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Plates Boundary and Structural Geology of Balochistan and Indus Basins through Field Observations on Chaman Transform Fault and Western Indus Suture (Pakistan): Dinosaurs from Pakistan with Attributed Bones and Key Features: Titanosaurs from India with Updated Assessment on *Jainosaurus*

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Abstract

The plate boundary between Balochistan and Indus basins is found on the position where Western Indus Suture and Chaman Transform fault converge in the south (Uthal-Bela-Ornach-Nal-Basima). From Basima to northward the both structures bifurcate and separate more than 50 km in the Zhob region, the Chaman Transform fault lies in the west as straight way in flysh and slates of Balochistan basin, and Western Indus suture lies in the east mostly straight and wide (more than 20 km wide) galaxy way like belt (gentle wavy in the central portion from Quetta to Zhob). Plate boundary between Balochistan basin and Indus basin lies in the Western Indus suture. The both structures are about 1000 - 1500 km trends northward. The northward bending of strikes in the southern Balochistan basin (from Arabian sea to Kharan) on the western flank of Chaman transform fault and dragging of Kharan limestones revealed left lateral strike slip fault. The structures of Balochistan basin are mostly imbricated while the structure of Indus basin is mostly folded. Different basins in Pakistan yielded dinosaurs and diverse Mesozoic vertebrates like poripuchian titanosaurian sauropods, vitakrisaurid abelisaurian theropods, induszalimids, sulaimanisuchid and mithsaraikistanid mesoeucrocodiles, saraikisaurid pterosaurs, wasaibpanchid bird, madtsoiid snake, zahrisaurid plesiosaur and some fishes. From Pakistan 10 titanosaurs were named while from India 5 titanosaurs were named and discussed here. The updated assessment for the attribution of bones to *Jainosaurus septentrionalis* resulted the braincase its type or in other case braincase and scapula referable to *Isisaurus colberti* matching its long articular surface for coracoid of distal scapula. Key bones which were previously referred to *Jainosaurus septentrionalis* belong to mostly *Gspsaurus pakistani* and *Balochisaurus malkani* (stocky titanosaurs) and a few bones to *Isisaurus colberti* and *Pakisaurus balochistani* (slender titanosaurs).

Keywords

Plates Boundary, Chaman Transform Fault, Western Indus Suture, Structural Geology, Balochistan Basin, Tethys Link, Indus Basin, Gondwanan Link, Dinosaurs, Titanosaurs, Comparison, Maastrichtian, Pakistan, India, *Jainosaurus*

1. Introduction

Due to northward journey from Southern Earth Hemisphere to Northern Earth Hemisphere, the Indo-Pakistan Subcontinental plate (Gondwanan link) came close to Asian plate during Late Cretaceous, then the stress created subduction of Tethys plate (at the line of Karakoram Suture) under Hindukush-Karakoram (Asian block) resulted in the form of Karakoram magmatic arc. Further stress at later created subduction of Tethys sea plate (at the line of Northern Indus Suture) under Kohistan-Ladakh belt (Tethys part) resulted in the form of Kohistan-Ladakh magmatic arc. When Indo-Pakistan subcontinental plate reached at the northern Indus Suture during latest Cretaceous, because of being stronger (than Kohistan Tethys part) was not able to subduct more but as a result folding, faulting and rising of mountains started. Due to first collision, uplift took place in the sutures and surrounding areas resulted in the birth of Paleo Indus river systems (northwest to southeast, north to south) and end of Paleo Vitakri river systems (east to west) especially in upper and middle Indus basins. There is a controversy regarding the plates boundary between Balochistan and Indus basins, which is being resolved here. Balochistan basin is divided into 9 sub basins on the basis of structure and lithologies of rocks and spatial distribution. Indus basin's major structures (anticlines and synclines) were mapped and described. The dinosaurs and other Mesozoic vertebrates of Pakistan discovered recently at the dawn of third millennium (since 2000) are terrestrial and marine reptiles, fishes, pterosaur and bird. The attributed bones, key elements, distinguishing features and their comparisons were also carried out. Previously many bones were attributed to *Jainosaurus septentrionalis* but here the present research revealed its updated attribution.

Institutional Abbreviations: GSP, Geological Survey of Pakistan, Quetta, Pakistan.

2. Materials and Methods

Here the materials used is the previous work, also new field work done during many field seasons and remote sensing by satellite images. All these data are used for the deduction of plates boundary and structural geology of Balochistan and Indus basins. Updates were also mentioned regarding dinosaurs from Pakistan. Further an updated assessment was also done for the attribution of bones, key bones, distinguishing features and comparison of titanosaurs from India and Pakistan. The methods used here are different discipline of geological sciences and description of data and fossils.

3. Results and Discussion

The results and discussion are presented here about the plates boundary and structural geology of Balochistan and Indus basins of Pakistan, Dinosaurs from Pakistan with different aspects, and Titanosaurs from India with updated assessment of *Jainosaurus septentrionalis*.

3.1. Plates Boundary between Balochistan Basin (Tethys Sea Link) and Indus Basin (Gondwanan Link) through Field Observations on Chaman Transform Fault and Western Indus Suture (Pakistan)

There are two major structural elements like Chaman Transform Fault and Western Indus Suture. The Indus Suture is divided into Northern Indus Suture and Western Indus Suture. The Northern Indus Suture (Fig. 1 of [1]) located in the northern part of Indus Basin while Western Indus suture (Fig. 1 of [1]) is located on the western extremity of Indus Basin (Bela-Khuzdar-Nal-Basima-Shaikh Wasil-Ghazaband-Gawal-Khanozai-Muslimbagh-Nisai-Zhob-Waziristan. Northward from Waziristan it enters into Afghanistan and return back into Pakistan into the Mohmand area where the junction of northern Indus Suture and western Indus suture are located. Indus Suture is more than 20 km wide and more than 2500 km long. Due to obduction of ophiolitic rocks from the oceanic crust, it is generally understood as the boundary of plates. It is represented by ophiolitic rocks and its sedimentary and metamorphic melanges. Many author estimated the obduction of ophiolitic rocks during late Cretaceous during the initial collision of Indo-Pakistan subcontinental plate with Asian plate. Toward west from the Western Indus Suture is the flysh sediments and magmatic arc of Balochistan Basin. It is necessary to mention that a lot of differences of rocks and their features are found in between the Indus basin and Balochistan basin. Balochistan basin has flysh marine clastic sediments and metasediments with negligible carbonate limestone (except the Shagala and Talar sandstones which are terrestrial in nature), while Indus basin has commonly marine carbonate and some terrestrial sediments upto Eocene, after Eocene mollasse type detritial sediments are common.

The second major tectonic structural element found is the Chaman Transform

Fault. The Chaman Transform Fault (Figure 1) runs from west of Uthal (west of Bela fracture zone), west of Bela, Ornach-Nal, Nal to Basima, Basima to Kharan-Noshki-Chaman to Jalalabad. Northward from Chaman, this transform fault runs into Afghanistan and reaches upto Jalalabad in Afghanistan or west of Mohmand area. This transform fault is left lateral strike slip fault. This movement is commonly known from the northward dragging of Kharan limestones and also northward deflection of strike of Ras Koh, Wazhdad-Zurati, Siahan and Makran ranges. Kharan Limestone is dragged many decades of kilometers from its type locality (Kharan area of Ras Koh Range) along Chaman Transform Fault.

There is a controversy to fix plate boundary between Balochistan basin and Indus Basin. There are two schools of thoughts; one thought is that the Western Indus Suture is the boundary between Balochistan and Indus Basins, while second thought is that the Chaman Transform Fault is the plate boundary. The author visited many areas like Uthal, Bela, Khuzdar, Ornach, Nal, Basima, Kharan, Noshki, Mastung (west of Shaikh Wasil-Ghazaband anticline), Chaman and Kamardin Kareez to confirm the contact of flysh clastic rocks of Balochistan Basin and marine carbonate sediments of Indus Basin. The present author believes that the Western Indus Suture is the plate boundary while Chaman transform fault is at places it is plate boundary especially in the southern part, *i.e.* west of Uthal and Bela, Ornach to Nal and then Nal to Basima. From Basima to northward, the Chaman transform fault is bifurcated westward from the western Indus Suture. Here the Chaman transform fault is not plate boundary in the central part of Chaman transform fault like Basima to Kharan to Noshki to Chaman. Here Chaman transform Fault is located within flysh sediments and slates of Balochistan Basin. The Ghazaband-Shaikh Wasil anticline and its further southward extension to Toba (west of Gidar) and western Surab area to Basima is the plate boundary between Balochistan and Indus basins. The author found a flysh sediments and metasediments of Balochistan Basin just at the western base of this anticline and east of Chaman Transform Fault (Figure 1). Further northward the Pishin basin or northern Balochistan basin or Kakar Khorasan basin of Zhob and Pishin area consists of commonly flysh sediments and metasediments of Balochistan (except Sharan Jogezai area where carbonates and fine clastics of Sharan Jogezai and Nisai groups, [1]) Basin. So it is confirmed this Pishin basin which is located east of Chaman transform fault and west of western Indus suture *i.e.* sandwiched between these two major structural elements belong to Balochistan basin (Figure 1) due to characteristic features of flysh sediments and metasediments and rare finding of carbonate rocks. From Ghazaband to west of Karchap to west of Toba and Sorab to western Basima, there is a north south longitudinal belt between the Chaman Transform Fault and Western Indus suture, this longitudinal belt belongs to Balochistan basin flysch and metamorphic slates. Southward from Basima toward Arabian Sea, both structural elements overlap or close to overlap with each other showing plates boundary.

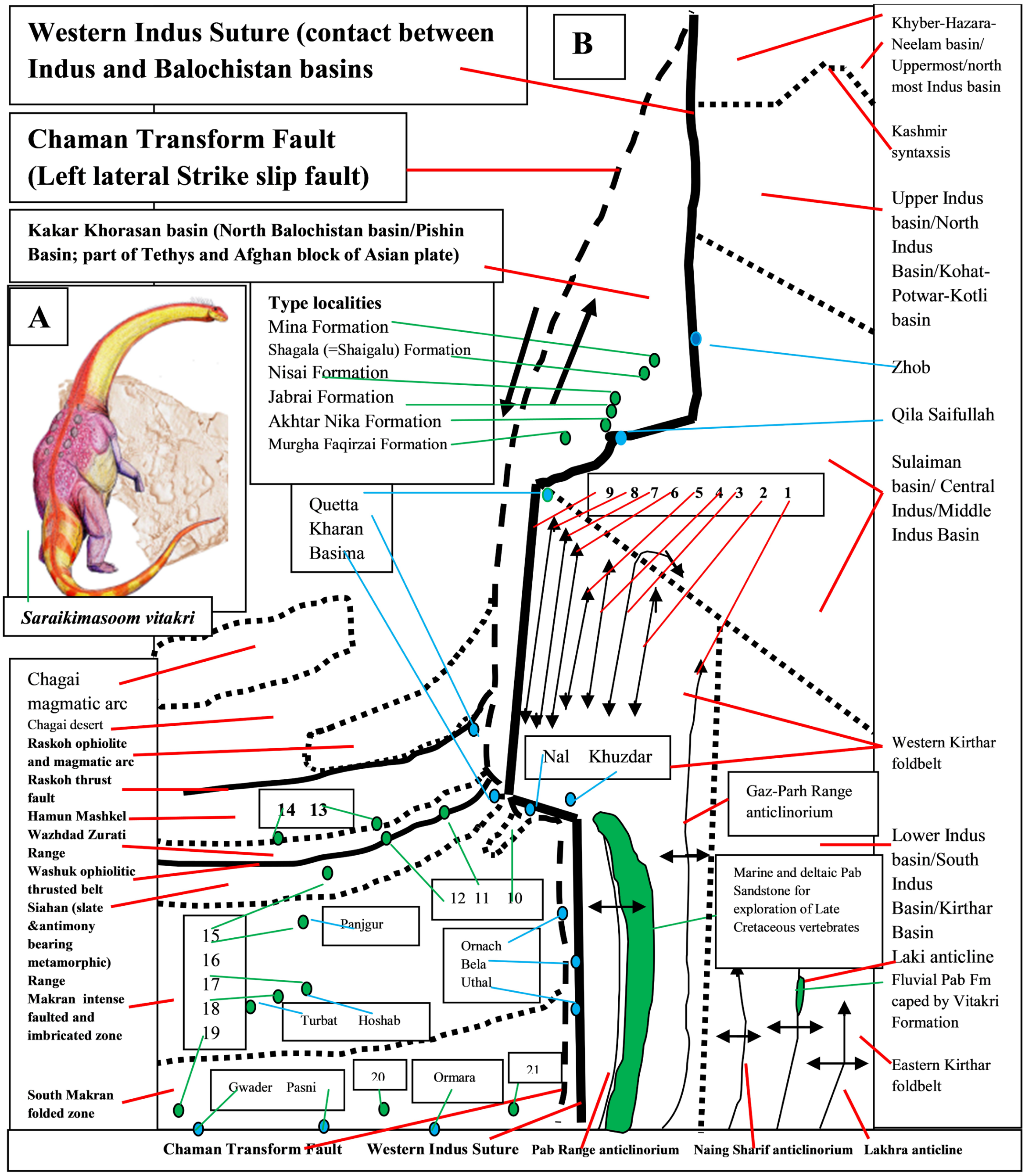


Figure 1. (A) *Saraikimasoom vitakri* model managed by British Journalist Nicholas Allen and prepared by Russian Paleoartist Dr. Dmitry Bogdanov. (B) Plates Boundary of Indus Basin (part of Gondwana) and Balochistan Basin (part of Tethys Sea). Western Indus Suture and Chaman Transform Fault are major structure located on and near the plates boundary of Balochistan and Indus Basins. 1, Gaz-Parh Range anticlinorium. 2, central Dilband anticlinorium. 3, western Dilband anticline. 4, Siah Koh anticline. 5, Koh Maran anticline. 6, Khad Kucha anticlinorium. 7, Shirinab anticlinorium. 8, Rodangi thrusted anticlinorium. 9, Ghazaband-Shaikh Wasil-Basima thrusted anticline, its western contact is suture between Balochistan and Indus basins. 10, Nal Limestone of Indus basin affinity found in Makran range showing butt contact. 11, Toe Koh intrusion. 12, Washuk ophiolite (Mazargati and Jahl localities). 13, Wazhdad volcaniclastic Formation. 14, Zurati Formation. 15, Siahan Formation (slates). 16, Panjgur formation. 17, Hoshab Formation. 18, Kech Formation. 19, Chatti Formation. 20, Talar Formation. 21, Parkini Formation (including Hingol River locality). All these anticlines/anticlinoria are alternated by synclines or synclinoria. Legend; Thick black line is Western Indus Suture, Thin black line is thrusted fault, Thick dashed line is Chaman transform Fault (Ornach-Nal-Basima-Chaman-western) Mohmand Transform Fault (Left Lateral Strike Slip Fault). Dotted lines are contact of basins/sub-basins.

3.2. Structural Geology (Folds and Faults) of Balochistan Basin (Tethys Sea Link) and Indus Basin (Gondwanan Link), Pakistan

Balochistan basin is located in the western Pakistan. This basin is contacted with Indus Basin via Western Indus Suture. The Chaman Transform Fault is located on eastern part of Balochistan Basin. Balochistan basin is the result of subduction of Arabian Sea plate just below the Chagai-Raskoh plate, a part of Tethys sea plate. The first subduction event is happened just after the first collision of Indo-Pakistan continental plate which may be forced the Arabian plate to travel northward and subsequently subduct below the Chagai-Raskoh plate (early Trench) at the late Cretaceous or Paleocene. The second subduction event occurred at Washuk ophiolitic thrust belt and subducted at the line of Washuk ophiolite belt and as a result the Wazhdad and Zurati volcaniclastics are developed (second trench) at the Early Eocene. After this the development of Makran and Talar groups are deposited under marine conditions except terrestrial Talar sandstone. The travelled backward (toward south at this moment) may be near the coastal areas (south of Jiwani-Gwader-Pasni-Ormara). Indus Basin is part of Indo-Pakistan Subcontinental plate which after long journey collided and converged with Asian plate and sandwiched Tethys belt (Kohistan-Ladakh belt) described as above.

Structural Geology (folds and faults) of Balochistan basin (Tethys Sea link), Pakistan: Balochistan super basin is divided here into 9 basins (**Figure 1**) based on structures, diverse lithologies and diverse spatial nature of deposition, etc. Traversing from north to south are, the northern basin is Pishin basin or Kakar-Khorasan basin or northern Balochistan basin located in the northern end of Balochistan basin. The Pishin basin (contacted with Katawaz basin of Afghanistan) strata trended as northeast and north south. This Pishin basin hosts sediments and metasediments including Cretaceous Sharan Jogezai Group (Akhtar Nika and Jabrai formations, hosting carbonates), Paleocene Nisai Group including Nisai limestone (and its coeval Ispikan Conglomerate in Panjgur area South Makran), and Eocene Shagala Group including Eocene Murgha Faqirzai (marine shale and slates), Mina Formation (marine green shale and sandstone) and Shagala Formation (terrestrial mottled and maroon to red shale and sandstone with *Pakitherium* large rhino bearing) [2]. The terrestrial strata of Vihowa and Sakhi Sarwar groups were also found on the northern part of Qila Saifullah area. Active extrusive mud volcano was also observed in Sharan Jogezai area just northwest of Qila Saifullah or north of Nisai. All these sediments and metasediments (with rare stibnite veinings) which represents most common imbricated thrust faults with moderate to high dips and some anticlinal and synclinal folds with low to moderate dips especially in the eastern part where Oligocene and later sequence is commonly folded. The second sub-basin is Chagai magmatic arc located in the western extremity of Pakistan, which followed by third sub-basin Chagai desert. The general trends of Chagai magmatic arc are northeast. The

Chagai magmatic arc consists of magmatic rocks (as clear from name) and lava flows under marine environments, marine sediments and metasediments varying from Cretaceous to Oligocene marine strata. While the Miocene to Recent age strata are terrestrial and fluvial, except Koh Sultan volcanic Group. In the Chagai desert the bed rocks are covered by eolian sand dunes.

The fourth sub-basin is Raskoh magmatic arc which is located in the east and southeast of Chagai arc and north of Hamun Mashkel. The general trends of Raskoh magmatic arc are northeast. The Raskoh magmatic arc consists of magmatic rocks (as clear from name) and lava flows under marine environments, and sediments and metasediments varying from Cretaceous to Oligocene marine strata. While the Miocene to Recent age strata are terrestrial and fluvial. Followed by fifth sub-basin Hamun Mashkel Subrecent to Recent eolian desert which covered or caped the bed rocks. The sixth sub-basin is the Wazhdad-Zurati arc situated just south of Hamun Mashkel (Mashkel desert) and north of Washuk ophiolitic thrust fault and also Siahan Range (**Figure 1**). The Wazhdad-Zurati arc consists of marine Wazhdad volcaniclastic rocks and metasediments, and marine Zurati Formation consisting of sandstone, shale and slates. The Wazhdad-Zurati range generally trends east west in the west and middle while it is northeast in the east where its general trends is deflected northward due to dragging along Chaman Transfer Fault. While the Pleistocene Kech or Kamerod Formation (is found on the contact of Zurati Range and Mashkel desert) consists of fluvial conglomerate, clays and sandstone. The seventh sub-basin Siahan Range (antimony and slate hosting range) trends east west in the west and middle portion, while it is also deflected northward in the east. The Siahan Range hosts marine sediments and metasediments including Cretaceous Ispikan conglomerate, Paleocene-Eocene Wakai limestone (a formation of Nisai Group), Eocene Siahan Group which includes Siahan (shale and slates), Zurati (Sandstone, shale, slates and volcaniclastics), Wazhdad volcaniclastics, Washuk ophiolite complex and Washuk Intrusion (Toe Koh intrusion), and Eocene-Oligocene Makran Group which includes Hoshab (shale and rarely sandstone) and Panjgur (sandstone and shale) formations. Antimony (stibnite with gold in the core of quartz-carbonate veins) found on and near the peak where intense and imbricated faults and high dip strata were common. Some anticlinal and synclinal folds show low to moderate dips. The Quaternary is terrestrial represented by fluvial Kech Formation [2].

The eighth sub-basin is north Makran faulted ranges (**Figure 1**) with general trends of strata as east west in the west and deflected northward in the east where contacted with Chaman Transform fault and also western boarder of Western Indus Suture. This hosts sediments and metasediments including Cretaceous Sharan Jogezai Group (Akhtar Nika and Jabrai formations, hosting carbonates in Mand area near Iran border), Paleocene Nisai Group including Ispikan Conglomerate in west of Panjgur area and sparsely distributed Wakai limestone, Eocene Siahan and Panjgur groups. The Quaternary is mostly terrestrial ere represented by Pleistocene terrestrial and fluvial Kech Formation. All these sediments and metasediments which represents most common imbricated thrust faults with moderate to high dips and some anticlinal and synclinal folds with low to moderate dips especially in the eastern part where Oligocene and later sequence is commonly folded. The last ninth sub-basin south Makran folded ranges (**Figure 1**) located just north of Arabian Sea. It consists of Makran Group (Panjgur and Hoshab formations) and Talar Group which consists of Parkini mudstone, Talar Sandstone and Chatti mudstone, Jiwani shelly limestone, Ormara and Kech formations and active extrusive mud volcanoes. Talar sandstone is terrestrial and hopeful for terrestrial fossils exploration. This sub-basin commonly show folded anticlinal and synclinal structures generally trending east west in the west and north east or north south in the eastern part (**Figure 1**) where contacted with Chaman Transform Fault and eastern boarder of Western Indus Suture.

Structural Geology (folds and faults) of Indus basin (Gondwanan link), Pakistan: Indus super basin is divided into Khyber-Hazara-Neelam basin (uppermost/North most Indus), Kohat-Potwar-Kotli basin (upper/North Indus), Sulaiman basin (middle/central Indus) and Kirthar basin (south Indus) (**Figure 1**). Khyber-Hazara-Kashmir consists of diverse sedimentary, igneous and metamorphic rocks. The faults and smaller folds are found in this basin. Having igneous rocks major structures like anticlines and synclines are not found in this belt. The metamorphic grade is increasing toward north Indus Suture. The Kohat-Potwar-Kotli basin consists of mostly sediments ranging in age from Precambrian to recent. This basin represents mostly repeated foldings alternated anticlines and synclines. However some faults are also found in this basin. This basin show major thrust faults in the north extremity commonly called main boundary thrust (MBT) and also south extremity thrust may be called as Salt Range-Surghar-Khisor thrust (SSKT). The Sulaiman basin (also called Koh Sulaiman basin) consists of exposed Permian to recent sediments. This basin consists of faults and also repeated folds in its northern part (presented with detail in [1]) and also southern part (presented with detail in [3]). This basin represents commonly alternated anticlines and synclines mostly trending north south in the north and trending almost east west in the south. In generally it forms arc shape trend. Some major and minor faults are also observed in this basin.

The Kirthar basin represents repeated folds (anticlines and synclines) (**Figure 1**) and also some faults. The Kirthar foldbelt was divided into Western Kirthar foldbelt and Eastern Kirthar foldbelt [4]. The northern part of western Kirthar foldbelt just west of Bibi Nani and Mach represents alternated nine anticlines and eight synclines (**Figure 1**). The anticlinal names from east to west are Gaz anticline alternated by a syncline, then Dilband anticline alternated by western Dilband syncline, Johan anticline alternated by Isplinji syncline, followed by Siahkoh anticline alternated by east Dasht syncline, Koh Maran anticline alternated by west Dasht syncline, eastern Khad Kucha anticline alternated by Khad Kucha syncline, Shirinab anticline repeated by Shirinab valley syncline, Rodangi anticline repeated by western Rodangi syncline and lastly Shaikh Wasil-Karchap anticline. These anticlines are doubly plunging (in the north and south). These anticlines are alternated by synclines trended mostly north south. The oldest core formations are Permian-Triassic Wulgai Formation (shale, marl and limestones) and Jurassic Chiltan Limestone. The youngest core formations are mostly Eocene strata and Chamalang Group. The dips of these structures are mostly moderate to high dips while at places low dips. The western base of Shaikh Wasil-Karchap anticline is contacted with Tertiary flysh deposits and metamorphic slates of Balochistan basin. This is the actual contact of Indus basin plate and Balochistan basin plate. The southern part of Western Kirthar foldbelts also represents Parh Range anticlinorium and Pab Range anticlinorium alternated by Hub synclinorium (**Figure 1**). The Chaman Transform Fault in the west and then thrust of Western Indus Suture and many other faults were found.

The eastern Kirthar foldbelt represents repeated anticlines and synclines (**Figure 1**). These tectonic structures represents from east to west are Lakhra anticline alternated by Ranikot syncline, Laki anticline alternated by Manchar synclinorium, Naing Sharif anticline alternated by a Naing sharif syncline. Then westward Parh Range anticlinorium of western Kirthar foldbelt are started (**Figure 1**). In eastern Kirthar the rocks and folded structure trends generally north south. In Lakhra anticline Paleocene Lakhra terrestrial and deltaic unit is exposed in the core which is surrounded by younger formation in the limbs and plunges. The eastern Ranikot syncline hosts mostly marine Laki limestone and terrestrial fluvial Vihowa Group or Manchar Group mollase strata. The anticlinal oldest core formation is the Late Cretaceous Pab Sandstone exposed in the Laki anticline. The Manchar syncline (trending north south just south of Lake) hosts mostly marine Laki limestone and rarely fluvial Vihowa Group or Manchar Group mollase strata. The Eastern Naing Sharif anticline which is alternated by Naing Sharif syncline, both hosts Eocene Laki limestone in the core. Laki anticlinal thrust fault is a major fault trended generally north south. Here the oldest exposed thrust strata are the Pab and Vitakri formations of Fort Munro Group and younger strata as mentioned above. Many smaller faults were also found.

3.3. Pakistani Dinosaurs and Other Mesozoic Vertebrates from Pakistan

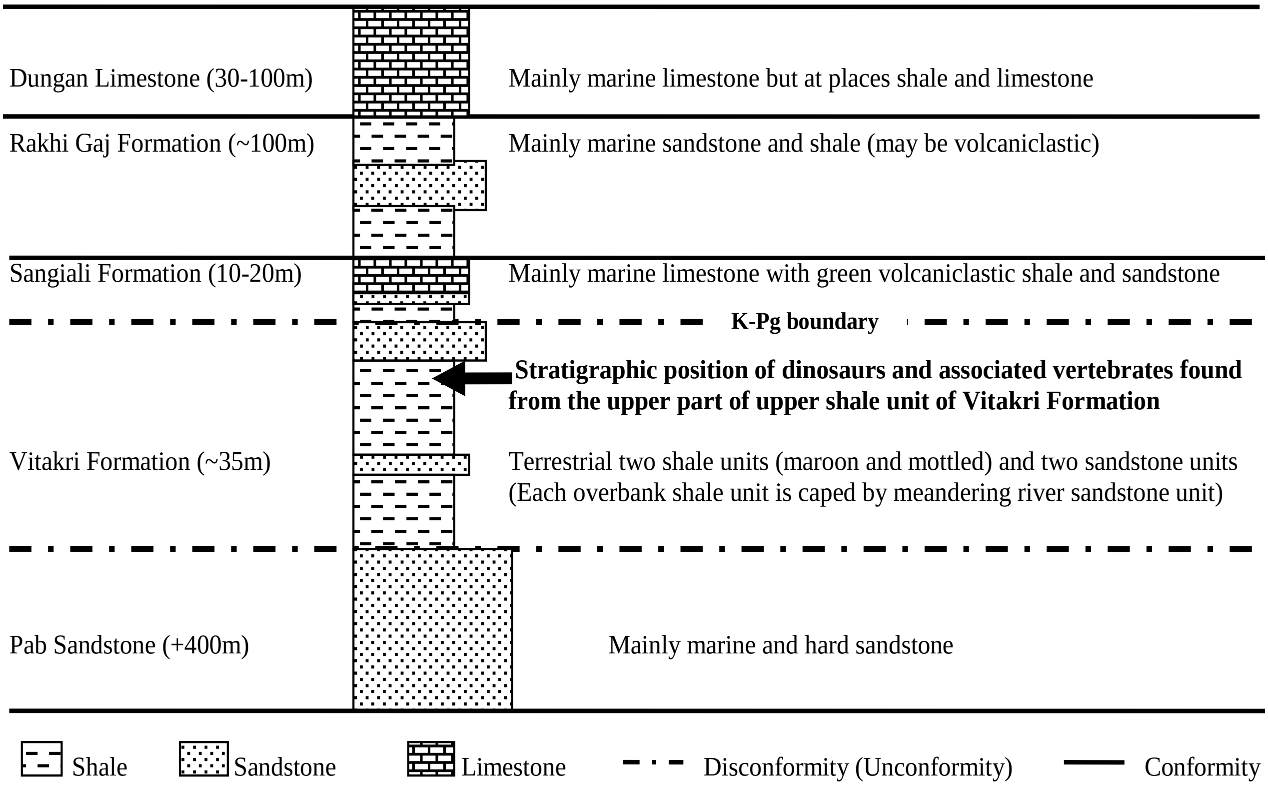
Recently from 2000 to so far the dinosaurs (and following vertebrates) were reported from different basins of Pakistan. The sediments of Hindukush-Karakoram basin and Kohistan-Ladakh magmatic arc yielded large number of invertebrates and seem low potential for marine vertebrates and very low potential for terrestrial vertebrate exploration. The Chapursan valley (northwest of Hunza area) is significant for Mesozoic terrestrial vertebrate's exploration. The Balochistan basin (including Chagai-Raskoh-Wazhdad magmatic arc) yielded significant numbers of fossils of paleofauna and rare fossils of paleoflora. Mesozoic vertebrates were not found from Balochistan basin so far but Eocene large rhinoceros *Pakitherium shagalai* [5] with her baby were reported. Hingol, Talar and surrounding areas in the south Balochistan basin and Shagala-Kamardin Kareez areas in the north Balochistan basin are significant for further Cenozoic terrestrial vertebrate exploration, the remaining areas may be explored for marine vertebrate fauna. The Indus basin also yielded significant numbers of fossils of paleofauna and rare fossils of paleoflora. Recent paleontological exploration during 2000-2022 yielded over than 50 new biotas from Pakistan like 1 bone taxa of titanosauriform, 10 bone taxa and 2 ichnotaxa of titanosaurian sauropods, 2 ichnotaxa of ornithischian or titanosaurian sauropods, 3 bone taxa and 2 ichnotaxa of theropods, 7 taxa of crocodiles, 1 bone taxon and 1 ichnotaxon of pterosaur (flying reptiles), 1 taxon of snake, 1 taxon of bird, 1 taxon of plesiosaur (marine reptile), 3 taxa of fishes, 9 taxa of mammals, 7 taxa of invertebrates and 1 taxon of plant [6] [7].

The Khyber-Hazara-Neelam Basin yielded large number of invertebrates but not any significant vertebrates. The Kohat-Potwar-Kotli basin yielded the following fauna. Recently a body section of Cambrian fish *Muzaffarabadmachli abbottabadi* [8] vide [7] was reported. The Kohat-Potwar-Kotli Basin yielded a few tracks and trackways from the latest Jurassic Samana Suk limestones such as *Malakhelisauroperus mianwali* [7] (=*Malasaurus mianwali* [9] =*Malakhelisaurus mianwali* [10] =*Malakhelpodus mianwali* [11]) Ornithopaonia Sauropoda/Ornithopoda, *Samanadrindoperus surghari* [7] (=*Samanadrinda surghari* [9] =*Samanapodus surghari* [11]) Theropaonia the large Theropoda, *Himalayadrindoperus potwari* [7] (=*Himalayadrinda potwari* [12] =*Himalayapodus potwari* [11]) Theropaonia the noasaurian theropod, and *Anmolpakhiperus alleni* [7] (=*Anmolpakhi alleni* [8]) =*Anmolpodus alleni* [11]) Pteropaonia the Pterosauria.

The Kirthar basin recently yielded Jurassic Plesiosaur *Zahrisaurus kilmoolai* [8] vide [7], Latest Jurassic or Early Cretaceous titanosauriform/early titanosaur *Brohisaurus kirthari* [6] [13], a bone of late Cretaceous titanosaur [14], and a bone of Cretaceous Crocodile *Khuzdarcroco zahri* [12] vide [7], an egg of Cretaceous crocodile and fish body cross section of Cretaceous *Karkhimachli sangiali* [12], a teeth of Early Eocene *Kilgai moolakharzani* [8] vide [7] sea cow Sirenian, many invertebrates like a Permo-Triassic *Moolatrilo chotoki* [8] vide [7], Cretaceous-Paleogene *Pakiring kharzani* [12] vide [7], Early Paleocene or Danian *Pakiwheel karkhi* [12] vide [7] and Early Eocene *Mulastar zahri* [12] vide [7]. A pes of sauropod Sauropaonia *Chiltansauroperus nicki* [7] (=*Chiltanpaer nicki* [6]) was reported from the latest Jurassic Chiltan Limestone of Kharzan Moola area of Khuzdar district.

The Sulaiman basin recently yielded ichnotype *Pashtosauroperus zhobi* [7] (=*Pashtosaurus zhobi* [12] =*Pashtopodus zhobi* [11]) Ornithopaonia, Dinosauria, and *Anmolpakhiperus alleni* [7] (=*Anmolpakhi alleni* [8]) =*Anmolpodus alleni* [11]) Pteropaonia the Pterosauria flying reptile from the sandstone beds of Sor Member [1] (dominantly maroon shale with subordinate sandstone) of Maastrichtian Pab Formation [1] and *Dgkhansauroperus maarri* [7] (=*Dgkhansaurus maarri* [6] =*Dgkhanpodus maarri* [11]) Sauropaonia the Sauropoda from Dhaola Member [1] (white sandstone with minor shale) of Pab Formation, and the following bone taxa from the latest Cretaceous (latest Maastrichtian) Vitakri Formation [15]. The Vitakri formation was upgraded as formation [15] from the upper Vitakri Member [16] (of Pab Formation). The Maastrichtian Pab Formation (marine sandstone with minor shale) is about 500 m thick in the Koh Sulaiman and surrounding area which is capped by 2 - 35 m thick latest Cretaceous (latest Maastrichtian) terrestrial Vitakri Formation (fluvial two shale units where each shale unit is capped by a sandstone unit). Most of the following Mesozoic vertebrates were collected from the exposed surface of terrestrial maroon and mottled upper clay/shale unit (just below the upper sandstone unit) of Vitakri Formation of Pakistan. However some bones were also produced from lower shale/mud unit in the Dhaola Range. Most of the vertebrates [6] collected from coeval strata and coeval position (**Table 1**) of different localities found just below the K-Pg boundary representing latest Maastrichtian age (~66.1-66 Ma). The holotypes of most of the taxa were found from the Vitakri dome anticline (Fig. 4 of [6]) and holotypes of *Balochisaurus malkani* from southern 3 sites and *Marisaurus jeffi* from northern 2 sites were found from eastern plunge of Mari Bohri-southern Fazil Chel anticline (just near the village of Mari Bohri) (Fig. 4 of [6]). In the Vitakri dome area the middle sandstone unit is mostly covered by colluvial sandstone and shale scree of upper shale and upper Sandstone units. The upper shale unit capped by upper sandstone unit was the guide marker for bone exploration. In the Vitakri dome area the dips of most of the producing localities are as low as 5^0. While the dips of Dhaola range are high, most of the dips of Mari Bohri, Pikal and Fort Munro ranges are moderate. The latest Maastrichtian Vitakri Formation and Danian (Earliest Paleocene) Sangiali Formation are developed only in the Vitakri and surrounding areas like Dhaola and Pikal ranges in the east and Mari Bohri in the west. In the remaining areas of Sulaiman basin the late Cretaceous Pab and Early Paleocene Rakhi Gaj formations are well developed. The overbank fluvial shales [11] [16] which host the bones on exposures erode easily being light and soft than the hosted heavy and hard bones. Consequently on wind or raining, the bones remain in situ or close to it being heavy and resistant while shale eroded away easily being light and soft. This is the reason many bone assemblages revealed associated bones and consistent skeletons. Due to collection on exposed surface of in situ clay/shale of Vitakri Formation, quarry maps were not drawn. Besides the following dinosaurs, the mesoeucrocodiles like *Pabwehshi pakistanensis* [17], *Induszalim bala* [12] vide [6], *Sulaimanisuchus kinwai* [18] vide [6] and *Mithasaraikistan ikniazi* [6], pterosaur the flying reptile *Saraikisaurus minhui* [12] vide [6], the bird *Wasaibpanchi*

Table 1. Stratigraphic position (shown as arrow) of dinosaurs and associated vertebrates like Poripuchian titanosaurs (Sauropoda), abelisaurian theropods, mesoeucrocodiles, pterosaur (the flying reptile), bird and snake found from the different localities [6] in the latest Maastrichtian Vitakri Formation of Fort Munro Group. This table is modified after Figure 3 of [6] and Figures 6-10 of [16]. Arrow shows the stratigraphic position of dinosaur (and associated vertebrates) found from the same horizon and same position in different localities of the Vitakri, Dhaola, Pikal, Fort Munro and Mari Bohri ranges [6] [15]. Here logged are Maastrichtian Pab Formation, latest Maastrichtian Vitakri Formation (just below the K-Pg boundary), Early Paleocene Sangiali and Rakhi Gaj formations and Late Paleocene Dungan Formation while pre and post strata are also exposed [6].



damani [6] and snake *Wadanaang kohsulaimani* [6] were discovered from Pakistan.

3.3.1. Poripuchian Titanosauria from Vitakri Formation of Pakistan; Updated Attribution, Key Elements, Distinguishing Features and Comparison

From India dinosaurs discovered since about 2 centuries ago [19] but from Pakistan dinosaur discovered recently about 2 decades of years (since 2000) [6] [7] [20]-[27]. All the Indian latest Cretaceous titanosaurs are unofficial and informal except *Isisaurus colberti* while all Pakistani latest Cretaceous titanosaurs are formal and official as per standard set by International Code of Zoological Nomenclature/ICZN [6] [7]. Ten titanosaur genera named so far from the Latest Maastrichtian (67 - 66 Ma) Vitakri Formation of Pakistan. Among these *Gspsaurus*, *Saraikimasoom*, *Pakisaurus*, *Sulaimanisaurus* and *Khetranisaurus* were formally described as per standard set by ICZN in August 2021 [11] and other four titanosaur taxa like *Balochisaurus*, *Nicksaurus*, *Maojandino* and *Marisaurus* were formally described as per standard set by ICZN in September 2021 [12] and

Khanazeem is being described here as per standard set by ICZN. Recently found titanosaur materials from Pakistan are considerably more than the titanosaur materials reported from India since round about 2 centuries ago. Some Pakistani titanosaurs consist of cranial and postcranial associated skeletons while some have vertebral and appendicular associated assemblages. Further most of Pakistani titanosaurs show overlapping holotypic bones with each other which provide the best opportunity for correlation and comparison among each other and coeval titanosaurian sauropods from India and also from global world. Titanosaurian osteoderms and armor bones reported from Pakistan in 2003 which were first reported from Asia and also Indo-Pakistan subcontinent [21]. Later these were assigned to species level [7] [11] [14] [24] [26].

Poripuchia [11] vide [6] is a clade of titanosaurs includes all tail procoelous vertebrae including distalmost procoelous caudals (except first biconvex caudal in *Balochisaurus* and *Marisaurus*) while lithostrotians have no distalmost procoelous caudals. From South Asia especially from Pakistan, some titanosaurian sauropods have distalmost procoelous caudals while others have not assigned distal caudals. *Gspsaurus*, *Balochisaurus*, *Marisaurus*, *Pakisaurus* and *Isisaurus* have yielded distalmost procoelous caudals and assigned as members of Poripuchian titanosaurs.

Titanosaurian sauropods from South Asia are divided into Pakisauridae [22] vide [6], Balochisauridae [22] vide [7], and Gspsauridae [12] vide [6]. Pakisauridae represents the titanosaurs which have caudals with no ventral reduction like *Pakisaurus*, *Khanazeem*, *Sulaimanisaurus*, *Isisaurus* and *Khetranisaurus*. Balochisauridae represents the titanosaurs which have caudals with ventral reduction and first biconvex caudal like *Balochisaurus* and *Marisaurus*. Gspsauridae is based on snout, mandible and dentition morphology. It is further subdivided into Gspsaurinae [12] vide [6] which have V-shaped lower teeth row like *Gspsaurus*, and *Saraikimasoominae* [12] vide [6] which have U-shaped lower teeth row like *Saraikimasoom*. The following titanosaurian sauropod dinosaur's taxa listed on chronological order based on published records as per standard set by ICZN.

Gspsaurus pakistani: *Gspsaurus pakistani* [12] vide [6] is a Gspsaurinae [12] vide [6], Gspsauridae [12] vide [6], Poripuchia [11] vide [6], titanosaurian sauropod which was formally (as per standard set by ICZN) described in 2021 [6]. Its holotype is represented by cranial and postcranial skeleton including snout and adjoining skull elements, braincase, cervical, dorsal and caudal vertebrae, ilia/sternal, left and right scapulae, radius, left femur, left and right tibiae [6] [24] found from the central Alam locality (19). Following fossils from Pakistan and India were referred to *Gspsaurus pakistani*. *Gspsaurus pakistani* bone assemblage from Top Kinwa 16 may belong to single individual includes dorsal vertebrae, a pair of sacral vertebrae (GSP/MSM-137-16; [23]), caudal vertebrae, distal caudal vertebra, convex part of sternal, sternal part, a pair of left and right distal scapulae, a pair of left and right proximal ulnae, distal ulna, part of ilia, acetabulum, proximal stocky tibia, a pair of proximal fibulae, cervical ribs, neural spine, mosaic type osteoderms, and oval ungual or osteoderms or sacral vertebrae [7] [24]. This bone assemblage found in the same site, same formation, no duplication and fit size and fit features, found in about 15 m diameter as surface finds on very gentle slope of Vitakri mud units. This bone assemblage is found very close to nearby peaks and there are no any chances of any far stream detritial source. *Gspsaurus pakistani* referred associated fossils (possibly a skeleton of single individual) from south Kinwa include atlas-axis complex, 5 caudal vertebrae, distalmost caudal vertebra, a pair of partial scapula, femur and large ellipsoidal armor bone [7] [24]. This bone assemblage found in the same site, same formation, fit size and fit features, and no duplication showing single individual skeleton. Further referred materials of *Gspsaurus pakistani* include a stocky typical type tibia from eastern Bor 2 locality of Vitakri Dome, a caudal vertebra (due to tall and ventral reduction matching) from Darwaza locality and a proximal humerus from Rahi Wali (referred tentatively) localities of Gambrak area (part of north western limb of Dhaola Range) [7] [24]. The referral of bone assemblages from Top Kinwa and South Kinwa of Pakistan [24], and Chhota Simla associated assemblage [28] [29] from latest Cretaceous Lameta Formation India like forelimb (left and right humeri, left radius) and hind limb (left femur, left tibia and left fibula) were referred to *Gspsaurus pakistani* discussed in detail by ([24], pages 458-459). A humerus GSP/Sangiali-1125 (**Figure 2**) from mid Sangiali [7] [24] which is being referred here to *Gspsaurus pakistani* found from adjacent stream with mid Sangiali assemblage and possibly eroded from upper Sangiali fossils of stocky titanosaur (*Gspsaurus*). Further a caudal vertebra K20/317 (Fig. 9 of [30]; Fig. 2c of [31]), a humerus from Bara Simla India (Plate IV, Fig. 1 of [30]; Fig. 2e and Fig. 8 of [31]) and right and left humeri from Rahioli Gujarat (GSI 20010, plate 1 and Figure 1 of [32]; GSI 20011, [32]), India are being referred here to *Gspsaurus pakistani* due to matching of key humeri (with medially inset straight and obliquely oriented deltopectoral crest) and caudal vertebra (tall and ventrally reduced) of *Gspsaurus pakistani.*

Gspsaurus pakistani has following distinguishing characteristics. It has V-shaped lower teeth row converged anteriorly while *Saraikimasoom vitakri* has U-shaped lower teeth row. It has conical, long and slightly recurved teeth (not closely contact but slightly spaced especially the mid of row) while *Saraikimasoom vitakri* has conical small to moderate sized slender and almost straight teeth. Its snout is relatively more larger than *Saraikimasoom vitakri.* Its teeth are slightly spaced especially in the mid row while *Saraikimasoom vitakri* has closely contacted teeth. It has relatively large sized braincase than *Saraikimasoom vitakri.* It has broad and constricted occipital condyle like *Saraikimasoom vitakri* while all coeval braincases from India have no constricted occipital condyle. It has decurved and much taller paroccipital processes of braincase than *Saraikimasoom vitakri* braincase. Its atlas-axis complex is broad [24] while axis from Nand, India [33] is tall may belongs to *Pakisaurus balochistani* or any other pakisaurids like *Khanazeem*

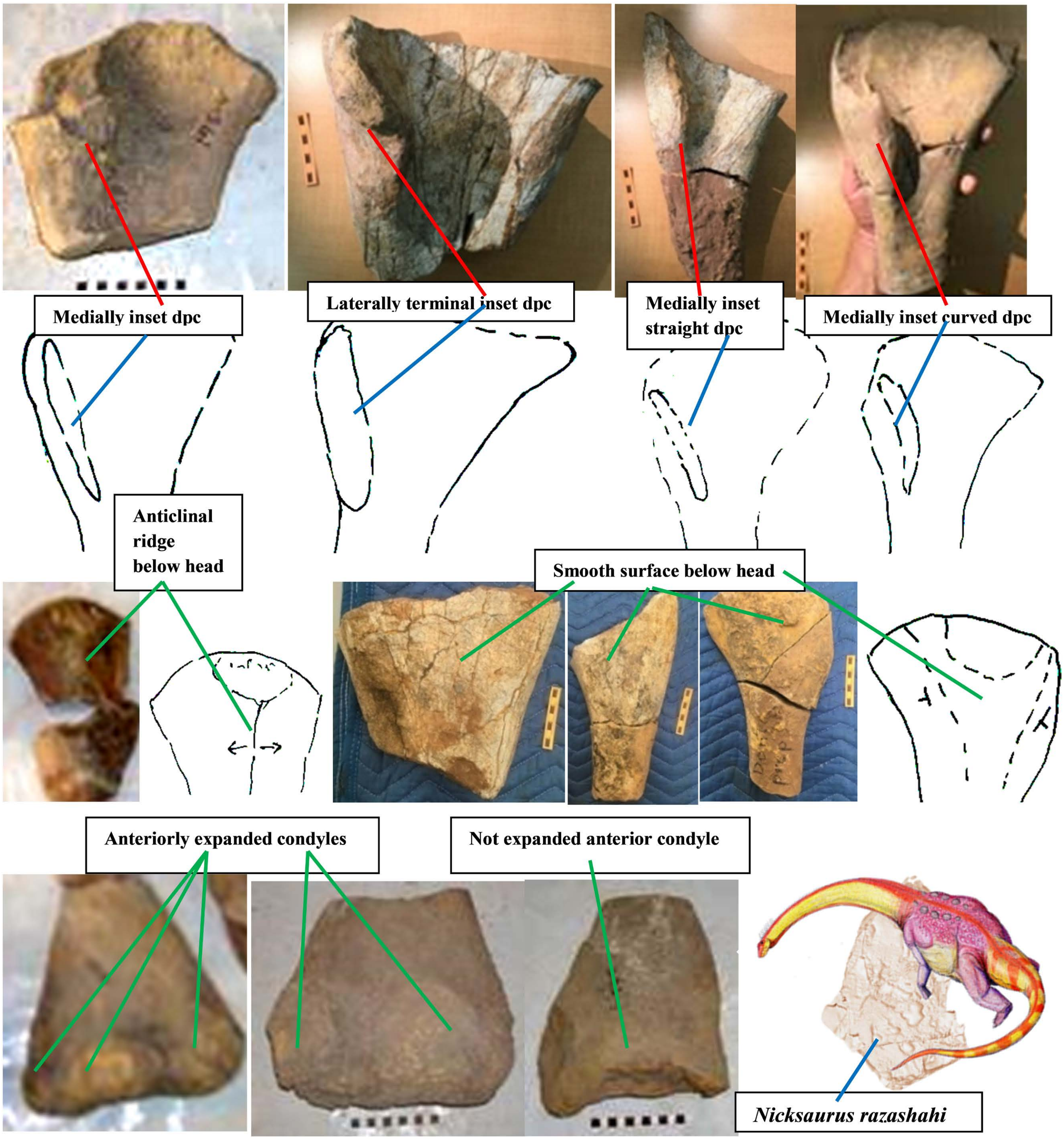


Figure 2. Humeri (4 morphs) of poripuchian titanosaurs from the latest Cretaceous Vitakri Formation of Vitakri dome area, Barkhan district, Balochistan Province, Pakistan. **Row 1 (Image)** and **Row 2 (line drawings)** of anterior views of proximal right humeri GSP/MSM-195-4 of *Pakisaurus balochistani*, GSP/Sangiali-1113 of *Balochisaurus malkani*, GSP/Sangiali-1125 of *Gspsaurus pakistani*, and GSP/Sangiali-1124 of *Sulaimanisaurus gingerichi*. **Row 3**, Posterior views of proximal right humeri GSP/MSM-202-4 (image and line drawing) (with mid humerus GSP/MSM-268-4) of *Pakisaurus balochistani*, GSP/Sangiali-1113 of *Balochisaurus malkani*, GSP/Sangiali-1125 of *Gspsaurus pakistani* and GSP/Sangiali-1124 (image and line drawing) of *Sulaimanisaurus gingerichi*. **Row 4**, anterior views of distal humerus GSP/MSM-193-4 of *Pakisaurus balochistani*, distal humerus GSP/MSM-174-15 of *Balochisaurus malkani* and distal humerus GSP/MSM-262-1 of *Sulaimanisaurus gingerichi. Nicksaurus razashahi* model managed by British Journalist Nicholas Allen and prepared by Russian Paleoartist Dr. Dmitry Bogdanov. Scale each black or yellow/black digit is 1cm. The specimen number like GSP/MSM-262-1 represents GSP for Geological Survey of Pakistan, Quetta, Pakistan, MSM for fossils collector M. Sadiq Malkani, 262 for specimen number and last 1 for Pakistani Dinosaur locality 1 (Sangiali 1).

saraikistani or *Sulaimanisaurus gingerichi* or *Khetranisaurus barkhani*. It has relatively less ventral reduction of slightly tall caudals while *Nicksaurus razashahi* represents more ventral reduction of broad caudals and *Balochisaurus malkani* represents more and strong ventral reduction of slightly broad to squarish caudals. It has medially inset and almost straight and slightly obliquely oriented deltopectoral crest with a posterior ridge [27] [28] [29] [32] opposite of deltopectoral crest of proximal humerus while *Balochisaurus malkani* has sinusoidal or curved (convexing medially and concaving laterally) deltopectoral crest (slightly overhangs its base) oriented at lateral extremity and not medially inset (**Figure 2**), and *Sulaimanisaurus gingerichi* and *Isisaurus colberti* has slender, curved (convexing medially and concaving laterally) and medially inset deltopectoral crest (**Figure 2**). *Gspsaurus pakistani* has anteriorly expanded radial condyle of distal humerus like *Balochisaurus malkani* and *Khanazeem saraikistani* while *Sulaimanisaurus gingerichi* and *Isisaurus colberti* has smooth and not anteriorly expanded radial condyle of distal humerus. Its proximal femur is stocky with straight lateral inclination while *Khanazeem saraikistani* has slender proximal femur with wavy shaped lateral inclination or have lateral concavity below the greater trochanter. Its distal femur is also stocky while *Khanazeem saraikistani* has relatively slender distal femur It has relatively more transversely expanded lense shaped proximal tibia (biconvex lense shaped with slightly more anteroposterior width than transverse width), while *Balochisaurus malkani* represents parallelogram shaped proximal tibia with almost equal transverse and anteroposterior widths while *Sulaimanisaurus gingerichi* [6] and *Khanazeem saraikistani* have transversely flat proximal tibia. Its distal tibia is transversely broad with parallelogram shaped or sub oval shaped trending transversely like *Balochisaurus malkani* [7] and *Nicksaurus razashahi* [7] while *Sulaimanisaurus gingerichi* [6] and *Khanazeem saraikistani* have anteroposteriorly broad distal tibia. *Gspsaurus pakistani* has moderately anteroposteriorly wide (about 14cm) proximal right and left fibulae from Top Kinwa, while *Balochisaurus malkani* has lesser anteroposteriorly broad (about 12 cm) proximal fibula from mid Sangiali), *Pakisaurus balochistani* has larger anteroposteriorly broad (about 15 cm) proximal fibula from south Kinwa and *Sulaimanisaurus gingerichi* has more larger anteroposteriorly broad (about 18 cm) proximal fibula from mid Sangiali. By observing this comparison, the Bara Simla fibula K27/489 [30] may belong to *Isisaurus colberti* which has largest anteroposteriorly broad (about 25 cm) among Indo-Pakistani titanosaurs. The transversely more expanded and strong proximal and distal tibia contacted with relatively smaller (anteroposteriorly less) and weak fibula to support and balance heavy weight. *Gspsaurus pakistani* has thin mosaic type sub rectangle shaped flat osteoderms and large oval shaped thick ellipsoidal armor bone with median groove (page 419, Fig. 4, row 6 of [7] [26]) like a titanosaur from Argentina [34], while *Malawisaurus* from Malawai have ellipsoidal armor without median groove [35], *Nicksaurus razashahi* has large thick oval shaped ellipsoidal armor bone without median groove from Pakistan (page 426, Fig. 6, row 5 of [7]) and from India [36], *Pakisaurus balochistani* has spongy fibrous long spine armor bone (page 430, Fig. 9, row 4 of [7]), *Sulaimanisaurus gingerichi* has small (about 6 cm diameter), thin, flat and subcircular platy osteoderm [21] [26] and *Balochisaurus malkani* has mosaic type moderately thick and sub oval shaped flat platy osteoderm (page 426, Fig. 6, row 4 of [7]). It is stocky and large sized among Pakistani titanosaurs.

Gspsaurus pakistani (*Maojandino alami* is synonym of *Gspsaurus pakistani*) poripuchian Gspsaurinae gspsaurid is round about 20 m long and is the largest Cretaceous sauropod of Pakistan [37], while *Saraikimasoom vitakri* and *Nicksaurus razashahi* Saraikimasoominae gspsaurid is round about 10 - 12 m long and is the smallest Cretaceous sauropod of Pakistan [37].

Saraikimasoom vitakri: *Saraikimasoom vitakri* [12] vide [6], a Saraikimasoominae [12] vide [6], Gspsauridae Malkani [12] vide [6], titanosaurian sauropod was formally (as per standard set by ICZN) described in 2021 [6]. It was based on holotypic snout with articulated mandible from south Kinwa 4s just west of the water gas spring and about 6 - 10 m downward on southern slope from ridge peak [6]. It has following diagnostic characteristics. It has 40˚ slope of craniofacial forehead. Its lower teeth row is U-shaped while *Gspsaurus pakistani* has V-shaped lower teeth row. It has almost straight teeth while *Gspsaurus pakistani* has slightly recurved teeth. It has conical slender teeth gradually decreasing width toward tip (except tip) like *Gspsaurus pakistani*. It has closely contacted teeth like *Nicksaurus razashahi* while *Gspsaurus pakistani* has spaced teeth (not closely contacted with each other especially mid of teeth row) and *Pakisaurus balochistani* has relatively more spaced teeth. It has relatively small sized skull while *Gspsaurus pakistani* has relatively medium sized skull [6] [12] [14]. *Saraikimasoom vitakri* revealed complete teeth row of more advance titanosaurs [14]. Many bone assemblages were referred (indirectly via *Balochisaurus malkani* and *Nicksaurus razashahi*) to *Saraikimasoom vitakri* [7] [14]. It is smallest Cretaceous titanosaur from Pakistan [37].

Pakisaurus balochistani: *Pakisaurus balochistani* [22] vide [6], a Pakisauridae [22] vide [6], Poripuchia [11] vide [6], titanosaurian sauropod was formally (as per standard set by ICZN) described in 2021 [6]. Its holotype includes axial elements like cervicodorsal, presacral, sacral (GSP/MSM-136-4, [23]) and caudal vertebrae, appendicular elements like left and right scapulae and sternal, and limb elements like humerus, left and right ulnae, radius, metacarpal, ilia, right femur and left fibula (see [6] [11] and references therein). Its holotypic skeleton was reported from type locality named as South Kinwa 4/4s or exactly southwestern Kinwa [6]. The referred materials are being mentioned as below. A partial skeleton of an individual of *Pakisaurus balochistani* from north Alam 19n (just close to Top Kinwa 16 eastern site) consists of caudal vertebrae, proximal pubis, proximal radius and distal ulna (page 430, Fig. 9, row 5 of [7]). This site is found on the right side (eastern side) of foot track. This bone assemblage (skeleton of single individual) was found at the same time in same mud horizon of

Vitakri Formation and also in the same site. There is fit size and features and no duplication of bones. This assemblage was found in about 10 m lengthy belt along strike on gentle slope formed by mud units of Vitakri Formation. In this site there are no any chances of any far stream detritial source.

The bones of *Pakisaurus balochistani* from Shalghara 3 include a fractured distal caudal vertebra, a distal caudal vertebra with horizontal groove on posterior cone, a proximal pubis with glenoid and fenestra, ulna, ungual with preserved thick skin (thick subsquarish anteriorly and tapering as rounded with terminal end) and thick and long armour spine (page 430, Fig. 9, row 4 of [7]) which may be associated and may belong to single individual because of finding at same time in same formation and in one locality with fit size and features and no duplication. Further the referred material of *Pakisaurus balochistani* reported from south Kinwa 4 include proximal right humerus, and from East Dolwahi 13 includes proximal rib (page 430, Fig. 9, row 5 of [7]) and from Mari Bohri 15 includes a caudal vertebra GSP/MSM-15-15 (pages 120-121, Fig. 5-9, row 1 of [22]). An axis from Nand, India [33] was referred to *Pakisaurus balochistani* [6] [7]. Right and left humeri from Rahioli Gujarat India area (GSI type no 20008, GSI 20009, plate 1, Fig. 2, 3a, 3b of [32]) which are being referred here to *Pakisaurus balochistani* matching with posterior ridge just below the head (as shown in holotypic humerus) and medially inset straight deltopectoral crest as shown in its referred humerus [6] [7].

Pakisaurus balochistani is distinguished as below. It has tall caudal centra with no ventral reduction, while *Gspsaurus*, *Marisaurus*, *Balochisaurus* and *Nicksaurus* represent ventral reduction, *Sulaimanisaurus* has squarish caudal with no ventral reduction and *Khetranisaurus* has ventral expansion of caudals. Its coracoid GSP/MSM-366-3 from Shalghara has lip on glenoid surface for humerus head rotation while *Balochisaurus malkani* left Coracoid GSP/Sangiali-1112 has apparently no lips (or weathered). The coracoid glenoid of *Pakisaurus* (10 cm) has same width as *Balochisaurus* coracoid but inferior end of *Pakisaurus* glenoid is sharp and pointed while *Balochisaurus* has rounded end. Further a deep gorge type depression of *Pakisaurus* is found in between the glenoid and infraglenoid process (**Figure 3**), while this depression is relatively shallow in *Balochisaurus* coracoid [27]. The infraglenoid process of *Pakisaurus* coracoid seems to be extended away like *Balochisaurus* (**Figure 3**). The *Pakisaurus balochistani* humeri show the following prominent features like the mid portion of proximal humerus is convex making slopes on lateral and medial sides (**Figure 2**); posteriorly there is a central ride on the posterior part of proximal humerus just below the head, while in humeri of *Gspsaurus pakistani*, *Balochisaurus malkani*, *Sulaimanisaurus gingerichi* and *Isisaurus colberti* this concavity is not found just below the head but have fairly V-shaped plain surface (**Figure 2**); and the radial condyle of mid condyle is expanded anteriorly located in the centre just posterior to olecranon cavity (**Figure 2**). These type of humerus from Pakistan (holotypic proximal humerus GSP/MSM-202-4, mid humerus GSP/MSM-268-4 and distal

Figure 3. **Row 1**, Intact skin enveloped on bone GSP/MSM-152-3 in different views of *Pakisaurus balochistani* titanosaur found from Vitakri Formation of Shalghara locality. **Row 2**, p1, 2, Fibrous muscle intact preservation on chevron GSP/MSM-313-4n of *Nicksaurus razashahi* found from north Kinwa in two views; P3, A bone injury mark or disease wound impression on neural spine GSP/MSM-150-16 of *Gspsaurus pakistani* found from Topkinwa. P4, *Saraikimasoom vitakri* Models managed by British Journalist Mr. Nicholas Allen and prepared by Russian Paleoartist Dr. Dmitry Bogdanov. **Row 3**, p1, 2, Coracoid GSP/Sangiali-1112 of *Balochisaurus* from Sangiali and GSP/MSM-366-3 of *Pakisaurus* from Kinwa; p3, fibula of *Balochisaurus* from Sangiali, p4, left and right proximal fibulae GSP/MSM-76-16 and MSM-77-16 of *Gspsaurus* from Top Kinwa, p5, proximal right fibula GSP/MSM-349-4 of *Pakisaurus* from Kinwa in 2 views, and left fibula GSP/MSM-253-7 of *Sulaimanisaurus* from Zubra peak. **Row 4**, p1, proximal right tibia of *Khanazeem saraikistani* from lower Bor and proximal right tibia GSP/MSM-73-16 of *Gspsaurus* from Top Kinwa, p2, 3, proximal left tibia GSP/MSM-181-2 of *Gspsaurus* from upper Bor/Eastern Bor, scale in inches, p4, 5, proximal left tibia GSP/MSM-246-15 of *Balochisaurus* from Mari Bohri in 2 views, and p6, left proximal tibia GSP/Sangiali-1120 of *Balochisaurus* from mid Sangiali. Scale, each black or white or yellow digit is 1 cm.

humerus GSP/MSM-193-4 [6] [11] and right and left humeri (GSI 20008, GSI 20009, plate 1, Fig. 2, 3, of [32]) from Rahioli Gujarat India belong to *Pakisaurus balochistani. Pakisaurus balochistani* has larger anteroposteriorly broad (about 15 cm) proximal fibula from south Kinwa, while *Sulaimanisaurus gingerichi* has more larger anteroposteriorly broad (about 18 cm) proximal fibula from mid Sangiali, *Isisaurus colberti* has more larger anteroposteriorly broad (about 25 cm) proximal fibula from Bara Simla, *Gspsaurus pakistani* has moderately anteroposteriorly wide (about 14 cm) proximal fibula from Top Kinwa, and *Balochisaurus malkani* has lesser anteroposteriorly broad (about 12 cm) proximal fibula from mid Sangiali. *Pakisaurus balochistani* has proximal fibula which has articular rugosities on proximal surface (on dorsal view) which is further extended into medial and lateral sides (**Figure 3**) with some extent, while this proximal rugosities are nor extended into medial and lateral sides (**Figure 3**) of *Gspsaurus pakistani*, *Balochisaurus malkani*, *Sulaimanisaurus gingerichi* and *Isisaurus colberti*. The relatively strong and large fibula may be contacted with flat tibia (relatively weaker) to support and balance heavy weight. *Pakisaurus balochistani* has spongy fibrous long spine armor bone (page 430, Fig. 9, row 4 of [7]) while *Sulaimanisaurus gingerichi* has small (about 6 cm diameter), thin, flat and subcircular platy osteoderm [21] [26], *Balochisaurus malkani* has mosaic type moderately thick and sub oval-sub rectangle shaped flat platy osteoderm (page 426, Fig. 6, row 4 of [7]), *Nicksaurus razashahi* has large thick oval shaped ellipsoidal armor bone without median groove (page 426, Fig. 6, row 5 of [7]) and *Gspsaurus pakistani* has thin mosaic type sub rectangle shaped flat osteoderms and large oval shaped thick ellipsoidal armor bone with median groove (page 419, Fig. 4, row 6 of [7]; [26]). It is slender and medium sized among Pakistani titanosaurs [37].

Sulaimanisaurus gingerichi: *Sulaimanisaurus gingerichi* [22] vide [6], a Pakisauridae [22] vide [6], Poripuchia [11] vide [6], titanosaurian sauropod was formally (as per standard set by ICZN) described in 2021 [6]. It was based on holotypic skeleton from South Kinwa is represented by seven caudal vertebrae [22]. A few vertebrae from Mari Bohri 15 and Shalghara 3, and the associated limb bones like humerus and femur from lower Sangiali 1, and associated tibia, fibula and metatarsal from Zubra peak 7 were also referred [6]. Its diagnostic characters are mosaic of following features. It has squarish caudal with no or slightly ventral reduction while *Pakisaurus balochistani* and *Gspsaurus pakistani* have tall caudals. *Sulaimanisaurus gingerichi* has slender, curved (convexing medially and concaving laterally) and medially inset deltopectoral crest of proximal humerus (**Figure 2**) like *Isisaurus colberti* while *Gspsaurus pakistani* has medially inset and almost straight and slightly obliquely oriented deltopectoral crest of proximal humerus and *Balochisaurus malkani* has stocky (thickened) and curved (convexing medially and concaving laterally) deltopectoral crest (slightly overhangs its base) oriented at lateral extremity (not medially inset) of proximal humerus. *Sulaimanisaurus gingerichi* on the basis of matching with distal humerus) has sinusoidal, curved (convexing medially and concaving laterally), gracile and medially inset deltopectoral crest of proximal humerus GSP/Sangiali-1124. This *Sulaimanisaurus gingerichi* humerus may be found in the lower part of attached or contacted stream which is derived from the nearby western site which yielded associated fossils of *Sulaimanisaurus gingerichi*. This type of humerus was also reported from Dongargaon, India is left humerus ISIR335/59 [38] assigned to *Isisaurus colberti*.

Its distal humerus has no anterior expansion of radial condyle of distal humerus like *Isisaurus colberti* while *Khanazeem saraikistani*, *Balochisaurus malkani* and *Gspsaurus pakistani* show anterior expansion of radial condyle on distal humerus. It has rugged flat transversely compressed proximal tibia like *Sulaimanisaurus gingerichi* while *Gspsaurus pakistani* and *Balochisaurus malkani* have relatively more transversely expanded proximal tibia. Its distal tibia is anteroposteriorly broad but less than distal tibia of *Pakisaurus balochistani* while *Gspsaurus pakistani*, *Balochisaurus malkani* and *Nicksaurus razashahi* have transversely broad distal tibia. *Sulaimanisaurus gingerichi* has more larger anteroposteriorly broad (about 18 cm) proximal fibula from mid Sangiali, *Isisaurus colberti* has more larger anteroposteriorly broad (about 25 cm) proximal fibula from mid Sangiali, Pakisaurus balochistani has larger anteroposteriorly broad (about 15 cm) proximal fibula from south Kinwa, *Gspsaurus pakistani* has moderately anteroposteriorly wide (about 14 cm) proximal fibula from Top Kinwa, and *Balochisaurus malkani* has lesser anteroposteriorly broad (about 12 cm) proximal fibula from mid Sangiali. The flat tibia (relatively weak) may be contacted with relatively strong and large fibula to support heavy weight.

Sulaimanisaurus gingerichi has small (about 6 cm diameter), thin, flat and subcircular platy osteoderm [21] [26] while *Pakisaurus balochistani* has spongy fibrous long spine armor bone (page 430, Fig. 9, row 4 of [7]), *Balochisaurus malkani* has mosaic type moderately thick and sub oval-sub rectangle shaped flat platy osteoderm (page 426, Fig. 6, row 4 of [7]), *Nicksaurus razashahi* has large thick oval shaped ellipsoidal armor bone without median groove (page 426, Fig. 6, row 5 of [7]) and *Gspsaurus pakistani* has thin mosaic type sub rectangle shaped flat osteoderms and large oval shaped thick ellipsoidal armor bone with median groove (page 419, Fig. 4, row 6 of [7] [26]). It is slender and medium sized Pakistani titanosaurs [37].

Khetranisaurus barkhani: *Khetranisaurus barkhani* [22] vide [6], a Pakisauridae [22] vide [6], titanosaurian sauropod was formally (as per standard set by ICZN) described in 2021 [6]. It was based on holotypic two caudal vertebrae from mid Kinwa locality 4 m [6]. It is characterized by broad ventral width of caudal centra than width of dorsal view of caudal centra while no any titanosaurs from Indo-Pakistan subcontinent has this feature. The reference [37] diagnosed as the smallest nemegtosaurian of Hindustan/South Asia.

Balochisaurus malkani: *Balochisaurus malkani* [22] vide [7], a Balochisauridae [22] vide [7], Poripuchia [11] vide [6], titanosaurian sauropod was formally (as standard set by ICZN) described in 2021 [7]. It was based on postcranial holotypic skeleton from southern two sites of Mari Bohri 15 locality includes axial elements like cervical, dorsal and caudal vertebrae including first biconvex caudal and trirays distalmost caudal, ribs and neural spine, and limb elements like left humerus, left ulna, metacarpal, left acetabulum, left femur and left tibia [7]. The bone assemblages of *Balochisaurus malkani* were reported from mid Bor 2, mid Sangiali 1 and Grut 9 localities. A bone assemblage from mid Bor 2 represents holotype of *Vitakrisaurus saraiki* and monospecific skeleton of *Balochisaurus malkani*. A skeleton of a single individual of *Balochisaurus malkani* from mid Bor includes a one cervical vertebra, one cervicodorsal vertebra, 6 dorsal vertebrae, a pair of sacral vertebrae (GSP/MSM-135-2, Fig. 2-5 of [23]), 3 caudal vertebrae, one trirays distal caudal centrum, distal part of cervical rib, distal rib, neural spine, distal rib/neural spine, parts of sternal, a coracoid, distal scapula, humerus, ulna, metacarpals, proximal ischium, a femur and metatarsals (page 425-426, Fig. 5 of [7]). This site is found on the right side (southern side) of Bor stream. This bone assemblage (skeleton of single individual) was found at the same time in the same site and in the same upper mud horizon of Vitakri Formation which is capped by upper sandstone unit of Vitakri Formation forming ridge peak. There is fit size and features and no duplication of bones. This assemblage was found in about 10 m as diameter on gentle slope of Vitakri mud units. In this site there are no any chances of any far stream detritial.

Mid Sangiali bone assemblage attributed to *Balochisaurus malkani* with postcranial specimens GSP/Sangiali-1101 to GSP/Sangiali-1123 and GSP/MSM-1-1 (Fig. 3-4 of [14]), except the *Sulaimanisaurus gingerichi* proximal right humeri GSP/Sangiali-1124 (Fig. 2 of [7]) and *Gspsaurus pakistani* proximal right humerus GSP/Sangiali-1125 (Fig. 2 of [7]). Beside these, many small sized bones/pieces of bones from GSP/Sangiali-1126 to GSP/Sangiali-1174 (Fig. 8, page 428 of [7]; Fig. 6, page 376 of [14]) are not diagnosable. The mid Sangiali site is found on the left side (northern side) of Sangiali stream. This bone assemblage was found in the same upper mud horizon of Vitakri Formation and also in the same site which is capped by upper sandstone unit of Vitakri Formation forming ridge peak. There is fit size and features. This assemblage was found in about 5 - 6 m in lateral width and about 8 - 10 m downward slope (moderate slope) on Vitakri mud units covered by partial upper sandstone colluvial blocks. In this site there are no any chances of any far stream detritial source.

The Top Kinwa following assemblage belongs to *Balochisaurus malkani* sharing with fit caudal vertebra. Its eastern Top Kinwa bone assemblage (may belong to single individual) includes braincase (GSP/MSM-2-16; GSP-UM 7000), caudal vertebra GSP/MSM-49-16 and metacarpal GSP/MSM-1036-16 (Fig. 9 of [14]; Figure 6 of [7]). This bone assemblage found in the same site, same formation, no duplication and fit size. *Balochisaurus malkani* Grut 9 Gambrak exemplar consists of caudal vertebra, proximal humerus with prominent head, distal ulna, transversely broad distal tibia and right astragalus (transverse length 15 cm, anteroposterior width 10 cm) (Fig. 9 of [14]; Fig. 6 of [7]). This site is found on the northwestern side of Dhaola peak axis (south of Basti). This bone assemblage (skeleton of single individual) was found at the same time in same site and same mud horizon of Vitakri Formation (here with westward high dips). There is fit size and features and no duplication of bones. This assemblage was found in about 15 m in lateral belt on mud or shale of Vitakri Formation. In this site there are no any chances of any far stream detritial source. A distal rib or neural spine GSP/MSM-5/02-Karkh (Fig. 9 of [14]; Fig. 6 of [7]) from South Karkh was referred to *Balochisaurus malkani* due to small size and massiveness (not spongy). Further *Balochisaurus malkani* referred materials include relatively small and thin osteodermal subcircular plate from mid Sangiali 1, suboval shaped mosaic type osteoderms from Dada Pahi 17 and many pieces of vesicular spongy coprolite or osteoderm from Vitakri dome (Fig. 6 of [7]). A femur (GSI/WR/M/90/84) from contemporaneous horizons in Rahioli, western India [27] is being referred to *Balochisaurus malkani* on the basis of same proportion and similarity with mid Sangiali femur (GSP/Sangiali-13; GSP/MSM-1-1) from Pakistan [27]. Further a right humerus GSI 20012 from Rahioli Gujarat state India (plate 1, Fig. 4 of [32]) and a humerus from Bara Simla India (plate V, Fig. 2 of [30]) which are being referred here to *Balochisaurus malkani* on the basis of matching features like robustness and laterally expanded and laterally terminal oriented deltopectoral crest with mid Sangiali humerus (GSP/Sangiali-1124; [7] [14]) of *Balochisaurus malkani* from Pakistan. Two caudal vertebrae GSP/MSM-50-4 and GSP/MSM-51-4 from south Kinwa was also attributed to *Balochisaurus malkani* (Fig. 6 of [7]; Figs. 9-12 of [22]).

Balochisaurus malkani has following diagnostic characters. It has first biconvex caudal centrum like *Marisaurus jeffi*. It has strong ventral reduction of squarish mid caudals while *Gspsaurus pakistani* and *Marisaurus jeffi* have relatively less ventral reduction of caudal centra. Its coracoid glenoid has apparently no lips (or it may be weathered) while Pakisaurus balochistani coracoid glenoid has lip (**Figure 3**) on glenoid surface for rotation of humerus head. Its coracoid has a conscious depression between glenoid and infraglenoid process (**Figure 3**), while *Pakisaurus balochistani* has deep gorge type depression with vertical walls between the glenoid and infraglenoid process. *Balochisaurus malkani* has stocky (thickened) and curved (convexing medially and concaving laterally) deltopectoral crest (slightly overhangs its base) oriented at lateral extremity and not medially inset (**Figure 2**) of proximal humerus while *Gspsaurus pakistani* has medially inset and almost straight and slightly obliquely oriented deltopectoral crest of proximal humerus and *Sulaimanisaurus gingerichi* and *Isisaurus colberti* have slender, curved (convexing medially and concaving laterally) and medially inset deltopectoral crest of proximal humerus. *Balochisaurus malkani* has anteriorly expanded radial condyle (**Figure 2**) of distal humerus like *Gspsaurus pakistani*, *Pakisaurus balochistani* and *Khanazeem saraikistani* while the *Sulaimanisaurus gingerichi* and *Isisaurus colberti* has smooth and not anteriorly expanded radial condyle of distal humerus. It has relatively stocky femur with straight proximolateral profile like *Gspsaurus pakistani*, *Nicksaurus razashahi* and *Marisaurus jeffi* while the femora of *Khanazeem saraikistani* is more slender and have wavy (concavity on) proximolateral profile. Its peak of the deltopectoral crest is found near its medial bend; there is it thickened and slightly overhangs its base. It has femur with obliquely straight profile on proximolateral part of femur while *Khanazeem saraikistani* has wavy type style with a depression between the proximolateral corner and lateral bulge (**Figure 3**). It has strongly transversely expanded proximal tibia (sub parallelogram shaped with equal transverse and anteroposterior width), while *Pakisaurus balochistani* and *Sulaimanisaurus gingerichi* have flat proximal tibia, and *Gspsaurus pakistani* has lense shaped proximal tibia. Its anterior and posterior limb width (on both side of maximum expansion/fibular condyle) on dorsal view of proximal tibia are considerably unequal (posterior limb is more expanded than anterior limb) while it is almost equal in *Gspsaurus pakistani*, *Pakisaurus balochistani* and *Sulaimanisaurus gingerichi*. It's referred distal tibia from Grut 9 locality is transversely broad with parallelogram shaped trending transversely like *Gspsaurus pakistani* and *Nicksaurus razashahi*, while *Khanazeem saraikistani* and *Sulaimanisaurus gingerichi* have anteroposteriorly broad distal tibia [6] [11]. *Balochisaurus malkani* has lesser anteroposteriorly broad (about 12 cm) proximal fibula from mid Sangiali, while *Sulaimanisaurus gingerichi* has more larger anteroposteriorly broad (about 18cm) proximal fibula from mid Sangiali, *Isisaurus colberti* has more larger anteroposteriorly broad (about 25 cm) proximal fibula from mid Sangiali, Pakisaurus balochistani has larger anteroposteriorly broad (about 15 cm) proximal fibula from south Kinwa, and *Gspsaurus pakistani* has moderately anteroposteriorly wide (about 14 cm) proximal fibula from Top Kinwa (**Figure 3**). The relatively more expanded (transversely) proximal tibia (relatively stronger) along with strong transversely broad distal tibia may be contacted with relatively small fibula (relatively weaker) to adjust and balance support. The *Balochisaurus malkani* is among medium sized (12 - 14 m long) and stocky poripuchian titanosaurs from Pakistan [37].

Nicksaurus razashahi: *Nicksaurus razashahi* [12] vide [7], a Saraikimasoominae [12] vide [7], Gspsauridae [12] vide [7], titanosaurian sauropod was formally (as per standard set by ICZN) described in 2021 [7]. Its holotypic skeleton consists of jaw with articulated teeth, cranial fragments, cervical, dorsal and caudal vertebrae, chevron, humerus, radius, left and right femora, left and right tibiae [7]. The bone assemblage include caudal vertebrae GSP/MSM-523-7 and GSP/MSM-524-7, scapula GSP/MSM-746-7 and osteoderm GSP/MSM-84-7 (Fig. 9 of [14]; Fig. 6 of [7]) from South Zubra 7 is being referred to *Nicksaurus razashahi* based on broad and ventrally reduced caudals. This bone assemblage shows same yellowish brown matrix, found in the same site, same formation and fit size and no duplication, found in about 15m down slope belt including colluvial materials originating from only Vitakri Formation forming peak.

It shows following diagnostic characteristic. Its jaw has small to medium sized slender teeth which are contacted closely like *Saraikimasoom vitakri*, while *Gspsaurus pakistani* have relatively more spaced and long teeth and *Khanazeem saraikistani* have relatively more widely spaced teeth. Its partial jaw is pneumatic like *Saraikimasoom vitakri* and *Gspsaurus pakistani*. It has broad caudals (may be anterior caudals) with strong ventral reduction, while *Balochisaurus malkani* has slightly broad to squarish caudals with strong ventral reduction, *Gspsaurus pakistani* has slightly tall to squarish caudals with relatively less ventral reduction, *Pakisaurus balochistani* and *Sulaimanisaurus gingerichi* have tall and squarish caudals respectively with no ventral reduction or slight ventral reduction, and *Khetranisaurus barkhani* in opposite shows slight ventral expansion (instead of reduction) of caudals. It has transversely broad distal tibia like *Gspsaurus pakistani* and *Balochisaurus malkani*, while *Pakisaurus balochistani* and *Sulaimanisaurus gingerichi* have anteroposteriorly broad distal tibia. It has transversely broad (relatively strong) distal tibia may be contacted with relatively small tibia (relatively weak). It has small sized braincase than *Gspsaurus pakistani*. It has broad and constricted occipital condyle like *Gspsaurus pakistani* while all coeval braincases from India have no constricted occipital condyle. *Nicksaurus razashahi* is included with Saraikimasoominae gspsaurid due to close matching of moderate size and closely contacted teeth with *Saraikimasoom vitakri*. It has small sized braincase than *Gspsaurus pakistani*. It has broad and constricted occipital condyle like *Gspsaurus pakistani* while all coeval braincases from India have no constricted occipital condyle. *Nicksaurus razashahi* has large thick oval shaped ellipsoidal armor bone without median groove from Pakistan (page 426, Fig. 6, row 5 of [7]) and also from India [14] [36] like ellipsoidal armor bone of *Malawisaurus* from Malawi [35] while a titanosaur from Argentina has ellipsoidal armor bone with median groove [34], *Pakisaurus balochistani* has spongy fibrous long spine armor bone (page 430, Fig. 9, row 4 of [7]), *Sulaimanisaurus gingerichi* has small (about 6 cm diameter), thin, flat and subcircular platy osteoderm [21] [26], *Balochisaurus malkani* has mosaic type moderately thick and sub oval-sub rectangle shaped flat platy osteoderm (page 426, Fig. 6, row 4 of [7]), and *Gspsaurus pakistani* has thin mosaic type sub rectangle shaped flat osteoderms and large oval shaped thick ellipsoidal armor bone with median groove (page 419, Fig. 4, row 6 of [7] [26]). It is smallest titanosaur from Pakistan [37].

Maojandino alami: *Maojandino alami* [12] vide [7], a Gspsaurinae [12] vide [6], Gspsauridae [12] vide [6], Poripuchia [11] vide [6], titanosaurian sauropod was first formally (as per standard set by ICZN) described in 2021 [7]. Its holotypic cranial and postcranial partial skeleton from central Alam includes braincase, cervical, dorsal and caudal vertebrae, sternal/ilia, left and right scapulae, radius, left femur, left and right tibiae [7]. The holotype of *Maojandino alami* is a dominant portion of the holotype of *Gspsaurus pakistani*. Further *Maojandino* *alami* in September 2021 [7] was formalized later than *Gspsaurus pakistani* in August 2021 [6]. This is the reason *Maojandino alami* is considered a junior synonym of *Gspsaurus pakistani.* It is stocky and large sized among Pakistani titanosaurs [37].

Marisaurus jeffi: *Marisaurus jeffi* [22] vide [7], a Balochisauridae [22] vide [7], Poripuchia [11] vide [6], titanosaurian sauropod was formally (as per standard set by ICZN) described in 2021 [7]. It was based on holotypic skeleton from northern two sites of Mari Bohri which includes caudal vertebrae (including first biconvex caudal and trirays distal caudal having two prezygapophysis type spines and one postzygapophysis type spine), scapula, pubis and femur [7]. Its reference materials include one dorsal vertebra GSP/MSM-134-8 [23] and one caudal vertebra GSP/MSM-40-8 [7] from Darwaza locality 8. Its diagnostic features are as below. It has relatively less ventral reduction of caudals like *Gspsaurus pakistani*, while *Balochisaurus malkani* and *Nicksaurus razashahi* have strong ventral reduction of caudals, *Pakisaurus balochistani*, *Sulaimanisaurus gingerichi and Khetranisaurus barkhani* have no significant ventral reduction of caudals. Its pubis iliac symphysial part is low and reduced, while the *Isisaurus colberti* [38] has elevated iliac symphysial. Its proximal pubis has wide and thick glenoid; and scapular short articular surface for coracoid articulation. *Marisaurus jeffi* bears no restricted articular posterior ball in caudals while *Gspsaurus pakistani* bears restricted articular posterior ball in caudals. *Marisaurus jeffi* is included in Balochisauridae due to overlapping of biconvex first caudal with *Balochisaurus malkani* [7]. It is stocky and among large sized (about 17 - 19 m long) latest Cretaceous sauropod of Pakistan [37].

Systematic Paleontology of *Khanazeem saraikistani* titanosaurian sauropod from the Vitakri Formation of Pakistan:

Dinosauria; Saurischia; Sauropoda; Titanosauriformes; Titanosauria; Poripuchia [11] vide [6]; Pakisauridae [22] vide [6].

Khanazeem saraikistani new genus and new species (**Figure 4**).

Holotype: Dentary ramus with articulated teeth GSP/MSM-143-2; caudal vertebrae GSP/MSM-16-2 and GSP/MSM-793-2; left proximal and mid femur GSP/MSM-69-2; right femur represented as proximal femur GSP/MSM-294-2, mid femur GSP/MSM-293-2 and distal femur in two parts GSP/MSM-266-2; proximal and mid partial humerus GSP/MSM-289-2 and distal humerus GSP/MSM-180-2; proximal partial humerus GSP/MSM-288-2 (proximal most and lateral part eroded), mid humerus GSP/MSM-290-2; a partial right tibia including proximal slender tibia GSP/MSM-72-2 and distal tibia GSP/MSM-186-2; proximal and mid left tibia GSP/GSP/MSM-286-2 (**Figure 4**). Holotype found at the same time as surface finds in the same formation, same site, size matches and no duplication, all shows association of a single individual. This partial skeleton is found few meters just below the small ridge peak on the north western side. Fossils are housed in museum of Geological Survey of Pakistan, Quetta, Pakistan. This assemblage was found on slope in about 15 m in lateral width and about

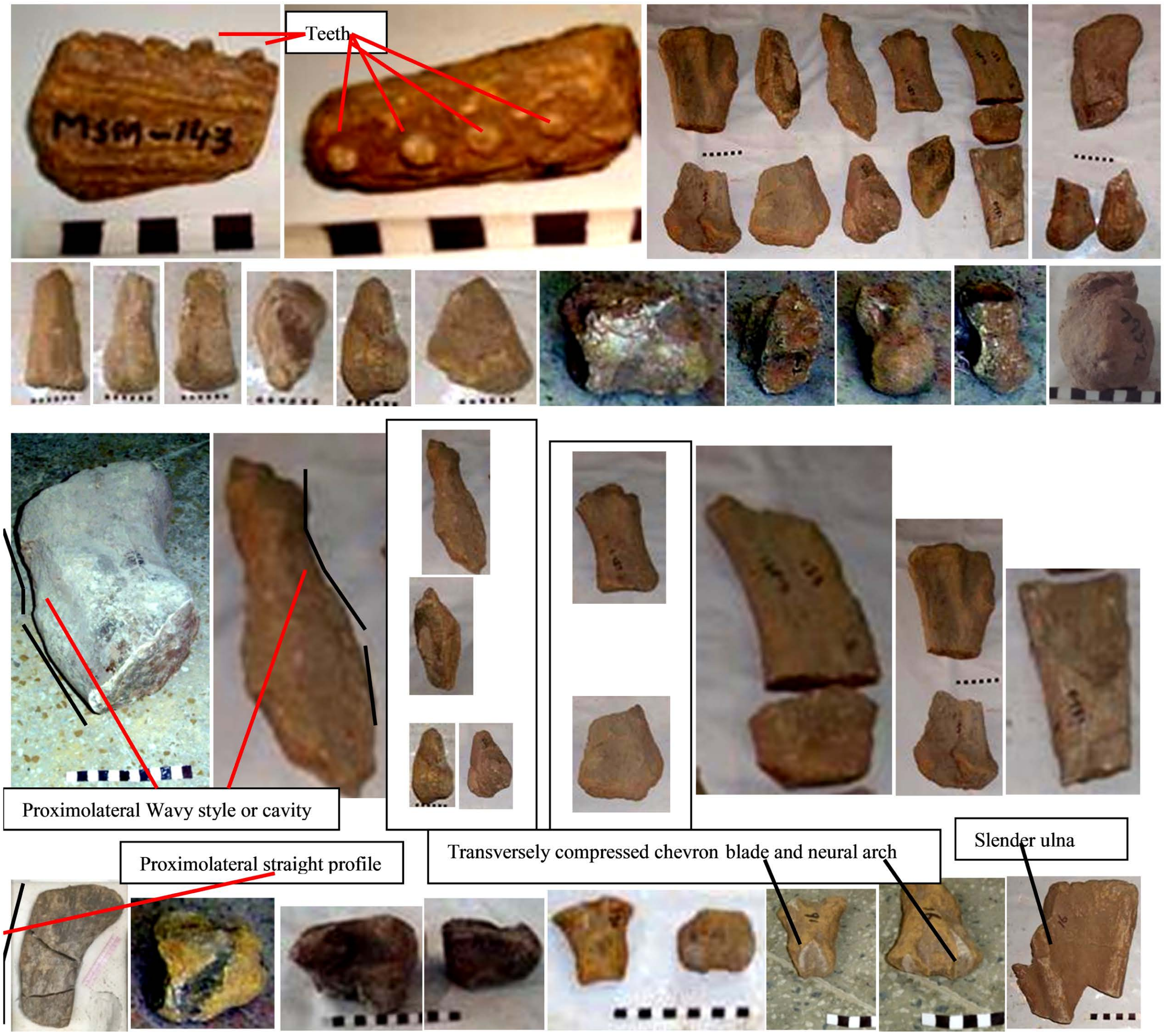


Figure 4. *Khanazeem saraikistani* holotypic cranial and postcranial skeleton (rows 1 - 3) from lower Bor type locality (Figure 4 of [6]) and referred bones (row 4 except 1st photo) from Top Kinwa (Figure 4 of [6]), Barkhan District, Balochistan, Pakistan. **Row 1**, p1, 2, dentary ramus with articulated teeth GSP/MSM-143-2; p3, column 1, proximal right tibia GSP/MSM-72-2, distal right tibia GSP/MSM-186-2; column 2, femur GSP/MSM-293-2 (may be adjusted with proximal and mid femur GSP/MSM-294-2), distal humerus GSP/MSM-180-2; column 3, proximal and mid right femur GSP/MSM-294-2, distal right femur GSP/MSM-266-2; column 4, mid right humerus GSP/MSM-289-2, humerus part GSP/MSM-498-2; column 5, proximal and mid left humerus GSP/MSM-288-2, mid humerus GSP/MSM-290-2, mid left tibia GSP/MSM-286-2; p4, proximal left femur GSP/MSM-69-2 (upper) and distal condyles GSP/MSM-272-2 and GSP/MSM-265-2 (lower). **Row 2**, p1-3, distal fibula GSP/MSM-183-2; p4-6, part of distal femur GSP/MSM-233-2; p7-10, caudal vertebra GSP/MSM-16-2 for scale see [22], and p11, caudal vertebra GSP/MSM-793-2. **Row 3**, p1, 2, proximal left femur GSP/MSM-69-2 and proximal right femur GSP/MSM-294-2; p3, proximal right femur GSP/MSM-294-2, mid femur MSM-293-2 and distal GSP/MSM-266-2 parts; p4, mid right humerus GSP/MSM-289-2 and distal humerus GSP/MSM-180-2; p5, proximal left humerus GSP/MSM-288-2, mid humerus GSP/MSM-290-2; p6, proximal right tibia GSP/MSM-72-2 and distal tibia GSP/MSM-186-2; p7, proximal and mid left tibia GSP/MSM-286-2. **Row 4**, p1, proximal left femur GSP/Sangiali-1118 of *Balochisaurus* from mid Sangiali; p2-4, caudal vertebrae GSP/MSM-17-16 for scale see [22], GSP/MSM-510-16 and GSP/MSM-154-16; p5, chevron GSP/MSM-330-16 and prezygapophyses GSP/MSM-327-16; p6, 7, chevron GSP/MSM-330-16; p8, proximal ulna GSP/MSM-1032-16. Scale, each black digit is 1 cm; Row 2 photos see row 1 scale.

15 m downward slope (moderate slope) on Vitakri mud. In this site there are no any chances of any far stream detritial source.

Type locality, horizon and age: Holotype was found in the lower Bor type locality (Pakistan dinosaur locality 2) with Latitude 29.68700 and Longitude 69.3771 (N 29˚41'12" and E 69˚22'37") (as shown in Fig. 4 of [6]) of Vitakri dome area, Barkhan district, Balochistan Province, Pakistan. Host horizon is the upper varicolored but dominantly maroon mud caped by upper sandstone unit of Vitakri Formation of Fort Munro Group [6] [11] [15]. Age is latest Maastrichtian [6] [11].

Referred specimens: The referred materials of *Khanazeem saraikistani* from Top Kinwa 16 locality (Fig. 4 of [6]) consists of 3 caudal vertebrae, a chevron, a pair of prezygapophyses and proximal slender ulna (page 430, Fig. 9, row 3 of [7]) which may be associated and may belong to single individual because of finding at same time in same formation and in one locality with fit size and features and no duplication. These fossils are housed in the museum of Geological Survey of Pakistan, Quetta.

Etymology: Genus name *Khanazeem* honors the Qaid Azeem Imran Khan Niazi Former Prime minister of Pakistan and great journalist and our great leader Qaid Azeem Imran Riaz Khan, Dr. Waqar Malik Khan and others leaders, who supported poor peoples of Pakistan, and Professor Dr. Shereen Sufyan Khan and Hisan Khan taking interest for the *Balochisaurus* and other Pakistani dinosaurs, *azeem* the Saraiki language meaning big or titan. *Khanazeem* generally may be understood as Khan titan. The genus name *Khanazeem* can be pronunciated as Khan Azeem. The species name *Khanazeem saraikistani* honors the Saraiki Koh Sulaiman area which hosts these fossils and most of the Cretaceous dinosaur fossils from Pakistan. The pronunciation of the species name *Khanazeem saraikistani* is as Sarai-kis-tani.

Diagnosis: *Khanazeem saraikistani* medium sized sauropod shares with the Titanosauria as vertebrae lacking hyposphene-hypantrum articulations; procoelous caudals; and forward insertion of neural arches on caudals. It shares with Poripuchia because of sharing with Pakisauridae. It shares with Pakisauridae on the basis of ratio of transverse dorsal width to the transverse ventral width is about 1 and flat slender tibia. *Khanazeem saraikistani* diagnosed as below. It has slender, circular and subcircular widely spaced teeth (**Figure 4**) while *Gspsaurus pakistani* has close to moderately spaced teeth, and *Saraikimasoom vitakri* and *Nicksaurus razashahi* have closely contacted teeth. It has slightly tall caudals (robust caudal) without significant ventral reduction (while *Pakisaurus balochistani* has relatively moderately tall and moderate robust caudals and *Titanosaurus indicus* has relatively more tall and slender caudals). Its distal humerus has anteriorly expanded radial condyle like *Pakisaurus balochistani*, *Balochisaurus malkani* and *Gspsaurus pakistani*, and unlike *Sulaimanisaurus gingerichi* and *Isisaurus colberti* (both lack anteriorly expanded radial condyle). Its femora possess extreme slenderness, concavity between the proximolateral corner of the femoral head and the lateral bulge (wavy style), and their inflected head is oriented more obliquely relative to the shaft [27]. It has flat (transversely reduced) proximal tibia like *Sulaimanisaurus gingerichi*, and unlike transversely expanded proximal tibia of *Balochisaurus malkani* and *Gspsaurus pakistani*. Its tibial shaft is oval with same thickness on anterior and posterior side (in cross section) while *Gspsaurus pakistani* has tibial shaft with posterior side more expanded than anterior side and *Balochisaurus malkani* has tibial shaft with posterior side strongly expanded than anterior side (or cnemial crest side). It has anteroposteriorly broad distal tibia like *Sulaimanisaurus gingerichi*, and unlike transversely expanded parallelogram shaped distal stocky tibia of *Gspsaurus pakistani*, *Nicksaurus razashahi* and *Balochisaurus malkani*. It has more transversely broad distal tibia than *Sulaimanisaurus gingerichi.* The relatively flat tibia (relatively weak) may be contacted with relatively large fibula (relatively strong) to support heavy body weight. Further comparisons can be seen as below.

Description: The bones of *Khanazeem saraikistani* are being described as follows.

Dentary ramus with articulated teeth: The specimen GSP/MSM-143-2 represents dentary ramus with 5 alveoli. 4 teeth are inserted in alveoli while in fifth alveoli tooth is eroded (**Figure 4**). The teeth are subcircular to suboval. The teeth width and length are mentioned from left to right like 0.5 × 0.5 cm/centimeter, 0.7 × 0.6 cm, 0.7 × 0.6 cm and 0.6 × 0.5 cm. In comparison the *Khanazeem saraikistani* has same proportion like *Gspsaurus pakistani* while *Saraikimasoom vitakri* and *Nicksaurus razashahi* have slightly less proportion (0.3 - 0.5 cm). Its teeth spacing is considerably more than *Gspsaurus pakistani* while *Saraikimasoom vitakri* and *Nicksaurus razashahi* have close contacted teeth. The jaw ramus is 4.5 cm dorsoventrally tall and transversely 2.25 cm transversely wide. *Khanazeem saraikistani* jaw ramus proportion is also less than *Gspsaurus pakistani* jaw ramus (5 - 6 cm dorsoventrally tall and about 2.25 cm transversely wide) and considerably more than *Saraikimasoom vitakri* (dorsoventrally tall is 1cm) and *Nicksaurus razashahi* (dorsoventrally tall is 0.7 cm). The jaw ramus clearly show parallel and alternated fine ridges and grooves, longitudinally trending anteroposteriorly throughout all preserved length (**Figure 4**).

Caudal vertebrae: Holotypic caudal vertebra and three referred caudal vertebrae from Top Kinwa (**Figure 4**) show slightly less tallness and more width (more robust), while *Pakisaurus balochistani* has moderate tallness and moderate width and robustness of caudals, *Titanosaurus indicus* has slender and strongly taller with relatively thin width of caudals, *Sulaimanisaurus gingerichi* and *Isisaurus colberti* have square caudals, *Khetranisaurus barkhani* has fairly square caudals, *Gspsaurus pakistani* and *Marisaurus jeffi* have tall and ventrally reduced caudals, *Nicksaurus razashahi* has broad and ventrally reduced caudals, and *Balochisaurus malkani* has almost square and strongly ventrally reduced caudals. Its caudals are procoelous and neural arch covers the mid and anterior portion of caudal centrum.

Humerus: Partial left and right humeri (**Figure 4**) were collected from lower Bor locality. Its mid section show oval/elliptical section while distal humerus show anteriorly expanded radial condyle.

Ulna: The referred proximal ulna (**Figure 4**) shows more slender and relatively thin limbs than proximal ulna of *Pakisaurus balochistani*.

Femur: Partial femora (proximal and mid left femur GSP/MSM-69-2, with distal condyles GSP/MSM-272-2 and GSP/MSM-265-2; **Figure 4**), and partial right femur (proximal and mid femur GSP/MSM-294-2 and part of distal femur GSP/MSM-266-2; **Figure 4**) show prominent features like extreme slenderness, concavity between the proximolateral corner of the femoral head and the lateral bulge and their inflected head is oriented more obliquely relative to the shaft [27] resulting as the more wide gauge locomotive movements of hind limb (with laterally directed distal scapula created fore limb wide gauge movements), while stocky limbed titanosaurs like *Balochisaurus malkani*, *Nicksaurus razashahi* and *Gspsaurus pakistani* which have relatively less wide gauge movements due to straight distal scapula and less oblique femoral head. Its lateral profile of proximal deflection is wavy type in proximal femur, while *Gspsaurus pakistani*, *Balochisaurus malkani* and *Nicksaurus razashahi* have straight and deflected medially lateral profile of proximal femora. The proximal femur also forms very gentle arc or curve on medial side of proximal shaft and in middle and lower part shaft becomes straight. Below the proximal deflection, the shaft of the femur becomes straight trending downward in both anterior and lateral views. A prominent dorsoventrally longitudinal ridge started from the posterolateral corner of greater trochanter and extends down upto mid femur and may be further downward. This ridge is sub parallel ridge to medial and lateral sides. The shaft section is elliptical but slightly concave anteriorly and convex posteriorly. The head is subrounded. The greater trochanter forms the proximolateral corner of the proximal femur. The distal end is bifurcated in two condyles as tibial and fibular condyles both have rugosities on ventral view. Femoral midshaft, transverse diameter is more than twice of anteroposterior diameter. Femoral distal condyles, ventrally more expanded tibial condyle than fibular condyle. The fibular condyle (including the epicondyle) is much broader transversely than tibial condyle. The articular surface of femoral distal condyles seems to be restricted to distal portion of femur.

Tibia: An almost complete slender right tibia (proximal narrow tibia GSP/MSM-72-2 and distal tibia GSP/MSM-186-2) (**Figure 4**) with well preserved proximal and distal ends and partial left tibia GSP/MSM-286-2 represent flat and slender nature. *Khanazeem saraikistani* tibia is transversely narrow and flattened tibia like *Sulaimanisaurus gingerichi*, while unlike the more transversely expanded tibia of *Gspsaurus pakistani* and the most transversely expanded tibia of *Balochisaurus malkani.* Its proximal tibia has expanded fibular condyle (more expanded in *Gspsaurus pakistani* and *Balochisaurus pakistani*) and a prominent dorsolaterally longitudinal ridge started from the fibular condyle and extends down and terminated upto ventral end of cnemial crest. It generally forms arc shape concaving toward cnemial crest forming scar and convexing anteroventrally (**Figure 4**). Its cnemial crest (anterior process) and posterior process has almost same transverse width (**Figure 4**), while *Gspsaurus pakistani* and *Balochisaurus pakistani* have more expanded posterior process (**Figure 3**) and relatively thin anterior process. The midshaft of the tibia is transversely compressed. Its shaft has oval shape with same width of anterior process and posterior process but *Gspsaurus pakistani* and *Balochisaurus pakistani* represent different width of anterior and posterior processes of shaft (**Figure 3**). It has almost same transverse width (**Figure 4**), while *Gspsaurus pakistani* and *Balochisaurus pakistani* have more expanded posterior process (**Figure 3**) and relatively thin anterior process. Its distal tibia is anteroposteriorly broad like *Sulaimanisaurus gingerichi* distal tibia but *Gspsaurus pakistani*, *Balochisaurus pakistani and Nicksaurus razashahi* have transversely broad distal tibia. Its distal tibia proportion is relatively more broader (about 20 cm anteroposterior width) than the Zubra peak 7 distal tibia (16 cm anteroposterior width) of *Sulaimanisaurus gingerichi* while the proximal anteroposterior width are approximate same as about 25 cm. The ratio of anteroposterior width of distal end (20 cm) to anteroposterior width of proximal end (25 cm) of *Pakisaurus balochistani* is 0.80 while the ratio of anteroposterior width of distal end (16 cm) to anteroposterior width of proximal end (25 cm) of *Sulaimanisaurus gingerichi* tibia is low as 0.64. The poorly preserved slender tibia K20/321 [30] from India did not provide detailed characters because of its poor preservation. The midshaft is oval and anteroposteriorly about thrice time than the transverse depth of *Sulaimanisaurus gingerichi*, while in *Gspsaurus* it is more than 2 times and in *Saraikimasoom* it is less than 1.5 times. At midshaft the tibia is not twisted in *Khanazeem saraikistani* and *Sulaimanisaurus gingerichi*, while it is twisted 90^0 toward distal end in *Gspsaurus pakistani*, *Balochisaurus malkani* and *Nicksaurus razashahi*. The proximal head of the tibia is generally flattened with moderately expanded fibular condyle that projects laterally and cone is tilted anteriorly (**Figure 4**).

Fibula: Distal fibula GSP/MSM-183-2 is subcircular to suboval shape (**Figure 4**). Fibular distal condyle size is highly expanded transversely (while opposite of its proximal portion) and not equal to mid shaft. Fibular distal condyle, size, expanded transversely, more than twice midshaft breadth. Distal fibula laterally has a notch or keel type structure at the distal ends. Medially slight dorsoventrally elongated concavity is found.

Four morphs of poripuchian titanosaur humeri (and other bones) from Indo-Pakistan: Atleast four existing poripuchian titanosaur sauropods were recognized from Indo-Pakistan on basis of discoveries of diverse cranial, vertebral and appendicular and limb elements from the latest Cretaceous Vitakri Formation of Pakistan (pages 433-437 of [11]). Four morphs of cranial materials [11] [14] [24], five morphs of caudal vertebrae (Fig. 1, f of [10]; pages 436-437 of [11]) and four morphs of appendicular elements were recognized [11]. Among these the four morphs of scapula are identified. The first morph of distal scapula belong to Isisaurus having longer articular surface of coracoid [38], the second morph of distal scapula of Pakisaurus having slender glenoid surface and short articular surface for coracoid [11], the third morph of distal scapula of Balochisaurus having stocky and robust glenoid surface and short articular surface for coracoid [14] [27], and the fourth morph of distal scapula of Gspsaurus having more stocky and more robust glenoid surface and short articular surface for coracoid [24]. Four morphs of humeri (**Figure 2**) are also found from Pakistan and also from India as described below. Four morphs of tibia (pages 433-435 of [11]) is significant which is described in detail [11] [14] [24]. Three or four morphs of femora were also found. Here updated four morphs of humeri (**Figure 4**) of different taxa of titanosaurs are reported from Pakistan and India. Four morphs of fibulae are also found. *Gspsaurus pakistani* has moderately anteroposteriorly wide (about 14 cm) proximal fibula from Top Kinwa, while *Balochisaurus malkani* has lesser anteroposteriorly broad (about 12 cm) proximal fibula from mid Sangiali), Pakisaurus balochistani has larger anteroposteriorly broad (about 15 cm) proximal fibula from south Kinwa and Sulaimanisaurus gingerichi has more larger anteroposteriorly broad (about 18 cm) proximal fibula from mid Sangiali. This shows that as the tibial transverse expansion reduced, the fibular anteroposterior width increase to balance and strengthen the weight. In other words as the transverse expansion of tibia increase, the balance these the proximal fibular anteroposterior width decrease. Like cranial and vertebral, the humeri and tibiae are tetra diverse.

***Pakisaurus* humeri morph** shows the following prominent features. Very distinguished feature of *Pakisaurus balochistani* humeri is the occurrence of dorsoventrally posterior median ride on the proximal humerus just below the head (**Figure 2**) while in humeri of *Gspsaurus pakistani*, *Balochisaurus malkani*, *Sulaimanisaurus gingerichi* and possibly *Isisaurus colberti* this central ridge or convexity is not found just below the head but have fairly V-shaped plain surface (**Figure 2**). *Pakisaurus balochistani* humeri has medially inset deltopectoral crest which can be seen in proximal right humerus GSP/MSM-195-4 (**Figure 2**) like *Gspsaurus pakistani* and *Sulaimanisaurus gingerichi*, and unlike *Balochisaurus malkani* which have terminal or laterally set (**Figure 2**). *Pakisaurus balochistani* humeri cross sectional view just below the deltopectoral crest is triangular (**Figure 2**) while *Balochisaurus malkani* is robust quadrangular, *Gspsaurus pakistani and Sulaimanisaurus gingerichi* are gracile quadrangular (more oval shaft). *Pakisaurus balochistani* has anteriorly expanded radial condyle or mid condyle located in the median part just posterior to olecranon cavity (**Figure 2**) while *Gspsaurus pakistani* and *Balochisaurus malkani* have anteriorly expanded radial condyle which is set on lateral side, and *Sulaimanisaurus gingerichi* has no expanded radial condyle (**Figure 2**). These types of humeri (**Figure 2**) represented from Pakistan are humeri from South Kinwa like proximal right humerus GSP/MSM-202-4, mid humerus GSP/MSM-268-4 and distal humerus GSP/MSM-193-4 (Fig. 7 of [6]; Fig. 1, 3, of [11]) and right proximal humerus GSP/MSM-195-4 (Fig. 9 of [7]; Fig. 5, of [11]) and right and left humeri (GSI

20008, GSI 20009, plate 1, Fig. 2, 3, of [32]) from Rahioli Gujarat India which are being referred to *Pakisaurus balochistani.*

Balochisaurus **humeri morph** has following major distinguishing features. The *Balochisaurus malkani* proximal humeri show a fairly V-shaped plain area just below the head on posterior view like *Gspsaurus pakistani*, *Sulaimanisaurus gingerichi* and possibly *Isisaurus colberti* while in opposite the *Pakisaurus balochistani* has posterior convexity (median ridge) trending dorsoventrally (from head to mid shaft) are located posteriorly in the dorsoventral trending axis line (**Figure 2**). Proximal humerus having a plain area just below the head with the lateral and medial side of the V-shaped plain is bended anteriorly. *Balochisaurus malkani* hosts sinusoidal or curved (convexing medially and concaving laterally) and robust deltopectoral crest (laterally expanded; slightly overhangs its base) oriented at lateral extremity due to its lateral expansion (not medially inset) of robust proximal humerus GSP/Sangiali-1113 (**Figure 2**) which was found from the mid Sangiali site, Pakistan which yielded possibly associated postcranial bones of *Balochisaurus malkani*. This type of humeri was also reported found from Rahioli Gujarat state, India (GSI 20012, plate 1, Fig. 4 of [32]) and from Bara Simla India (plate V, Fig. 2 of [30]) which are being referred here to *Balochisaurus malkani*.

Sulaimanisaurus **humeri morph** has the following major distinct characteristics. The *Sulaimanisaurus gingerichi* proximal humerus shows a fairly V-shaped plain area (**Figure 2**) just below the head in the posterior view like *Gspsaurus pakistani*, *Balochisaurus malkani* and possibly *Isisaurus colberti* while in opposite the *Pakisaurus balochistani* has posterior convexity (median ridge) trending dorsoventrally are located posteriorly in the dorsoventral trending axis line. *Sulaimanisaurus gingerichi* has sinusoidal, curved (convexing medially and concaving laterally), gracile and medially inset deltopectoral crest of proximal humerus GSP/Sangiali-1124 (**Figure 2**). This *Sulaimanisaurus gingerichi* humerus may be found in the lower part of attached or contacted stream which is derived from the nearby western site which yielded associated fossils (**Figure 2**) of *Sulaimanisaurus gingerichi*. This type of humerus (**Figure 2**) was also reported from Dongargaon, India is left humerus ISIR335/59 [38] assigned to *Isisaurus colberti*.

Gspsaurus **humeri morph** has following major distinction features. The *Gspsaurus pakistani* proximal humerus show a fairly V-shaped plain area just below the head in posterior view like *Balochisaurus malkani*, *Sulaimanisaurus gingerichi* and possibly *Isisaurus colberti* while in opposite the *Pakisaurus balochistani* has posterior convexity (median ridge) trending dorsoventrally are located posteriorly in the dorsoventral trending axis line (**Figure 2**). *Gspsaurus pakistani* has medially inset and almost straight and slightly obliquely oriented and gracile deltopectoral crest of proximal humerus GSP/Sangiali-1125 (**Figure 2**). The attribution of this humerus with *Gspsaurus pakistani* is done on the basis of shape, size and similarities with Chhota Simla humeri (**Figure 2**). Further this *Gspsaurus pakistani* humerus may be found in upper part of attached or contacted stream which is derived from the upper part (southern Sangiali) where a few fossils of this stocky limbed titanosaur ([20], page 68) were observed. These types of humeri (**Figure 2**) were also reported from India are left humerus NHMUK R5932 [28] [29] and right humerus NHMUK R5931 [28] [29] from Chhota Simla and one humerus (plate IV, Fig. 1 of [30]) from Bara Simla, and right and left humeri (GSI type no 20010, GSI 20011, plate 1, Fig. 4 of [32]) reported from Rahioli Gujarat India. All these types of humeri and associated bones are being referred to *Gspsaurus pakistani*. So the above mentioned humeri from Bara Simla and Rahioli are being referred to *Gspsaurus pakistani* sharing with similarities like straight and obliquely oriented deltopectoral crest with the *Gspsaurus pakistani* humeri from mid Sangiali (**Figure 2**) and Chhota Simla humeri [28] [29] which were previously referred to *Gspsaurus pakistani* [7] [24].

Intact skin surrounded on bone of Poripuchian titanosaur: Intact preserved skin surrounded on bone GSP/MSM-152-3 (**Figure 3**) (larger Figures 3-10 of [39]) of *Pakisaurus balochistani* discovered from the latest Maastrichtian Vitakri Formation of Fort Munro Group in the Shalghara locality 3 (latitude 29˚40'56"N; longitude 69˚22'47"E; Fig. 4 of [6]) (Fig. 1-2 of [39]) of Vitakri dome, Barkhan district, Balochistan Province, Pakistan. Skin mostly being soft is rarely preserved with bone. Here the skin is enveloped on distal phalange or last phalange of pes. The distal phalange is covered by skin in all surfaces except the articular surface connecting with previous phalange. This fossil has major two portions, the central thick bone which is surrounded by thin skin cover. The articular surface (preserved thick end) of bone is subcircular and thick which is covered by skin as outer layer or portion. This bone is tapering toward the thin end and cone end of bone. On this tapered end the skin shows oval contoured structures (larger Fig. 5 of [39]). This bone is slightly curved representing concave curvature possibly ventrally and convexing dorsally. The remaining all portions like ventral, dorsal, left and right lateral and also distal cone all are enveloped by skin. This skin thickness is about 0.5 - 1.0 cm. Its colour is maroon and reddish maroon. It is spongy with fine mosaic and has rough surface (**Figure 3**). This skin texture matches with the skin impression revealed from natural cast of footprint (page 950 of [8] [40]) which shows tubercles, pits, fractures and rough surface pattern. Detail study of skin may reveal the further results. This intact skin fossil of latest Cretaceous titanosaur from Pakistan is being first time reported from Indo-Pakistan subcontinent (South Asia). There are three options for the bone position. Firstly this bone may belong to diapophysis or neural spine but in this position meat muscles commonly cover the bone. This bone on anterior view represents two laminae or ridges. Secondly it may belong to distal caudal but commonly distalmost caudal may be thick like this bone. Thirdly it may belong to armor spine or spike but the bone is massive because armor bones are mostly pneumatic. Fourthly it may belong to distal phalange of pes, because in titanosaur there are no phalanges in manus.

Muscle fossil surrounded on chevron bone of *Nicksaurus razashahi* titanosaurian sauropod dinosaur: Muscles fossils preserved as coating on a chevron GSP/MSM-313-4n (**Figure 3**) (larger Figs. 11-12 of [39]) of *Nicksaurus razashahi* [7] [12] found from the latest Cretaceous Vitakri Formation of Fort Munro Group of the north Kinwa locality (Fig. 4 of [6]) of Vitakri dome, Barkhan district, Balochistan, Pakistan. Muscle fossils coated on chevron represented by tubercles oriented in lines may belong to attached muscle of meat or skin.

Bone injury in neural spine of *Gspsaurus pakistani* poripuchian titanosaur: A bone injury is found in the neural spine GSP/MSM-150-16 (**Figure 3**) of *Gspsaurus pakistani* found from the latest Cretaceous/latest Maastrichtian Vitakri Formation of Fort Munro Group of the Top Kinwa locality (Fig. 4 of [6]) of Vitakri dome, Barkhan district, Balochistan Province, Pakistan. The bone injury is subrounded and deep in the neural spine (**Figure 3**). It seems original injury due to shape and also because no subsidiary fractures found in and around deep injury. It may represents deep injury by any predatory animal or any bone disease or any other reason.

3.3.2. Theropod Dinosaurs from the Vitakri Formation of Pakistan: Updated Attribution, Key elements, Distinguishing Features and Comparison

Vitakridrinda, *Vitakrisaurus* and *Shansaraiki* theropods are known from Pakistan.

***Vitakridrinda sulaimani*:** *Vitakridrinda sulaimani* [22] vide [6] is a Vitakrisauridae [18] vide [6] theropod which was formally (as per standard set by ICZN) described in 2021 [6]. It was based on holotypic skeleton consisting of more than 10 teeth, a pair of femora and a pair of dorsal vertebrae from central Alam 19 locality [6]. Its referred materials include anterior dorsal vertebra from Sangiali 1, two tall dorsal vertebrae, a single distal tail vertebra and meta tarsal from Top Kinwa 16, one anterior caudal and one middle caudal vertebrae from Mari Bohri locality 15, a single anterior dorsal vertebra from Sangiali 1 and a metatarsal from south Kinwa 4 (page 302 of [6]; page 301, Fig. 9, row 5 of [6]). Its distinguishing characters are as follows. *Vitakridrinda sulaimani* has short and broad oval teeth like *Indosuchus raptorius.* It has also subcircular teeth while *Shansaraiki insafi* and *Indosuchus raptorius* have oval shaped teeth convexing lingually and labially. It also has teardrop type teeth like *Rahiolisaurus gujaratensis*. Its proximal femoral shaft with slightly transversely broad with thick peripheral bone enveloped on the central hollow cavity while distal shaft is more broader. Its femoral anterior trochanter is vertically oriented and blunted at tip. Its dorsal centra are constricted transversely in the mid forming neck and this feature is not found in the centra of *Rajasaurus narmadensis* and *Rahiolisaurus gujaratensis*. Its dorsal centra has ventral smooth plain and forming reduced neck at the dorsal portion which also differentiates it from the *Rajasaurus narmadensis* and *Rahiolisaurus gujaratensis* both have dominant ventral keel on dorsal centra [6] [25]. *Vitakridrinda sulaimani* have elongated, tall and ventrally expanded dorsal vertebrae while *Shansaraiki insafi* have elongated cylindrical dorsal vertebrae and *Rajasaurus narmadensis* have short and tall dorsal vertebrae. *Vitakridrinda sulaimani* have elongated and square shaped to cylindrical caudal vertebrae while *Vitakrisaurus saraiki* have elongated and tall caudal vertebrae. *Vitakridrinda sulaimani* did not have ventral keel in dorsal and also caudal centra, while *Rajasaurus narmadensis* and *Rahiolisaurus gujaratensis* have ventral keel on dorsal and caudal centra. *Vitakridrinda sulaimani* neural canal is dorsoventrally tall suboval shaped in anterior caudal vertebrae while *Vitakrisaurus saraiki* neural canal is dorsoventrally compressed, transversely oval shaped in anterior caudal and also in middle caudal vertebrae. *Vitakridrinda sulaimani* have amphicoelous biconcave caudal vertebrae, while *Rajasaurus narmadensis* and *Rahiolisaurus gujaratensis* have amphiplatyan or flat articular surfaces or feeble amphicoely. Its distal caudal is anteroposteriorly elongated subcylinder type with long parallel ridges alternated by long grooves on all sides, except the anterior and posterior concave articular surfaces. This distal centrum has no apparent neural arch connection. It is medium to large sized theropod.

Vitakrisaurus saraiki: *Vitakrisaurus saraiki* [18] vide [6] was a Vitakrisauridae [18] vide [6] theropod which was formally (as per standard set by ICZN) described in 2021 [6]. Its holotypic skeleton includes caudal vertebrae, humerus, ulna, manus and a few other limb bones from mid Bor locality 2 [6] [25] and referred materials include a few limb bones from Pakistan [6] and an amphicoelous vertebra with small sized chevron from India [6] [30]. *Vitakrisaurus saraiki* have elongated and tall caudal vertebrae while *Vitakridrinda sulaimani* have elongated and square shaped to cylindrical caudal vertebrae. *Vitakrisaurus saraiki* neural canal is dorsoventrally compressed, transversely oval shaped in anterior caudal and also in middle caudal vertebrae while *Vitakridrinda sulaimani* neural canal is dorsoventrally tall suboval shaped in anterior caudal vertebrae. Its comparison and detailed description of above bones can be found in [6] [25].

Systematic Paleontology of *Shansaraiki insafi* theropod from Pakistan: Dinosauria; Saurischia; Theropoda; Ceratosauria; Abelisauroidea; Vitakrisauridae [18] vide [6];

Shansaraiki insafi new genus and new species (**Figure 5**).

Holotype: left and right anterior mandibular rami fused at symphysis GSP/MSM-140-3, partial mid ramus with articulated partial teeth base GSP/MSM-5-3 and a dorsal vertebra GSP/MSM-57-3 (**Figure 5**). Holotypic bones found as fragmentary on the surface of same Formation, same locality, same time, fit size and no duplication shows associated bones of single individual. Fossils are housed in museum of Geological Survey of Pakistan, Quetta, Pakistan.

Type locality, horizon and age: Holotype was found in the Shalghara locality 3 with Latitude 29.68288 and Longitude 69.38008 (N 29˚40'58"; E 69˚22'48") (as shown in Fig. 4 of [6]) of Vitakri dome area, Barkhan district, Balochistan Province, Pakistan. Host horizon is Vitakri Formation of Fort Munro Group [6] [11] [15]. Age is latest Maastrichtian [6] [11].

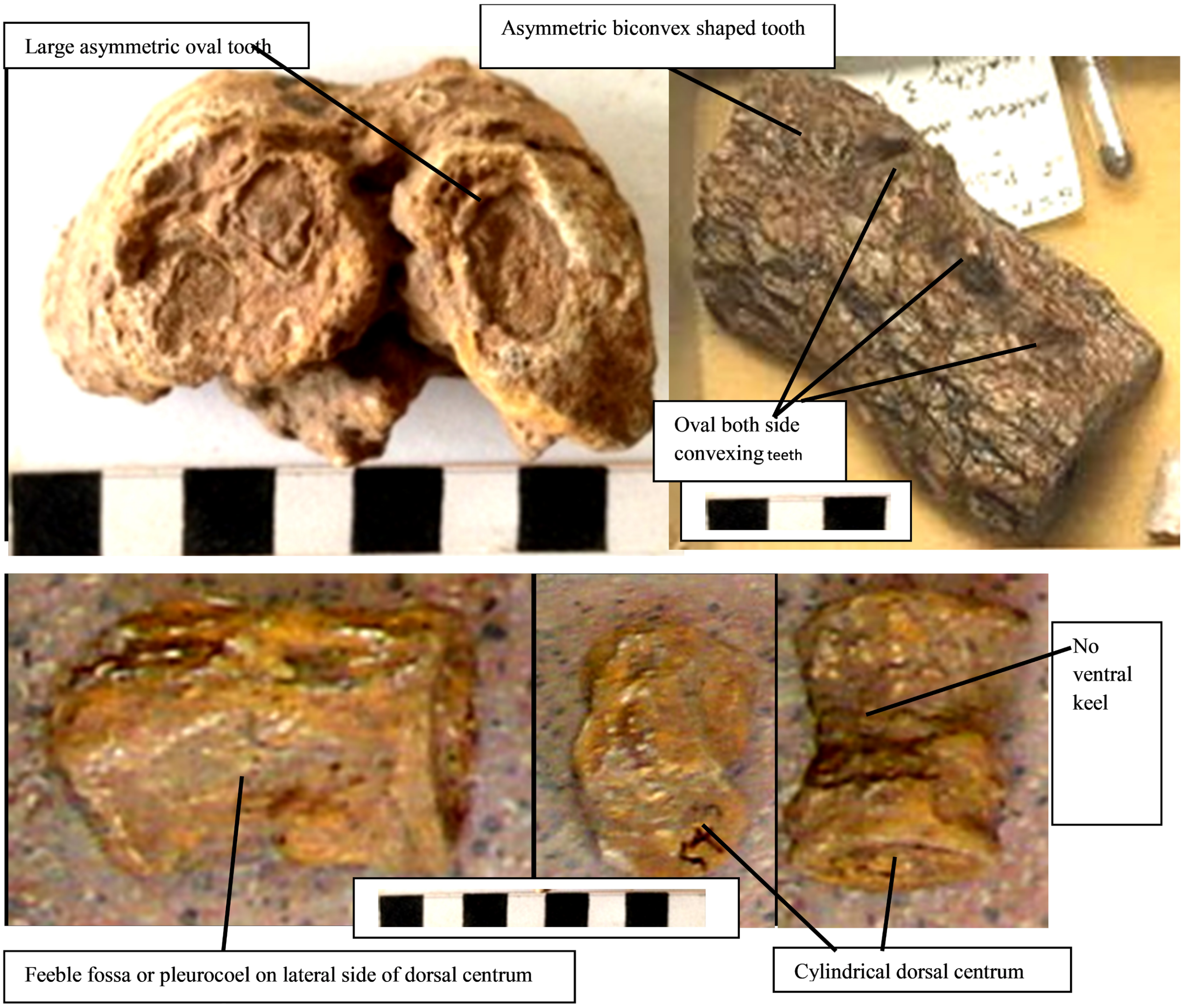


Figure 5. *Shansaraiki insafi* holotypic fossils (row 1 and 2) collected from Shalghara type locality (Figure 4 of [6]), Barkhan district, Balochistan Province, Pakistan. **Row 1**, anterior dentary with symphysis GSP/MSM-140-3, and dentary ramus with five teeth/alveoli GSP/MSM-5-3. **Row 2**, dorsal vertebra GSP/MSM-57-3 in 3 views. Scale, each black and white digit is 1 cm.

Etymology: Genus name *Shansaraiki* can be understood as *Shan*, Saraiki language means respect and honor, *saraiki* means Saraiki peoples and areas which host the fossils. Qaid Azeem Imran Khan is the shan and honour of the Saraiki peoples By the efforts of Qaid Azeem Imran Khan Niazi and other leaders, the South Punjab (Saraiki area) civil secretariat were established at Multan and Bahawalpur and construction of buildings of South Punjab civil secretariat happened, besides other facilities for these remote Saraiki areas. The genus name *Shansaraiki* can be pronunciated as Shan Saraiki. The species name *S. insafi* honor the Pakistani leaders, journalists (Waqar Malik, Imran Riaz Khan, Shahbaz Gil, Mustafa Nawaz Khokhar, Sami Abraham, Sabir Shakir, Shaheen Sehbai, Irfan Hashmi, Shaheed Arshad Sharif, Adv. Abdul Ghaffar, Siddique Jaan, Dr. Moeed Pirzada, Former Lt. Gen. Amjad Shuaib, Sajid Gondal, Fayyaz Raja, Abdul Qadir, Asad Ullah Khan, Fahim Akhtar, Makhdoom Shahab-ud-Din, Faisal

Tarar, Essa Naqvi, Adeel Warraich, Faiq Siddiqi, Tariq Mateen, Jameel Farooqui, Muhammad Zameer, Zain Ali and others), lawyers, farmers, labors and peoples of Pakistan which support insaf (justice), rule of law and deletion of corruption in Pakistan. Pronunciation of species name *insafi* is as In-safi.

Diagnosis and comparison: *Shansaraiki insafi* overlapping features with Abelisauroidea Ceratosauria are as biconvex and broad oval shaped teeth, pitted structure on dentary and medium to large sized amphicoelous vertebra. *Shansaraiki insafi* characters and comparison is as below. It form V-shaped (**Figure 5**) anteriormost end of dentary symphysis (blunted as w-shaped) while *Rahiolisaurus* anterior jaw ramus shows curvature representing U-shaped anterior symphysis. Dentary ramus is thick and deep and represents rough pitted structures and irregular lineations. *Shansaraiki insafi* has spaced teeth on ramus while *Indosuchus* [30] have short, recurved and closely contacted teeth. Its teeth have different morphology on different positions. *Shansaraiki insafi* has oval and biconvex teeth (convexing on labial and also lingual sides) while *Vitakridrinda* [6] has commonly D-shaped, oval and subcircular teeth. Its anteroposteriorly broad teeth matching with *Indosuchus* but differ on teeth shape. It has oval shaped teeth while *Vitakridrinda* has D-shaped, oval and subcircular teeth and *Rahiolisaurus* [41] has symmetrical cross sectional shape of teeth. Its teeth size and interdental spacing is almost same as *Rahiolisaurus* [41]. It has relatively rounded mesial keel and sharp distal keel on one tooth while *Rahiolisaurus* [41] has a faint mesial keel but rounded distal edge. It has symmetric and asymmetric both type of teeth, while *Rahiolisaurus* [41] has symmetrical oval teeth (*Rajasaurus* [42] has no preserved teeth for comparison). Its anteroposterior width of teeth is same as *Vitakridrinda* teeth [6] but relatively large than *Rahiolisaurus* teeth [41]. Its dorsal centrum is elongated cylindrical with circular shaped articular surfaces (**Figure 5**), while *Vitakridrinda* has tall and elongated dorsal centra (**Figure 5**), and *Rajasaurus* [42] has tall and short dorsal centrum. Its dorsal centrum is not spool-shaped, with its articular faces not deeper than broad while *Rajasaurus* [42] dorsal centrum is spool-shaped, with its articular faces deeper than broad [19]. It has well developed amphicoelous concave articular surfaces (**Figure 5**) while the *Rajasaurus* [42] and *Rahiolisaurus* [41] have flat or gentle or faint amphicoelous nature.

Description: The description of bones is provided as below.

Dentary symphysis: Holotypic dentary symphysis (GSP/MSM-140-3) shows weak anterior articulation and pitted structures. It form V-shaped (**Figure 5**) anteriormost end of dentary symphysis (blunted as w-shaped) while *Rahiolisaurus* anterior jaw ramus [41] shows curvature representing U-shaped anterior symphysis. Articulated first dentary tooth is large and biconvex (convexing on labial and also lingual sides) on one ramus, while 1st and 2nd dentary relatively small teeth on opposite relevant position on another ramus. This shows variation of teeth size on same position of both jaws/rami confirms assignment to theropods than mesoeucrocodile. Because mesoeucrocodile have mostly same size teeth on relevant position on both sides of rami/jaws like *Mithasaraikistan* [6] and *Pabwehshi* [17].

Dentary ramus: Holotypic dentary ramus (GSP/MSM-5-3) is thick and deep (**Figure 5**) and represents rough pitted structures and irregular lineations. The teeth articulated with dentary ramus are relatively large to moderate in size, asymmetric oval and D-shaped and not closely contacted (**Figure 5**). *Shansaraiki insafi* dentary ramus has spaced teeth while *Indosuchus* [30] have short, recurved and closely contacted teeth. Dentary ramus lack vertical ridges and also dental foramina.

Teeth/Dentition: The teeth articulated with dentary ramus are relatively large to moderate in size, asymmetric oval, subcircular and D-shaped and not closely contacted (**Figure 5**) and possibly low crown (interpreted from sharp decreasing of thickness) recurved teeth. Teeth have different morphology may belong to different positions. It has oval and biconvex teeth (convexing on labial and also lingual sides) while *Vitakridrinda* has commonly D-shaped, oval and subcircular teeth [6]. It has spaced teeth while *Indosuchus* [30] have short, recurved and closely contacted teeth. Its anteroposteriorly broad teeth matching with *Indosuchus* but differ on teeth shape. It has oval shaped teeth while *Vitakridrinda* has D-shaped, oval and subcircular teeth and *Rahiolisaurus* [41] has symmetrical cross sectional shape of teeth. Its teeth size and interdental spacing is almost same as *Rahiolisaurus* [41]. It has relatively rounded mesial keel and sharp distal keel on one tooth while *Rahiolisaurus* has a faint mesial keel but rounded distal edge. Symmetric and asymmetric both type of teeth found in *Shansaraiki insafi*, while *Rahiolisaurus* [41] has symmetrical oval teeth (*Rajasaurus* [42] has no preserved teeth for comparison). The anteroposterior width of teeth of *Shansaraiki insafi* is same as *Vitakridrinda* teeth but relatively large than *Rahiolisaurus* teeth representing *Shansaraiki insafi* and *Vitakridrinda* relatively larger animal than *Rahiolisaurus*.

Dorsal vertebra: Holotypic dorsal vertebra GSP/MSM-57-3 include complete centrum (**Figure 5**) and provide information especially differentiation from *Vitakridrinda* [6], *Rajasaurus* [42] and *Rahiolisaurus* [41]. This dorsal centrum is amphicoelous, slightly waisted and has lateral feeble fossa or pleurocoel (**Figure 5**). The centrum length is 6.6 cm, width 6.6 cm and length 8.3 cm (**Figure 5**). This dorsal centrum is elongated cylindrical with circular shaped articular surfaces (**Figure 5**), while dorsal centra of *Vitakridrinda* is tall and elongated (**Figure 5**), and the dorsal centrum of *Rajasaurus* [42] is tall and short. *Vitakridrinda* and *Vitakrisaurus* [6] did not have ventral keel (**Figure 5**) and in this regards differ from *Rajasaurus* [42], *Rahiolisaurus* [41] and *Nhandumirim* which have longitudinal keel on ventral surface of centrum. The proximal and posterior articular surfaces of the centrum are circular and concave (**Figure 5**). They have slightly constriction and slight concave profiles of the ventral margin of centra in side view (**Figure 5**). The dorsal centrum is not spool-shaped, with its articular faces not deeper than broad while *Rajasaurus* [42] dorsal centrum is spool-shaped, with its articular faces deeper than broad [19]. *Shansaraiki insafi* have well developed amphicoelous concave articular surfaces (**Figure 5**) while the *Rajasaurus* [42] and *Rahiolisaurus* [41] have flat or gentle or faint amphicoelous nature. *Shansaraiki insafi* has elongated dorsal centrum (**Figure 5**) jointed on all dorsal view anteroposterior length with neural arch.

3.4. Titanosaurs from India with Updated Assessment of *Jainosaurus*

Named titanosaur taxa from India and their comparison: Among 17 titanosaurs taxa from latest Cretaceous of Indo-Pakistan, the 15 titanosaurs named after fossils found from the latest Cretaceous strata of Indo-Pakistan subcontinent (South Asia). Further a few bones were only referred to titanosaur taxa like Titanosaurus madagascariensis and others from India. The 5 titanosaurs from the bone fossils are known from the latest Cretaceous Lameta Formation of India. While the 10 titanosaurs based on recently found bone fossils are named from the latest Maastrichtian Vitakri Formation of Pakistan. Indian titanosaur taxa named from Maastrichtian Lameta Formation are informal by the standard set by ICZN like *Titanosaurus indicus* [43], *Titanosaurus blanfordi* [44], *Titanosaurus rahioliensis* [45] and *Jainosaurus septentrionalis* [46] except *Isisaurus colberti*. While Pakistani titanosaur taxa (mentioned as above) from the Latest Maastrichtian (67 - 66 Ma) Vitakri Formation are formal by the standard set by ICZN [6] [7]. From India in 1977 the reference [43] established *Titanosaurus indicus* on two caudal vertebrae explored from Bara Simla. Among these, one caudal is procoelous and other caudal is amphicoelous. This combination is not consistent for a single individual when observing other titanosaurs from India and Pakistan. The *Titanosaurus indicus* has tall and slender caudal centrum while *Pakisaurus balochistani* has relatively moderate tall and robust caudal centrum and *Khanazeem saraikistani* has relatively less tall and more robust caudal centrum without significant ventral reduction. Further its procoelous and amphicoelous nature of centra are discussed in page 432 of [7]. In 1979, the reference [44] established *Titanosaurus blanfordi* based on one long and one short procoelous caudal vertebrae from Bara Simla which are again are not diagnostic and consistent with each other for a single individual and species. Further these caudal vertebrae indicate procoelous nature of titanosaurian synapomorphies and did not furnish any autapomorphy. From Pakistan only *Khetranisaurus barkhani* is attributed only 2 caudals (but distinct nature that dorsal width is less than ventral width of centrum), while 1 Pakistani titanosaurs attributed snout, 4 attributed cranial and postcranial fossils and 5 other attributed vertebral and appendicular and limb bones. In 1987, the reference [45] established *Titanosaurus rahioliensis* based on teeth (apparently one tooth). The shape of this one tooth is different than *Gspsaurus pakistani* [24], *Saraikimasoom vitakri* [14] and *Nicksaurus razashahi* [7] [24]. The *Khanazeem saraikistani* has teeth articulated with dentary (**Figure 4**) but most of teeth crown is damaged. The comparison of one tooth of *Titanosaurus rahioliensis* was compared with Pakistani titanosaurs in page 432 of [7]. In 1994/1995, the fourth titanosaur named from India is *Jainosaurus septentrionalis* [46] (for *Antarctosaurus septentrionalis* [30] in India) which are being assessed here as below. In 1997, the reference [38] established *Titanosaurus colberti* (renamed as *Isisaurus colberti*) is only diagnostic titanosaur from India which based on vertebral and appendicular elements from Dongargaon and detailed described by [38]. Isisaurus colberti has autapomorphies like scapular articular surface for coracoid is longer (unlike *Gspsaurus pakistani* which have scapular shorter articular surface for the attachment of coracoid and robust glenoid with relatively more expanded transversely distal scapula, *Balochisaurus malkani* which have scapular shorter articular surface for the attachment of coracoid and robust glenoid with relatively expanded transversely distal scapula and *Pakisaurus balochistani* which have scapular shorter articular surface for the attachment of coracoid and slender glenoid with relatively less expanded transversely distal scapula or relatively slender distal scapula), medially inset and curved deltopectoral crest (like *Sulaimanisaurus gingerichi* and unlike *Gspsaurus pakistani* which has medially inset and straight deltopectoral crest, *Balochisaurus malkani* which has curved and laterally terminal inset (expanded laterally deltopectoral crest) on anterior side of humerus, and *Pakisaurus balochistani* which has medially inset and straight deltopectoral crest with posteriorly longitudinal anticlinal ridge starting at the base of head trending dorsoventrally), and expanded pubis symphysial condyle for the attachment of ilia (while *Marisaurus jeffi* has small symphysial condyle for the attachment of ilia).

Updated assessment of *Jainosaurus septentrionalis*: The reference [46] named *Jainosaurus septentrionalis* [46] (for *Antarctosaurus septentrionalis* [30] in India) on fragments of skull and postcranial elements like caudal vertebrae, chevron, fore limb and sternal plate from the same bed and same locality [46] without considering the condition set by ICZN. Further they mentioned that these postcranial elements were collected over several years atleast from 1917-1919, it appears they were arbitrarily assigned to this taxon [46]. The reference [47] separated the Indian *Antarctosaurus septentrionalis* skeletal elements on the basis of large size, slenderness and close similarity to Patagonian *Antarctosaurus wichmannianus*. According to [47] some of the postcranial elements were similar to Patagonian species like humerus (plate 4, Fig. 1 of [30]) and others are not like scapula (plate 3 of [30]) and braincase of two taxa are very different [47]. The reference [46] established *Jainosaurus septentrionalis* with lectotypic braincase Geological Survey of India K27/497 from Bara Simla (Jabalpur, India). The postcranial elements were considered as paralectotype because their exact association with lectotype is not determined [46]. If the lectotype GSI K27/497 cannot be located, then the reference [46] proposed as a neotype the left scapula (plate III, Fig. 2 of [30]). The reference [31] reassessed *Jainosaurus septentrionalis* and attributed many bones to it. Later on [29] attributed Chotta Simla bone assemblage like Caudal vertebra NHMUK R16481, left humerus NHMUK

R5932, right humerus NHMUK R5931, right radius NHMUK R5933, left femur NHMUK R5903, left tibia NHMUK R5903 and left fibula NHMUK R5903 to *Jainosaurus septentrionalis*. This attribution was based on key humerus which matching with *Jainosaurus septentrionalis* humerus with main features are medially inset and curved/sinusoidal deltopectoral crest in proximal humerus, and anteriorly exposed radial condyle of distal humerus. The reference [24] mentioned chimeraic nature of materials of *Jainosaurus septentrionalis*. Here a comparison is being tried between bones of *Jainosaurus septentrionalis* [30] [31], *Gspsaurus pakistani* [6] [7] [24] and Chhota Simla assemblages [28] [29]. These comparison exposed significant and interesting results.

Now the recent discoveries of *Gspsaurus pakistani* holotypic skeleton [6] from Pakistan revealed that the [46] [47] assessment became correct because *Gspsaurus pakistani* (and also some other named titanosaurs from Pakistan) has sufficient overlapping and comparable materials with cranial and postcranial materials of *Jainosaurus septentrionalis* described by [30] [31] and Chotta Simla materials described by [28] [29]. Comparison of *Jainosaurus septentrionalis* materials [30] [31] with *Gspsaurus pakistani* ([6] [7] and as above mentioned), *Balochisaurus malkani* ([7] and as above mentioned), and *Isisaurus colberti* [38], indicated *Jainosaurus septentrionalis* is a not only chimeraic ([6], page 435) but show triple affinity to these 3 titanosaurs. The possible comparison of lectotypic braincase and paralectotypic vertebra, scapula and humerus [30] of *Jainosaurus septentrionalis* are being presented here. The braincase K27/497 (plate II, Fig. 1a, 1b of [30]; Figure 2a of [31]) of *Jainosaurus septentrionalis* has D-shaped which is differentiated from w-shaped occipital condyle bearing braincase of *Gspsaurus pakistani*. The *Gspsaurus pakistani* braincase GSP/MSM-62-19 has w-shaped ventrally constricted and transversely more broader occipital condyle and *Balochisaurus malkani* Top Kinwa braincase has transversely more broader and feebly w-shaped ventrally constricted occipital condyle. It represents that the stocky and robust forms of poripuchian titanosaurs from Indo-Pakistan has transversely more expanded along with w-shaped ventrally constricted occipital condyle of braincase. It indicates the slender family Pakisauridae of poripuchian titanosaurs from Indo-Pakistan subcontinent shows affinity to D-shaped (and transversely relatively less broad). The tall and ventrally reduced caudal vertebra K20/317 (Fig. 9 of [30]; Fig. 2c of [31]) of *Jainosaurus septentrionalis* matches with the tall and ventrally reduced caudal vertebrae of *Gspsaurus pakistani*. The right scapula (plate III, Fig. 1 of [30]; Fig. 2d of [31]) has relatively longer articular surface for coracoids which matches with the scapula (Fig. 18 of [38]) of *Isisaurus colberti* and differentiated from Pakistani titanosaurs, like this articular surface for coracoid is relatively shorter in the *Pakisaurus balochistani*, *Balochisaurus malkani* and *Gspsaurus pakistani*. Further the right humerus (plate IV, Figure 1 of [30]; Figure 2e of [31]) of *Jainosaurus septentrionalis* from Bara Simla India have medially inset and almost straight and obliquely oriented deltopectoral crest like *Gspsaurus pakistani* (mid Sangiali right humerus

GSP/Sangiali-1125, Fig. 6 of [30]; Figure 8 of [7]) (**Figure 2**) which is referred here to *Gspsaurus pakistani* (as above), and right humerus (plate V, Fig. 2 of [30]) of *Jainosaurus septentrionalis* from Bara Simla India have robust and laterally expanded and also almost terminally inset deltopectoral crest on anterior side just close to lateral profile like *Balochisaurus malkani* (mid Sangiali right humerus GSP/Sangiali-1113, Figure 6 of [30], Figure 8 of [7]) (**Figure 2**) which is referred here to *Balochisaurus malkani* (as above). It is necessary to mention that the Chotta Simla humeri ([29], fig. 4) along with other associated bones [29] except caudal vertebra were previously referred to *Gspsaurus pakistani* [7] [24] based on key and guide elements. The sternal plate (plate IV, Fig. 2 of [30] which may be right femur), left scapula (plate III, Fig. 2 of [30]; Fig. 2d [31]), left femur (plate V, Fig. 1 of [30]), radius (Fig. 17 of [30]; Fig. 2f of [31]) and ulna (Fig. 18 of [30]; Fig. 2f of [31]) of *Jainosaurus septentrionalis* are weathered, eroded (at typical points) and incomplete and not comparable. The ribs (Figs. 11-15 of [30]; Fig. 2b of [31]) did not show any distinguished affinity to *Jainosaurus* or *Gspsaurus* or any other taxa. Conclusively this updated assessment shows that the braincase of *Jainosaurus septentrionalis* may be its type as interpreted by [47], or it may be referable to any pakisaurids (*Pakisaurus*, *Sulaimanisaurus*, *Khetranisaurus*, *Khanazeem* and *Isisaurus*), or in other case the braincase and right scapula of *Jainosaurus septentrionalis* are referable to *Isisaurus colberti* because of sharing of scapular longer articular surface for coracoid which is differentiated from other Indo-Pakistani titanosaurs. The caudal vertebra and right humerus (as mentioned above) of *Jainosaurus septentrionalis* are referable to *Gspsaurus pakistani*. The other right humerus (as mentioned above) of *Jainosaurus septentrionalis* is referable to *Balochisaurus balochistani*. This represents triploid affinity of *Jainosaurus septentrionalis* bones described by [30] with *Gspsaurus*, *Balochisaurus* (stocky titanosaurs) and *Isisaurus* (slender titanosaur).

Some of the Chotta Simla materials [28] were referred to *Jainosaurus septentrionalis* by [29]. In this way comparison of Chotta Simla materials [28] [29] from India with *Gspsaurus pakistani* materials from Pakistan represents perfect similarity with each other (except caudal vertebra NHMUK R16481 [29] which is referable to *Pakisaurus balochistani* based on tall, relatively robust and flat sided, while *Titanosaurus indicus* has slender and flat sided caudal and *Khanazeem saraikistani* has more robust and flat sided caudals). For example left tibia NHMUK 5903 [29] (it is right tibia and key element) is similar with holotypic tibiae (left proximal tibia GSP/MSM-119-19, left distal tibia GSP/MSM-569-19, right distal tibia GSP/MSM-710-19) and referred tibia (GSP/MSM-73-16) of *Gspsaurus pakistani* [6] [24], showing resemblance on expanded fibular condyle and posterior process of proximal tibia and also expanded posterior limb of shaft than anterior limb which host cnemial crest dorsally. This is discussed in detail (pages 458-460 of [24]). The Chotta Simla humeri NHMUK R5931 and NHMUK R5932 and *Gspsaurus pakistani* humerus GSP/Sangiali-1125 are similar with the main feature as the deltopectoral crest is medially inset, fairly straight and oriented obliquely (see above 4 morphs of humeri from Pakistan, **Figure 2**). While the *Balochisaurus malkani* humerus shows robust, sinusoidal or curved (concavity on lateral side and convexity on medial side) and lateral extremity inset occurrence of deltopectoral crest, and *Sulaimanisaurus gingerichi* humerus shows gracile, sinusoidal or curved (concavity on lateral side and convexity on medial side) and medially inset of deltopectoral crest [27]. The Chotta Simla robust left femur NHMUK R5903 is similar with the femur of *Gspsaurus pakistani* [24], both have straight lateral profile between the proximolateral corner of the femoral head and the lateral bulge. This feature is differentiated from the *Khanazeem saraikistani* which has slender femur shows concavity between the proximolateral corner of the femoral head and the lateral bulge (wavy lateral profile of proximal femur). *Balochisaurus malkani* femora are robust like *Gspsaurus pakistani* but differentiated with other key bones like tibia, humerus, etc. The size and shape of Chotta Simla fibula NHMUK R5903 is similar with the Top Kinwa fibula of *Gspsaurus pakistani* [24]. While fibulae of *Pakisaurus balochistani* and *Sulaimanisaurus gingerichi* are relatively larger than *Gspsaurus pakistani* and *Balochisaurus malkani* (**Figure 2**). The size and shape of proximal radius GSP/MSM-215-19 of *Gspsaurus pakistani* [24] matches with Chotta Simla proximal radius. Conclusively this updated assessment of Chhota Simla bones assemblage as mentioned by [29] is referable to *Gspsaurus pakistani* (as explained above), except the caudal vertebra which is referable to *Pakisaurus balochistani* (also explained above) as also discussed in [24].

4. Conclusions

There is a controversy for the position of boundary between Balochistan basin and Indus basin which is being solved here. From Basima to Nal-Ornach to Arabian Sea, the Chaman Transform fault and western Indus Suture converge with each other and represent plate boundary between these two basins. While in the north from Basima to Jalalabad the Chaman Transform fault bifurcated and located on the western side away 5 - 50 kms from western Indus Suture. The 50 km separation distance in between these two elements is found from Musafarpur or Mina Bazar to Shagala to Kamardin Kareez. Balochistan basin shows mostly imbricated faults with subordinate folds created by subduction of Arabian Sea plate under Chagai block, while Indus basin mostly shows folds and subordinate faults created by collision of Indo-Pakistan plate with Asian plate. Significant paleontological collections from terrestrial Mesozoic strata were done. Recently at the dawn of third millennium, many dinosaurs (titanosaurian sauropods and theropods), mesoeucrocodiles, pterosaur, bird and snake were discovered from Pakistan. From Indo-Pakistan 15 titanosaurs were named, among these 10 were named from Pakistan and 5 were named from India. The previously attributed bones to *Jainosaurus septentrionalis* are not consistent and show triploid affinity. The updated assessment of *Jainosaurus septentrionalis* bones revealed braincase as its type or in other case braincase and scapula which are referable to *Isi-*

saurus colberti due to matching distal scapular long articular surface for the attachment of coracoid. Other most of the key elements were assigned to *Gspsaurus pakistani* and *Balochisaurus malkani* (stocky titanosaurs) and a few bones to *Isisaurus colberti* and *Pakisaurus balochistani* (slender titanosaurs).

It is necessary to mention that the Pakistan Council for Science and Technology recently published Technology Foresight on Mineral Sector, Expert Panel Report, in which the recent studies mentioned in bibliography on updated and revised Mineral Resources of Pakistan (its different provinces, basins and regions) along with different aspects of Geology especially by present author (MSM) and their colleagues on pages 172-173 of [48] to fill the missing links.

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This work is a contribution to the Geological Survey of Pakistan.

Conflicts of Interest

Author declares no conflicts of interest regarding the publication of this paper.

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