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SHORT COMMUNICATION

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The first discovery of a brachiosaurid from the Asian continent

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Abstract Described here is a sauropod tooth from the Early Cretaceous of South Korea, similar to *Brachiosaurus*. The crown of the tooth is beveled off lingually so that when worn it presents a chisel-like edge. This find confirms the presence of a brachiosaurid in East Asia during the Early Cretaceous.

Dinosaurs from the Jurassic and Cretaceous of South Korea are rare, being known only from trace fossils and fragmentary bones (Lee et al. 1997; Lim et al. 2000; Yang 1982). In recent years footprints discovered in the Cretaceous rocks of South Korea have presented a variety of dinosaurs, including sauropods, ornithischians, and theropods (Lim et al. 1989; Yang 1982).

An isolated sauropod dinosaur tooth was collected from the lacustrine Early Cretaceous (Barremian-Aptian) Jinju formation (shale facies) in the Kyongsang supergroup of South Korea. The Kyongsang supergroup has produced plants, freshwater shells, insects, estheriids, tortoises, dinosaur tracks, and bird tracks, including those of web-footed species (Lee 1987; Lim et al 2000).

Sauropod teeth exhibit a range of variation related to their herbivorous diet (McIntosh 1990). They can be divided into two functional types: the thick spoon-shaped teeth typified by *Camarasaurus* and *Brachiosaurus*, and the slender peg-like teeth of *Diplodocus* with unexpanded cylindrical crowns. The spatulate tooth type is associated with more robust jaws and a long tooth row with upright teeth while the pencil-like teeth of diplodocids are concentrated in the anterior fourth of the jaw (Sander 1997). Wear facets on the teeth of both camarasaurid and diplodocid types show that the diet did not consist merely of succulent ferns. Cycads, high-rising tree ferns, and conifers provided a major proportion of their diets (McIntosh et al. 1997).

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Titanosaurid teeth have more slender crowns than those of *Camarasaurus* and *Brachiosaurus*, retain labial grooves, but have lost the lingual concavity (Upchurch 1998). Teeth of titanosaurids also closely resemble those of *Brachiosaurus* in the pattern of the wear facets and tooth-to-tooth contact (Salgado and Calvo 1997).

The crown of KS (Kyeongnam Science High School Museum) 7002 is only slightly lingually curved, strongly compressed, and lacks the longitudinal, bilateral striations common in *Camarasaurus*. The labial and lingual sides of KS 7002 are convex with an overall egg-shape, and a well-developed, chisel-like wear facet on the tooth's lingual surface. Such is also the case in *Brachiosaurus*, where the upper teeth are beveled on the lingual surface and the lower ones on the labial side so that the worn teeth present chisel-like edges that are self-sharpening (White 1958). The crown on KS 7002 is rectangular and broadest in the middle, with subequal apical and basal thickness. Based on the position of wear facets, tooth size and shape, and the position of the lingual ridges, which vary in position and shape along the tooth row, KS 7002 is a left upper tooth, either number 8, 9, or 10 in the maxillary bone.

The crown of KS 7002 is thicker than in *Camarasaurus grandis* (Gunma Museum of Natural History 101). The teeth of *Camarasaurus* are larger in size anteriorly, becoming smaller posteriorly (Carey and Madsen 1972). Teeth of *Camarasaurus* and *Brachiosaurus* are generally spatulate (spoon-shaped), but Marsh (1888) distinguished teeth of *Pleurocoelus nanus* (Brachiosauridae) from teeth of *Camarasaurus* in that *Pleurocoelus* teeth are mainly compressed cones, and not spoon-shaped as in *Camarasaurus*. Brachiosaur teeth diminish in size towards the back of the mouth, and the crowns also become more compressed, losing the spatulate oval depression (Russell and Zheng 1993).

Russell and Zheng (1993) distinguished *Brachiosaurus* teeth from those of *Camarasaurus* in the absence of well-defined longitudinal striations on the crowns of brachiosaur teeth. The tooth from Korea (KS 7002) lacks such longitudinal striations when compared with KUVP

Table 1 Measurements of teeth of KS 7002 and *Camarasaurus* (in mm) (*Camarasaurus grandis*, GMNH 101 and a Camarasaurid tooth, KUVP 129713)

	Thickness between side lingual side and labial at the apex of crown	Thickness between lingual side and labial side at the middle of crown (spatulate depression)	Thickness between lingual side and labial side at the base of crown	Ratio: Thickness between lingual side and labial side at the base of crown/ Thickness between lingual side and labial side at the apex of crown
KS 7002	9.9	10.1	12.7	1.3
GMNH 101 Left maxillary no. 7	5.3	8.3	11.7	2.2
GMNH 101 Left maxillary no. 8	3.9	7.8	11.6	3.0
GMNH 101 Left maxillary no. 10	3.8	7.0	10.2	2.7
GMNH 101 Right maxillary no. 7	5.0	6.1	9.9	2.0
GMNH 101 Right maxillary no. 8	4.4	9.8	11.7	2.7
GMNH 101 Right maxillary no. 9	5.6	7.3	12.2	2.2
GMNH 101 Right maxillary no. 10	4.4	6.0	10.0	2.3
KUVP 129713	4.4	10.3	12.8	2.9

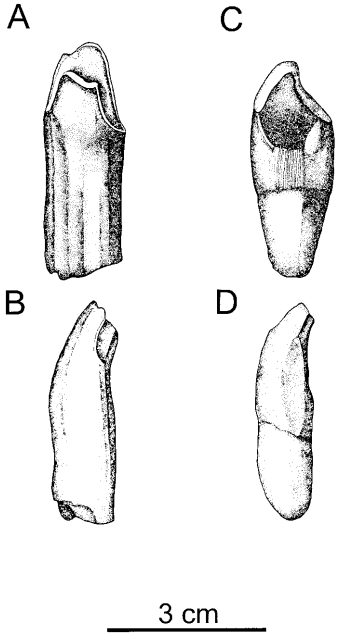

Fig. 1 Lingual views and lateral views of KS 7002 (**A**, **B**) and *Euhelopus zdanskyi* (PMU.R233) (**C**, **D**: modified from Wiman 1929)

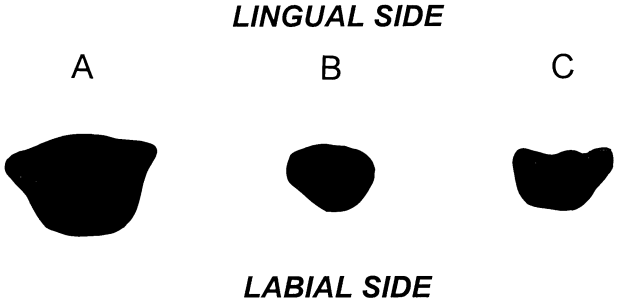

Fig. 2 Cross-sections (taken near the crown base) of teeth (*top*: lingual side and *bottom*: labial side). **A** *Brachiosaurus brancai* (modified from Janensch 1935/6), **B** KS 7002, and **C** *Camarasaurus* (KUVP 129713)

(University of Kansas Natural History Museum Vertebrate Paleontology) 129713, a *Camarasaurus*, with striations at the base of the crown (Fig. 1).

Comparisons of the cross-section of KS 7002 with a *Camarasaurus* tooth (KUVP 129713) show differences in shape. The labial and lingual sides of KS 7002 are convex with an overall egg-shape, while the lingual side of the *Camarasaurus* tooth is concave, forming a spoon-shaped crown (Fig. 2). Teeth of *Brachiosaurus brancai* (Museum für Naturkunde der Humboldt-Universität S116) are also convex lingually and labially in cross-section.

One major difference between *Camarasaurus* and *Brachiosaurus* teeth is the type of tooth wear. The tooth, KS 7002, has beveled tooth wear on the lingual side, suggesting it is a brachiosaurid upper tooth (Fig. 1).

KS 7002 differs from the tooth of a Chinese camarasaurid, *Euhelopus zdanskyi* (Paleontological Museum, Uppsala, Sweden R233), in that the crown of KS 7002 is rectangular and broadest in the middle while the crowns of *Euhelopus* are subtriangular in profile and broadest at the base (Russell and Zheng 1993; Wiman 1929). Based on measurements of crown thickness of KS 7002 and *Camarasaurus*, KS 7002 differs from *Camarasaurus*. The thickness at the apex of the crown compared with the thickness at the base in KS 7002 is similar, while in *Camarasaurus*, thickness at the base of the crown is more than twice as great as at the apex (Table 1).

Osborn (1924) described a posterior tooth of *Asiatosaurus mongoliensis* from Mongolia and compared it with *Camarasaurus*. The tooth of *Asiatosaurus* (American Museum of Natural History 6264) is similar to KS 7002 in the asymmetry of the summit of crown, but it is different from KS 7002 in having vertical a groove near each edge. *Asiatosaurus* and *Camarasaurus* have a small median groove extending vertically through the base of the spoon-shaped depression that is lacking in KS 7002.

Brachiosaurids occupied North America, Europe, South America and Africa up to the Albian, Late Early Cretaceous (Upchurch 1995). Although first described in North America, our knowledge of brachiosaurid anatomy results largely from German expeditions to Africa early in the twentieth century (Janensch 1929, 1935/6), and it is not completely certain that the African and American examples are congeneric. The presence of a brachiosaurid at a relatively high latitude in Asia has biogeographic significance for any potential connection between the North American and African populations. The discovery of a brachiosaurid tooth in direct association with a sauropod trackway suggests a brachiosaurid maker and may prove useful in the reconstruction of brachiosaurid behavior. Azuma and Tomida (1995) have mentioned that the Tetori Group of Japan produced remains of *Brachiosauridae* gen et sp. indet., but no more detailed description of this specimen is available.

This discovery of KS 7002 is the first report of a brachiosaurid from the Asian continent.

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