Pristichampsine cranial remains from the basal redbed facies of the Subathu Formation (Himachal Pradesh, India) and some palaeobiographical remarks

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Abstract

The first fossil ziphodont crocodile premaxilla and two isolated teeth referred to the Pristichampsinae are reported from the Eocene sediments of the Subathu formation (Himachal Pradesh, Northern India). They suggest that the Indian subcontinent had already collided with Eurasia by Early-Middle Eocene times.

Contents

Abbreviations

VPL/L: Vertebrate Paleontology Laboratory, Loyal collection, Department of Geology, Panjab University, India.

1. Introduction

The Early Tertiary sediments comprising the Subathu Formation (Palaeocene-Middle Eocene; Mathur, 1978; Bhatia, 1982, 2000) and the gradationally overlying Dagshai (Upper Eocene-?Oligocene) and Kasauli (Miocene) Formations provide an insight into the geodynamics of the India-Asia collision, the consequential narrowing of Tethyan corridors and the palaeobiogeography of the Indian plate. The Subathu Formation was deposited in a shallow Tethyan transgressive-regressive phase and documents the events and sequence stratigraphy in the southern foreland basin during the terminal phase of drift of the Indian plate (Bhatia, 1985; Najman *et al*., 1993). The stratotype at the Kuthar River (extending from northwest to southeast up to Dharampur, 16 km south of Subathu; figure 1) comprises a folded sequence of the Subathu Formation (figure 2), with a thickness of about 200 m around the Subathu cantonment (Sahni *et al*., 1981a, b; Loyal, 1986a, b). The basal lithofacies (Green Facies) comprises predominantly green-grey calcareous shales alternating with oyster-bearing limestones, nummulitic marls and mudstones with thin sandstone laminae. The Green Facies has yielded abundant invertebrate taxa, especially gastropods and bivalves, along with rich assemblages of benthic foraminifers and ostracodes. The ossiferous red beds yielding the present pristichampsine remains comprise the siliclastic Red Facies, which either alternates or has tectonic contact with the Green Facies, although in some places the contact between the two facies is obscured. The dominant lithofacies in the red beds are massive sandstones, siltstones and ossiferous conglomerates.

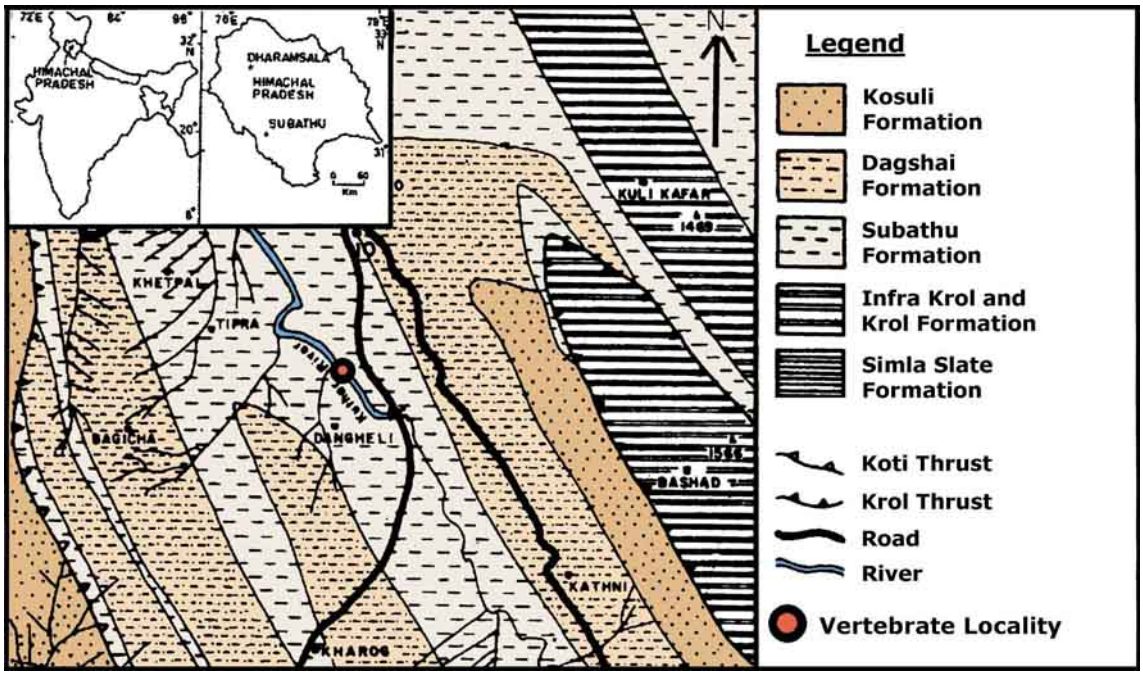

Figure 1. Geological map of Subathu area, Himachal Pradesh, showing the vertebrate locality where the fossil crocodile was recovered. Inset shows map of India and geographic location of Subathu. Modified from Loyal (1986) & Kumar & Loyal (1987).

2. Occurrence, age and environments

The present locality (30º 57' 41" N; 76º 58' 59" E) was earlier documented as locality KK by Loyal (1986b) and Rifle Range locality by Kumar & Loyal (1987). The pristichampsine remains were recovered from a 5 m thick fine to medium grained red overbank microconglomerate overlying the channel sandstone, which grades laterally into a partially shaly gypsiferous siltstone. There is a faint development of cream-yellow coloured caliche in the siltstone. The ossiferous microconglomerate is characterized by millimetric sized quartz, calcite, and ferromagnesian clasts, embedded in a laterally varying matrix of sand, silt, and clay components. Besides the pristichampsine remains, abundant fragments of heavily mineralized turtle bones and small sized bone debris were also recovered.

The red beds comprising the ossiferous conglomerate are correlated with the lower part of Zone III of Mathur (1978), which has been dated as Lower Eocene on the basis of the diagnostic bivalve species *Venericardia* (*Glyptoactis*) *mutabilis* Archaic & Haime, 1854 and the ostracod *Neocypredeis*. Presence of ossiferous red beds in Zone III has also been suggested by Bhatia (1982), who critically reviewed the faunal

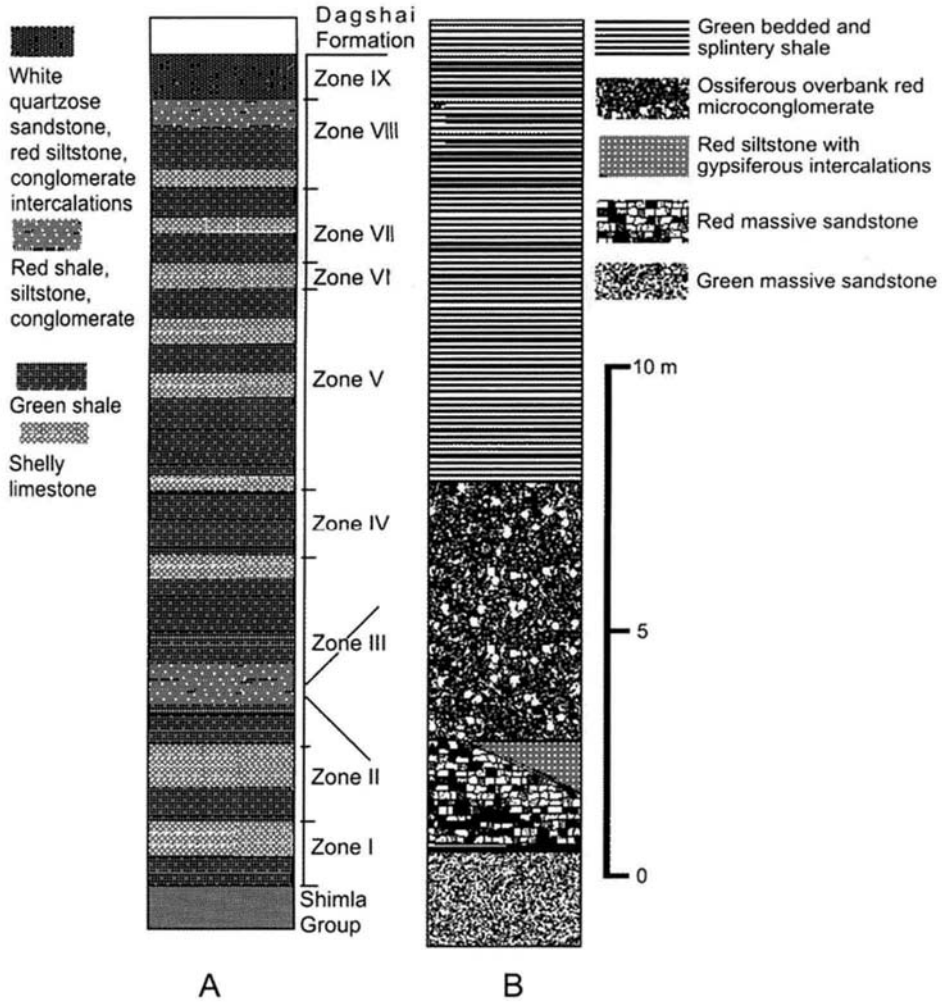

Figure 2. Composite stratigraphic section of Subatus formation (A), Kuthar River, Himachal Pradesh, showing bio-stratrigraphic zones (I-X). Zone I, Late Palaeocene; Zones II-VI, Early Eocene; Zones VII-IX, Middle Eocene; overlain by red sandstones and siltstones of Dagshai Formation. Section modified after Mathur (1978) and Bathia (1982). Section B shows ossiferous section, 30 57 41 N, 76 58 59 E, altitude 930 m, associated with Zone III (Early Eocene in the composite Zone).

content of Mathur's (1978) zones across the entire north-western Early Tertiary belt. Bajpai & Gingerich (1998) reported the pakicetid *Himalayacetus subathueansis* Bajpai & Gingerich, 1998, from Zone III in association with *Nummulites atacicus* Leymerie, 1846, suggesting a late Early Eocene age for these deposits.

The lower and middle part of Zone III indicates the presence of brackish water followed by near-shore lagoon conditions (Bhatia, 1982). The presence of *Ilyocypris* indicates freshwater conditions (Mathur, 1979). On the basis of the presence of intraformational pebbles in the conglomerate, migration of meandering channels in a shallow fluvial environment was suggested (Wells, 1983). Najman & Garzanti (2000) also observed the red beds in the Subathu Formation in the Kuiana basin of northern Pakistan and related them to delta plain, coastal and tidal environments. Based on the petrography and geochemistry of the Subathu sandstones, these authors suggested a recycled sedimentary source for the Subathu sediments. The red siltstone layer lying below the ossiferous conglomerate is interpreted as a silt influx from rivers flowing from adjoining land in an estuarine or outer tidal flat environment.

3. Other crocodilian collections from Subathu Formation

The Subathu Formation has over the last two decades been subject of intense vertebrate explorations. First major vertebrate report came through the work of Sahni *et al.* (1981a, b), with diverse assemblages of fishes, crocodiles, and fragmentary mammal teeth from the coeval basal beds of conglomeratic limestones

exposed in the Kuthar River. Chelonian (Genus *Trionyx*) and crocodilian bones and teeth referable to *Crocodylus* sp.), were reported in these works. Another locality on the Dharampur-Kasauli Road, DKL, is worth mentioning, with rodent remains along with *Turritella*, *Corbula* and *cf. Pristichampsus* (Kumar & Loyal, 1987; Kumar *et al*. 1997). The basal Subathu beds have yield associated vertebrate remains include marine fishes, such as condrichthyians, holosteans, teleosteans (Loyal, 1984a, b; 1986a, b), Kumar & Loyal, 1987).

One of the most promising and richly fossiliferous horizon lies at the top of Subathu Formation, which comprise the uppermost redbeds of the Subathu Formation (equivalent to Passage Beds of Bhatia & Mathur, 1965; Bhatia & Bhargava, 2002); herein along with rodent and other mammalian faunas, are crocodilian teeth and bone elements found in the Jammu-Rajauri belt of Jammu and Kashmir as well as in Subathu Type Section of Himachal Pradesh. Ziphodont crocodiles referable to pristichampsines and associated with fresh water gastropods *Physa* and *Planorbis* were recorded by Sahni & Srivastava (1976), Srivastava & Kumar (1996); Locality EBGL with abundant ziphodonts and the rare form *Crocodylus*) and Sahni *et al*. (1978) from this bone bearing horizon of district Rajauri of Jammu and Kashmir. Besides, EAL locality of Kumar & Loyal (1987) and Kumar *et al*. (1997) associated stratigraphically with uppermost redbeds, also yielded well-preserved serrated teeth assigned to *Pristichampsus.*

Further, crocodilian teeth (*Pristichampsus*) and chelonian remains are also known from Bilaspur area of Himachal Pradesh, associated with Zone III; along with numerous molluscan taxa and ostracode (Bhatia, 2000).

4. Systematic palaeontology

Order Crocodylia Gmelin, 1788
Suborder Eusuchia Huxley, 1875
Family Crocodylidae Cuvier, 1807
Subfamily Pristichampsinae Kuhn, 1968
Pristichapsinae indet.

Material: VPL/L 800086: a *Pristichampsine* indet. Kuhn, 1968 left premaxilla accompanied by the anteriormost part of the left maxilla; VPL/L 10110: Isolated ziphodont teeth; VPL/L 10120: Isolated ziphodont tooth still imbedded in matrix.
Locality: Rifle Range locality, near Subathu, Himachal Pradesh, Northern India.

4.1. Description

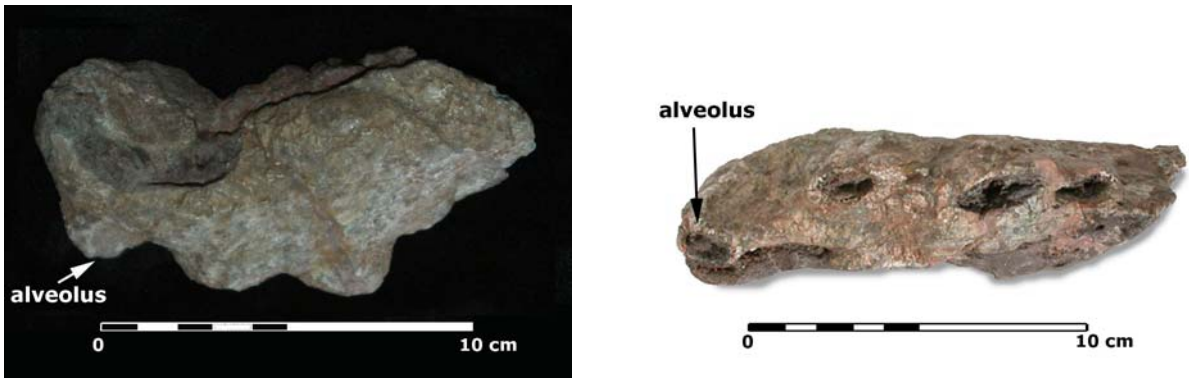

Figure 3. Lateral (left) and ventral view (right) of the ziphodont's left premaxilla and part of the left maxilla. Photograph by X. Panadés I Blas.

Specimen VPL/L 800086 consists of a left premaxilla and the anteriormost portion of a left maxilla (figure 3). There are four premaxillary alveoli (instead of five as in *Pristichampsus vorax* Troxell, 1925; Langston, 1975; Busbey, 1986), which are strongly laterally compressed. No teeth are preserved. The first, second and fourth alveolus are subequal in size, while the third is clearly the largest and occupies the lowermost place in the lateral festooning of the premaxilla. Its lateral (labial) border reaches further downward than the medial (lingual) one and has a subtriangular shape.

The alveoli are not regularly spaced. The largest interalveolar distance is between the first and the second alveoli. At this level, there is a clear depression in the lateral surface of the premaxilla for the reception of the first dentary tooth. In this, the present specimen is also different from *P. vorax*, in which the first dentary

tooth fits in a small pit in the ventral surface of the anterior portion of the premaxilla, medial to or in the interalveolar space between the first and second premaxillary tooth. The second and third alveoli are clearly apart from each other but their interalveolar distance is smaller than that between the first and the second. The fourth alveolus is close to the third and their interalveolar distance is the smallest.

Posterior to the fourth alveolus, the premaxillo-maxillary notch is visible as a shallow triangular depression in the lateral surface of the posteriormost part of the premaxilla and the anteriormost part of the maxilla. It received the fourth dentary tooth, which, like the first, was enlarged as a 'caniniform'.

The lateral surface of the premaxilla is vertical, instead of the more 'splayed outward' profile typical of crocodilians adapted to an amphibious life, indicating altirostry. Despite the differences in the dentition, the general shape of the premaxilla is very similar to that of *P. vorax*. This surface is slightly sculptured by sparse, irregular and shallow pits. The left half of the external naris is preserved. It reaches forward to the level of the anterior tip of the snout and backward to the level of the interalveolar space between the second and third premaxillary alveoli. In ventral view, the foramen incisivum is partially preserved, its left lateral and part of its posterior borders being visible. It reaches forward to the level of the posterior border of the first premaxillary alveolus and backward to the level of the anterior third of the second premaxillary alveolus. The external naris projects dorsally like in other eusuchians instead of anterodorsally like in crocodilians of mesosuchian grade (Brochu, 1997).

The premaxillary posterodorsal process reaches backward only to the level of the premaxillary-maxillary notch. The ventral part of the specimen is damaged and the backward extent of the premaxillary ventral process is unknown. The maxillary anterodorsal process reaches forward to the level of the third premaxillary alveolus. The anteroventral maxillary process is not preserved.

Specimen VPL/L 10110 (figure 4) is an isolated ziphodont tooth with a length of 2.3 cm and a maximum width of 0.95 cm. Specimen VPL/L 10120 is an isolated tooth still imbedded in the matrix with a length of 1.4 cm and a maximum with of 0.55 cm. Both are laterally compressed and bear fine serrations along their anterior and posterior carinae.

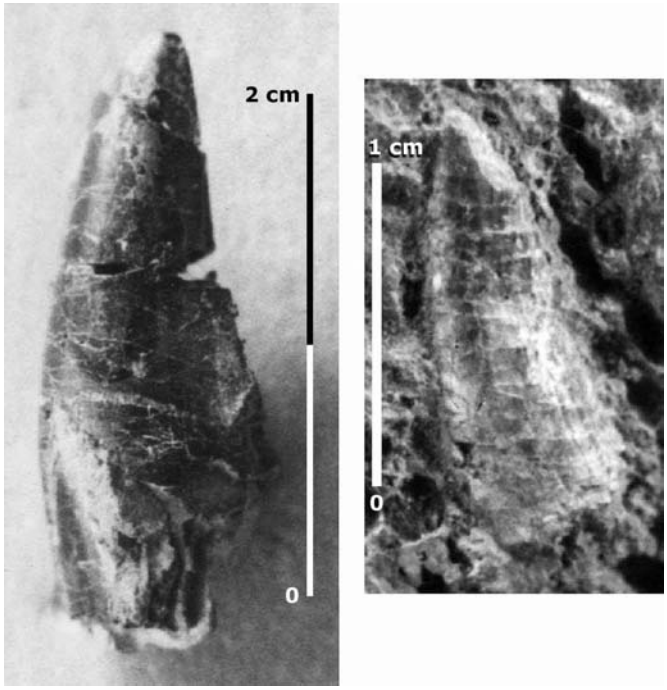

Figure 4. Two isolated ziphodont teeth, one still imbedded in matrix. Photograph by R.S. Loyal.

5. Discussion and conclusion

The laterally compressed alveoli, the presence of a well-developed but narrow premaxillary notch, the depth of the premaxilla, and the presence of a single and large external narial opening in dorsal position, as well as the morphocharacteristics of the teeth (ziphodonty: laterally compressed and with serrated carinae) makes the present specimens the first unambiguous record of a pristichampsine crocodilian in the Indian subcontinent.

Former finds included isolated ziphodont teeth, procoelus vertebrae and limb bones (Buffetaut, 1978a; Sahni & Schleich, 1990). However, none of these could be attributed with certainty to the Pristichampsinae,

since ziphodont teeth are also known in other crocodyliformes (Buffetaut, 1978b, 1979, 1982a, b, 1986, 1988, 1989, 1994; Wilson *et al.,* 2001; Prasad & Broin, 2002) including groups such as the Baurusuchidae and possibly the Trematochampsidae that were present in the Indian subcontinent in the Late Cretaceous (Wilson *et al.,* 2001; Prasad & Broin, 2002). They also show that by Early-Middle Eocene times the Indian subcontinent had already collided with the Eurasian plate, allowing Eurasian faunal elements like the pristichampsines to migrate into the former.

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