largely subjective, and the reader must decide for himself what to make of the assignments Perhaps more serious, however, is the status of new names, of which some nine new ones at species-group level are introduced here Of these, all but one are based on at most two specimens

To conclude, the present work marks a valuable addition to our knowledge of the Subaustral Jurassic in western India In this, even if the development at Jaisalmer may not claim to be more than following behind the leading position of Kutch, it is none the less valuable for that It is good to see the present descriptions following in the steps of the early explorers and still in the same series of publications, the *Palaeontologia Indica*

Univ College, London JOHN CALLOMON
Email john-h callomon@tiscali co uk

DISCUSSION

Crustal Velocity Structure of the Narmada-Son Lineament along the Thuadara-Sendhwa-Sindad Profile in the NW Part of Central India and its Geodynamic Implications by A R Sridhar, H C Tewari, V Vijaya Rao, N Satyavani and N K Thakur
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D.N. Avasthi, C-190, Sarita Vihar, New Delhi - 110 076, *Email* dnavasthi@ hotmail com comments

In the paper, the authors have identified a 12-16 km thick layer of P-wave seismic velocity of 7 2-7 5 km/sec at the base of the crust to a magmatic underplating of the crust probably due to the Deccan volcanism caused by the transit of western India over Reunion Hot Spot, which was activated by a major mantle plume It is mentioned that when the mushroom type plume head finds a low viscosity environment of a weak decoupling lower continental crust, it spreads the plume material (magma) laterally leading to magmatic underplating The extrusion of plume material (i e magma) on the surface leads to flood basalts, which in the case of India is known as the Deccan Flood Basalt The authors have drawn support for this theory from a few decades old publications, and mainly from White et al , Geophys Jour Roy, Astron Soc , 1987)

However, the difference in the P-wave velocity values in the assumed underplated layer below the crust (~7 4 km/sec) and in its assumed surface extrusion as Deccan Basalts (~4 9 km/sec) is too glaring to be ignored If Deccan Flood Basalts represent the surface extrusion of the plume material underplating the lower crust, it becomes imperative to examine the physico-chemical process by which the surface extrusion of the mantle material gets depleted in its elastic property to over 65% of what it possesses as underplated mantle material Experimental data explaining this very significant material of density 2 9-3 3 kg/l and modulus of elasticity ~169-76 MKS units to ~66 03 <KS units in Deccan Trap rocks of density 2 5-3 0 kg/l would be needed to support the theory assumed by the authors

Considerable progress in the understanding of solid earth processes has been made over the last two decades and it would be prudent to look for other possibilities that can explain the 7 4 km/sec P-wave velocity in the layer between the lower crust and the upper mantle without invoking underplating of the lower crust by the magma In this regard, attention is invited to the seismic tomographic work done by Replumaz et al (EPSL, 2004), CSS work in western offshore by the DGH, India (Avasthi, DCS Newsletter, 2003) and in Makran coast by Schluter et al (Marine Geology, 2002) The cause of low P-wave velocity layer below the crust could be due to the behaviour of lithospheric plates in the plate tectonics regime When an oceanic plate collides with a continental plate, linearity of subduction process gets distorted, resulting in a roll back of the upper mantle Simulation of active tectonic process between a convecting mantle and moving continent has shown that roll back of subduction takes place in front of moving continent (Trubitsyn et al Geophy Jour Intl , 2006), leading to the continental crust over-riding the subducting oceanic crust Because of the roll back of the subducting plate, the ocean crust and the upper mantle below it continues to rest below the continental crust over a long distance before it seeps down into the mantle, unlike the collision of oceanic plates, where the subducting plate plunges down into the mantle more sharply, giving rise to the breaks in the subducting plate known as the Benioff zones Examples of such over-riding juxtaposition of continental and oceanic crusts have been reported from the analysis of earthquake data (Rai et al Proc Indian Acad Sci (EPL), 1996), magnetotelluric studies (Gokarn et al 2006) and from detailed seismic imaging by Schluter et al (Marine Geology, 2002) and Avasthi (DCS Newsletter, 2003)

A.R. Sridhar, NGRI, Hyderabad - 500 007, *Email* azhisur74@yahoo co in replies

The comments of Dr D N Avasthi are very important, useful and thought provoking The response to the comments is given below

Velocity of the Deccan volcanics/trap determined from seismic studies from various profiles (Kaila and Krishna, 1992) is around 4 8-5 1 km/s Similar velocity is observed in the Rajmahal volcanics in the Mahanadi and Bengal basins The source for these volcanics is deep seated in the mantle of velocity >8 0 km/s The lower crust in most of these regions exhibits a high-velocity of 7.0-7.4 km/s, attributed to accretion of magma at the base of the crust due to the crust-mantle interaction. The source for Deccan flood basalts observed on the surface and the underplated layer at the bottom of the crust lies in the mantle, as both have evolved from the magma.

1) Continental flood basalt adds significant amount of material on the Earth's surface and is a manifestation of the mantle plume activity. This intra-plate volcanism (different from convergent and divergent plate boundary volcanism) being global phenomena, a large number of temporal, spatial and compositional similarities are observed in widely distributed flood basalts. Most of these events are the result of mantle plume activity and the Deccan basalts are no exception (Coffin and Eldhem, 1994, Campbell and Griffiths, 1990, Richards, 1989). Flood basalts and hotspot traces represent plume heads and tails respectively. Various studies over the Deccan basalts for the last few decades establish a close relationship between mantle plume and flood basalts.

2) The continental lower crust is ductile, relatively less viscous, rheologically weak and decouples itself from the upper crust as well as upper mantle. Because of this very few earthquakes are observed in it and most of the faults terminate at upper / middle crust. A number of channel flow models explain the lower crustal flow in the Himalayas to understand the geodynamics of Tibet (Clark and Royden, 2000). The rheology of the lower crust supports the theory that the mantle plume, which is responsible for the observed flood basalts on the surface may also be responsible for the underplating the weak, decoupling lower crust in the study region. It is pertinent to note that the spherical plume head with a long narrow tail after reaching the base of the lithosphere, which is rheologically weak, flattens and melts by decompression and produces enormous quantities of magma, which erupt in a short period. The high magma density inhibits surface eruption and spread out at the base of the crust because its density is intermediate between that of the crust and mantle. The Moho acts as a boundary under which magma from the mantle is ponded (underplated). Many of the magma chambers, which feed volcanoes, appear to be located at the base of the crust. Effectively, the flood basalts seen on the surface are entirely detached from the mantle source and are fed instead from the crust-mantle boundary (Cox, 1980). Thus, the continental crust acts as a density filter through which only evolved magma containing water may pass.

3) To understand the difference in P-wave velocity / density of the Deccan basalts (5.0 km/s / 2.5-2.9 kg/l) and underplated lower crustal layer (7.0 km/s / 2.9 3.1 kg/l), the physico-chemical processes responsible for depletion of the elastic properties of the extruded mantle material needs to be evaluated as the two are compositionally different even though they are derived from the same mantle material. This difference is due to different P-T conditions at the base of the crust and at the surface. During the rise of magma from the mantle to the surface the crust is extracted from the mantle due to differentiation. Extensive melting of plume head beneath the lithosphere results in a high olivine content magma. Olivine crystalisation and removal at a density trap, usually around the Moho at a typical depth of 30-40 km, generates basaltic magma. The fractionation results in surface flood basalts that do not represent primary magma as compositionally heavier material settle at the bottom and the lighter one reaches the surface. Thermal diffusion causes surrounding material to become buoyant and rise along with plume. Consequent to such heating, the crustal material melts and contaminates the original magma leading to compositional change and reduction in velocity of the surface flood basalt. The dehydration reactions and granulite facies metamorphism of the lower crustal materials enhance seismic velocity when compared with low-grade metamorphism of the surface rocks. During the process of phase transformation such as, gabbro-eclogite that occurs at appropriate P-T conditions (depth), the density / velocity of the rocks increases. The mafic content of crystallized olivine exhibits a high velocity of 7.0-7.4 km/s (density of 2.9-3.1 kg/l) in the underplated lower crust. Possibly some other processes are also taking place during the process of magma reaching to the surface from great mantle depth as the velocity in the lower crust, just above Moho, is 6.8-7.4 km/s whereas the velocity in the upper mantle, just below Moho, is 8.0-8.4 km/s. This difference is also quite high, even though the source of parent magma is the same (Herzberg et al. 1983). High pressure prevailing at lower crustal depths decreases the pore space / fractures, whereas the atmospheric low pressure increases pore space for the surface rocks. Presence of fractures increase fluid content, which also reduces seismic velocity of surface rocks.

4) In the present study the velocity of the Deccan basalts, the underplated lower crustal and upper mantle rocks are measured using travel times and amplitude modeling. The relationship between seismic velocity (V) and elastic constant (E) of a medium is given by $V=\sqrt{E/d}$, where 'd' is the density of the medium. The elastic constants of Deccan basalts and underplated rocks calculated using the above formula, incorporating the velocity and density values observed in the present study, are ~66.03 MKS units and ~169.76 MKS units respectively, as suggested by Dr. Avasthi. Experimental data to explain reduction in velocity and elastic constants of these rocks is beyond the scope of present study. Even the high pressure (related to lower crustal depths) experimental studies on the surface basalts may not yield proper values of velocity and elastic constants of the underplated lower crustal rocks because compositionally the basalts represent secondary magma derived from the primary picritic magma, of different composition, fractionated as underplated rocks.

5) Our response to alternative mechanisms for the presence of 7.0-7.4 km/s velocity in the lowermost crust with respect to our study area is as follows.

We agree that there are various other mechanisms to explain underplating of the crust. For example the seismic tomographic study (Replumaz et al. 2004) across the Himalayan collision zone shows that the Indian subcontinent overrode its own overturned, downwelling lithospheric mantle. The seismic reflection study by DGH, in the western offshore of Kachchh and Saurashtra coast of India (Avasthi, 2003) that shows evidence for continental crust over-riding the oceanic crust. The tectonic scenario that exists at the collision zone of oceanic-continental plates and oceanic-oceanic plates (Trubitsyn et al 2006) and the formation of Makran accretionary wedge by subduction of the oceanic crust of Arabian plate under the Eurasian plate (Schluter et al 2002) are entirely different to that of the NSL zone No such explanation is valid to this zone, where the latest tectonic activity is intracontinental extension rather than compression at the inter-continental plate boundary The seismic structure here is attributed to the major activity of mantle plume rather than subduction / collision at the plate boundary regions Though the Mesozoic sea intruded into the present study area, no plate boundary activities of subduction, juxtaposition and over-riding of continental / oceanic plates have yet been reported in the region after the formation of Narmada basin A large number of dykes of ~66 Ma age, contemporaneous with the Deccan volcanism, observed all along the NSL and west coast of India, indicate a close relationship between dykes and Deccan basalts and to the crust-mantle interaction process leading to underplating

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Three-Phased Temporal Evolution of the Jhirgadandi Granite Complex, Sonbhadra District, Uttar Pradesh by D Bhattacharya, Madhuparna Roy and G B Joshi Jour Geol Soc India, v 70, 2006, pp 730-744

S. Viswanathan, Flat B-203, Block-B, Unite Avenue Apts, South End, 7-1-29, Ameerpet, Hyderabad - 500 016 comments

1 In the caption for Fig 2, Modal mineralogical classification for rocks of the Jhirgadandi granite" (p 737), a filled square is shown as the symbol for the "first phase melanocratic rock" However, no melanocratic rock has been plotted on this diagram In "Table 1 Modal data for leucocratic, mesocratic and melanocratic rocks from Jhirgadandi (p 732), the modes of nine mesocratic rocks are given However, only eight samples have been plotted on the QAP diagram (Fig 2, p 737) The reason for this not clear

2 What analytical technique was used for obtaining the major element and trace element data given in Tables 1 (p 734), 2 (p 735) and 3 (p 736)? What are the accuracy and precision of these analytical data?

3 In "Fig 4, K_2O vs Na_2O, K_2O-CaO and CaO-Na_2O-K_2O diagrams of samples from Jhirgadandi" (p 738), the "fields" are stated to be after Harpum (1963) and Barker and Arth (1976) Which of the "fields" in the three diagrams (Fig 4a, b, and C) are from Harpum (1963) and which are from Barker and Arth (1976)? In the section, 'Discussion', paragraph 1 (p 739), the Figure numbers for the CaO-K_2O and K_2O-Na_2O diagrams should have been 4b and 4a and not 4a and 4b as stated

4 In Table 2 (p 734), 3 (p 735) and 4 (p 736), *the values for the K/Rb ratios* of the samples of the leucocratic, mesocratic and melanocratic rocks from Jhirgadandi are given to the second decimal point This is improper The ratio of a major element, as the numerator, to a trace element, as the denominator, should be given only in whole numbers Some other examples of such ratios used in geochemical studies of granitic rocks are K/Sr, K/Ba, K/Pb, K/U, K/Th, Ca/Sr, Ca/Ba and Ca/Pb

5 In "Table 4 Chemical and normative data of melanocratic rocks from Jhirgadandi" (p 736), the "Average" of the Ba content is stated to be for "(n=4)", although the "Range" covers the Ba contents of the five samples listed The reasons for this is not clear

6 In the 'Abstract' (p 730), the authors have stated that "Geochemical data suggests that the granitic rocks of the three phases are comagmatic" Under 'Discussion', paragraph 1, (p 740), they state that "fractionation and differentiation process may have played a major role in the evolution of this suite" For such an interpretation to hold true, the K/Rb ratios should have progressively decreased in the sequence melanocratic phase to mesocratic phase *to leucocratic phase However, the* average K/Rb ratio is lowest in the melanocratic phase (192, see Table 4 on p 736) and is the highest in the mesocratic phase (240, see Table 3 on page 735) The average K/Rb ratio of 216 for the leucocratic phase (see Table 2 on p 734) is between the value of 192 for the melanocratic phase and of 240 for the mesocratic phase

7 Citing the initial Sr^{87}/Sr^{86} ratio of 0 7038±0 0038 for the mesocratic phase of the Jhirgadandi suite reported by Pande et al (1996), the authors have stated that "the granitic magma might have been formed by the partial melting of the lower crust or upper mantle and got gradually fractionated from mafic to intermediate source" (see 'Conclusions', para 3, pp 742-743) If this inference is to be correct, the average K/Rb ratios of the melanocratic phase and the mesocratic phase, 192 and 240, respectively,