also occurs beneath an allochthonous lid in collision belts, producing tectonic windows [3].

To meet the tightness-of-fit requirement I offer my (now) 26yr-old model for constructing thick plate at MORs [5,6], on the basis that it must, at depth, be broadly similar to that which constructs IC. It has a deep axial, laterally-accreting, narrow (20cm?) mantle crack. So even an initially curved splitting line is precisely followed, as the B&B geometries commonly require. But, as separation proceeds, differential accretion to the walls makes the crack become straight and orthogonally segmented [5], as seen at MORs. The crack walls are driven apart by another mantle metamorphic process, the garnet peridotite to spinel peridotite phase change, which produces, per joule conducted into the walls, many times more volume increase than plain thermal expansion. So an eruption makes the walls bulge inwards at the level of the phase change (50-60km?), closing the crack and forcing it apart along strike to induce another eruption there. The resulting push-apart force, due to solid-state recrystallization, may be at least an order greater than produced by the standard divergent flow MOR model. It is not convection but apparently is an efficient heat engine; I see it as a major player in plate motivation [7,8].

Over the years I have done Plate Kinematic Analyses, of varying quality, of very many parts of the world. From these, to the extent that time permits, I will show the following examples of PKA, each a record of relative major-plate motions, based on distinguishing IC-floored 'chasmic basins' from MCC's positive epeirogenic behaviour, a contrast often not completed until a lot later ('failed arms', 'break-up unconformities').

(1) Calabria: differential epeirogenic rejuvenation of Hercynian MCC blocks, following Neogene allochthon emplacement from the Tyrrhenian Sea; documenting 3-stage Permian(?) detachment and CCW rotation of Adria from 'Africa'.

(2) Shelf-forming 2-stage separation of Greenland-Svalbard from Norway after Scandian closure had thrust the Greenland-built UHP Western Gneiss onto Norway (story in ref [3]).

(3) 5-stage Siluro-Devonian sequence in central Ireland: mechanical completion of Iapetus closure forced reactivation of the old S-ward flat-slab subduction, with its roof back-thrusting the Longford accretionary structure onto MCC; and detaching southwards, beneath this lid, by slab pull (yes!), blocks of the MCC underlying that structure - Aughty, Bernagh-Arra, plus others now still under, and uplifting, the residual southern part of that roof - Devilsbit, Bloom).

(4) Extraction of New Zealand plus Campbell Plateau from its Ross Sea embayment during 90-83Ma, and related separations within Campbell Plateau [9].

(5) Former craton juxtaposition of NW Baltica against W Angara and its geometrically well-constrained separation stages (680-480Ma?), involving the Timan-Pechora-Novaya Zemlya area, the Minusinsk and Kuznetsk basin systems, and the extraction and break-up of Kazakhstan microplates from where now is the Junggar Basin. This shows that the relationships favoured by the Rodinia hypothesis are disproven by the intervening rocks, so the entire idea needs reconsideration. There are surely other ancient relationships between cratons which palaeomagnetists have felt free to play games with but may now be constrained by PKA.

I hope to persuade metamorphic petrologists (which I am not) that they now have a role, as never before, in the game of global plate motions at all scales and what drives them. Sadly, there is no chance whatever of sampling *in situ* the rocks currently performing the actions I invoke here, or of laboratory simulation at the scale required, so constrained calculation is essential. Why has the former presence of impounded metamorphic water, here seen as a principal epeirogenic agent, apparently been so difficult to detect by looking at the exhumed rocks?

References (all except [4] and [9] are available (pdf) from me on demand by e-mail).

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