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Discovery of partial skull and dentary of Titanosauria (Sauropod Dinosaur) from the late Cretaceous Pab Formation of Vitakri area, Barkhan District, Balochistan, Pakistan

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ABSTRACT: *Partial Skull and dentary of Marisaurus Titanosauria have been discovered for the first time in Pakistan from the Late Cretaceous Pab Formation of Vitakri area, Barkhan District, Balochistan, Pakistan. Discovered cranial parts are found mainly as three masses on same locality and also nearby axial elements such as some cervical, dorsal and caudal vertebrae, and also supported by some appendicular elements. The first mass consists of anterior skull such as articulated upper and lower jaws, articulated vomer and associated piece consists of articulated left quadrate, partial quadratojugal and possibly lowermost portion of squamosal.The second mass consists of central cranial parts such as preserved articulated posterior vomer, palatine, pterygoid, ectopterygoid and possibly parasphenoid. The posterior width (possible) of vomer is 1.5 cm and maximum thickness is 6mm. Palatine and ectopterygoid seem to be fused. The maximum horizontal transverse width from right to left tip of palatine and ectopterygoid is about 9 cm. It seems to be slightly compressing. The third mass consists of braincase which has been described as separate. The majority of second mass and third mass (braincase) is covered by matrix.*

Recently five new genus and species of Titanosauria (Titanosaurids/Pakisaurids, and Saltasaurids) are erected on the basis of morphology of caudal vertebrae but the assignment of partial skull and dentary may belong to a marisaurus jeffi (Saltasaurids Titanosauria), based on nearby findings of some cervical, dorsal and caudal vertebrae and some appendicular elements. Titanosaurids were by far the predominant sauropods in the Late Cretaceous, but their relationship to other families remain an enigma, in part because no good skulls are known. This discovery will be useful for generic-level comparisons and phylogenetic resolution. In this regard, the Indo-Pakistan will enter in hypothesis of Gondwanan dinosaur biogeography in future. These new discoveries from Vitakri and its vicinity have proved a well developed Vitakri Cretaceous Park for terrestrial ecosystem.

INTRODUCTION

Partial Skull and dentary of Titanosauria have been discovered for the first time from Pakistan in the Late Cretaceous Pab Formation of Vitakri region, Barkhan District, Balochistan, Pakistan (Fig. 1). The firstever discovery of dinosaurs from Pakistan has also been made from the Late Cretaceous (70-65 million years before) upper part of Pab Formation, Vitakri region. This discovery was made during the year 2000, when the

author was working for the evaluation of gypsum deposits of Barkhan and Kohlu districts, Balochistan, Pakistan. First time, I collected distal portion of Titanosaurian femur during early 2000. The diagnosis of this first bone relating to dinosaurs or rhinoceros/elephant remained a controversy. This bone was confirmed as of dinosaur by Dr. Philip D. Gingerich and Dr. Jeffrey A. Wilson of Michigan University, USA. Professor Philip congratulated the Geological Survey of Pakistan (GSP) for this first ever dinosaur discovery from Pakistan. During late 2000, Professor Phillip D. Gingerich visited the Pakistan. On his visit to Vitakri, were I showed him the in-situ fragmentary bones. About 100 bones/pieces of bones are sent to Museum of Paleontology, University of Michigan, USA. About 1700 bones/pieces of bones from Vitakri and various places in the Barkhan, Kohlu, Dera Bugti, Dera Ghazi Khan districts and Sulaiman range were collected during 2001 for further studies. The Vitakri and vicinity areas seem to be graveyard of terrestrial ecosystems of Vitakri Late Cretaceous Park. These localities of archosaurs are easy for excavation due to soft mud/clay host rocks to find the articulated skeleton of these exceptional animals.

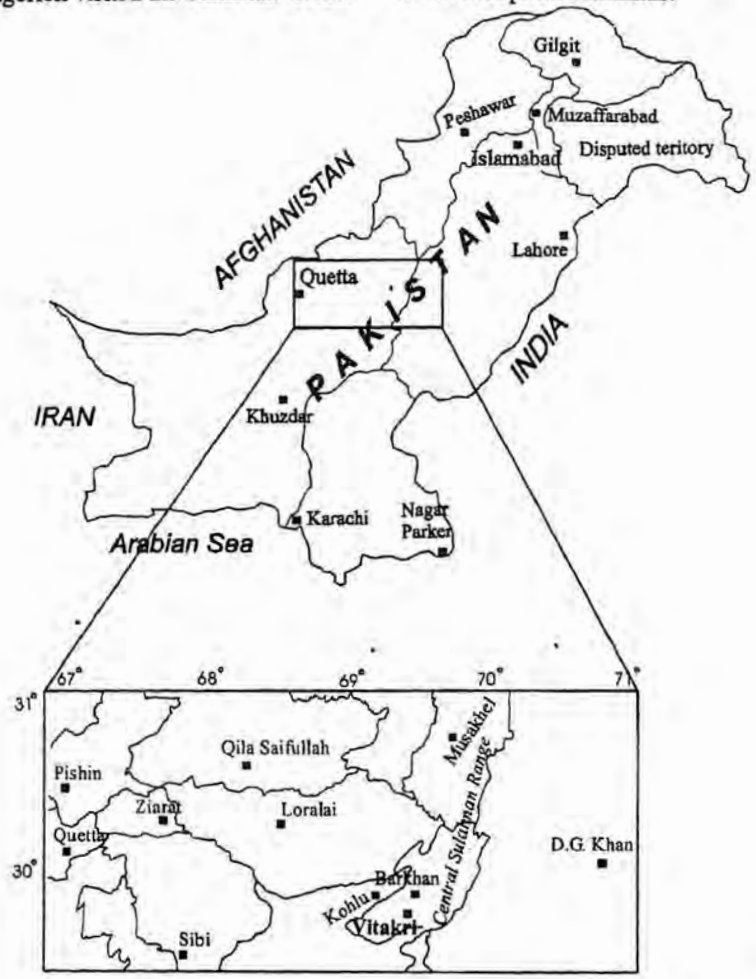

Fig. 1. Index map showing the Vitakri Region, Central Sulaiman Range, Pakistan.

Virtually complete skulls and mandibles are known in Diplodocus, Camarasaurus, Brachiosaurus and Shunosaurus. Partial skulls and jaws are known in Apatosaurus, Euhelopus, Dicrasaurus, Omeisaurtus, Datosaurus, Nemegtosaurus, Quaesitosaurus, Antarctosaurus, Barosaurus africanus and Cetiosaurus mogrebiensis. The other genera of Sauropod are known from a few skull elements or more often from nothing but possibly a few teeth. In this latter category are such important forms as Haplocanthosaurus, Barosaurus, Opisthocoelicaudia, Cetiosaurus, Pleurocoelus, Barapasurus, Vulcanodon, Mamenchisaurus, Alamosaurus, and almost all the other Titanosaurids. Titanosaurids were by far the predominant sauropods in the Late Cretaceous, but their relationship to other families remain an enigma, in part because no good skulls are known (McIntosh, 1990). New discoveries from Pakistan including a variety of large vertebrate that indicate five new genus and species of herbivorous Titanosaurian Sauropod and one new genus and species of carnivorous Abelisaurid Theropod Dinosaurs and Baurosuchid Pabwehshi Pakistanensis and Mesoeucrocoreptilia (Malkani & Anwar, 2001; Malkani et al., 2001; Wilson et al., 2001). Present discovery will be useful for generic-level comparisons and phylogenetic resolution, and Indo-Pakistan will enter in hypothesis of Gondwanan dinosaur biogeography. First and new discoveries by author from Vitakri and its vicinity areas of Pakistan have proved a well developed Vitakri Cretaceous Park for terrestrial ecosystem.

DESCRIPTION OF PARTIAL SKULL OF TITANOSAUR FROM PAKISTAN

Discovered cranial parts are found mainly as three masses on same locality and also nearby axial elements such as some cervical, dorsal and caudal vertebrae. The first mass consists of anterior skull such as articulated upper and lower jaws, articulated vomer; and associated piece consists of articulated left quadrate, partial quadratojugal and possibly lowermost portion of squamosal (Figs. 2-5). Articulated anterior skull and dentary rami are compressed transversely/laterally. The anterior skull has mid line contact. The right premaxillary and right maxillary teeth are cemented on the anterior and lateral side of right dentary ramus. Maxilla seems to be broken at two places at near the contact of premaxilla and other at 3 cm back from this point. Dentary is preserved in articulation with the upper jaw. Left dentary ramus is covered by quadrate, quadratojugal, possible squamosal and matrix. Dentary symphysis seems to be weak. A thin vertical Splenial lies beneath the Meckelian canal on the medial face of the dentary, covering the lateral plate like extension of the dentary. The left splenial on the ventral side is going to below from the level of left dentary ramus. It may be attributed to lateral compression. The preserved dentary ramus having length 12 cm, depth 4.5-5 cm and width (with splenial) 18 mm. The anteroventral marginal shape of dentary is gently rounded. Palatine lateral ramus is rod shaped and has narrow maxillary contact. The maximum thickness of vomerine palate is 8mm and width is about 2 cm on one side. It is compressed laterally/transversely; and contact anteriorly with premaxilla. The transverse length along the preserved bone exposure of at the level of about 5thor 6th maxillary tooth is 15 cm and due to compressing its horizontal cross-section approaches as 7 cm. Maxilla has 1.5 cm thick alveolus ramus and the upper/dorsal portion, which is about 0.5 cm thick.

Preserved quadrate plate is about 1cm thick and 10 cm long and 7 cm wide. On the dorsal of quadrate seems to be partial squamosal which is also about 1 cm thick. The place for posterior fossa of quadrate is covered by matrix. Quadrate plate is slanting

to downward and forward. Laterally it is articulated with quadratojugal. Quadratojugal is thick about 1-2.5cm and dorsal process rotate at an angle of about 40-50 degree from anterior process of quadratojugal. The ventral surface is smooth.

Right premaxillary teeth are about 4 and preserved maxillary teeth are about 5 or 6, which are cemented by matrix on the anterior and lateral side of right dentary. The teeth row broadly arched forming U shaped. Tooth crowns do not overlap and their cross-sections vary from circular to subelliptical. The lengths of premaxillary teeth vary from 10 mm to 18 mm, width varies from 4 mm to 6 mm and depth is not measured due to matrix and fixing. However, thickness is going to be increased going far from saggital symphysis or midline. The first maxillary tooth is thick and long comparatively from premaxillary teeth. Its length is 28 mm and width is 7-8 mm and following other tooth/teeth is not well exposed i.e., it is covered by matrix. Other tooth at a distance of about 2 cm (from first maxillary tooth) is again long and thick as first maxillary tooth. After this one or two small tooth seems to be fixed in matrix. The alternating small and large teeth may represents the replacement phenomena of teeth. Maxillary teeth are articulated with maxilla. However, spacing between teeth is increasing toward posterior/back. Premaxillary tooth crowns apex are slightly curved toward lingual side and mid crowns convexing slightly towards labial side while the maxillary teeth convexing are parallel to premaxillary teeth i.e., the central crown convexing towards anterior and upper crown are curved towards posterior/backward. Some teeth are cone forming and some are blunted or having wear facet. Pulp cavity of 3 fragmentary teeth but associated with skull and matrix, measured at base as 3 mm, 4 mm, and 7 mm maximum diameter on the basal part of crown, teeth thickness 7 mm, 8 mm, 9 mm and width 8 mm, 9 mm, 10 mm respectively. All the teeth bear irregular pattern of rugosities (wrinkled). Dentary teeth are not exposed and covered by anterior upper skull.

Fig. 2. Anterior skull and articulated dentary of Titanosauria, ventral view in the top. Posterior vomerine, fused palatine and pterygoid of titanosauria, ventral view (scale in centimets).

Fig. 3. Anterior skull and articulated dentary of Titanosauria, anteroventral view at top. Posterior vomerine, fused palatine and pterygoid of Titanosauria, anteroventral view at the bottom (scale in centimeters).

Fig. 4. Anterior skull and articulated dentary of Titanosauria, interior view of cross section of skull at the level of about posterior maxilla (scale in centimeters).

Fig. 5. Anterior skull and articulated dentary of Titanosauria, posterodorsal view of cross section of skull at the level of about posterior maxilla in the top. Posterior vomerine, fused palatine and pterygoid of Titanosauria, posterororsal view (scale in centimeters).

Teeth are long, narrow, slender, finger and pencil shaped. The teeth having wear facet at apex/tip are supposed to be finger shaped, while the teeth having conical shape tip or sharp pointed end are supposed to be pencil shaped. Preserved teeth are curved backward at the distal ends and some strongly to moderately arched in the middle. Faint longitudinal ridges are also observed which constitute almost along the whole length of the teeth.

The second mass consists of central cranial parts such as preserved articulated posterior vomer, palatine, pterygoid, ectopterygoid and possibly parasphenoid (Figs. 2-5). The posterior width (possible) of vomer is 1.5 cm and maximum thickness is 6 mm. Palatine and ectopterygoid seem to be fused. The maximum horizontal transverse width from right to left tip of palatine and ectopterygoid is about 9 cm. It seems to be slightly compressing. The third mass consists of braincase, which has been described as separate (in press). The sizes of bones represent the adult/subadult animals. The majority of second mass and third mass (braincase) is covered by matrix. Recently five new genus and species of Titanosauria (Titanosaurids/Pakisaurids, and Saltasaurids) are erected on the basis of morphology of caudal vertebrae but the assignment of partial skull and dentary may belong to a marisaurus Titanosauria), based on nearby findings (paper in process) of some cervical, dorsal and caudal vertebrae, and some appendicular elements.

CONCLUSIONS

The partial skull of titanosaurian Sauropod dinosaur of Vitakri region is beautifully preserved and provide a wealth of anatomical information. It is confirmed that the partial skull described briefly here found from the upper part of Late Cretaceous Pab Formation of Vitakri region, Balochistan, Pakistan, are referable to marisaurus Titanosaurian Sauropod dinosaurs. This is confirmed on the basis axial and appendicular elements of marisaurus Titanosauria. Titanosauria were by far the predominant sauropods in the Late Cretaceous but their relationship to other families remain an enigma, in part because no good skulls are known. Present discovery from Pakistan will partially solve this problem. The skull of Chinese form like nemegtosaurus and quaesitosaurus represent non association of axial and appendicular elements. But the present discovery will provide the facility of finding the appendicular and axial elements. The discovery of partial skull from Pakistan will provide the facility for comparisons with the already discovered skulls in the world to deduce the actual taxonomic and paleobiogeographic targets. The excavation at many sites in the Vitakri region is suggested to explore the articulated dinosaurs, which will really be useful phylogeny and paleobiogeography.

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