~ 10 dph cm^{-2} yr^{-1} during 1963–64 from a constant natural fallout of ~ 5 dph cm^{-2} yr^{-1} observed during the late '50s, '60s and early '70s. But such a large contribution from nuclear tests is definitely not observed, indicating the absence of bomb-produced ^{210}Pb in Greenland precipitation.

It is also evident from Figure 1*b* that the slope of the theoretical decay curve is different from that of the regression line drawn on the basis of 5-year means of observed specific activities (dph per kg ice) of ^{210}Pb during the span of ~ 100 years. Based on these observations, an apparent half life of 35 years is deduced for the observed ^{210}Pb decay. The longer decay period is a result of variation in the fallout of ^{210}Pb over the past century.

The step and smooth curves shown in Figure 1*c* represent the 5-year means and 25-year running means respectively of initial ^{210}Pb fallout. They indicate a decreasing trend of initial ^{210}Pb fallout during the past 100 years and that the observed ^{210}Pb fallout for the period 1920–75 is lower by at least a factor of two than that for the period 1885–1920. This decreasing trend cannot be explained as being due to a changing rate of annual accumulation of the Greenland ice sheet as the latter has remained fairly constant (Figure 1*a*). Sanak *et al.*[4] suggested that drastic changes occurred at the South Pole either in the accumulation rate of ice or in ^{210}Pb content of freshly fallen snow in 1920 and 1954. The present data for Greenland also show considerable changes around the same time. This can be explained only by higher deposition of ^{210}Pb in view of the fairly constant accumulation rate of ice (Figure 1*a*).

The signatures of the violent volcanic eruptions of Katmai (1912), Krakatoa (1883), etc. have been identified by increase of acidity in Greenland ice cores[1,2]. These volcanoes ejected large amounts of volcanic gases, dust and other impurities into the atmosphere, which in turn got deposited on Greenland ice within a year or two after the eruption[2]. It is therefore interesting to compare the ^{210}Pb fallout with the volcanic impurity concentration index[13] on the same timescale. Such a comparison shows a good correlation between ^{210}Pb deposition (1880–1920) and volcanic activity (Figure 1*d*). This cannot, however, explain the observed ^{210}Pb fallout trend, which is monotonously decreasing. If volcanic eruptions were the cause of higher fallout during 1880–1920, then the fallout pattern should have shown sharp changes in response to the residence time of one year for ^{210}Pb aerosols in the stratosphere.

^{222}Rn emanation depends primarily on the nature of the soil (porosity, grain size, soil moisture, etc.) and environmental conditions (temperature, wind pattern, etc.). The observed excess of ^{210}Pb fallout can be partially explained as being due to enhanced ^{222}Rn exhalation from land from breaking of virgin soils in north-west America. With the presently available data, we are unable to offer any definite cause for the observed decreasing trend of ^{210}Pb fallout over Greenland.

The assumption usually made in geochronological studies that ^{210}Pb fallout has remained constant over the last 100 years does not hold for Greenland. If this trend is valid on a global scale, geochronological studies based on ^{210}Pb would have to be reassessed.

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Raoellid astragali from the Kalakot zone (Subathu Group): evidence for assignment to the Artiodactyla

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Size correspondence as well as *in situ* association of morphologically distinct artiodactyl astragali and at least two genera of the family Raoellidae conclusively prove their ordinal assignment. This contention, in the light of recent work, has important bearing on studies dealing with the evolution and radiation of several mammalian orders in the area of the Himalayan Tethys.

THE Raoellidae[1] represents a family of primitive ungulates that are morphologically distinct from any known form outside the Indian subcontinent. Hence they represent essentially endemic forms restricted to the early-middle Eocene of northwestern India and Pakistan. Different raoellid genera have earlier been assigned to Dichobunidae[2–5], Choeropotamidae[6], Helohyidae[7–10] and Anthracotheriidae[11]. Some genera have also been assigned to different orders, including Artiodactyla[2,4,5,12], Condylarthra[9], Perissodactyla[13] and Proboscidea[10,14,15]. Despite detailed descriptions in several works, especially subsequent to the early 1970s, no consensus opinion regarding the taxonomic assignment of these forms could be arrived at. Sahni *et al.*[1] first proposed the inclusion of these genera in a new artiodactyl family, namely the Raoellidae (six genera presently known, viz. *Indohyus*, *Khirtharia*, *Metkatius*, *Kunmunella*, *Pilgrimella* and *Haqueina*).

Additionally, a perusal of all the literature describing forms referable to the Raoellidae from India and Pakistan shows that the record and documentation of the postcranial material is grossly inadequate and in most cases entirely lacking. Most works have been restricted to a detailed treatment of only the dental elements. Though Sahni *et al.*'s[1] proposal has generally been followed in all subsequent publications, there remains a degree of skepticism regarding the ordinal assignment of these forms (e.g. J. J. Jaeger, personal communication) which is perhaps based on the aforementioned lack of documentation of postcranials referable to the Raoellidae.

In 1983 a project was initiated with a view to try and work out the palaeoecologic and environmental aspects of the middle Eocene Kalakot Zone (Upper Subathu Formation) vertebrate faunas, as part of the work of the Vertebrate Palaeontology Laboratory, Panjab University, on the Lesser Himalayan Palaeogene vertebrates[1,12,16–18]. During field investigations in Rajauri district (Jammu and Kashmir), a new fossil locality was discovered at Sindkhatuti (23° 14′ 25″ N, 74° 22′ 32″ E, Figure 1), where the clay-rich vertebrate-bearing lithology allows bulk wet-screening of the matrix. The processing of over 800 kg of matrix over four field seasons at this locality resulted in the concentration of what is presently perhaps the single largest collection of Lesser Himalayan middle Eocene vertebrates, including mammal, reptile and fish skeletal elements. Moreover, the sample included the first serpent (Boinae) known from the Palaeogene of India (Jolly and Sahni, under preparation) and the first record of the oldest artiodactyl (*Diacodexis*) from India[17]. Besides these, bulk screening techniques for the first time allowed the recovery of several thousand hitherto unknown mammalian postcranial elements. Perhaps the most significant among these are a number of artiodactyl astragali which show excellent relationship with three raoellid genera of comparable body weight extrapolated from M/1 crown area (Jolly and Sahni, under preparation).

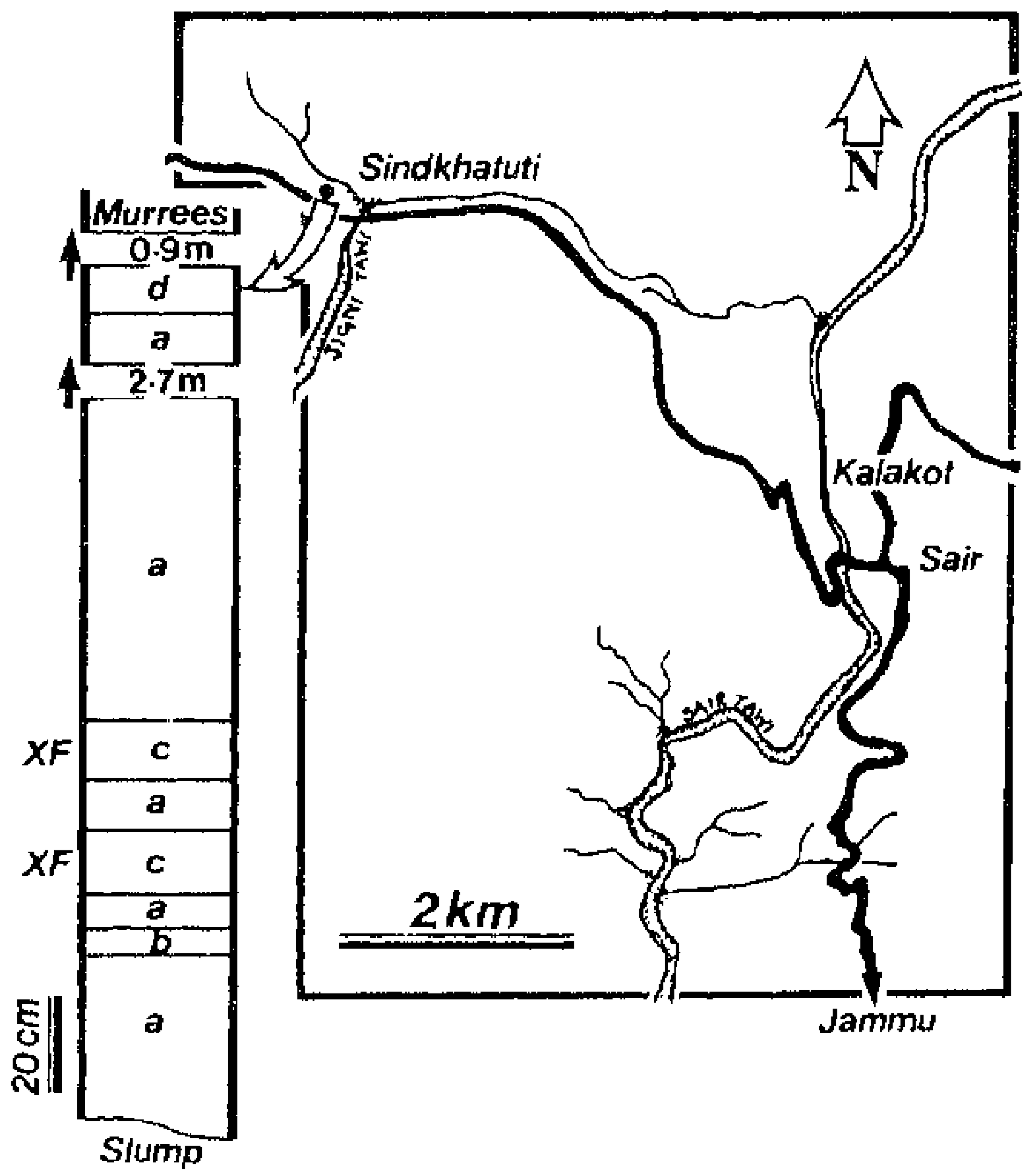

Figure 1. Map of the Kalakot area showing the stratigraphic section at the fossil vertebrate locality at Sindkhatuti. a, Shale; b, claystone; c, siltstone; d, quartzose sandstone; XF, vertebrate fossil-bearing levels; vertical arrows indicate continuing lithology.

The tarsal bones described here provide additional and conclusive criteria in establishing the taxonomic assignment of the Raoellidae as demonstrated below.

Raoellidae gen. et sp. indet.

Two complete astragali (VPL/J1002 and VPL/J1002A, Figure 2) along with at least six fragmentary specimens. In anterior view, both proximal and distal trochlea developed as pulleys of almost equal width. Distal trochlea exhibits slight medial rotation. Tibial trochlea strongly curved with a deep vertical groove. Strong U-shaped incurvation present laterally between proximal and distal trochlea. Prominent ridge on distal trochlea separates facets corresponding to the navicular and cuboid. Distal calcaneal facet protrudes laterally. Lateral, proximal edge of cuboid (fourth tarsal) facet directed downwards and curved laterally. In posterior view, sustentacular facet slightly convex. Particularly strong ridge on medial side. Proximal, distal (i.e. distal stop facet for sustentacular facet of the calcaneus) and medial side of sustentacular facet strongly excavated. Cuboid stop facet bound proximally by a groove. Navicular stop facet not well defined. In medial view, posterior border of the tibial trochlea weak and tibial stop facet merged. In lateral view, border of sustentacular facet laterally bound by a strong ridge. Sustentacular and cuboid facets have an interrupted contact. Distal calcaneal facet rounded on anterior side

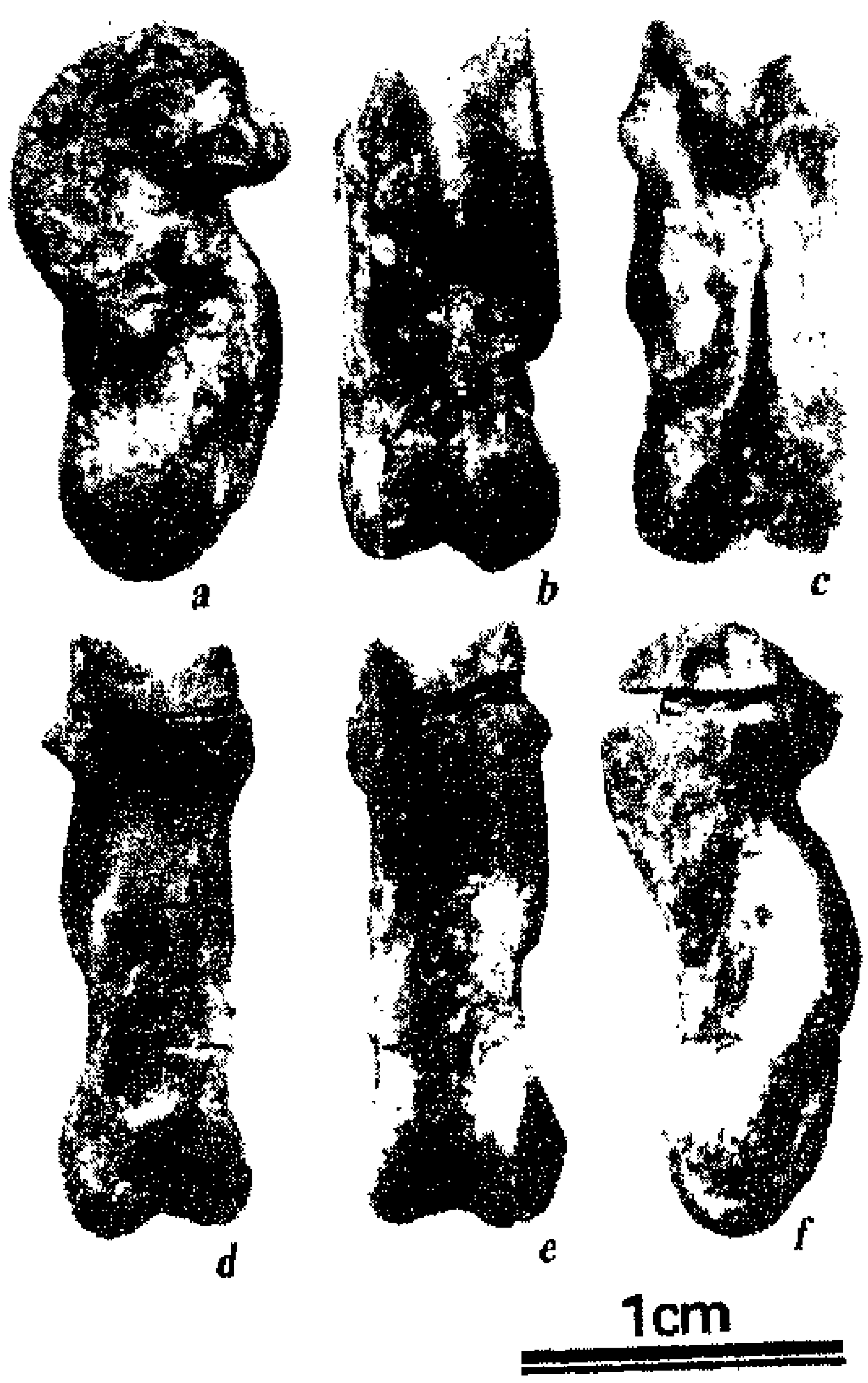

Figure 2. Raoellid astragali from the Kalakot Zone at Sindkhatuti. *a–c*, Left astragalus (VPL/J 1002) lateral, anterior and posterior views. *d–f*, Left astragalus (VPL/J 1002A) posterior, anterior and lateral views (specimen somewhat compressed laterally).

and proximal calcaneal facet extends to the extremity of the trochlea. The preceding morphological description of the astragalus is based on terminology used in Hussain *et al.*[19]

The gross morphology of the present specimens is somewhat similar to those reported earlier from the Eocene of Pakistan; for instance, an astragalus (BMNH.M15800)[7] referred to *Khirtharia dayi* and a specimen (UM 65871)[5] from the Kuldana Formation referred to *Haqueina*. In a recent work[15], a much larger (though morphologically similar) specimen has been described as Artiodactyla indet. for lack of size correspondence with known raoellid genera.

The indices of M/2 width/distal astragalar width and M/2 width/proximal astragalar width for the present astragali (using molar widths for known raoellids, viz. *Haqueina haquei*, *Kunmunella kalakotensis* and *Khirtharia inflatus*) show excellent comparison with such indices measured in the recent *Pecari angulatus* (UM R 1626)[15] as well as those determined from dimensions given for BMNH.M15800[7]. Table 1 gives these indices calculated for each of the three raoellids mentioned above along with those for the Pakistan material. No generic assignment has been attempted for the present astragali because, firstly, as demonstrated they show good size correspondence with three different genera, and secondly, the material is not derived from articulated skeletons. However, *in situ* association of the astragali with size-comparable raoellid genera dispels any doubt regarding their assignment to the family Raoellidae.

In conclusion, the various genera comprising the family Raoellidae can safely be assigned to the order Artiodactyla and their astragali have all the morphological features generalized for artiodactyls. Though not corroborated, it is further felt that the larger astragalar fragments from Pakistan[15] may correspond to forms like *Pilgrimella* or *Indohyus major*[15]. Additionally, besides representing material that has not been previously described from any of the Indian Eocene localities, the astragali described above also represent the first detailed descriptive account of any raoellid postcranial remains from the Kalakot zone.

The present find suggests that the Raoellidae are in fact artiodactyls. If this contention is considered with the earlier record of *Diacodexis pakistanensis*[17], which is

Table 1. Indices of M/2 width/distal and proximal astragalar width.

	VPL/J 1001	VPL/J 1002	BMNH.M. 15800	UM.R. 1626	GSP-UM 1413
M/2 width/distal astragalar width	0.72	0.85	0.82	0.77	—
	(*Haqueina haquei*)		(*K. dayi*)	(*P. angulatus*)	
	0.71	0.84	—	—	—
	(*Kunmunella kalakotensis*)				
	0.72	0.85	—	—	—
	(*Khirtharia inflatus*)				
M/2 width/proximal astragalar width	—	0.74	—	0.86	0.61
	(*H. haquei*)			(*P. angulatus*)	(*Indohyus major*)
	—	0.73	—	—	—
	(*Kunmunella kalakotensis*)				
	—	0.74	—	—	—
	(*Khirtharia inflatus*)				

Average M/2 widths based on several teeth were taken for determining indices in case of VPL/J 1001 and VPL/J 1002. Indices significantly closer to those observed in the recent *P. angulatus* (UMR 1626) were achieved when specific teeth were used. Parentheses indicate species from which tooth dimensions were used. Catalogue numbers indicate those for the astragalar fragments.

ancestral to all artiodactyls, it becomes evident that the centre of origin for this order may lie in the region of the Tethyan Himalaya. Some of the larger raoellids, like *Pilgrimella*, *Lammidhania*, etc., are considered close to the Sirenian–Moerithere (Proboscidea) lineages. Consequently this suggestion would imply that the Himalayan Tethys was a centre of origin and radiation for not only the Artiodactyla, but also for other mammalian orders like the Sirenia, Proboscidea, Desmostyla and Cetacea.

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Anorthosite dyke from the Pasupugallu gabbro pluton, Prakasam district, Andhra Pradesh, India

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The rare anorthosite dyke from the Pasupugallu gabbro-anorthosite pluton contains 91% (by vol.) plagioclase (An_{56}), 5% hornblende, 2% biotite, 1% opaques and traces of calcite, apatite, zircon and corundum. It is relatively enriched in SiO_2, Al_2O_3 and Na_2O, and depleted in CaO, FeO and MgO compared to the massive anorthosite; the normative femics of the dyke are more iron-rich (and plagioclase more albitic) than those of the massive anorthosite. The dyke may represent the residual liquid derived from a melt parental to the massive anorthosites.

Rare occurrences of dykes of anorthosites and of gabbroic anorthosites described from peninsular India include: (i) anorthosite dyke from Nadimidoddi, Andhra Pradesh[1]; (ii) gabbroic anorthosite dyke from Nuggihalli schist-belt, Karnataka[2,3]; and, (iii) gabbroic anorthosite dyke from Hunsur, Karnataka[4]. This note records the occurrence of a minor fine-grained anorthosite dyke from the Pasupugallu gabbro(-anorthosite) pluton.

In the Prakasam district of Andhra Pradesh, both basic (gabbro-anorthositic) and alkaline bodies were emplaced at the junction zone of the Dharwar group of rocks (towards west) and granulite facies rocks (towards east). Of the many basic plutons, the oval-shaped Pasupugallu (15°48′ N and 79°48′ E) gabbro(-anorthosite) pluton[5,6] dominantly comprises gabbro and leucogabbro with subordinate amounts of dark-looking massive anorthosite, dykes of dolerite, lamprophyre, nepheline syenite[7], quartz syenite and rare anorthosite dyke. The pluton is enveloped by the quartzo-felspathic gneisses (± cordierite) with intercalated amphibolites.

The Pasupugallu anorthosite dyke occurs as a sharply bounded planar body which measures 100×0.15 m (Figure 1) and trends N80°E. It is located about 3 km west of the village Turkapalem (15°45′15″ N, 79°50′15″ E). The dyke is light-coloured and fine- to medium-grained, with average grain size of plagioclase ranging from 1 to 2 mm in length (Figure 2), in contrast to the massive anorthosites, which are highly coarse-grained, with average grain size ranging from 4 to 5 mm in length (Figure 3). The dyke exhibits alignment of the plagioclase crystals parallel to its strike length; it is however devoid of any perceptible chilled margins. It occurs within the dark-coloured, massive and coarse-grained leucogabbros which have very crude foliation trending NE.

The rock exhibits, under the microscope, hypidiomorphic texture, and is dominated by subhedral plagioclase (91% by volume); the accessories include hornblende (5%), biotite (2%), opaques (1%) and traces of calcite, apatite, zircon and corundum. The dyke is characterized by the total absence of olivine and clinopyroxene, which are present in the enclosing leucogabbros.

Plagioclase felspar shows twinning commonly on the albite law, and rarely on the combined Carlsbad-albite law; very rare pericline twinning is also noticed. Smooth planar boundaries and triple junctions between