
Volume 30, issue 2, 20 April 2007
ISSN 1367-9120
ELSEVIER
Journal of
Asian Earth Sciences
(Formerly the Journal of Southeast Asian Earth Sciences)
Editor-in-Chief
BOR-MING JAHN

Available online at www.sciencedirect.com
ScienceDirect
Journal of Asian Earth Sciences 30 (2007) 417–421
Journal of Asian Earth Sciences
www.elsevier.com/locate/jaes

Comment on "Biochronological continuity of the paleogene sediments of the Himalayan foreland basin: Paleontological and other evidences" – Bhatia, S.B. & Bhargava O.N., 2006, JAES 26, 477–487

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Received 3 July 2006; received in revised form 14 November 2006; accepted 14 November 2006

Abstract

A number of studies have documented a major disconformity in the Himalayan foreland basin, separating marine facies extending to Lutetian age, from alluvial facies dated <31 Ma. Due to the unfossiliferous nature of the alluvial facies, dating has been achieved largely by isotopic methods. Recently, Bhatia and Bhargava (JAES 2006 v26, 477–487) called into question the validity of the isotopic dates obtained for these rocks, and proposed a conformable contact between the marine and alluvial facies, based on biostratigraphic evidence. In this discussion article, I review the biostratigraphic evidence presented by Bhatia and Bhargava, respond to their comments on the validity of the isotopic data, and conclude that the contact between the marine and alluvial facies is disconformable, as a number of previous studies document.

Keywords: Himalayan foreland basin; Subathu Formation; Dagshai Formation; Biostratigraphy; Unconformity

Bhatia and Bhargava (2006) quote fossil taxa from the Himalayan foreland basin, from which they assert that the Subathu Formation is of Late Thanetian to Mid Lutetian age, the overlying Passage Beds are Late Lutetian to Middle Bartonian, and the overlying Dagshai Formation is Late Bartonian to Rupelian. From these data they assert that the conclusion of Najman et al. (1997) (and others), who use isotopic evidence to demonstrate a Late Eocene–Early Oligocene ($<31.0 \pm 1.6$ Ma) disconformity between the Subathu and Dagshai Formation is "no longer tenable". In this paper I discuss the biostratigraphic data presented by Bhatia and Bhargava, and reply to their comments on the degree of rigour of the isotopic evidence.

The upper part of the Subathu Formation is well dated at Lutetian (Mathur, 1978; Batra, 1989). Age diagnostic fossils are uncommon in the overlying Passage Beds: Bhatia (2000) proposes a Lutetian age, in agreement with the Lutetian age of the underlying Subathu Formation. There have been suggestions that the Passage Beds could extend into the Early Priabonian (discussed in Bhatia and Bhargava), but in view of their meagre thickness (ca 5–20 m) it is unlikely they would stretch considerably younger than the well dated limestones directly below.

Dating the Dagshai Formation is hampered by a poor fossil record. Some workers considered the Dagshai and Subathu Formations as coeval (Raiverman and Raman, 1971). However, biostratigraphy, mapping (Batra, 1989; Najman et al., 1993, 1994) and palaeomagnetic dating of the Dagshai Formation at 35.5 ± 6.7 Ma, showed these rocks to be younger than the Subathu Formation. However, since no angular unconformity is visible, and the error bars on the palaeomagnetic data are large, the disconformable nature of the contact was not identified until fission track dating of detrital zircons showed the basal Dagshai

DOI of original article: 10.1016/j.jseaes.2004.10.007
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1367-9120/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jseaes.2006.12.001

bed to be <31 Ma ± 1.6 Ma (Najman et al., 2004), with beds higher up the succession dated from Ar–Ar ages of detrital micas at <28 Ma and <25 Ma (Najman et al., 1997). These dates, within error of the age determined by the less sensitive palaeomagnetic method, confirm earlier views of the disconformable nature of the contact (e.g., Gupta and Thakur, 1974; Wadia, 1975) and date the hiatus as spanning Late Eocene to Early Oligocene. The contact is also recorded as disconformable in Pakistan and Nepal (DeCelles et al., 1998; Najman et al., 2001, 2005).

Bhatia and Bhargava list Mid/Late Eocene–Oligocene fossils from the axial foreland basin and Sulaiman ranges to dispute the isotopic evidence and propose the Dagshai Formation as Oligocene. They explain the discrepancy between the fossil data and the Ar–Ar dating of detrital micas by suggesting that Najman et al. (1997) mistakenly sampled the younger Siwalik Group rather than the Dagshai Formation. They dismiss the fission track data with the comment "between fossil data and FT dates, the former a time-tested criterion, is always preferable". On the discrepancy between the fossil data and the magnetostratigraphic dating, they note that "the magnetic polarity data, totally divorced from corroborative fossil evidence carry little conviction". I respond to these comments as follows:

The authors suggest that Najman et al., sampled the younger Lower Siwalik (Nahan) Formation, in error, rather than the Dagshai Formation. They state that "Detailed field work and also critical perusal of earlier geological maps reveal that no Dagshai outcrop exists at Locality 1 of Najman et al. (1997) or even in its vicinity.... The location of the second sample is ambiguous....there is but little doubt that it also came from the Nahan rocks". This statement is incorrect. Locality 1 lies in Tons valley near Kalsi (Kalsi: N30°31′60.00″ E77°49′60.00″) below the thrust-contact with the overlying Lesser Himalayan rocks. This locality is mapped as Dagshai Formation in Fig. 1 of Mathur (1978). Dagshai Formation is also recorded at this locality by Valdiya (1980) – p. 67 and 211, (referred to as the "red facies" of the Subathu, since he supported the interpretation of Raiverman and Raman (1971) that the Subathu and Dagshai Formations were coeval – as discussed above). Locality 2 lies NW of Nahan (Nahan: N30°33′31.65″ E77°17′20.22″) on the road to Sarahan (Sarahan: N30° 42′57.21″ E77° 11′21.49″) above the thrust contact with the underlying Siwaliks, as mapped by Raiverman et al. (1983) (p. 79) who referred to the Dagshai Formation as the "Kumarhatti En-Seq". Whilst I may disagree with these authors over the designation of the Dagshai Formation as "Red Subathu" or "Kumarhatti En-Seq". I am in agreement with where they have located the rocks, regardless of their interpretation. Furthermore, the petrography of the two analysed samples in question contrasts strongly with that of the Siwalik Formation. Siwalik rocks contain significant garnet. By contrast, the samples discussed here contain no garnet. Their petrography instead fits with that of the recognised Dagshai Formation (Najman and Garzanti, 2002).

Finally, no ambiguity can exist over the location of the sample Hm96-9A from which detrital zircons were used to date the base of the Dagshai Formation at younger than 31 Ma (Najman et al., 2004). It is from the distinctive sandstone that forms the marker bed at the base of Dagshai Formation (Raiverman and Raman, 1971; Batra, 1989). The locality (N31°15.968′ E076°54.655′) can be located on the map of Raiverman and Raman (1971) where their RIV (Dagshai Fm) and GV (Subathu Fm) contact cuts the Naugaon link road, and on the map of Batra (1989) where it is the slightly more southerly equivalent of their Subathu–Dagshai contact Locality B7. The sedimentology of this contact, and others in the map region are detailed in Najman (1995). Batra (1989) mapped the biozones at these contacts and concluded that the uppermost Subathu Formation was Early Lutetian. According to the structural interpretation of Najman et al. (1993), Batra's Locality B8 is the equivalent contact to that where sample HM96–9A is located, on the opposite folded limb. Thus, at this location, the evidence for a disconformity accounting for >10. My duration between Early Lutetian fossil evidence in the uppermost Subathu Formation and 31 Ma fission track data from the directly overlying basal Dagshai Formation, is robust.

With respect to the magnetostratigraphic dating, it is certainly not ideal that no fossil material was available to correlate the Birdhar–Chimnun section (White et al., 2001). Nevertheless, in this section, the succession passes up into the Siwaliks which are well dated throughout the basin (Burbank et al., 1996). The few million years of potential diachroneity for the start of Siwalik sedimentation precludes the use of the base of the succession to calibrate the Dharamsala Formation magnetostratigraphic data, but it provides a "guide rail". Furthermore, mica modal values from the Lower Dharamsala are 22–24 Ma (White et al., 2002), in accord with the magnetostratigraphy which dates the base of the measured section at 20 Ma. Note however that White et al., made no assertion as to the age or nature of the contact of the basal Dharamsala beds.

With respect to the comments by Bhatia and Bhargava on fission track vs fossil dating, it might be prudent to point out that in spite of the "time tested nature" of fossil evidence, it has not been without its limitations in the Himalaya: revisions of age-ranges of taxa are ongoing, and a number of examples of disputed identification have occurred. The discussion on the Late Eocene–Oligocene forms presented by Bhatia and Bhargava to date the Dagshai Formation are reviewed below, and serve to illustrate this point. This is not in any way to devalue the important contribution that palaeontological data can provide to age dating. However, no technique is without its limitations and uncertainties, and when fission track and isotopic data appear to differ, it is not a rigorous approach to dismiss the former merely on the basis that the latter is a "time tested criterion".

Bhatia and Bhargava (2006) present Late Eocene–Oligocene fossil data from the axial part of the peripheral foreland basin to dispute the existence of the Late Eocene–Early Oligocene basin unconformity. The Oligocene data from the Bugti Beds, Sulaiman Ranges, are not relevant: the Sulaiman ranges are located in the Lower Indus Basin rather than the axial part of the foreland basin, were thus likely not subjected to the same tectonic/basinal regime, and therefore need not be expected to display the same disconformity. Indeed, Oligocene deposits are recorded in both the eastern and western Himalayan remnant ocean basins (Johnson and Alam, 1991; Reimann, 1993; Qayyum et al., 1996). In any case, if the Bugti beds are dated as Late Oligocene (see Lindsay et al. (2005)) this would not be at variance with the Late Eocene–Early Oligocene (<31 ± 1.6 Ma) disconformity in the axial foreland basin, whilst an Early Oligocene age (ca 31 Ma) (Marivaux et al., 1999) lies within error of the isotopic data.

Bhatia and Bhargava (2006) date the Dagshai/Kasauli/Dharamsala as Late Eocene–Oligocene based on (1) foraminifera *Linderina*, (2) charophyte *H*. cf. *vasiformis*, (3) palynomorphs assigned to *Psilodiporites hammenii–Proxaperites operculatus* Zone, and *Spinizonocolpites echinatus–Morgocolporites sahnii* Zone, (4) palynomorph *Meyeripollis* sp. (5) vertebrate fauna *Leptomeryx, Menoceras* and *Microbunodon*. These data are discussed below.

(1) Presence of *Linderina* (“unpublished data” of Bhatia and Bhargava, quoted at Late Bartonian–Priabonian): If this datum is be used as evidence, it first needs to be published. However, even if published, the quoted age range appears open to debate, since this form is also recorded in the lower part of the Subathu Formation, of Ypresian age, (Mathur, 1978). Thus the fossil’s presence taken as diagnostic of Late Bartonian–Priabonian, is questionable and reworking from the Subathu Formation should be considered.
(2) Presence of *H*. cf. *vasiformis*, (quoted at Mid Bartonian–Mid Priabonian), documented by Mathur et al. (1996). Bhatia and Bhargava state that “Although Mathur et al. (1996) were tentative about this identification, comparison with topotype material available with us confirms this identification”. If such material is to be used as evidence, it needs to be published. However, even if published, the quoted age range is open to debate since *H*. cf. *vasiformis* is recorded in the Ypresian part of the Subathu Formation (Mathur, 1978). Thus the fossil’s use as age-diagnostic of the Mid Bartonian–Mid Priabonian is open to question. Reworking from the Subathu Formation should be considered.
(3) Occurrence of palynomorphs assigned to *Psilodiporites hammenii–Proxaperites operculatus* Zone (late Early Eocene–Mid Eocene; Lower Dharamsala Formation), and *Spinizonocolpites echinatus–Morgocolporites sahnii* Zone (Late Eocene–Oligocene; Lower Dharamsala Formation) are recorded from the Changartalai well, Punjab (Berry et al., 1996). For this data to be adequately assessed, the following details are required: sample type (core, sidewall, and cutting); sample spacing; quantitative data, i.e., raw range charts with absolute counts; size fractions ran; photographs of the critical fossils; discussion/evidence of any reworking, caving or local range top depression due to climatic/environmental factors. Additionally, if the author’s assignment of a late Early Eocene–Mid Eocene age to the rocks of the Lower Dharamsala Formation (Psilodiporites hammenii–Proxapertites operculatus Zone) is correct, this would indicate that the Subathu and a part of the Dagshai/Dharamsala Formation were coeval, a contention now considered incorrect (e.g. Bhatia, 2000, p. 90–91).
(4) Rare presence of *Meyeripollis* sp.: the taxon has been discovered in strata both older and younger than the Oligocene (e.g. Baruah et al., 1996), and researchers consider that the taxon ranges from Late Eocene to Early Miocene and thus cannot be used as a guide fossil for the Oligocene (Banerjee, 1975; Datta and Banerjee, 1980).
(5) The vertebrate fossils recorded by Ranga Rao (1986) are “poorly documented” according to Bhatia and Bhargava. Confining comment to Bhatia and Bhargava’s discussion of better documented fauna of “definite Oligocene taxa” (p. 484), *Menoceras, Leptomeryx* and *Microbunodon*: Assignment of *Menoceras* as a typical Oligocene form is puzzling, since the original authors consider it most likely to be Miocene (Kumar and Kad, 2003). In addition, the authors only assign the fossil found at this location to *Menoceras* with “a question mark” due to some difference in morphology with the standard form.

With respect to *Leptomeryx* and *Microbunodon*, the fossils are located in a fossiliferous horizon found at two locations, Sialsui-I and Sialsui-II, (located ca 500 m apart according to the map of Kumar and Kad (2003) – Fig. 2), in Kalakot, Jammu. In the fossiliferous horizon at SialSui-I, Mehta and Jolly (1989) record *Leptomeryx*, which they align as having greatest affinity with Oligocene forms. At this location, *Microbunodon* is reported by Kumar and Kad (2003, and references therein) with reservations, as described below. At SialSui-II, the fossiliferous horizon contains the Miocene fossil *Primus Microps* (Kumar and Kad, 2002, 2003). In spite of the discrepancy in proposed age range between the two fossil beds, and uncertainty in structural correlation due to the tectonised base of SialSui-II, Mehta and Jolly (1989) correlate the two beds on faunistic grounds. Kumar and Kad (2003) explain the discrepancy by asserting that the identifications of *Leptomeryx* and *Microbunodon* are “doubtful” (p. 45). They write that “this leptomerycid cannot be taken as indicative of an exclusive Oligocene age because the known range of Leptomeryx is Lower Oligocene–Lower

Miocene…..if the leptomerycid does belong to *Leptomeryx*, it definitely represents a new species, which would be too difficult to define on the basis of available material" (p. 48) and therefore "its precise age is uncertain" (Kumar and Kad, 2003, p. 739). They note that they can only tentatively assign their fossil to that of Microbunodon, and detailed examination of the specimen of Ranga Rao is not possible due to the poor description and illustration. In addition, recent work shows *Microbunodon* extends into the Miocene (Lihoreau et al., 2004).

Finally, Bhatia and Bhargava, quote Kumar and Kad (2003) as noting "the present evidence does not rule out the possibility of the Murree Group [equivalent to Dagshai] extending into Oligocene" because there are 575 m of Murree Fm below the fossil-bearing bed at SialSui. However, in the remainder of the discussion, Kumar and Kad conclude that the Subathu–Murree boundary is not conformable: "The stratigraphic boundary between the Murree and the underlying Eocene succession (Subathu Group) is entirely conformable, as there is no field evidence particularly in the Indian sections to suggest a break. However, the faunal evidence speaks otherwise … the composition, evolutionary level and the age range of the hitherto recovered Murree mammal fauna suggests the lack of continuum in the Murree and Subathu faunas and this certainly does not support the continuity of the Subathu and Murree successions". In addition, Kumar and Kad (2002) note that the diagnostic Miocene taxa *P. microps* is also found in the Murree Formation in Pakistan a mere 2 m above the contact with the underlying Eocene limestones (DeBruijn et al., 1981). Kumar and Kad continue "there is no firm basis yet to support the view that Subathu and Murree are continuous sequences. Even if the age of the leptomerycid and rodent-yielding lower Murree beds is taken as Middle Oligocene–Lower Miocene, there is no account of Late Middle Eocene, Late Eocene and Early Oligocene. After the deposition of Subathu Formation, which completed in the Early Middle Eocene time (Early Lutetian), there is absolutely no fossil evidence to account for the gap". Presence of fossils of later Oligocene age would not be incompatible with a disconformity spanning Upper Lutetian to <31 Ma. Fossils from earlier in the Oligocene might be expected at more northern locations in the basin, due to the likelihood of the time transgressive nature of the disconformity (Najman et al., 2001).

From the above it can be seen that the isotopic evidence is not at variance with itself, and is in accord with field and biostratigraphic data. At the best-constrained location, where both the *uppermost* Subathu Formation and passage beds and the *lowermost* Dagshai Formation are dated, by biostratigraphy and fission track dating, respectively, the interpretation of a disconformity of more than 10 Mys, encompassing the Late Eocene and Early Oligocene is upheld. Considering the uncertainties in the fossil data presented by Bhatia and Bhargava, it would seem premature at this stage to dismiss the isotopic data, and to proclaim the existence of the unconformity as untenable.

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