First Jurassic mammals from Kyrgyzstan

LEV A. NESSOV, ZOFIA KIELAN-JAWOROWSKA*, JØRN H. HURUM, ALEXANDER O. AVERIANOV, PETR V. FEDOROV, DANIEL O. POTAPOV, and MERETHE FRØYLAND

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The discovery of fragments of Asian Middle Jurassic mammals, from the Balabansai Formation (Middle Jurassic) of Kalmakerchin near the Kokart River in Kyrgyzstan is reported. The fragments consist of an upper molar with a worn crown and a fragment of the proximal ulna. The molar, because of the presence of three roots and roughly rectangular shape, is tentatively assigned to the Docodonta. A mammalian incisor or reptilian tooth is also described. The red clays and sandstones of the Balabansai Formation, and their faunistic assemblage (plants, fish, frog, salamanders, turtles and dinosaurs) indicate terrestrial and fresh to brackish water environments.

Key words: Mammalia, Docodonta, Jurassic, Kyrgyzstan.

Lev A. Nessov, Petr V. Fedorov, Daniel O. Potapov, Institute of Earth's Crust, St. Petersburg University, St. Petersburg, 199034, Russia.
Zofia Kielan-Jaworowska, Jørn H. Hurum, Paleontologisk Museum, Universitetet i Oslo, Sars gate 1, N-0562 Oslo, Norway.
Alexander O. Averianov, Zoological Institute, Russian Academy of Sciences, St. Petersburg 199034, Russia.
Merethe Frøyland, Mineralogisk-Geologisk Museum, Universitetet i Oslo, Sars gate 1, N-0562 Oslo, Norway.
**) To whom correspondence should be addressed.*

Introduction

The Jurassic record of mammals is strongly punctuated both stratigraphically and geographically (Simpson 1928a, 1929; Lillegraven *et al.* 1979; Clemens 1986; Sigogneau-Russell 1991; Kielan-Jaworowska 1992). The only Southern Hemisphere Jurassic mammals described to date are the Liassic morganucodontid triconodonts from the Stromberg Series of South Africa (Crompton 1974; Jenkins & Parrington 1976), an edentulous dentary possibly of a peramuran (*Brancatherulum*) from the Late Jurassic of

Tanzania (Dietrich 1927; Simpson 1928b) and mammalian footprints from Argentina, of Middle Jurassic age (Casamiquela 1961). The majority of the known Jurassic mammals derives from Europe and North America (Clemens 1986).

From the vast Asian continent, Early Jurassic mammals (morganucodontid triconodonts, and *Sinoconodon*, a sister group of other mammals) are known from China (Kermack *et al.* 1973, 1981; Crompton & Sun 1985; Crompton & Lou 1993). Symmetrodonts, but possibly also other groups of as yet undescribed mammals have been reported from India (Datta *et al.* 1978; Datta 1981; Yadagiri 1984, 1985). A triconodont *Klamelia* was described from the Middle or Late Jurassic of Uygar, China (Chow & Rich 1984). Late Jurassic mammals are known also from Sichuan Province of China, represented there by *Shuotherium*, known from a dentary with therian-like teeth, but with a 'talonid' situated in front of the trigonid (Chow & Rich 1982). No mammals, however, have been reported so far from the uncontested Middle Jurassic of Asia.

The first vertebrate remains from the Jurassic Balabansai Formation in Kyrgyzstan (Kirghizia) were found by N.N. Verzilin in 1966 (Verzilin *et al.* 1970). During 1967 and 1971 field work N.N. Verzilin and L.A. Nessov found remains of sauropods, theropods, turtles, sharks and coprolites. Since 1981 L.A. Nessov and M.N. Kaznyshkin have collected Jurassic vertebrates in the Balabansai Formation near the town of Tashkumyr. They discovered remains of sharks (*Paleobates*, *Polyacrodus*), ptycholepidid palaeoniscoids, amioid holosteans, ichtyodectiform teleosts, dipnoans, labyrinthodonts, lizards, crocodiles, stegosaurs, pterosaurs and others, but during three field seasons (1981–1985) no mammals were found. In 1986 and 1987 P.V. Fedorov (joined by L.A. Nessov in 1987) mapped the NE Fergana region, and new groups of salamanders and actinopterygians were found (Nessov & Fedorov 1989).

During the summer of 1992 L.A. Nessov led the expedition of the Institute of Earth's Crust, St. Petersburg University to Kyrgyzstan. The aim of the field work was to search for Jurassic vertebrates in the Balabansai Formation near the stratotype in the vicinity of Tashkumyr and at Kalmakerchin by the Kokart River. The team consisted of (in alphabetical order) A.O. Averianov, P.V. Fedorov, M. Føyland, J.H. Hurum, L.A. Nessov and D.O. Potapov. Approximately 1050 kg of sediments were washed during three weeks of field work. Near Kalmakerchin, the expedition found one badly damaged upper molar, a part of mammalian ulna and a reptilian tooth or mammalian incisor. Although these fragments are incomplete and poorly preserved, we thought it desirable to report their discovery and briefly describe them. These are the first remnants of Jurassic mammals found on the territory of the Commonwealth of Independent States, and possibly the first Middle Jurassic mammals from Asia.

The specimens described in this paper are housed in the Zoological Institute of the Russian Academy of Sciences in St. Petersburg, abbreviated as ZIN.

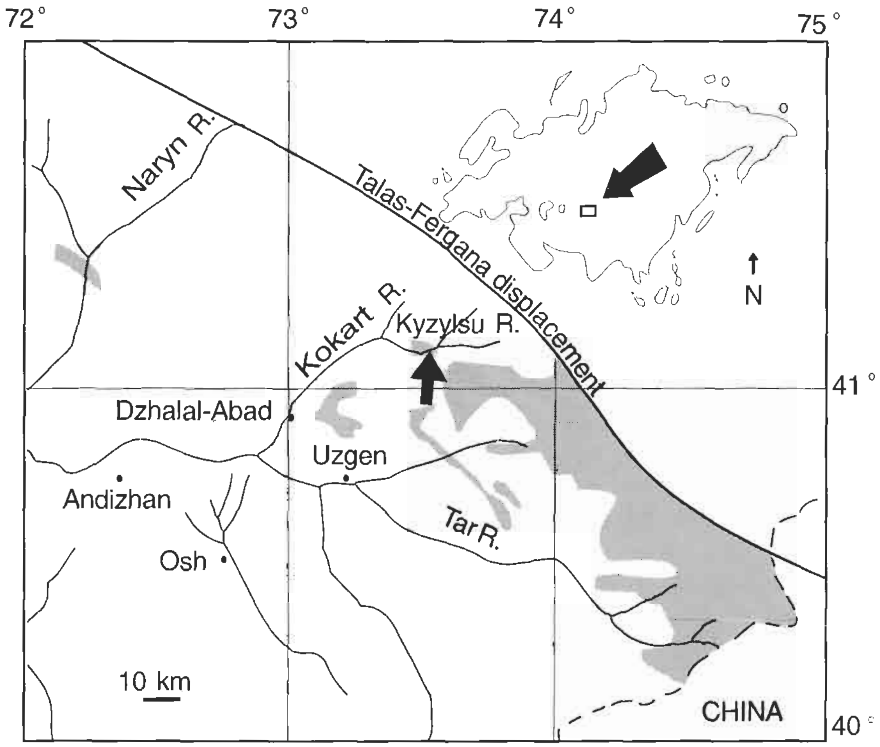

Fig. 1. Diagrammatic map of the Fergana Region. Areas with Jurassic deposits in the NE Fergana are in gray.

Geology

The site yielding Jurassic mammal remains in Kyrgyzstan is situated in the northeastern part of the Fergana Depression, within the Tien-Shan Mountains (Fig. 1). The depression is bordered on the north by the Kuramin and Chatkal Ridges, on the east by the Fergana Ridge and on the south by the Altai and Turkestan Ridges. The ridges around the Fergana Depression are mostly Paleozoic rocks, but the Fergana Ridge also contains Jurassic and Cretaceous deposits. A discontinuous belt of Jurassic outcrops is situated at the periphery of the depression and is overlain by red colored sediments of Cretaceous age. The thickness of the Jurassic sediments ranges from one to several hundred meters. The mammal molar and ulna were found in the lowermost part of the red-colored interval of the Jurassic. The mammalian incisor or reptilian tooth came from the upper part of this interval and was found close to a distal fragment of a humerus of a frog and some other vertebrate remains. The locality where the incisor was found is situated 1 km west from the locality that yielded a molar and an ulna fragment.

The Early Jurassic and most of the Middle Jurassic deposits are grey, greenish or bluish-grey and the Early Jurassic are often coal-bearing. The latest Middle Jurassic and the Late Jurassic deposits are red, greenish-red or with alternations of red and grey colored sediments.

For many years the sediments above the coal-bearing sequence of the upper part of the Early Jurassic, were referred to as Cretaceous. Mushketov (1928) suggested a possible Jurassic age of the lowermost part of the red colored interval of this section (see also Ognev 1946 and references therein). Simakov *et al.* (1957) demonstrated that the alteration of red-colored clays, sandstones, silts and clayish shales, which lay above the coal-bearing deposits is of Middle to Late Jurassic age rather than Cretaceous.

The stratotype of the Balabansai Formation (see Anonymus 1959: Tab. 13) is situated in northern Fergana, 7 km NW of Tashkumyr in the Balabansai Ravine. The lower boundary of the formation is defined at the base of the Jurassic red beds. The formation consists of multicolored (mostly red, also grey, bluish and greenish) sandstones, siltstones and clays. The thickness of the formation usually ranges from 50 to 185 m, but in the Kalmakerchin area the thickness is up to 429 m. Verzilin *et al.* (1970) regarded the Balabansai Formation as Late Jurassic on the basis of fresh- and brackish-water molluscs and turtles, which were found in the stratotype area. In the similar, mostly red-colored sediments of the NE Fergana on the Kokart River near Kalmakerchin (Figs 2, 3) Verzilin found a flora that was erroneously determined by Turutanova-Ketova as Early Cretaceous (Verzilin 1963). The new samples of flora from the same deposits (collected by one of us, PVF) include: *Selaginellites* sp., ferns *Dictiophyllum* sp., *Coniopteris angustiloba*, *C. himenophylloides*, *C. latifolia*, *C. pulcherrima*, *Eboracia lobifolia*, *Gonatosorus sphenopteroides*, *Cladophlebis lobifolia*, cycadophytes *Ptilophyllum* sp. cf. *P. cutchense*, *Podozamites* sp., ginkgopsids *Ginkgo concinna*, *Gingko* sp., *Sphenobaiera* sp., *Leptostrobus* sp., conifer *Pityophyllum longifolium*, and gymnosperms of uncertain affinities *Carpolithes* sp., *Radicites* sp. This assemblage demonstrates the Middle Jurassic age of the red-colored sediments (Burakova & Fedorov 1989).

The level with plant remains overlies conformably the layer that yielded mammals and salamanders of the family Karauridae, which is known only from the Jurassic (Estes 1981). Above the mammal-bearing horizon, there are two levels with paleoniscoid fish of the family Ptycholepididae, known from the Triassic and Jurassic but not from the Cretaceous. Gastropods (determined by G.G. Martinson), sharks and turtles, which were found with the mammals and above in the Balabansai Formation are also of Jurassic age (Nessov & Kaznyshkin 1988; Kaznyshkin *et al.* 1990). This is why at least the lower 394 m of the red-colored deposits of the Balabansai Formation in Kalmakerchin are identified as Jurassic. The uppermost 35 m of the deposits within the formation produced only undeterminated holostean fish scales and their age (Jurassic or Cretaceous) cannot be

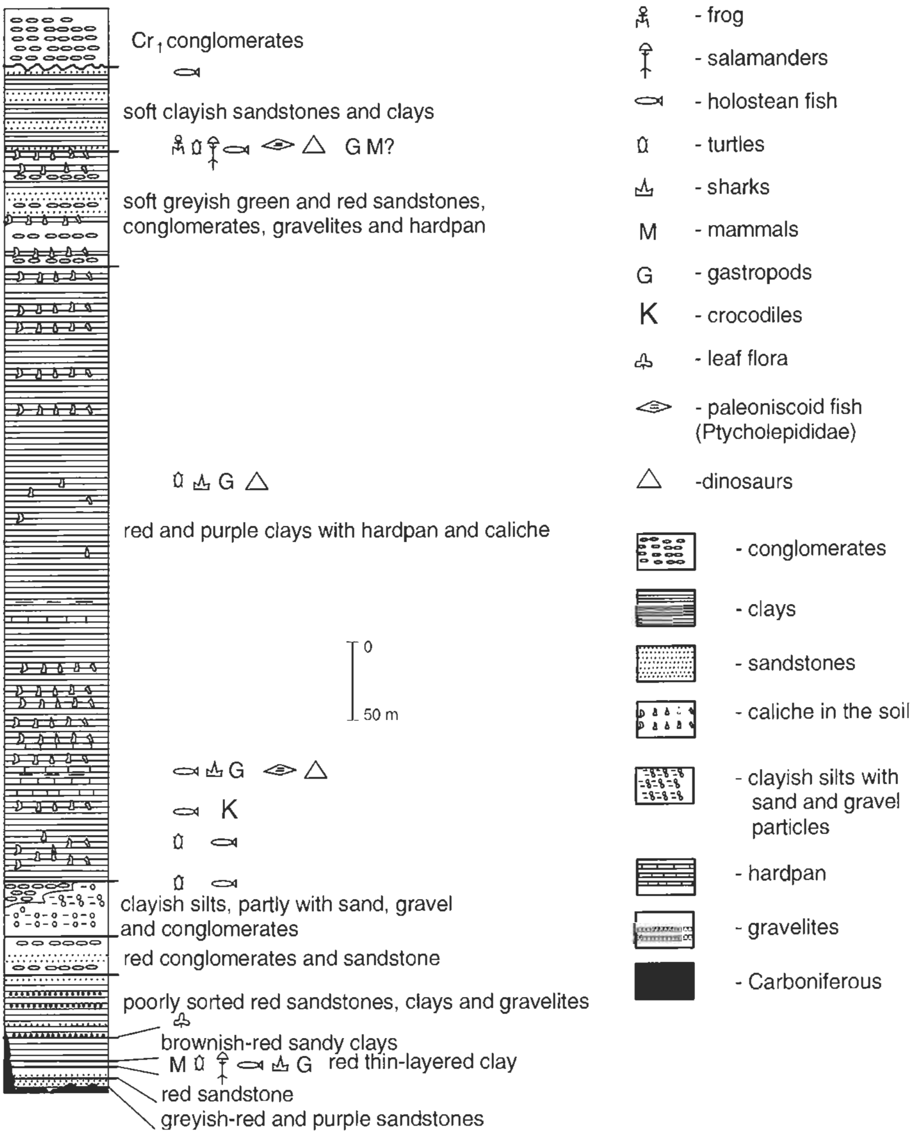

Fig. 2. Idealized geological section of the Jurassic deposits at the Kokart River.

determined with any certainty. The lower mammal-bearing horizon is recognized as Middle Jurassic. The upper level with possible reptilian tooth may also be of Middle or of Late Jurassic age.

The upper boundary of the formation is marked by a disconformity; the overlying conglomerates and eolian sandstones of the Khodzhiabad Formation are tentatively referred to the Early Cretaceous (Verzilin 1963; Verzilin *et al.* 1970). Above this formation there are clays and silts of the Khodzhaosman Formation that contain remains of Early Cretaceous fish and ostracodes.

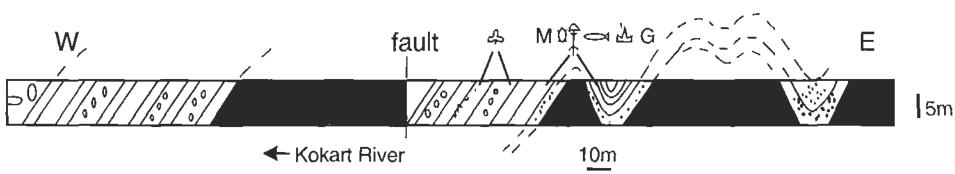

Fig. 3. Section of the outcrops alongside the water level of Kokart River, near the junction with Kyzulsu River. Figure captions as for Fig. 2.

The red-colored Jurassic deposits are exposed in small outcrops alongside the Kokart River. The outcrops are tectonically isolated from one another. The Balabansai Formation in the area of the junction of the Kyzylsu and Kokart Rivers and alongside the latter overlies disconformably the deeply weathered shales, limestones and sandstones of Carboniferous age. A idealized section of the Balabansai Formation by Kokart River includes 10 lithologically distinct units (Fig. 2).

The rocks of the Balabansai Formation on the Kokart River were deposited partly in shallow water and partly under terrestrial conditions with soil horizons and roots of plants. Brackish water sharks of the family Polyacrodontidae indicate an estuarine environment, and assemblages without sharks possibly indicate freshwater conditions.

Paleontological descriptions

?Docodont left upper molar. – The left upper molar fragment ZIN 79026 from the lower part of the Balabansai Formation. Northern Fergana, 7 km NW of Tashkumyr (Fig. 4B–D) is 2.5 mm long and 2.57 mm wide. It is cracked in several places. The enamel is preserved only on the labial shelf, which was probably directed vertically at angle of about 90° in respect to the occlusal surface of the crown. The middle and lingual part of the crown is completely destroyed and only the outline is preserved (Fig. 4B, D). The labial shelf has thickened and rounded anterior and posterior margins, and a small ectoflexus. It is slightly asymmetrical with the more expanded part identified as anterior, and therefore the tooth as upper left. No cusps have been preserved, but it cannot be excluded that the middle part of the labial shelf was prolonged ventrally as a cusp. The outline of the tooth is roughly trapezoidal; the labial part is longer than the lingual; the lingual part is slightly asymmetrical, more expanded posteriorly than anteriorly. On the dorsal (root) side (Fig. 4C) three damaged, broken roots are preserved, two labial and one lingual, filled with minute crystals of calcite, which also cover the area between the roots.

Mammalian ulna. – In the preserved fragment of the right ulna ZIN 79027 from the same locality, the olecranon is strongly compressed laterally and rectangular in cross section. The shaft is also compressed laterally, but slightly less so than the olecranon and is triangular in the

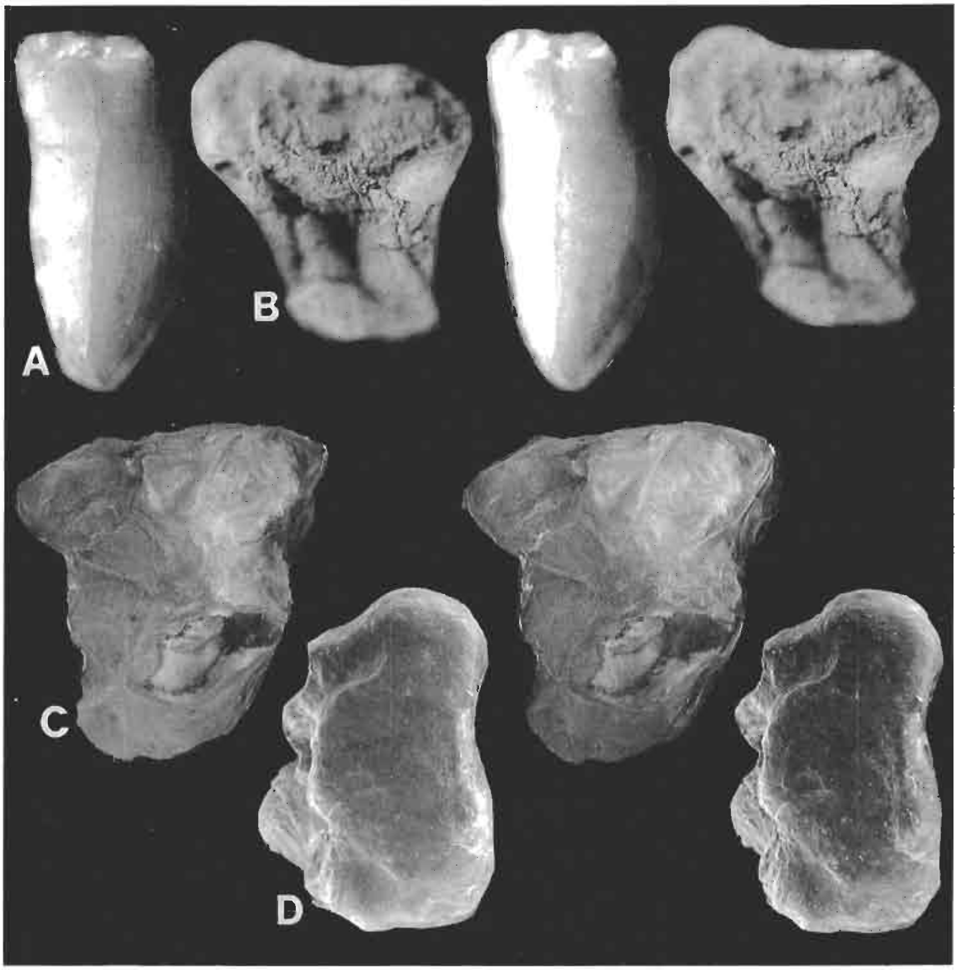

Fig. 4. ❑A. Mammalian incisor or reptilian tooth, ZIN 79028. ❑B–D. ?Docodont left upper molar ZIN 79026. B. Occlusal view. C. Dorsal view. D. Labial view. C, D are SEM micrographs. Stereo-pairs. A, B × 17. C, D × 20.

cross section. It seems that there are articulating surfaces (facets) both for the ulnar and radial condyles, which, however, are poorly seen, because of the bone fragments, which we interpret as the fragments of humeral condyles, cemented to them. The proximal two-thirds of the facet for the ulnar condyle is obscured by the fragment of the humeral condyle, and the shape of the facet can only tentatively be recognized. The facet was possibly very large, strongly concave, arranged slightly obliquely distolaterally-proximomedially. Medial to it there extends a deep, longitudinal groove. Lateral to the distal half of the ulnar facet, separated by an elevated ridge (trochlear notch), there is a much smaller facet for the radial condyle, obscured possibly by the remnant of the humerus. Distally to the facet for the radial condyle there is a damaged radial notch, the most distal part of which is missing. Lateral to the facet for the radial condyle a longitudinal groove extends onto the olecranon. The facets for ulnar and radial condyles are arranged approximately at right angles to one another. The radial notch in ZIN 79027, if correctly identified, was possibly situated more proximally than in other mammals, lateral to the posterior part of the facet for the ulnar condyle, rather than distolateral to it. As the apparent radial notch is placed in a different plane than the facet for the ulnar condyle, the radius, although extending high proximally, would not interfere with the distal part of the humerus moving against the facets for the ulnar and radial condyles.

Mammalian incisor or reptilian tooth. — The incisor, ZIN 79028 from the upper part of the Balabansai Formation, Northern Fergana, 7 km NW of Tashkumyr (Fig. 4A) has a well preserved crown, that is slightly bulbous, widest at the middle of the height and bears two longitudinal ridges, the one of which is seen in Fig. 4A. As preserved, the tooth is 2.8 mm high and almost completely covered with enamel, that is missing only in some parts of its proximal end. The crown is 1.5 mm long (antero-posteriorly) at its widest part. The tip of the tooth is worn. There is an oval wear facet, extending from the tip upwards for about 1.5 mm, 0.6 mm wide.

Discussion

The docodonts, which are a sister group of all other mammals (Lillegraven & Krusat 1991), were until recently known only from the Jurassic of Europe and North America. We assign the upper molar ZIN 79026 tentatively to Docodonta, because of its roughly rectangular outline with the labial part longer than the lingual, as is characteristic of known docodont molars, and presence of three roots (Simpson 1929; Jenkins 1969; Krusat 1980; Butler 1988; Lillegraven & Krusat 1991). ZIN 79026 and other mammal fragments described above are relatively large by Jurassic standards. If ZIN 79026 is indeed a docodont, it would be the largest representative of this order so far known, and the first representative of the Docodonta from Asia (we disagree with the suggestion of Kermack *et al.* 1987, that *Shuotherium* from the Late Jurassic of China might be a docodont).

The part of a ulna, ZIN 79027, found in the same locality and horizon as the molar ZIN 79026, does not belong either to the Triconodonta or to the Multituberculata. In both these orders the facet for the radial condyle is less obvious than in ZIN 79027, and the radial notch is placed more distally than in ZIN 79027, laterodistal in respect to the distal part of the facet for the ulnar condyle (Granger & Simpson 1929; Jenkins & Parrington 1976; Jenkins & Schaff 1988; Jenkins 1973; Krause & Jenkins 1983). ZIN 79027 does not belong to Theria, as it does not have the humeral trochlea. In therians the radial notch is situated distal in respect to the

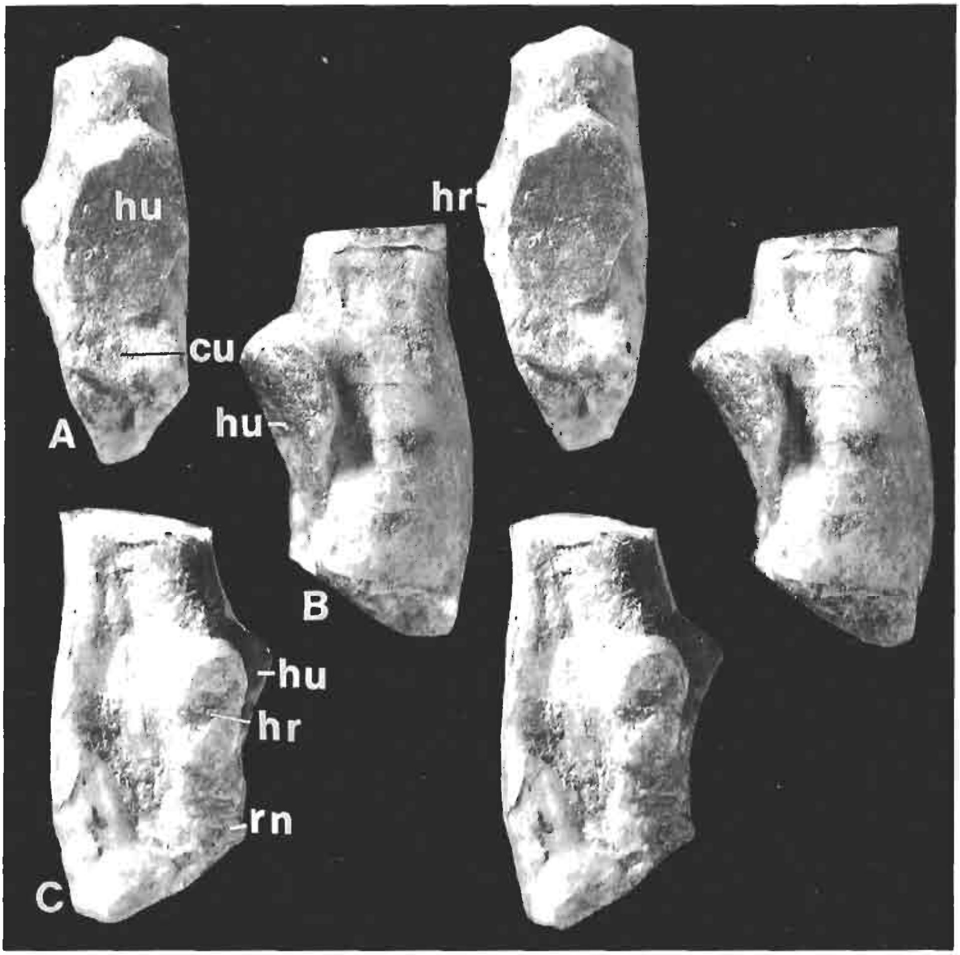

Fig. 5. Proximal part of the mammalian right ulna, ZIN 79027. A. Anterior view. B. Lateral view. C. Medial view. Abbreviations: cu – distal part of the ulnar condyle; hu – fragment of the humerus cemented to the ulnar condyle; hr – ?fragment of the humerus cemented to the radial condyle; rn – badly damaged proximal part of the radial notch. Stereo-pairs; × 8.

trochlea (e.g., Lessertiseur & Saban 1967; Jenkins 1973; Evans & Christensen 1979). The only 'eupantothere' ulna so far known is that of *Henkelotherium* from the Kimmeridgian of Portugal (Krebs 1991), but the details of articular surfaces are not known, as the humerus has not been removed from the joint.

The docodont ulna, found in *Haldanodon* (Krusat 1992) is now being studied by Dr. Georg Krusat. The attribution of our ulna to docodonts cannot be demonstrated, because of its incompleteness, and because of the cemented fragment of the humerus.

Of Mesozoic mammals ulnae so far described, ZIN 79027 is reminiscent of the ulna of an unidentified Jurassic mammal from the Morrison Formation figured by Jenkins (1973, Pl. 1, Fig. 21). In that ulna the ulnar and radial condyles are situated at different planes, separated from one another by a ridge (trochlear notch), and the proximal part of the radial notch is situated lateral to the distal part of the articular surface for the ulnar condyle, as characteristic of ZIN 79027.

The tooth identified by us as an incisor ZIN 79028 is slightly bulbous. Similar teeth occur in various reptiles, e.g., in scincomorph lizards (Estes 1983) and in some primitive crocodiles, which are, however, bigger (e.g, Walker 1972). The length of ZIN 79028 is 0.6 that of the upper molar ZIN 79026. In most Mesozoic mammals (see e.g., Lillegraven *et al.* 1979) the upper incisors are relatively small in relation to the upper molars. In a peramuran *Vincelestes neuquenianus*, however, from the Early Cretaceous of Patagonia, the first three upper incisors are very large in respect to the relatively small molars (Bonaparte & Rougier 1987; Rougier 1990). The upper incisors of docodonts are known only in *Haldanodon exspectatus* (Krusat 1980; Lillegraven & Krusat 1991) and are very different from the discussed incisor. We cannot demonstrate with any certainty whether ZIN 79028 belonged to a reptile or to a mammal.

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