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TRACKING THE LARGEST LAND MAMMAL: PALEOICHNOLOGICAL ASSESSMENT, PEDOBAROMETRY, AND DISCOVERY POTENTIAL OF THE TERTIARY RHINOCEROS *(PARACERATHERIIDAE)* FOOTPRINTS

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Introduction: Vertebrate traces comprise a rich archive of behavioral and paleo-environmental information [1]. To date, no conclusive evidence exists of the footprints of the largest terrestrial mammal – the extinct Oligocene rhinoceros (Fig. 1A)[2]. These herbivores, previously known as indricotheres and baluchitheres, have been recently combined into a large family of paraceratheriids (Perissodactyla, Paraceratheriidae, *Paraceratherium* sp., Forster-Cooper, 1911) [3-7]. They left a rich skeletal record, from crania to limb bones (some preserved as upright individuals were buried *in situ*) that have been described by early paleontologists [4-6], including the pioneer of taphonomy I.A. Efremov [8].

Despite much interest and ongoing research [3,7], the lack of photographic evidence or field description of paraceratheriid footprints is noteworthy [2]. Such information will add an important aspect to the paleoecological and paleoenvironmental context of these mammals. This paper proposes the general appearance and dimensions of potential footprints (paleoichnology), estimates the loading pressure based on the allometry of modern rhinocerotoids (pedobarometry), and assesses the preservation (taphonomy) and recognition (discovery) potential of paraceratheriid traces in Tertiary sedimentary formations.

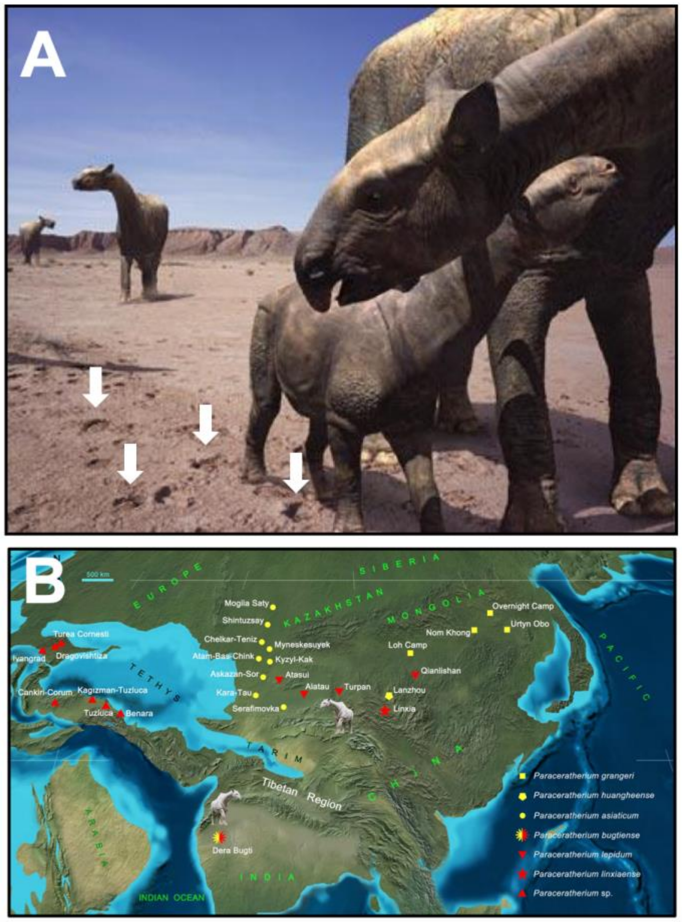

Figure 1. Paraceratherium sp.: A) Some artistic reconstructions depict tracks with raised rims (image source: *primeval.forumieren.de*); B) Distribution of skeletal remains [7].

Methodology: Considerations of footprint type, dimensions, and discovery potential are synthesized according to known paleontological research [4-7]. Quantification of foot loading pressures (pedobarometry) was based on previously published allometric information [9-14](Fig. 2).

Results and Summary: Based on their paleoecology and allometry, the potential for track discovery can be assessed by addressing the filtering effects of formation-preservation-recognition biases [16]. For paraceratheriids, the lack of ichnological record is due to hard-packed nature of contemporary semi-arid scrubland substrates, logistically challenging accessibility to productive Eurasian sites (Fig. 1B), and finds of skeletal remains in coarse-grained fluvial strata. Favoring track preservation are wide home/migration ranges and presence of fine-grained and lime-rich facies in fluvio-deltaic/lacustrine areas and watering holes.

The typical rhinocerotoid digital structure predicts that paraceratheriids left large plantigrade tridactyl (digits II-III-IV) footprints in Oligocene sedimentary formations (Figs. 1A and Fig. 2C). Following the pioneering vertebrate ichnotaxonomy of O.S. Vialov, the tracks can be classified as *Rhinoceripeda* isp. [17]. Based on fleshed limb dimensions of these perissodactyls, the prints should be at least 50-60 cm in width. Scaling to elephant and rhinoceros pedobarometry (mass ~ juvenile indricotheres; Fig 2B), planti-/digitiportal *Paraceratherium* sp. males with a conservative maximum weight of 15 tonnes likely exerted mid-stance foot pressures of ~200 kPa (edge loading ~1,500 kPa; Fig. 2A).

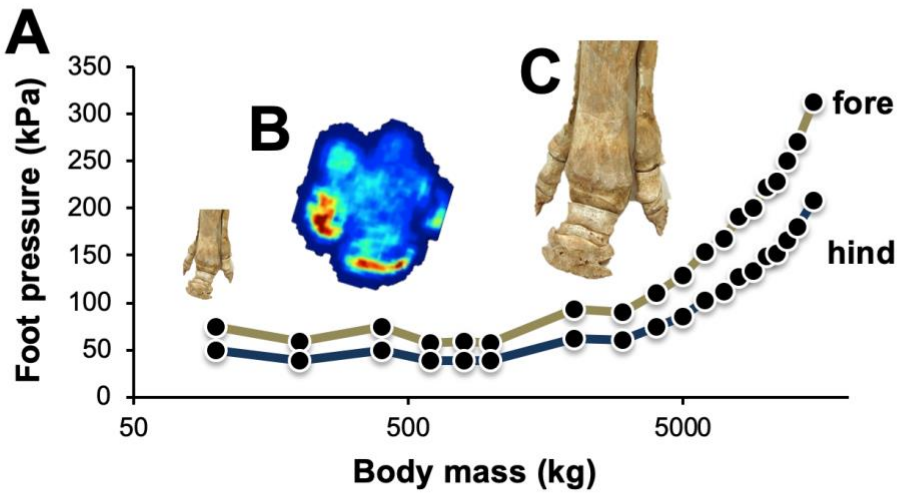

Figure 2. Pedobarometry: A) Approximate plantar foot pressure (non-edge loading) of a slow-moving paraceratheriid; B) Pressure map of the left forelimb of an extant rhinoceros [14]; C) hind foot bones of *P. transouralicum* (AMNH).

Once paleo-surfaces at the most favorable localities are constrained, search for naturally weathered traces can be complemented with high-frequency ground-penetrating radar (>500 MHz GPR) imaging for identifying traces and undertracks [19-22], especially in sand-rich hyporelief. Efforts focused on mapping tracking surfaces, combined with GPR imaging of mammoth tracks and neoichnological experiments with modern megafaunal locomotion in varying substrates, should eventually lead to trackway discoveries, shedding light on the distribution, geomorphic impact, speed, and behavior of these extinct giants.

This study suggests that large tridactyl footprints of *Paraceratherium* sp. should be preserved under favorable conditions, with the greatest potential near Oligocene paleo-lake basins [2,7]. Neoichnological experiments with adult rhinoceroses will aid in improving the recognition potential usual visual [14,15,18] and subsurface imaging tools.

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