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New remains of the baluchithere *Paraceratherium bugtiense* (Pilgrim, 1910) from the Late/latest Oligocene of the Bugti hills, Balochistan, Pakistan

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Abstract

New dental and postcranial remains referred to the giant rhinocerotoid *Paraceratherium bugtiense* are described, originating from its type locality (Lundo Chur), in eastern Balochistan (Pakistan). Probable sexual dimorphism is revealed on the lower incisors. The manus was tridactyl, with a reduced fifth metacarpal. The stratigraphic range of both *P. bugtiense* and the amynodontid *Cadurcotherium indicum* extends from the Early Early Oligocene to the Late/latest Oligocene in the Bugti Hills.
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Keywords: Rhinocerotoidea; *Paraceratherium*; *Cadurcotherium*; Late Oligocene; Lundo Chur J2; Bugti hills; Pakistan

1. Introduction

The baluchitheres— or indricotheres—number among the largest land mammals that ever lived (Osborn, 1923; Granger and Gregory, 1936; Fortelius and Kappelman, 1993). These giant rhinocerotoids had a widespread distribution in Asia during the Oligocene period (Lucas and Sobus, 1989). Still, the first indricothere ever described was *Paraceratherium bugtiense* (Pilgrim, 1908) from 'Chur Lando' in the Bugti Hills of eastern Balochistan, central Pakistan (Fig. 1). This taxon was named on the basis of large dental and cranio-mandibular elements (Pilgrim, 1910, 1912; Forster-Cooper, 1911, 1913a,b, 1924, 1934). However, huge skeletal remains from the same area—for which the correct local name and spelling are 'Lundo Chur'—were first referred to another rhinocerotoid taxon: *B. osborni* (Forster Cooper, 1913b). Owing to associated limb bones and cranio-dental remains, documenting other indricotheres in the Oligocene of Kazakhstan (Borissiak, 1915, 1923; Pavlova, 1922) and Mongolia (Osborn, 1923; Granger and Gregory, 1935, 1936), the genus *Baluchitherium* was later recognized as a junior synonym of *Paraceratherium* Forster-Cooper, 1911 (Matthew, 1931; Gromova, 1959; Lucas and Sobus, 1989; Fortelius and Kappelman, 1993).

Since 1910, nobody could investigate the Tertiary of the Bugti Hills because of the incessant tribal clashes in the vicinity of the Bugti-Marri Agency. Yet, a team of the Geological Survey of Pakistan (GSP) got permission to undertake short fieldwork in the Lundo Chur area in 1985 and 1987 (Shah and Arif, 1992). More recently, seven fieldwork seasons in the Bugti Hills (1995–2002) led by a French-Balochi paleontological team (Mission Paléontologique Française au Balouchistan, MPFB) have thoroughly reviewed and updated both the geology and paleontology of the Tertiary of that area (Fig. 2; Welcomme and Ginsburg, 1997; Welcomme et al., 1997, 1999, 2001; Antoine and Welcomme, 2000).

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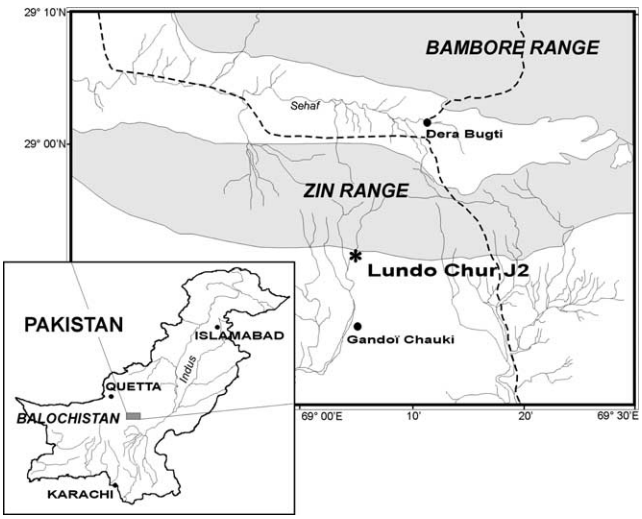

Fig. 1. Location map of the Lundo Chur J2 locality (= 'DBJ2': Dera Bugti locus J2 sensu Welcomme et al., 2001). The locality is denoted by an asterisk.

This article deals with undescribed fossil remains (Fig. 3), unearthed in the yellow sands of the Lundo Chur J2 locality (Antoine et al., 2003b) during the mid 1980s GSP fieldtrips. They are stored in the collections of the Pakistan Museum of Natural History (PMNH) in Islamabad. We have studied these specimens during the January/February 2003 MPFB-PMNH joint project. All of them are referred to *P. bugtiense*.

2. Systematics

Order Perissodactyla Owen, 1848
Family Hyracodontidae Cope, 1879
Subfamily Indricotheriinae Borissiak, 1923
Genus *Paraceratherium* Forster-Cooper, 1911
Paraceratherium bugtiense (Pilgrim, 1910) (Fig. 3)

Referred material and measurements. M.V.103, left fragmentary maxilla with M2–M3 (M2: length = 82; anterior width = 80; posterior width = 69; height = 44/M3: length = 86; anterior width = 76.5; posterior width = 56; height = 50); M.V. without number, fragmentary palate with left M2 and M3 (much worn); M.V.86, left lower incisor (female?) (preserved length = 120; width = 35; height = 48; antero-posterior diameter of the crown > 32; root width = 31; root height = 40); M.V.87, right lower

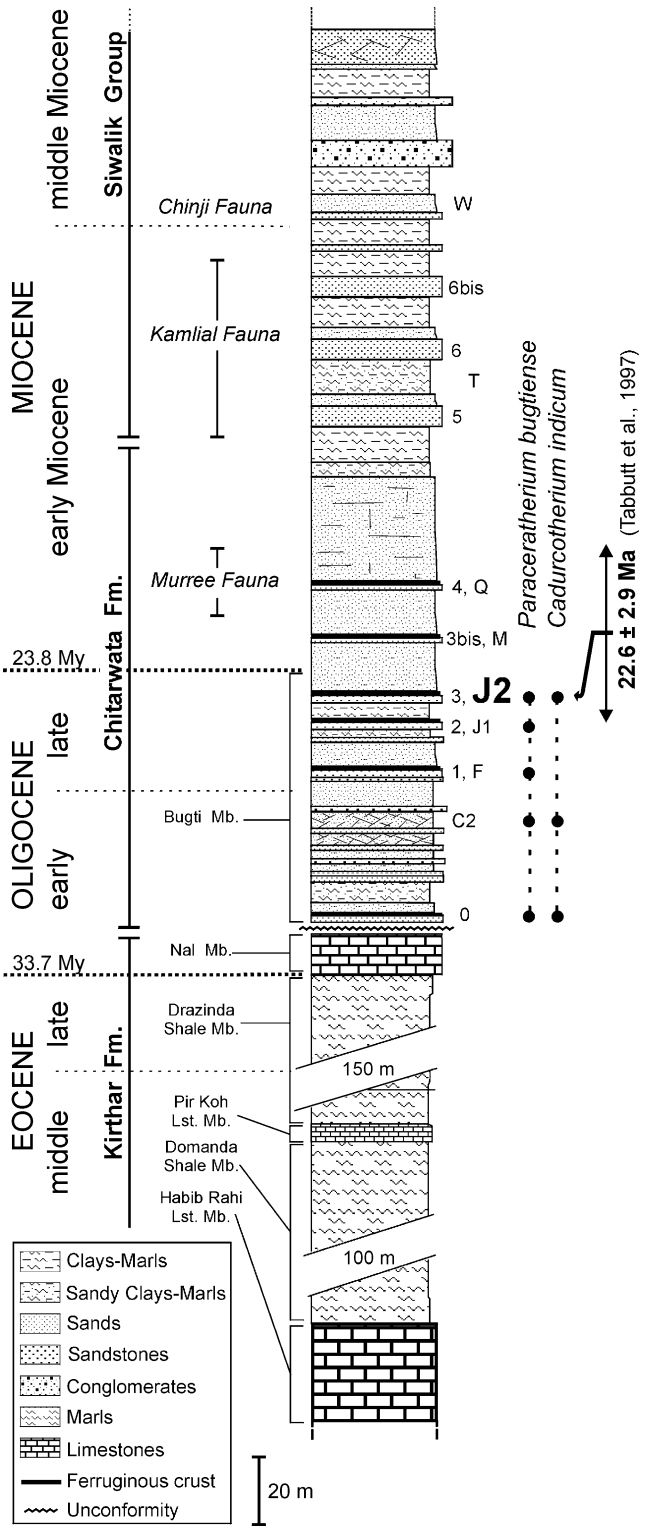

Fig. 2. Stratigraphic position of the Lundo Chur J2 locality (bold-typed and indicated by an arrow) in the synthetic section of the Tertiary deposits from the Bugti Hills (Balochistan, Pakistan). Lundo Chur J2 corresponds to yellow fluvial sands topped by a ferruginous crust, within the upper part of the Bugti Member of the Chitarwata Formation (Late/latest Oligocene; Welcomme et al., 2001; Antoine et al., 2003b). Numbers (0 up to 6 bis) and letters (C2 up to W) located on the right of the stratigraphic section indicate the successive mammal-bearing levels recorded in both southern and northern sides respectively of the Zin Range (Fig. 1). Lateral equivalences between both sides have been established on the basis of direct lithostratigraphic and faunal comparisons (Welcomme et al., 2001; Métais et al., 2003; Antoine et al., 2003b). Levels denoted by a black dot have yielded *P. bugtiense* (Pilgrim, 1910) and/or *Cadurcotherium indicum* Pilgrim, 1910 (new collections). Correlations with Potwar Plateau mammal localities (italicized) are mentioned for information only. Fm., Formation; Mb., Member. The age of the Lundo Chur J2 locality (22.6 ± 2.9 Ma) was obtained by fission track dating on zircon grains (Tabbutt et al., 1997). Modified after Antoine et al. (2003b).

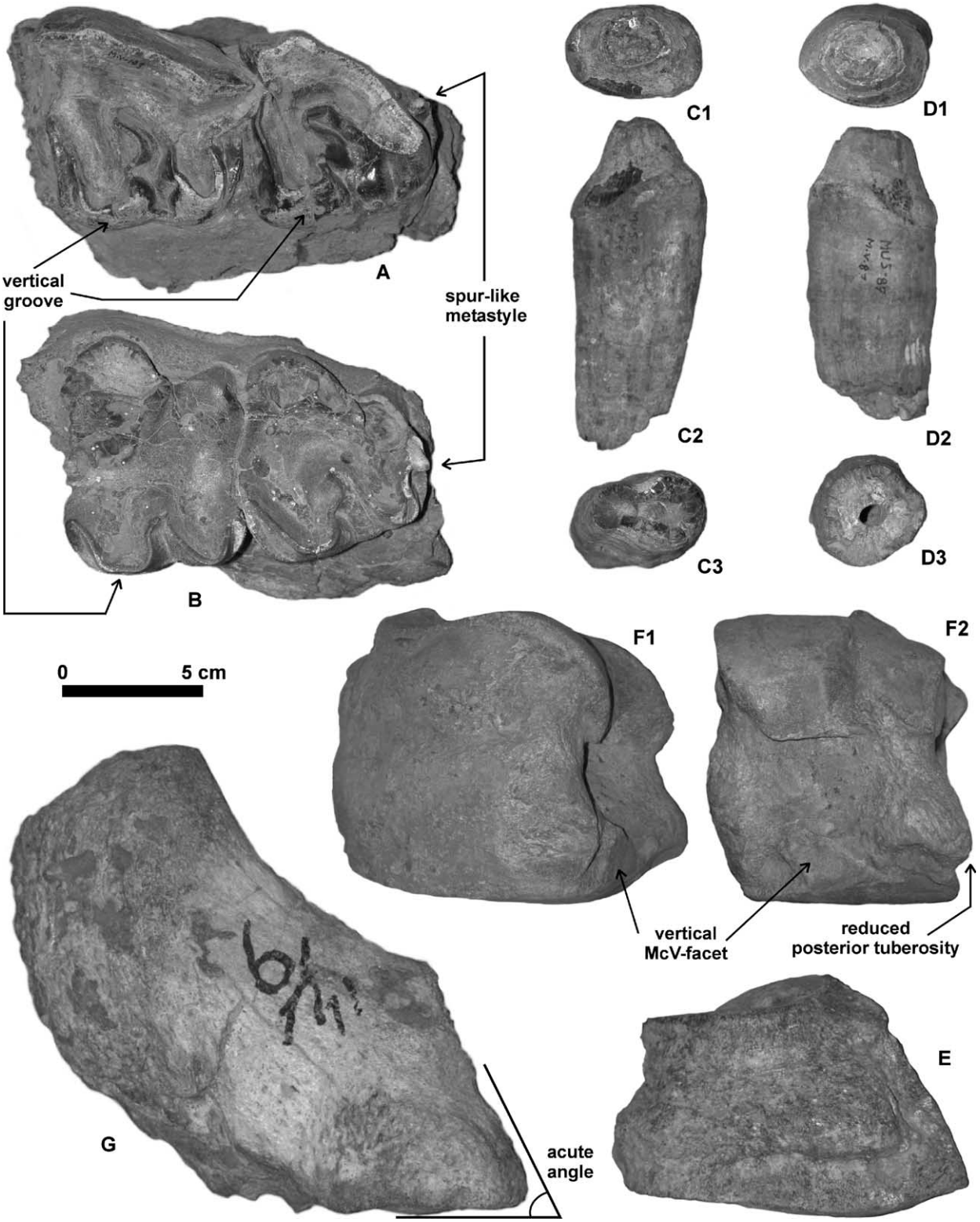

Fig. 3. *P. bugtiense* (Pilgrim, 1910). Late/latest Oligocene of Lundo Chur, Bugti Hills, Balochistan, Pakistan. (A) left maxilla with M2–M3, PMNH M.V.103, occlusal view; (B) left maxilla with M2–M3, PMNH M.V. without number, occlusal view; (C) left i1 (female?), M.V.86, in rostral view (C1), lingual view (C2), and caudal view (C3); (D) right i1 (male?), M.V.87, in rostral view (D1), lingual view (D2), and caudal view (D3); (E) left magnum, M.V.45, anterior view; (F) left unciform, M.V.46, in anterolateral view (F1) and posterolateral view (F2); (G) right calcaneus, lateral view. All the specimens are stored in the Pakistan Museum of Natural History in Islamabad. Scale bar = 5 cm (all the specimens are × 0.5).

incisor (male?) (preserved length = 108; width = 36.5; height = 47.5; antero-posterior diameter of the crown > 35; root width = 39; root height = 45); M.V.45, left broken magnum (transverse diameter > 134; anterior height = 84; transverse diameter of the McIII-facet = 130); M.V.46, left unciform (transverse diameter = 102; height = 104; antero-posterior diameter = 143; Semilunate-facet: transverse diameter = 45/antero-posterior diameter = 107; Pyramidal-facet: transverse diameter = 48/antero-posterior diameter = 108; Magnum-facet: transverse diameter = 29/antero-posterior diameter = 55; McIII-facet: transverse diameter = 32/antero-posterior diameter = 66; McIV-facet: transverse diameter = 55/antero-posterior diameter = 105); M.V.69, left broken calcaneus (height > 215; articular height = 98; transverse diameter of the tuberosity = 76; transverse diameter of the sustentaculum > 96; Minimal posterior transverse diameter = 52; Astragalus-facet 3: transverse diameter = 42/height = 12); M.V.70, right calcaneus (height = 227; articular height = 100; Tuberosity: transverse diameter > 67/antero-posterior diameter = (110); minimal posterior transverse diameter = 52; minimal posterior antero-posterior diameter = 107; Astragalus-facet 1: transverse diameter = 63/height = 63; Cuboid-facet: transverse diameter = 40/height = 88). Dimensions given in millimeter.

Horizon and locality. Fluvial yellow sands of the Lundo Chur J2 locality ('Chur Lando' sensu Pilgrim, 1912; 'SUI-1' sensu Shah and Arif, 1992; 'DBJ2': Dera Bugti locus J2 sensu Welcomme et al., 2001), about 25 km southeast of Dera Bugti, southern Sulaiman Range, eastern Balochistan, Pakistan. Upper part of the Bugti Member, Chitarwata Formation (Raza and Meyer, 1984). Late/latest Oligocene (Welcomme et al., 2001; Métais et al., 2003; Antoine et al., 2003b).

Description. No cranial feature can be described on the base of the available material.

Two lower incisors (i1) are preserved, with conical crowns and straight roots (Fig. 3C and D). The roots somewhat differ in their shape (cylindrical in M.V.87; conical in M.V.86) and cross section (circular in M.V.87; pear-like in M.V.86). Besides, M.V.87 bears an anterolingual sagittal ridge on the crown, lacking in M.V.86. The lingual cingulum is strong on the neck of M.V.87 and tenuous on M.V.86.

The M2 and M3 M.V. without number are much worn; the ectolophs are broken (Fig. 3B). The M2 and M3 M.V.103 have conical crowns, without enamel folding (Fig. 3A). The labial, anterior, and posterior roots are separated, while the lingual roots are thinly connected. The enamel, thinly wrinkled on the ectoloph, is very thick (ca. 4 mm on the hypocone of M3). Cement covers the ectolophs by places, forming a thin layer. The labial cingulum is strong and continuous, and forms a narrow salient strip close to the neck. The lingual cingulum is interrupted on the cusps (three specimens) or absent (M3 M.V.w.n.). The paracone fold is present on the whole of the available teeth. It is stronger on M3 due to lesser wear. The parastyle is thick and sagittally directed. The mesostyle is present, but very smooth and weak on M2. There is no metacone fold. The metastyle is short with respect to that of rhinocerotid molars. The posterior cingulum is continuous, very close to the metaloph on M2. The protoloph is straight, without any anterior constriction. The antecrochet is strong on both M2 and M3. There is neither crochet, nor crista, nor cristella, nor medifossette. The median valley is much more widely open on M3 than on M2, with a low transverse pad continuing the antecrochet until the lingual opening of the median valley. The metaloph is short on M2, the tooth being much narrower posteriorly than anteriorly. The postfossette of M2 is very shallow and short sagittally. There is a basal vertical groove on the lingual side of the protocone (M2). Another groove occurs on the anterolingual side of the hypocone of the molars M.V.103, whereas it is lacking on the other series. The M3 are quadrangular, with a wide posterior part, especially nearby the neck (conical crown). These teeth display a straight ectometaloph with a robust hypocone. There is a vertical and conical spur on the posterolabial side of M3. It might be expected that this spur is a metastyle inasmuch as the latter is usually retained in most of hyracodontids. This spur, associated with the posterior cingulum, forms a shallow postfossette. The posterior cingulum is developed apart from the spur, surrounding it on both M3. After wear, the vestigial ridge (metastyle) is joining the ectometaloph, thus reproducing distinct ectoloph and metaloph.

The magnum (M.V.45) is a massive bone, on which the posterior part is broken. In proximal view, the magnum is triangular, with a large anterior side and a thin posterior tip. The whole proximal surface is articulated. The kidney-shaped anterior facet, for the scaphoid, is nearly flat and extends backward as a narrow stripe. Posterolaterally to it, is the semilunate-facet, crescent-like and convex sagittally. This facet is elongated anteroposteriorly and widens backwardly. In anterior view, the magnum is trapezoidal, wide and low, with a straight proximal border and an oblique lateral border (bone narrower proximally). The anterior side is free of articular facet (Fig. 3E). A thick and salient pad (insertion of the *M. extensor digitorum*) occupies the centre of the anterior side. It is still more salient laterally. The distal border is slightly convex. The medial side displays a large trapezoid-facet, contiguous to the anterior border, on the whole height of the bone. It displays a median constriction, posteriorly to a tendon insertion. The bone is depressed backwardly, forming a deep fossa with a rough surface. In lateral view, the bone is roughly square, with a S-shaped posteroproximal semilunate-facet and a large posterodistal unciform-facet (triangular). The distal side is subtriangular and essentially articulated with the McIII. Yet, a small triangular McII-facet is located at the anteromedial tip of the bone. The posterolateral border of the McIII-facet is deeply inflected due to a muscular/tendon insertion.

The unciform (M.V.46) is massive, deeper than wide. The posterior tuberosity is extremely reduced, especially with respect to that of rhinocerotids (Fig. 3F). Most of the proximal side is occupied by two articular facets, sagittally elongated: the medial one (semilunate-facet) is L-shaped. Contiguous to it, the pyramidal-facet has a kidney-shaped outline. They are flat transversally, except in the posterior tip of the pyramidal-facet, which is concave. Both facets are equally developed. They have a sigmoid vertical cross section (sagittal). In front of the articulation lays a thick rounded tubercle corresponding to the insertion for the *M. interossei*. The anterior side is not articulated. It forms a quarter circle, the right angle being proximolaterally situated. The surface is smooth, excepts for the salient muscular insertion, which strengthens along the distomedial border of the bone. It is extremely developed medially (exceeding 20 mm in height). The mediodistal border is regularly convex. In medial view, the unciform is roughly rectangular. The proximal border (semilunate-facet) is sigmoid, concave anteriorly and convex posteriorly. This facet nearly reaches the posterior tip of the bone. A narrow sagittal magnum-facet, vertical and sinuous occurs on it distally. The McIV-facet appears as an oblique stripe occupying the anterior half of the distal border. The lateral side is essentially non-articulated, except in its posterior third, with the posterior part of the pyramidal-facet, concave transversely and strongly convex sagittally. Distally to it is a deep fossa, below which the McV-facet is visible. This facet forms a small triangle (28×16 mm), subvertical and orientated transversally. The distal border is nearly flat, corresponding to the McIV-facet. The distal side, mostly articulated, forms a rounded rectangle, with a small posteromedial process. There are three contiguous facets separated by smooth grooves: the magnum-facet is a small triangle in the anteromedial angle. Close to it is the larger, narrow and oblique McIII-facet. This facet is flat and trapezium-shaped. The largest facet articulates with the McIV. It is triangular, deeper than wide, widening backwardly. It is essentially flat, but convex sagittally in its posterior quarter. The McV-facet is hardly visible, since it is limited to a straight transverse line.

Two calcanei are available, both damaged and incomplete. They have similar dimensions and proportions. The *processus calcanei* is slender and longer than the articular region. The non-articulated surface of the bone is rough, especially on the *tuber calcanei*. The lateral side is flat, except for the deep and longitudinal *sulcus tendinis fibularis longi*. This side displays a pentagonal outline. In lateral view, the distal tip forms a dihedral angle ca. 60° (Fig. 3G). The triangular As1-facet is mostly flat, slightly concave in its medial half, with a large distal expansion. The *sustentaculum tali* is narrow (M.V.69). The As2-facet is subcircular and split into two contiguous subfacets; the proximal one is vertical while the distal subfacet is deeper and oblique. The As1- and As2-facets are nearly connected ($D = 8$ mm). The As3-facet is a small and narrow crescent-like stripe along the posterodistal border of the bone. The cuboid-facet is kidney-shaped, elongated vertically and narrow transversely. It is flat, apart of a slight concavity in its proximal third.

Discussion. Several morphological features—large and conical i1, thick enamel, strong antecrochet on upper molars, ectoloph and metaloph fused and hypocone strongly developed on M3, reduced posterior tuberosity on the unciform, acute angle between the distal side and the anterior side on the calcaneus (60° instead of 90° in other perissodactyls)—, as well as the huge dimensions and proportions of the postcranials characterize the derived indricotheriine genus *Paraceratherium* (sensu Lucas and Sobus, 1989, i.e. including *Indricotherium* Borissiak, 1915). Moreover, the dental morphology is typically that of *P. bugtiense* (Forster-Cooper, 1911, 1913a, 1924, 1934; Pilgrim, 1908, 1910, 1912): among indricotheres, a lingual groove on the protocone of M2 and a spur-like metastyle on M3 are only observed in the specimens from Lundo Chur, described and illustrated by Pilgrim (1912; M3 C283) and Forster-Cooper (1924) and (1934).

The differences between both i1 (circular/pear-like cross section; cylindrical/conical root; strong/tenuous lingual cingulum) were formerly observed in other indricotheres, and interpreted as documenting two different taxa (Gromova, 1959). In agreement with Lucas and Sobus (1989), we rather consider such differences as expressing a sexual dimorphism within a single taxon, particularly since similar schemes are observed in the anterior dentition of several fossil rhinocerotid species (Antoine, 2002). In that respect, M.V.86 could belong to a female, and M.V.87 to a male. As a matter of fact, a strong sexual dimorphism, based on body size, was already suggested for *P. transouralicum* by Fortelius and Kappelman (1993).

The fifth metacarpal of *P. bugtiense* is undocumented so far. However, the orientation of the McV-facet on the unciform of the ceratomorph perissodactyls (tapirs, rhinos, and their extinct relatives) depends on whether the fifth metacarpal is developed or not (Antoine, 2002). As this facet is vertical on the unciform M.V.46, one can deduce that *P. bugtiense* had a reduced McV, like in *P. prohorovi* and *P. transouralicum* (Granger and Gregory, 1936; Gromova, 1959) but unlike *Juxia* from the late Eocene-early Oligocene of Asia (Lucas and Sobus, 1989). In the latter taxon, the fifth metacarpal and its phalanges are fully developed (Heissig, 1989).

3. Age of the '*Paraceratherium/Cadurcotherium* beds' in the Bugti Hills

The age of the '*Paraceratherium* beds' in Balochistan has been disputed (Oligocene vs early Miocene (Pilgrim, 1912; Raza and Meyer, 1984; Lucas and Sobus, 1989; Shah and Arif, 1992)) until an Oligocene age was argued (Welcomme and Ginsburg, 1997), then corroborated on a biochronological

basis thanks to new collections (Welcomme et al., 1999, 2001; Antoine et al., 2003a,b; Métais et al., 2003). In fact, recent fieldwork by the MPFB have established that indricotheres were occurring in five successive levels (0–3 on the northern side of the Zin Range; 0 to J2 on the southern side of it; Figs. 1 and 2), i.e. all along the Bugti Member of the Chitarwata Formation (Fig. 2).

A similar dating problem concerns the poorly documented amynodontid *Cadurcotherium indicum*, for a long time restricted to its type locality in the eastern part of the Bugti Hills ('Upper Nari of Khajuri Nala'; Pilgrim, 1910, 1912). Preliminary study, based on new findings by the MPFB (unpublished data), states that *C. indicum* is strictly contemporary with *P. bugtiense* (Fig. 2). This large amynodontid occurs from the basal ferruginous crust of the Bugti Member (0 in Fig. 2) up to a lateral equivalent of Lundo Chur J2, on the northern side of the Zin Range (3 in Fig. 2; 'Kumbi 3' locality; Welcomme et al., 2001).

As a matter of fact, the yellow sands of Lundo Chur J2 represent the uppermost indricothere-bearing levels in the Bugti Hills (Fig. 2): the mammal fauna includes *P. bugtiense*, the rhinocerotid *Aprotodon*, the entelodontid *Paraentelodon*, and the pseudo-bovid *Palaeohypsodontus* (Welcomme et al., 2001; Antoine et al., 2003a; Métais et al., 2003). In addition to *Paraceratherium*, these taxa are limited to several Palaeogene localities throughout Asia (Antoine et al., 2003a; Métais et al., 2003). Besides, a complete faunal turnover is observed between Lundo Chur J2 (= DB3 = Kumbi 3) and the following levels, 25 m above (DBM = DB3bis), according to Welcomme et al. (2001): by contrast, these conglomerates yield a typical Early Miocene fauna, with elasmotheriine rhinocerotids, deinotheres, bovids, and listriodontine suids (Antoine and Welcomme, 2000; Welcomme et al., 2001). Thus, although an earliest Miocene age cannot be excluded for the Lundo Chur J2 locality (fission track dating of 22.6 ± 2.9 Ma in the vicinity of it (Tabbutt et al., 1997)), we do consider it as most likely documenting the Late/latest Oligocene (Fig. 2).

To sum up, the stratigraphic range of both *P. bugtiense* and *C. indicum* extends from the Early Early Oligocene (levels 0 and C2; Marivaux et al., 1999, 2001; Antoine et al., 2003; Marivaux and Welcomme, 2003b) up to the Late/latest Oligocene (Lundo Chur J2; this work) in the Bugti Hills.

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