Discussion of

Nd and Sr isotope systematics and geochemistry of plume related early Cretaceous alkaline mafic-ultramafic igneous complex from Jasra, Shillong Plateau, Northeastern India

by

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22nd December 2006, Surendra P. Verma

Srivastava and Sinha present new data on major and trace elements as well as Sr and Nd isotopes for ~105 Ma rocks from the poorly studied Shillong Plateau of northeastern India and interpret them in terms of a Kerguelen hotspot-mantle plume system proposed to have been established since ~132 Ma. Briefly, this "plume relationship" is mainly based on: (i) the fact that Shillong Plateau geochemistry does not suggest any direct genetic relationship amongst the different rock types; (ii) low (<1) values of the agpaitic index of differentiated nepheline syenite magmas, which suggest CO_2-related activity in their genesis; (iii) major element chemistry showing an OIB affinity; and (iv) inferred initial $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ data that suggest mixing of HIMU, EMI, and EMII mantle components.

None of the above-mentioned features actually demands (or even supports) a plume relationship. The lack of a genetic relationship between different rock types may have to be explained in terms of heterogeneous mantle sources and crustal processes as well as more complex petrogenetic models than attempted by the authors. The agpaitic index based on the major elements Na, K, and Al, without any reference to the actual CO_2 contents, can hardly be used to suggest involvement of CO_2-related activity. The OIB affinity per se cannot be interpreted as exclusively plume-related (see, for example, Fitton, this volume). The interpretation of Sr and Nd isotope data in terms of solely mantle components is based on the assumption that crustal contamination was insignificant, which may not be the case. The thickness and type of continental crust underlying the Shillong Plateau may have to be investigated and taken into account. Furthermore, their interpretation of Sr and Nd isotope data is not unique in terms of these three mantle components (HIMU, EMI, and EMII in their Fig. 6a); other combinations, such as the one formed by BSE, EMI, and EMII, are equally feasible. Finally, the spatial relationship of Shillong Plateau magmatism with the Kerguelen plume is not clear from their Fig.1; for clarification, plate reconstructions for the past and their uncertainties will have to be carefully analyzed.

The "plume related" clause in the title of the paper by Srivastava and Sinha therefore reflects the authors' preference for the plume hypothesis rather than an evaluation of all plausible models.

1st January, 2007, Rajesh K. Srivastava

First we thank Surendra P. Verma for his thoughtful interest in our work. Verma raises a question on the genetic association of the studied early Cretaceous Jasra alkaline complex with the Kerguelen hotspot-mantle plume system of the Indian Ocean. This association has already been established by many previous workers (Mahoney et al., 1992; Storey et al., 1992; Kent et al., 1997, 2002; Kumar et al., 1996; Ray et al., 1999; Coffin et al., 2002; Duncan, 2002; Srivastava et al., 2005 and many more). In our chapter we present additional data which further support this association. The studied complex comes from a region where many magmatic rocks are reported and all these are thought to be associated with the Kerguelen plume. Most of these rocks were emplaced in the period 105 – 115 Ma. Kerguelen-plume-derived rocks are not only found on the Shillong plateau but also in adjacent western regions over and within Gondwana basins. The rocks of the present study show a similar emplacement age and similar geochemical and isotopic compositions. Thus we favor the plume model. Another point is that there is no geological or geophysical evidence available which support a subduction or rift setting for the Shillong plateau (Evans, 1964; Desikachar, 1974; Nandy, 1980; Gupta and Sen, 1988; Das Gupta and Biswas, 2000; Kayal et al., 2006).

5th January, 2007, Don L. Anderson

A plume origin of continental basalts (CFB) is often based on similarities with ocean island basalts (Hooper et al., this volume; Srivastava and Sinha, this volume). The continental origin of some ocean island basalts is based on the reverse argument (see references in Anderson, this volume). The delamination of lower continental crust can explain the similarity in composition of these paired igneous provinces (Anderson, this volume) plus the asthenospheric signature in CFB. Asthenosphere upwells as the eclogitic lower crust sinks. At the same time, the absence of precursory uplift, heatflow anomalies, and high magma temperatures are also explained. The continental affinity of Kerguelen is well known.

30th January, 2007; Kamal K. Sharma

Srivastava and Sinha (this volume) endorse spatial and temporal association of the Jasra igneous complex, Shillong Plateau, Northeastern India, with Kerguelen plume activity. They also state that the absence of evidence for extensional tectonics supports the plume model for the genesis of Jasra igneous rocks. The magmatic activity of the Kerguelen Plateau, Broken Ridge, Naturaliste Plateau, Bunbury, Rajmahal-Sylhet, and Ninety East Ridge are interpreted as Kerguelen hotspot activity. I make the following comments:

1. The origin of the Rajmahal-Sylhet trap, Bengal basin, Eighty- and Ninety-East degree ridges, Andaman-Nicobar ridge and eastward subduction are important tectonic features of the southeastern Indian plate, which evolved through the prolonged period of time of

approximately 120 Ma. The tectonic evolution of these features cannot be explained as Kerguelen hotspot activity. The hotspot model for the evolution of the Rajmahal Traps and/or the break-up of Gondwanaland is a matter of conjecture and dispute. The controversy still exists as to whether the supposed plume is at Crozet rise or Kerguelen and whether the path was associated with Eighty East degrees or Ninety East degrees, respectively (Baksi 1994; Subrahmanyam et al., 1999; Singh et al., 2004). In view of this, it is not feasible to explain the Jasra igneous complex with the Kerguelen hotspot model.

2. Mukhopadhyay et al. (1986) and Mukhopadhyay (2000) suggested that the structural style, Gondwana sedimentation, and volcanism implies that the Rajmahal Traps evolved through decompressional melting subsequent to rifting of Gondwanaland. Inter-trappean shales and sandstones are reported along with traps from Rajmahal (Naqvi, 2005), which indicates subsidence of a basin and an extensional tectonic regime during the early Cetaceous. The correlating the Jasra igneous complex with the Rajmahal traps by Srivastava and Sinha (this volume) accords a similar extensional tectonic setting there. The association of the Jurassic – early Cretaceous N-S trending faults and lineaments of the Shillong plateau with early Cretaceous igneous intrusions, including alkaline and carbonatite complexes, is clearly indicative of extensional tectonism rather than plume-lithosphere interaction.
3. There is debate regarding the continental or oceanic origin of the Kerguelen Plateau. The presence of granitic and syenitic plutons suggests a continental origin. Thus, Kerguelen represents a continental mass at the Antarctic margin during early opening of the Indian Ocean (Naqvi, 2005 and references therein). Figure. 1 in the paper shows the southwest Indian ridge as divider between Kerguelen and the Ninety degree ridge and other tectonic elements. Considering all this, associating Kerguelen hotspot activity with the Jasra igneous complex seems inappropriate. Almost similar Ar-Ar age data from Jasra, Rajmahal, Broken Ridge and Bunbury, Western Australia compels one to consider alternative, non-plume mechanisms for their evolution.

4th February, 2007, Rajesh K. Srivastava & A.K. Sinha

We agree with the comments made by Anderson, 5th January, 2007.

Sharma (comment 30th January, 2007) doubts the relationship between the Jasra igneous complex and the Kerguelen hotspot-mantle plume system. We appreciate his interest in our work but his comments are exclusively based on the Rajmahal traps and Gondwana sedimentation. We do not compare our data with Andaman-Nicobar ridge volcanism. He ignores other geological facts (mentioned in our paper and others) regarding igneous activity associated with the Kerguelen hotspot-mantle plume system. Even for the Rajmahal-Sylhet traps Kent et al. (1997, 2002) clearly associated the basalts with the Kerguelen plume. There are many papers (e.g., in the Special Volume of Journal of Petrology, v. 43, 2002) related to magmatism associated with the Kerguelen hotspot-mantle plume system. The other igneous complexes (including the famous Sung Valley igneous complex) reported from the Shillong plateau also clearly show their association with the Kerguelen hotspot-mantle plume system. These observations are based on detailed geological and geochemical (including isotopic) data.

We, on the basis of data from the Jasra igneous complex, and also data available from other, similar complexes of the Shillong Plateau, reached the conclusion that the Jasra complex has very similar geological and geochemical signatures to those observed in other magmatic rocks associated with the Kerguelen hotspot-mantle plume system of the Indian Ocean. Available data on the Jasra igneous complex is closer to "plume-related" magmatisn than to extensional tectonism. Of course, further detail work is required before an unquestionable conclusion can be reached.

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