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A NEW ENIGMATIC LARGE RHINOCEROTID FROM THE UPPER UNIT OF THE CHITARWATA FORMATION AT ZINDA PIR DOME, WESTERN PAKISTAN

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ABSTRACT

Several upper molars and part of a maxilla of a large rhinocerotid were collected from two localities in coastal facies of the upper unit of the Chitarwata Formation at Zinda Pir Dome in western Pakistan. Preserved features of the dentition are widely symplesiomorphic and do not permit clear assignment to a known species from the diverse rhinocerotid fauna at Dera Bugti or to the rhinocerotini subtribes. The teeth of the rhino from the upper unit of the Chitarwata Formation have a rudimentary likeness to another enigmatic but smaller species, *Rhinoceros blandfordi*, from Bugti Hills, suggesting a possible evolutionary link. However, additional fossils from the region are required to test this supposition. Likewise, the well-established pattern of barrier-free rhinocerotoid dispersal between the Indian subcontinent, Europe, and Asia during the early Miocene also makes it plausible that this large rhinocerotid came to the Indian subcontinent as part of an early Miocene immigration event.

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INTRODUCTION

The Chitarwata Formation of western Pakistan is a thick rock sequence recording the late Oligocene and early Miocene geological and biological history of the western Himalayan fForeland. Near Dalana in the Zinda Pir Dome region west of Dera Ghazi Khan (Figure 1a) the Chitarwata Formation is over 400 m thick and represents deposition in marginal marine settings (Downing et al. 1993; Downing and Lindsay, this issue). Vertebrate remains have not been recovered from the thick eolian sandstones comprising the middle unit of the Chitarwata Formation. However, a diverse small and large mammal fauna, described by Flynn and Cheema (1994), Lindsay (1995), Baskin

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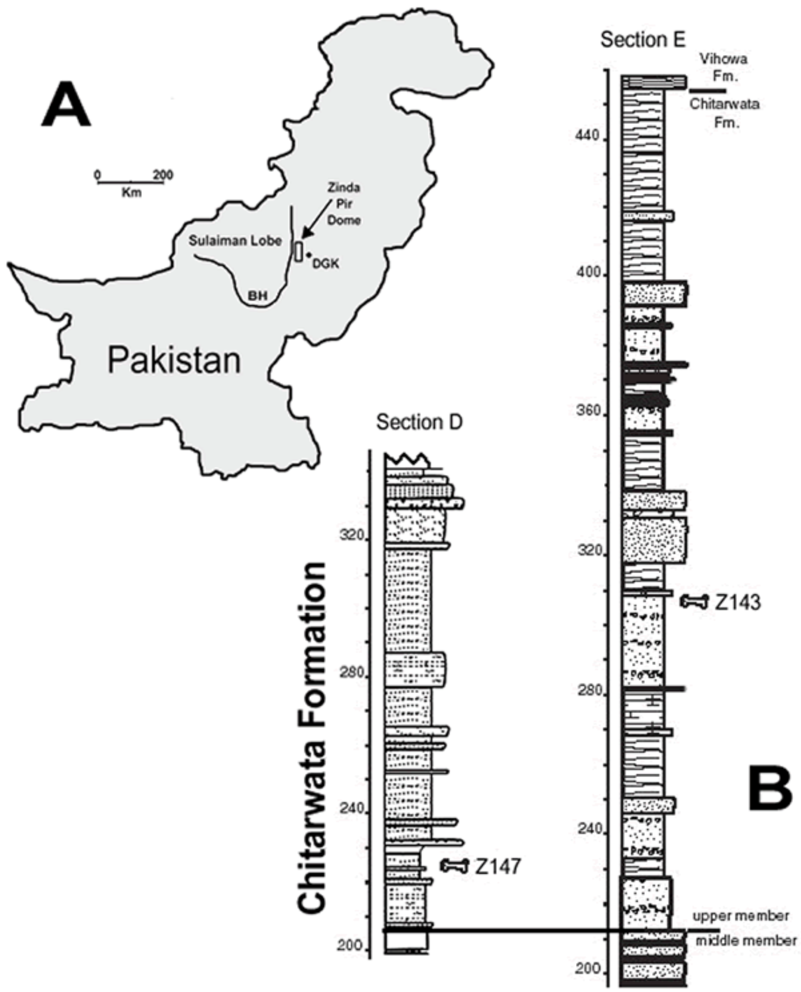

Figure 1. A. Locality map of the Zinda Pir Dome region of Pakistan, north of the Sulaiman Lobe in the Western Himalayan Foreland. Abbreviations are: DGK-Dera Ghazi Khan; BH-Bugti Hills,l, **B.** Stratigraphic sections of the upper unit of the Chitarwata Formation showing the position of localities where rhinoceros fossils were collected.

(1996), and Lindsay et al. (this issue), has been recovered from numerous fossiliferous levels within the Chitarwata Formation's lower and upper units. However, the remains of very large mammals have been sparse in the Chitarwata Formation in the Zinda Pir area, although specimens of deinotheres, gomphotheres, rhinocerotoids, and chalicotheres have been collected (Lindsay and Downs 2000). Near the base of the lower unit of the Chitarwata Formation (locality Z153) hyracodontid (Indricotheriinae) fossils have been found. Evidence of rhinocerotoids in the Chitarwata Formation at Zinda Pir Dome area is typically limited to enamel fragments of teeth or isolated postcranial remains.

By comparison, an exceptionally diverse Oligocene and early Miocene record of rhinocerotoids has been developed for the Bugti Hills localities in Baluchistan over the last 160 years since fossils were reported by Vickary in 1846. Early collections and study by Lydekker (1881), Pilgrim (1912), and Forster-Cooper (1934) have been recently augmented by the Mission Paléontologique Française au Balouchistan (Welcomme et al. 2001). The classic "Bugti fauna" and its diverse rhinos have been collected in two primary areas of the Bugti Hills region, the "Dera Bugti Valley" and the Gandoi Plain. The localities Lundo Chur and Paali Nala in the Gandoi plain have yielded the Oligocene giant hyracodontid, *Paraceratherium*, the amynodontid *Cadurcotherium* and the rhinocerotid *Epiaceratherium* (Welcomme and Ginsburg 1997; Antoine et al. 2003a). In younger deposits in this area *Aprotodon*, *Cadurcotherium*, and smaller varieties of *Paraceratherium*, are recovered. The early Miocene Dera Bugti Valley rhinos from Dera Bugti 4 and Kumbi 4b-c and 4f, include *Aprotodon*, two species of *Dicerorhinus*, *Protaceratherium*, *Plesiaceratherium*, *Brachypotherium*, *Hoploacerathe-rium*, as well as the small elasmotheriine, *Bugtirhinus* (Welcomme et al. 1997; Antoine and Welcomme 2000; Welcomme et al. 2001). The late Miocene Sartaaf locality in the Dera Bugti Valley has produced *Alicornops* (Antoine et al. 2003b).

This report examines new rhinocerotid fossils recovered from two localities in the upper unit of the Chitarwata Formation at Zinda Pir Dome, Z143 and Z147 (Figure 1b) near stratigraphic sections D and E (Lindsay et al. this issue). The upper unit was considered to represent the interval from approximately 17.4 to 19 Ma based upon magnetostratigraphy (Lindsay and Downs 2000), but reassessment of this information in light of additional fossil localities, sections, and magnetostratigraphic sampling (Lindsay et al. this issue) supports a provisional age of 19.5 Ma (chron C6n) for the Chitarwata Formation-Vihowa Formation contact in the southern end of Zinda Pir Dome and two possible ages 23.5 Ma (chron C6Bn) or 27.0 Ma (chron C8n) for the base of the upper unit.

Specimens from Z143 were recovered about 100 m stratigraphically above the contact of the middle and upper units of the Chitarwata Formation as float in close proximity to one another and derived from a fine-grained sand with an iron-rich cement. They are presumed to be from one individual based on the context of recovery, similarity of the fossils' preservational condition, and tooth wear state. The only other notable vertebrate fossils observed near Z143 were abundant crocodile remains several meters stratigraphically below the Z143 locality. The Z147 molar was found in isolation about 20 m above the contact of the middle the upper unit of the Chitarwata Formation in coarse sand also with iron-rich cement. Based upon the chronostratigraphic age estimates for the contact between the middle and upper units of the Chitarwata Formation described above, the rhinoceros teeth are late Oligocene or early Miocene in age. The upper unit of the Chitarwata Formation is characterized by local concentrations of marine molluscs and is interpreted as a tidal flat-tidal channel environment (Downing et al. 1993). Presumably this rhino's habitat included lowland forests near the coastal plain and may have been similar to the habitat of the modern Javan Rhinoceros.

SYSTEMATIC PALEONTOLOGY

Family RHINOCEROTIDAE Owen 1845
Subfamily RHINOCEROTINAE Owen 1845
Tribe RHINOCEROTINI Owen 1845
Subtribe *incertae sedis*
Indeterminate Genus and Species

Material

Fossils were collected in January 2000, from the upper unit of the Chitarwata Formation at Zinda Pir Dome near the village of Dalana. The Pakistan Museum of Natural History (PMNH) is the repository for the specimens, which are designated Z2269A, left P2; Z2269B, right M2; Z2269C, right M3 with fractured and dislocated partial maxilla; Z2269D, left M3; Z2268, right M1 (Figures 2, 3). Z2269 specimens are from locality Z143, and specimen Z2268 is from locality Z147. Specimens of *Paraceratherium* and *Rhinoceros blandfordi* addressed herein are from the collections at the Natural History Museum of London (NHM).

Methods

Classification designation of the Rhinocerotinae follows the phylogenetic analysis by Antoine et al. 2003b, and perissodactyl dental terminology generally follows Hooker 1989. Dental orientations follow the conventions of Smith and Dodson (2003). Measurements of Chitarwata Formation rhinocerotid teeth (mm) are provided in Table 1.

Description

The teeth are moderately hypsodont with minor cement (as observed on chipped Z2269B), large sized, and moderately worn. All but the P2 have incomplete crowns. The molars display prominent accessory cuspules between the protocone and hypocone, large antecrochets, and narrow preprotocrista. Prominent cingula are restricted to the mesial tooth edge near the protocone on the molars.

P2: The tooth (Z2269A, left P2) is roughly quadrate but narrows mesially with the metaloph longer than the protoloph. The buccal enamel is thick (4.9 mm), and lingual edge enamel is thin (2.0 mm). The buccal side of the tooth has two shallow grooves producing a trilobed buccal occlusal outline. A narrow cingulum is present along the mesial side of the protocone, narrowing on the lingual side of the protocone, broadened into a spade-shaped accessory cuspule (*sensu* Hanson 1989) between the protocone and hypocone, and ascending towards the hypocone. A strong protocone-hypocone connection is present at this state of wear. A small elliptical prefossette is present with its axis directed parallel to the buccal edge of the tooth. A large heart-shaped postfossette is also present. The crista is small and projects into the lingual valley. The lingual valley between the protoloph and the metaloph is deep, isolated, and Y-shaped. The preparacrista is thin (2.7 mm) as is the preparaconule crista (3.2 mm). The metaloph has a rela-

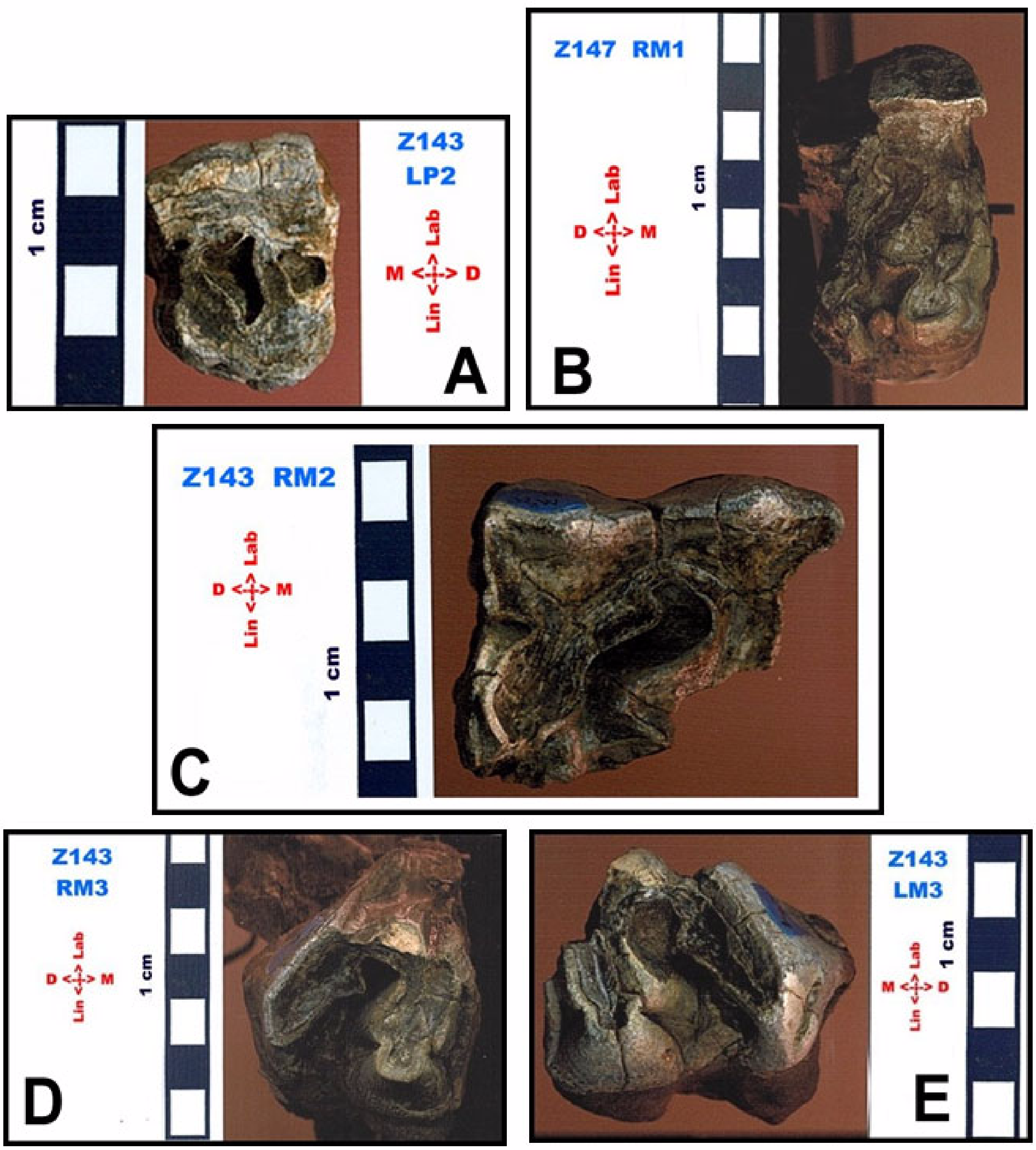

Figure 2. Rhinocerotid teeth from the Chitarwata Formation at Zinda Pir Dome. **A.** Z2269A, left P2, **B.** Z2268, right M1, **C.** Z2269B, right M2, **D.** Z2269C, right M3, E. Z2269D, left M3. Abbreviations are: M-mesial; D-distal; Lin-lingual; Lab-labial.

tively uniform thickness displaying a slight increase in breadth from the neoformed crest (4.0 mm) to the prehypocrista (4.7 mm).

M1: The tooth (Z2268, right M1) is roughly quadrate, and the enamel is thin (1.6 mm). At this state of wear, the mesial portion of the ectoloph (parastyle-preparacrista-paracone) is raised high (17.2 mm) above the level of the rest of the metaloph and protoloph. The parastyle projects beyond (4.8 mm) the mesial edge of the tooth. The protocone is conical with a narrow preprotocrista producing a "constricted protocone" condition. There is a broad cingulum originating low on the mesial side of the protocone and ascending and joining with the metaloph across from the antecrochet. The antecrochet is large, extends beyond the distal limit of the protocone, and is directed toward the hypocone. The protoloph and the metaloph are roughly parallel. There are two small rounded crochets on the metaloph (here designated as crochet 1 = buccal side of metaloph; crochet 2 = lingual side of metaloph) There is a large (9.0 mm) spade-shaped accessory cuspule between the protocone and hypocone, and it connects low on its buccal side to the antecrochet and crochet 2. The resulting lingual valley is sinuous and open. This tooth is con-

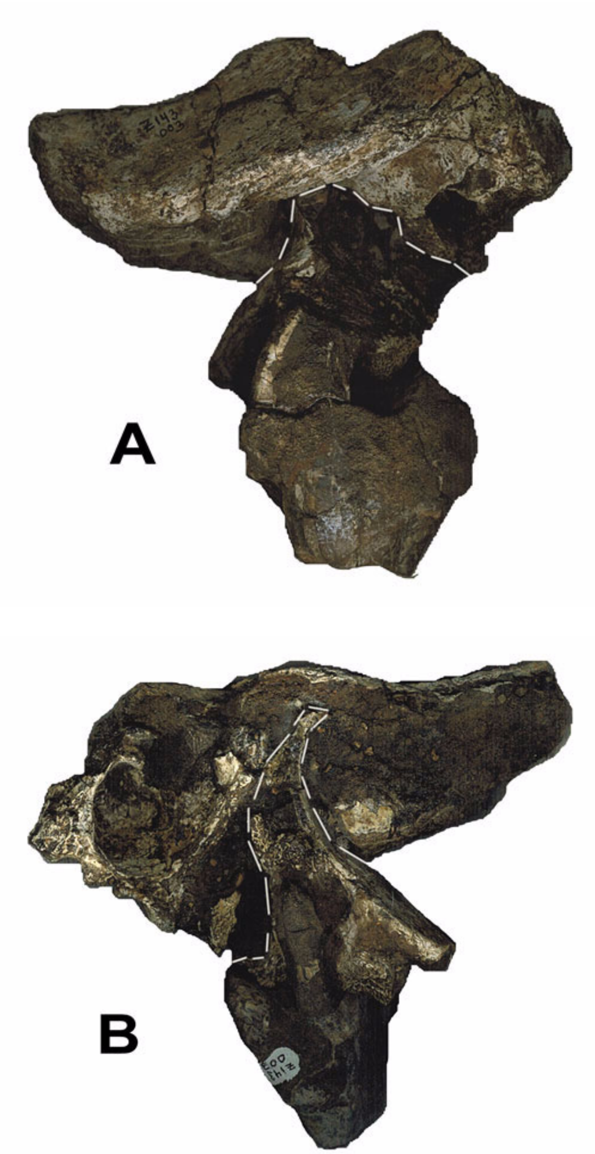

Figure 3. Rhinocerotid partial maxilla from the Chitarwata Formation at Zinda Pir Dome. **A.** lateral view of Z2269C, **B.** medial view of Z2269C. White dashed lines mark the contact where the M3 is crushed into the partial maxilla. Specimen length is 165 mm.

sistent in several ways with the Z2269B M2 from locality Z147 (described below) including: constricted protocone, large antecrochet extending beyond the distal limit of the protocone, large spade-shaped accessory cuspule, sinuous lingual valley, and proportional tooth size. Hence, although it comes from older strata, this M1 is provisionally linked to the same indeterminate genus.

M2: The tooth (Z2269B, right M2) is roughly quadrate, and the enamel is thin (2.0 mm). At this wear stage the ectoloph height is approximately the same as the metaloph and protoloph. The parastyle projects well beyond (8.4 mm) the mesial edge of the tooth and has a "fold" on the buccal edge. The antecrochet is large, extends beyond the distal limit of the protocone, and is directed towards the postfossette. There is a large (8.2 mm) spade-shaped accessory cuspule between the protocone and hypocone, and it connects low on its buccal side to the crochet 2. The resulting lingual valley is sinuous and open.

Table 1. Measurements in mm of Chitarwata Formation Rhinocerotid Teeth. Abbreviations: L, Length; ant W, anterior Width; post W, posterior Width; H, crown Height at wear stage. An asterisk (*) indicates estimate.

Specimen		L	ant W	post W	H
Z2269A	P2	27.6	28.7	36.5	13.1
Z2268	M1	43.1	64.1	-	30.0
Z2269B	M2	64.6	-	-	30.8
Z2269C	M3	61.4	66.1*	68.7*	-
Z2269D	M3	60.5	-	-	-

M3: The teeth (Z2269C, right M3 with partial maxilla; Z2269D left M3) are triangular, but with an enlarged talon, and the enamel is moderate in thickness (3.0 mm). At this state of wear, the metaloph is beveled downwards making it lower than the protoloph. The protocone is conical and buccolingually compressed. The protoloph narrows at the preprotocrista producing a "constricted protocone" condition. The antecrochet is moderate in size and extends beyond the distal limit of the protocone. There is a broad cingulum originating low on the mesial side of the protocone and ascending and joining with the metaloph in alignment with the buccal limit of the lingual valley. There is a thin short cingulum on the distal edge of the tooth below the hypocone. A prominent T-shaped accessory cuspule is situated between the protocone and hypocone. The crochet is well developed, and the lingual valley is open.

Maxilla: A small portion of the right maxilla (Z2269C) and zygomatic arch is preserved including: part of the aveolar region for the M2, the groove between the jugal and maxillary, and about 140.0 mm of the anterior jugal. Despite some missing bone, the base of the anterior portion of the zygomatic arch appears to be high. Anchored by matrix to this portion of the maxilla, but dislocated during original preservation, the M3 and a fragment of the maxilla (or palatine) comprising a small portion of the orbit are preserved.

TAXONOMIC COMPARISON AND DISCUSSION

Forster-Cooper (1934) revised the extinct rhinoceroses known in the Dera Bugti area. Of the fossils he discussed, the specimens assigned to

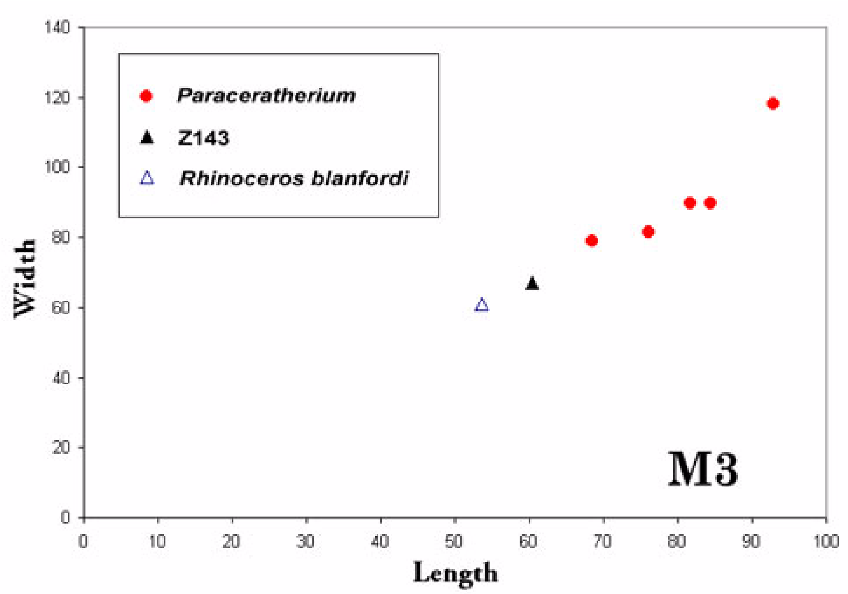

Figure 4. Bivariate plot for the M3 of Rhinoceros blandfordi (Forster-Cooper 1934), *Paraceratherium* and rhinocerotid from the upper unit of the Chitarwata Formation (in mm).

Rhinoceros blandfordi, including the partial palate NHM 15365, show the closest affinities to the teeth from localities Z143 and Z147 of the Chitarwata Formation.

Zinda Pir rhinoceros teeth were compared to those from Kumbhi at Dera Bugti described and assigned to *Rhinoceros blandfordi* by Forster-Cooper (1934; plate 67, figures 34 and 36). Shared features are a quadrate premolar with slight crista, molars with constricted protocone, large antecrochet, and accessory cuspules between the protocone and hypocone. However, as Forster-Cooper (1934, p. 593) pointed out, "such characters as a strongly constricted protocone, a large anterocrochet, a cingulum, etc., are features too widely spread to afford any safe guide to generic distinction." The Zinda Pir rhinoceros differs from the Bugti Rhinoceros blandfordi having a cingulum restricted in position and extent, a small or absent metastyle in M2 and probably M3 (based on Z2269C), and two small rounded crochets on the metaloph resulting in a more sinuous shaped lingual valley. The Zinda Pir rhinoceros M3 is also larger than the Bugti Hills *Rhinoceros blandfordi* approaching the size range of smaller *Paraceratherium* (Figure 4).

The phylogenetic analysis of the rhinocerotids by Antoine et al. 2003b provides a paradigm to evaluate the phylogenetic assignment of the Z143/Z147 rhinoceros based on its preserved dental and maxillary characteristics. That analysis proposed that the: 1) Aceratheriina are united by an indentation of the metaloph (i.e., postfossette) on the P2-4 and an "irregular" origination of the zygomatic process on the maxillary, 2) the Teleoceratina (excluding *Brachypotherium*) are united with the base of the anterior zygomatic process positioned low and the antecrochet always present on the upper molars, and 3) the Rhinocerotina are united by cheek teeth with cement present, lingual cingula on P2-4 reduced to a knob, and absence of the labial cingula on upper molars.

A comparison of the distribution of these synapomorphic dental and cranial character states of the Rhinocerotinae against those of the Z143/Z147 rhinoceros indicates a mixture of features from the Aceratheriina, Teleoceratina, and Rhinocerotina as summarized in Table 2. For example, the indentation of the premolar metaloph combined with the maxillary features of regular origination and a "high" position for the zygomatic process is consistent with the Aceratheriina. The Rhinocerotina also show a high position of the zygomatic process, but in the analysis by Antoine et al. (2003b), only *Brachypotherium* displays that condition in the Teleoceratina. The presence of a pronounced antecrochet on all of the molars is consistent with the Teleoceratina. Affinity to the Rhinocerotina is suggested by the reduction of a lingual cingulum on the premolar to a knob (i.e., the spade-shaped accessory cuspule), absence of the labial cingulum on upper molars, and incipient cement on the cheek teeth. As a whole, the fossil teeth and partial maxilla from the upper unit of the Chitarwata Formation do not display synapomorphies that persuasively place this rhinoceros into one of known early

Table 2. Distribution of selected synapomorphic dental and cranial character states of the Rhinocerotinae to the Z143/Z147 Rhinocerotid.

Aceratheriina	Z143/Z147	Teleoceratina	Z143/Z147	Rhinocerotina	Z143/Z147
Indentation of the metaloph (postfossette) on the P2-4	+	The base of the anterior zygomatic process positioned low	-	Cheek teeth with cement present	+
An irregular origination of the zygomatic process on the maxillary	-	Antecrochet always present on the upper molars	+	Lingual cingulum on P2-4 is reduced to a knob	+
				Labial cingula on upper molars always absent	+

Miocene subtribes or genera on the Indian subcontinent.

It should be observed that although Forster-Cooper (1934) considered the constriction of the protocone a plesiomorphic character, and this is generally supported in the analysis by Antoine et al. 2003b, the degree of protocone constriction observed on the Z143 and Z147 specimens (e.g., M3 and M1) is not ubiquitous among the rhinoceros genera of the Oligocene and early Miocene of Dera Bugti. This pronounced protocone constriction is observed for *Rhinoceros blandfordi*, as well as the small Elasmotherine *Bugtirhinus* (Antoine and Welcomme 2000). It is prevalent in the Teleoceratina clade (e.g., *Teleoceras*) but is not present (Antoine et al. 2003b, character 116) in *Brachytherium* and *Aprotodon*. Thus, while this feature does not support a particular Bugti Hills candidate for assignment, it may broadly suggest a closer evolutionary affinity of the Zinda Pir form to *Rhinoceros blandfordi.* Also notable, the structure of the metacone-metastyle portion of the metaloph is broad on the Zinda Pir M2 and similar to that of *Aceratherium incisivum* and *Brachypotherium.*

SUMMARY

The Zinda Pir rhino has dental features that do not warrant its placement in an existing genus, the erection of a new genus, or even its placement into a rhinocerotine subtribe. Taken together, the features and size of the Zinda Pir rhinoceros do not suggest a close relationship to the currently described rhinoceros genera of the Dera Bugti Valley and Gandoi Plain reviewed above. The character of the zygomatic arch provides little support of this species' connection to the Teleoceratina unless this portion of the cranium is like *Brachypotherium*. Moreover, except for size, its limited cingula, and broader metacone region, the general morphology of the molars including the accessory cuspules and extensive protocone constriction have a rudimentary likeness to the ambiguous *Rhinoceros blandfordi*. It is possible Z143/Z147 rhinoceros has a closer phylogenetic connection to *Rhinoceros blandfordi* representing a larger and possibly more advanced form.

It is not extraordinary that the rhinoceros from the upper unit of the Chitarwata Formation does not have an ancestral or complementary record at Bugti Hills. The commoness of rhinocerotoid genera in Asia and India during the Oligocene makes it clear that the Himalayan Foreland was not isolated by physical barriers to dispersal. This barrier-free condition lasted through the early Miocene, evidenced by first appearances of rhinoceros in Pakistan and subsequent appearances in Europe during this interval (Antoine et al. 2000a, 2000b, 2003a). Hence it is also possible this large rhinoceros will ultimately be determined to have an ancestry elsewhere in Asia or Europe. Alternatively, this upper Chitarwata Formation rhinoceros may be endemic but remain an enigmatic part of the diverse early Miocene rhinoceros of the Indian subcontinent until the more definitive remains can be collected from strata recording its coastal habitat.

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