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Geology and Mineral Deposits of Saraikistan (South Punjab, Koh Sulaiman Range) of Pakistan: A Tabular Review of Recently Discovered Biotas from Pakistan and Paleobiogeographic Link: Phylogeny and Hypodigm of Poripuchian Titanosaurs from Indo-Pakistan

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Abstract

Saraikistan (South Punjab and surrounding) area of Pakistan is located in the central Pakistan. This area represents Triassic-Jurassic to Recent sedimentary marine and terrestrial strata. Most of the Mesozoic and Early Cenozoic are represented by marine strata with rare terrestrial deposits, while the Late Cenozoic is represented by continental fluvial deposits. This area hosts significant mineral deposits and their development can play a significant role in the development of Saraikistan region and ultimately for Pakistan. The data of recently discovered biotas from Cambrian to Miocene age are tabulated for quick view. Mesozoic biotas show a prominent paleobiogeographic link with Gondwana and Cenozoic show Eurasian. Phylogeny and hypodigm of Poripuchian titanosaurs from India and Pakistan are hinted at here.

Keywords

Geology, Minerals, Cement, Dams, Biota, Tabular Data, Paleobiogeography, Saraikistan, South Punjab, Sulaiman Range, Pakistan, Titanosaurs, Indo-Pakistan

1. Introduction

Sulaiman basin (also called middle Indus basin) consists of Sulaiman foldbelt (or Koh Sulaiman Ranges or Sulaiman Ranges) and Sulaiman plain area. The Sulaiman foldbelt is bounded in the east by Indus River (D. I. Khan to Taunsa to D. G. Khan to Rajanpur to Kashmor to Jacobabad), in the west by western Indus Suture (Razmak North Waziristan to Wana South Waziristan to Zhob to Qila Saifullah to Muslimbagh to Khanozai to Quetta), in the north Kurram to Banu to Tank to northeastern part of D. I. Khan, and in the south by Jacobabad to Sibi to Mach to Coalpur to Quetta. The Sulaiman plain area is bounded in the west by Indus River belt, in the east by Lahore to Cholistan desert, in the north by northern part of D. I. Khan to Sargogha high to Lahore and in the south by Jacobabad to Shikarpur to northern part of Khairpur. Here, the studied Saraikistan area is the South Punjab (Dera Ghazi Khan, Multan and Bahawalpur divisions) and some surroundings. The western mountain belts of Rajanpur, Dera Ghazi Khan and Taunsa areas fall under Koh Sulaiman Ranges (located in central Pakistan). The stratigraphy and structural geology of Koh Sulaiman Range is previously described [1]-[11]. Here, the lithology and distribution of Cretaceous mostly marine Pab Formation (Dhaola, Kali and Sor Members) and terrestrial Vitakri Formations are described. Most of the mineral resources (except the radioactive/nuclear minerals and petroleum) fall under the territory of provinces. This is the reason why the geology of Saraikistan (South Punjab and surrounding) is being reported here for easy understanding of relevant scientists, government and private stakeholders. Keeping this in mind, the every province should know the potential of their mineral resources, so they can development the significant mineral deposits that can play an important role in the development of Saraikistan and ultimately for Pakistan. The data for recently discovered paleontological fauna and flora are tabulated for quick view and their paleobiogeographic links with Gondwana during Mesozoic and Eaurasia during Cenozoic were revealed. Further evolution and distinguishing features of Poripuchian titanosaurs from India and Pakistan are briefly mentioned.

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

2. Materials and Methods

The materials belong to compiled data from previous work especially mentioned in references and also new field materials collected by present author during numerous field seasons regarding the following purposes like the Stratigraphy, Geological Structure and Mineral Resources of Saraikistan (South Punjab, Koh Sulaiman Range) area of Pakistan. Beside these, the tabular overview of recently discovered biotas (during 2000-2023) of Pakistan and their Paleobiogeographic link were also incorporated. Further, the key features of Poripuchian Titanosaurs (Sauropoda, Dinosauria) from Indo-Pakistan were briefly discussed. The methods applied here are many disciplines of purely geological and paleontological procedure and description.

3. Results and Discussion

Here, the results and discussion are represented as the stratigraphy, structural geology and mineral resources of Saraikistan (South Punjab, Sulaiman basin) are of Pakistan. Further, the tabular overview of recently discovered biotas of Pakistan and their Paleobiogeographic link were mentioned. Beside these, major key features of Poripuchian titanosaurian sauropods of Indo-Pakistan Subcontinent (South Asia) were also incorporated.

3.1. Stratigraphy, Structural Geology and Mineral Resources of Saraikistan (South Punjab, Koh Sulaiman Range), Pakistan

These aspects are described as below.

3.1.1. Stratigraphy of Saraikistan (South Punjab, Koh Sulaiman Range) Area, Pakistan

Koh Sulaiman Range falls into central part of middle Indus basin (Sulaiman basin) and is also located in the eastern part of Sulaiman Foldbelt. The Koh Sulaiman Range hosts the exposed sedimentary rocks which are Triassic-Jurassic Sulaiman Group comprising of Wulgai (shale, marl and limestone), Loralai (thin to medium bedded Limestone), Chiltan (thick bedded and massive limestones), Dilband (ironstone, ferruginous siltstone/marl and shale), Lower Cretaceous Parh Group includes Sembar (shale), Mekhtar (sandstone, Goru shale and marl/siltstone) and Parh (white limestones), Late Cretaceous Fort Munro Group represented by Mughalkot (shale and sandstone with rare limestone), Fort Munro (limestones), Pab (mostly marine sandstones; Dhaola, Kali and Sor Members, see below), and Vitakri (terrestrial fluvial shale/mud and sandstones), Paleocene Sangiali Group consists of Sangiali (limestone, greenish grey sandstone and shale), Rakhi Gaj (sandstone and ironstone of Girdu Member; shale of Bawata Member; both members have Deccan volcaniclastic materials) and Dungan (limestones), Eocene Chamalang Group consists of Shaheed Ghat (shale), Toi (marine to deltaic green to grey sandstone and shale), Kingri (terrestrial red to maroon sandstone and shale) and Drug (rubbly limestones) and Baska (gypsum and shale) and Kahan Group represents Domanda (marine shale), Habib Rahi (brownish white marl and limestones), Drazinda (marine shales) and Pirkoh (white marl and limestones), Oligocene-Pliocene Vihowa Group represents Chitarwata (fluvial ferruginous sandstone, conglomerate and shale), Vihowa (fluvial shale and sandstone), Litra (fluvial sandstone with minor shale) and Chaudhwan (fluvial shale, sandstone and conglomerate) and Pleistocene-Holocene Sakhi Group consists of Dada (high energy fluvial conglomerate) and Sakhi Sarwar (fluvial shale/mud, sandstone and conglomerate) Formations and Subrecent and recent alluvium (Figure 1 of [1]; Figure 2 of [2]). The etymology, description, contact relationship, fossils and age of formations are mentioned in detail [1]-[11]. The type localities of formations are shown well in Figure 1 of [2] [11].

Beside the above exposed sequence, some relatively older geological formations were encounter in drill holes in the eastern plain areas. Some major hints and variations are mentioned as below. The PermoTriassic Wulgai formation consists of marine shale, marl and limestone mostly exposed in and around the Western Indus Suture. After this, the Early-Middle Jurassic Loralai Formation consisting of thin to medium bedded limestone with subordinate shale were deposited under marine condition. The Late Jurassic Chiltan Formation consisting of medium to thick bedded limestone with negligible shale were deposited under marine condition with relatively less fine clastic source. The Chiltan Limestone mostly forms peak of high mountains in Balochistan such as Chiltan, Takatu and Murdar Ghar ranges and Takht Sulaiman Range. The western slope of Takht Sulaiman Range lies in Balochistan and eastern slope in Khyber Pakhtunkhwa and South Punjab (Saraikistan). The limestone content of Parh Group is relatively low in Sulaiman foldbelt than in Kirthar foldbelt. The Formations of Fort Munro Group and Sangiali Group are being reduced toward west in the western Sulaiman foldbelt. The Mughalkot Formation has porcellaneous mudstone in the Rakhi Gaj Girdu section while it consists of shale and sandstone in the northwest. The Pab and Vitakri Formations are famous for dinosaur and other vertebrate fossils (as below). The sandstone of Ghazij Group is missing in the southeastern Koh Sulaiman Range while it is dominant in the north and west showing its source from the North West (from western Indus Suture and Afghan block). Dungan limestone is more thicker (best petroleum host) in the Zindapir and northward to Drazinda Shirani area, and also Kaha Harrand to southward, while it is thinner in the Rakhi Gaj and surroundings areas of Koh Sulaiman Range. Habib Rahi and Pir Koh Formations marl/limestones are thicker (best petroleum host) in the southern Koh Sulaiman Range (Mari Bugti hills) while Domanda and Drazinda Formations shale is more thicker in the north near Drazinda, Domanda and Mughalkot areas of Shirani.

Reference [12] (p. 132) first reported Cretaceous sandstone and crocodilian 2 or 3 vertebrae in olive shale containing bivalve *Cardita beaumonti* in Bara hills of Laki anticline (Sindh, eastern Kirthar foldbelt). This olive shale belongs to Early Paleocene Khadro or probably Bara Formations [13]. Later, [14] [15] described the Cretaceous sandstone from the Des valley, Mazar Drik (Balochistan; western Sulaiman foldbelt). References [16] [17] increased distribution of Cretaceous sandstone at Pab Range (western Kirthar foldbelt) where he named Pab sandstone after this type locality. He correlated the Bara, Pab Range and Des-Mazar Drik (Pazha area) sections. Reference [18] mapped the Pab Sandstone in the central and western Kirthar and Sulaiman foldbelt. The Geological Survey of Pakistan mapped (1:50,000 scale) most of the area especially the eastern part of Sulaiman and Kirthar foldbelts. Recently, present author ([1] [2] [6] [11] [19] [20] and references therein) visited all these areas and reported distribution of Cretaceous-Paleogene boundary (Cretaceous-Tertiary boundary), Pab and Vitakri Formations. Reference [20] divided the Pab Formation into three members such as Dhaola, Kali and upper Vitakri Members. Reference [21] upgraded the Vitakri member as Vitakri Formation. Sor Member [11] of Pab Formation is well exposed in the north western part (Qila Saifullah Zhob to North Waziristan) of Sulaiman foldbelt [11]. In short, the Pab Formation is now represented by Dhaola Member (white sandstone), Kali Member (grey black weathered colored sandstone) and Sor Member (maroon shale and sandstone). The distribution of these 3 members are reported in many reports and also briefly mentioned as below. In Kirthar basin the Dhaola Member of Pab Formation is exposed in Bara and surrounding in the core of Laki anticline, the Kali Member (black weathering) is exposed in Pab Range from Karachi to Khuzdar and Karkh-Moola areas. Further north, one or only a few thick beds of Pab sandstone are exposed in the Johan-Dilband-Sor Range areas where it is included in Late Cretaceous Moro Formation. In Sulaiman basin the Dhaola Member of Pab Formation is well exposed on both limbs of north south trending anticlinoria from Takht Sulaiman area (in the north) to Maarri peak area (in the south of easternmost Sulaiman foldbelt). Westward from these anticlinoria the trends of Pab and associated other formations changed toward southwest and east west. From Waziristan-Shirani-Zhob-Qila Saifullah (northern Sulaiman foldbelt) the Sor Member of Pab Formation is well exposed (Figure 8 of [2]). In the central east west traverse from Kingri Musakhel to Mekhtar to Tor Thana, the Dhaola Member is exposed in Musakhel areas while Kali Member of Pab Formation is exposed in the western part (Mekhtar, Tor Thana and surrounding areas). From Tor Thana to westward in the Karu-Sanjawi-Ziarat and surrounding (Loralai and Ziarat districts) the Pab Formation is missing. Here, only green and grey shale of Mughalkot Formation capped by thin unit of laterite and red to maroon and mottled clays of Vitakri Formation are exposed, while sandstone and limestones at the level of Mughalkot, Fort Munro, Pab, Vitakri, Sangiali and Rakhi Gaj Formations are missing. Here, the Vitakri laterite is capped by Dungan Limestone. This Mughalkot shale is graded further westward (west of Ziarat town) to Mughalkot shale and volcanics. Shifting traversing section further southward, the Bahlol-Chamalang-Hosri to Nana Sahib Ziarat to Sembar-Mazar Drik (Des valley, Pazha area), the Pab Formation is well exposed especially Kali Member in the north and north west of Pazha village and southwest of Nana Sahib Ziarat (southern limb of Sembar-Mazar Drik anticline). Pazha areas are found just on the south and southwest of Yaru Shahr and Ismail Shahr of Duki area of Loralai. Traversing southward extremity, the Pikal-Siah Koh to Dhaola-Andari ranges to Vitakri-Fazil Chel to Mawand-Gamboli areas the Pab and Vitakri Formations are well exposed. The sandstone of Pab Formation is dominant in the eastern Sulaiman foldbelt while westward the shale proportion is increasing (revealing source in the east/Indo-Pakistan shield). The footprints of dinosaurs and pterosaurs, large wood fossil and non-confirmed eggs were reported (see below). The age of the Pab Formation has been reported as Maastrichtian by many previous researchers on the basis invertebrate fossils such as *Orbitoides* (*Lepidorbitoides*) *minor* [16] [17], *Globotruncana* aff. *G. linnei*, *Lituola* sp., *Omphalocyclusmacropora*, *Orbitellamedia*, *Orbitoides* sp., and *Siderolites* sp. [18].

The Vitakri Formation [21] in type locality and surroundings consists of over bank fluvial two mud units sandwiched and capped by meandering river deposited sandstone two units [20]. The mud units are maroon, green, grey and mottled which weathered into maroon and green colors. The middle sandstone unit is relatively thin and have lenticular (pinching and swelling) nature, while the upper sandstone unit is relatively more thick and prominent. Both fluvial sandstone units are grey and white having quartzose and also muddy matrix while Pab Sandstone is mostly quartzose and marine. Their differentiation criteria are based on matrix and sandwiched fluvial muds. So far collected archosaur bones found mostly from the upper part of the upper mud unit, while lower mud unit also yielded a few bones [11]. In the Kingri area of Musakhel, the Vitakri Formation is represented by carbonaceous shale (commonly called Kingri coal) with some sandstone. Further northward, the Vitakri Formation is represented by a few centimeters to a few meters of laterite and carbonaceous shales. In the western Sulaiman foldbelt (Sanjawi-Ziarat and surroundings, Mina Tangi Sor Kach; Figure 1 of [3],) the Vitakri Formation is represented by a few centimeters to a few meters of laterite and lateritic muds. In the Bara Nala section (Jam Shoro District) of Laki anticline the Vitakri Formation is represented by a thick unit of red and maroon shale and sandstone. Toward west in the Karkh and Moola Zahri Range it is represented by a few to many centimeters thick laterite. This laterite of Vitakri formation in Kharzan Moola area is hosted by a bivalve (*Pakiring kharzani*, see as below) which is typical and unique in Pakistan. In the upper Indus basin (Kohat and Potwar-Kotli basin) it is represented by its coeval Indus Formation. The Vitakri Formation coeval in India is Lameta Formation. The Vitakri Formation has unconformable upper and lower contacts in the areas of laterite and lateritic clays while it has conformable contact in the Vitakri and surrounding areas of eastern Sulaiman foldbelt and Bara-Khadro Nai and surroundings area of eastern Kirthar foldbelt where it has reasonable thickness. The Vitakri Formation is found between the well dated Maastrichtian Pab Formation and the equally well dated Paleocene Sangiali, Rakhi Gaj and Dungan Formations and further, the presence of theropod fossils suggests a latest Cretaceous age [22]. The Vitakri Formation is considered latest Maastrichtian because it is sandwiched between well date Maastrichtian Pab Formation and Early-Late Paleocene Ranikot and Sangiali Groups of lower and middle Indus basins. The Ranikot and Sangiali Group are derived from volcaniclastic materials from the east and Deccan basalt during Paleocene. The Vitakri Formation was considered the latest Maastrichtian age (67 - 66 Ma) based on stratigraphic position, well dated upper and lower contacted formations and dinosaur fossils ([3], p. 47; [8], pp. 40-41; [9], pp. 76-77; [23], pp. 416-418). After the deposition of Paleocene Sangiali Group in Sulaiman and northwestern Kirthar foldbelts, the eastern sources of clastic material and river direction changes from east west trend to northwest-southeast trend (or generally north south trend). The author found terrestrial fossils bivalves and archosaur in the Vitakri strata, and nautiloids and bivalves in the Sangiali Formation. All these field observations revealed that the upper boundary of Vitakri Formation in lower and middle Indus while the Indus Formation in upper Indus basin is the K-Pg boundary.

3.1.2. Structural Geology (Folds and Faults) of Saraikistan (South Punjab, Koh Sulaiman Basin), Pakistan

The exposed structures of Koh Sulaiman Range are represented by almost foldings with minor faultings. Traversing from east to west in the southern part of Koh Sulaiman Range, the first observed is Fort Munro anticline, then Phailawagh syncline, Moranj anticline, Beakar-Rakhni syncline, Siah Koh-Pikal anticline, Nisau-Jhabar-Kharcha syncline, Dhaola-Mazara anticline, Gambrak-Ishani-Lakha Kach-Rara Sham-Kingri-Drug More (Musa Khel) syncline, southern Fazil Chel-Mari Bohri-Vitakri Dome anticline. Traversing from east to west in the central part of Koh Sulaiman Range, the first observed is Zinda Pir anticline, then Barthi syncline, Fort Munro anticline, Manjhail-Pir Gahno Kharar Buzdar syncline, Rar Khan-East Drug anticline, Indarpur syncline, western Indarpur anticline, Kingri-Khan Mohammad syncline and anticline, Tangi Sar anticline contacted with high angle fault/syncline with eastern Drug More (Musa Khel) anticline, Drug More syncline, Musa Khel Bazar anticline. Traversing from east to west in the northern part of Koh Sulaiman Range, the first observed is Zinda Pir-Domanda anticline, then Barthi-Savi Ragha-Zamri-Sheikh Manda-Drazinda syncline and Shinghar-Dhana Sar-Koh Sulaiman peak (Shirani area of Zhob and D. I. Khan) anticline. The structures of southern part Koh Sulaiman Range and foldbelt is mapped and shown in Figures 2-7 of [1] and northern part is shown in Figures 3-8 of [2]. The detail description of structures especially foldings and faultings are provided by [1] [2].

3.1.3. Mineral Resources of Saraikistan (South Punjab, Koh Sulaiman Basin), Pakistan

The reported area and surroundings host significant and huge mineral resources (**Figure 1**) which are shown as below. These minerals along with other natural resources can play a significant role for the development of area and country Pakistan [24]-[29]. Most of these mineral resources are the property of provinces. Keeping in mind, previously the mineral resources of Balochistan Province [30] [31] [32], Khyber Pakhtunkhwa [33] [34], north Punjab and South Punjab [35], Sindh Province [36] [37], Gilgit Baltistan and Azad Kashmir [38] [39] have been reported so far. Further, the mineral resources among basin wise were also presented for the researchers [19]. Here, the geology and mineral resources of Saraikistan area (South Punjab, Koh Sulaiman Range) is being presented.

Abrasives: Gritty sandstone from Pab Formation of Fort Munro areas and Kingri Formation in the northwest Sulaiman Range can be used for abrasive purposes. Some ochre deposits fit for abrasives while most of the ochre deposits found especially in K-Pg boundary, Habib Rahi and other formations are suitable for paint industry.

Lithium deposits: Lithium deposit in laterite of different horizons may host lithium and can be explored and analyzed in different lateritic, alluvial and other

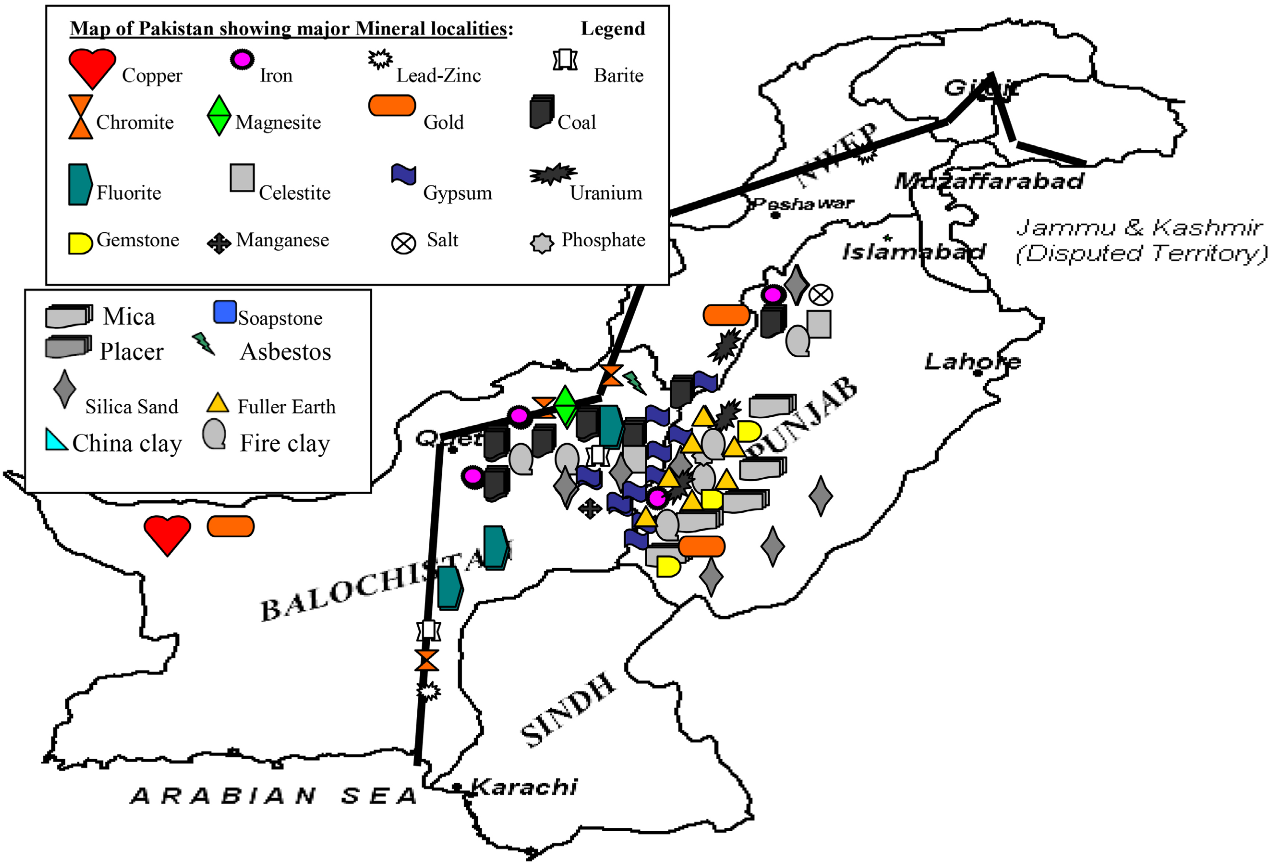

Figure 1. Map of Pakistan showing major mineral of Saraikistan (South Punjab, Koh Sulaiman and surroundings) shown in central Pakistan. (Some major minerals in Balochistan are also shown).

formations. The laterites are significant because India is producing lithium from laterite just east of boundary. For lithium the Tor Ghundi pegmatite is significant for exploration.

Laterite and ochre: Low grade but large deposits of ferruginous shales/clays and ochre and aluminous found in Vitakri, Kingri, Drazinda, Chitarwata and Vihowa and other younger formations. The deposits of Fort Munro, Rakhi Gaj and its vicinity areas found in the Vitakri Formation (equivalent to Indus Formation of Upper Indus Basin). The disconformity in the Late Eocene Drazinda Formation and Early Oligocene Chitarwata in the eastern Sulaiman fold belt also seems significant for ochre and lateritic materials. The possible low grade but large deposits of Ochre/Iron from Chitarwata, Vitakri, Drazinda formations and Vihowa group of Sulaiman Foldbelt have been expected.

Celestite deposits: The celestite mineral showings are found in the Eocene limestone of D. G. Khan and Rajan Pur areas of South Punjab, so the Eocene strata of Sulaiman foldbelt are also significant for further exploration because the celestite associated with extensive gypsum beds/deposits which show further exploration for celestite [40] [41].

Fluorite deposits: Previously fluorite deposits are found from Dilband and Zahri Range (western Kirthar foldbelt) and Mekhtar and Loralai and surroundings (western Sulaiman Range) in the Loralai and Chiltan/Zidi Limestones [40] [41]. Fluorite deposits are found in Mekhtar, Murgha Kibzai and Loralai area (western Sulaiman Range) in Loralai and Chiltan Limestone. In this way, fluorite can be prospected in the eastern and northern Sulaiman Range because of vast exposures of host limestones. The Chiltan Limestone are well exposed in the major peak forming anticlines/anticlinoria such as Shin Ghar, Dhana Sar and Takht Sulaiman peak and Wana (South Waziristan) and Razmak (north Waziristan). This belt started from Toi Sar Thana area (north of Musa Khel Bazar) and extended upto Shirani and Waziristan regions. The exploration of fluorite in these belts may be successful. The light green fluorite from Loralai, Pakistan is best for thermoluminiscence (TL) [42].

Lithium, REE, gold and silver, zircon and heavy minerals in placer deposits: The heavy and resistant minerals like gold, tungsten/sheelite etc, titanium/rutile, zirconium/zircon, ilmenite, etc, may be found in placer deposits of Indus River which cover the large area in south Punjab. The exploration of these placer minerals may be beneficial. The exploration of Lithium mica and associated with other minerals as in laterite of India and REE in placer sand and fluvial deposits of Koh Sulaiman Range and its Daman area and also in Cholistan sand are significant.

Ironstone: Fort Munro ironstone deposits are found in Early Paleocene Girdu (Gorge beds) Member of Rakhi Gaj Formation [4] [5]. This iron is found in the eastern and western limbs of Fort Munro anticlinorium. Its chemical analysis shows $Fe_2 O_3$ 14% - 21%. The iron is found mostly as ferruginous sandstone and minorly as ferruginous shale. The greenish grey and red spotted and red wavy laminated sandstone show iron (alongwith phosphate) mineralizations found in both Girdu and Bawata Members. The hematite and possibly hydrous iron silicates (chamosite and glauconite) are major iron mineralization. This ironstone deposits are very large but low grade. It's testing for steel, cement and other industries may prove worthy. The extensive iron beds thickness varies from 2 to 50 m. The highly anomalous thickness is found in Khar, Top Girdu, Fort Munro and Rakhi Gaj and its vicinity areas. Its reserves seem to be 400 million tons from surface exposure to easily mineable depth 200 m. Its mining is easy due to exposure above the ground surface, and at places low dips. This iron deposits seem to be feasible due to huge but low grade raw materials, favorable locations on metalled road and near to D. G. Khan railway station [4] [5].

Gemstone and jewelry resources: Indus river placer is very significant for gold-silver-platinum panning and further exploration. The chalcedonic silica like Chert, flint, jasper, etc, along with other significant and beautiful pebbles and cobbles are found as detritial/placer in the conglomerate and conglomeratic sandstone/gritstone are found in the Oligocene-Pliocene Vihowa Group and also in the Pleistocene-Holocene Sakhi Sarwar Group in the Sulaiman foldbelt. These are significant for jewelry resources as found relatively easy. Further beautiful calcite veins are commonly found in the limestone of different ages especially the Loralai and vicinity regions.

Agromineral resources: The Sulaiman basin has extensive reserves of shales/clays, so Alum shales exploration may be encouraged. The exploration for rock phosphate should be accelerated because Pakistan is an agricultural country and its demands are increasing. The Tertiary, Cretaceous and Jurassic sequence in Sulaiman range were studied by [43]. They found black phosphatic nodules with 5% P_2O_5 in Domanda and Drazinda shales, which are encouraging for further study. The Rakhi Gaj area show nodules with 5% - 20% P_2O_5 and Zinda Pir area show 5% P_2O_5 of D. G. Khan district in Sangiali group (Sangiali, Rakhi Gaj and Dungan formations) and lower Ghazij/Chamalang group (Shaheed Ghat shale). Phosphate nodules are found in about 20 m shale interval of probably Rakhi Gaj formation. Nodules with <5% phosphate in Late Cretaceous Mughalkot formation in Karim Kach Khwar to the east of Kurgali (on Mughalkot and Dhana Sar road section) are found [43]. It has been reported from Eocene Chamalang Group (Ghazij Group), and Paleocene Sangiali Group (Sangiali and Rakhi Gaj formations) in the Sulaiman foldbelt [25]. There is little or no economic value due to its low P_2O_5 content [44] but indicates for **large deposits**. Further try should be made because Pakistan is agricultural country and large money will be saved by reducing imports. The phosphate from green and black shale and greenish grey sandstone of Mughalkot formation and green to greenish grey shale and greenish grey to red spotted and red wavy laminated sandstone of Rakhi Gaj (both Girdu and Bawata members) formation seems to be significant [4] [5] [25].

Cement raw material resources and huge gypsum deposits: According the new hypothesis presented by [45] that calcareous clay resources of Pakistan can be used ecofriendly for production of cement instead of Limestone Clay Cement LC^3 [45]. This Limestone Clay Cement (LC^3) is commonly being used in Pakistan but ecologywise more dangerous and economic wise more expenditure. The clay resources can be used for cement industry ecofriendly. Previously clay is being used about 25% in Cement preparation. If new hypothesis will be adopted, the area has huge and vast clay/shale deposits for cement industries installation. Only Lucky cement at Pezu (Khyber Pakhtunkhwa) and D. G. Cement at Zinda Pir anticline (South Punjab) are working now. Cement Industry raw materials are huge in Pakistan and especially in Sulaiman basin. The rocks generally contain 50% calcium oxide, less than 5% silica and less than 1% iron oxide making suitable for cement. A small fraction of resources are being used by cement industries in Pakistan. More than a dozen cement industries can be installed in the Rajan Pur and D. G. Khan districts on the foot mountain of Sulaiman foldbelt. The cement industry suitability will be strengthens by the close occurrence of raw materials like limestone, gypsum and shale which will be provided to industry by belts and not by trucks. Pakistan has lowest per capita cement consumption and paying several hundred million rupees every year for calcium chemicals and also rapidly increasing population, it is highly desirable and vital to take step for extending cement, lime and calcium chemicals industries, so that the country will be self-sufficient with cheap rates and able to export these materials to earn foreign exchange. Inexhaustible reserves of limestone, shale and gypsum are found in Saraikistan area (as shown below). It is vital to take step for installing more cement, lime and calcium chemicals industries especially in Zinda Pir Ziarat, Zin, Mahoi, Gulki/Taunsa, Sorra, Kharar (Kharat), Pir Gahno, Kachiwanga Luni, Rakhi Gaj, Dalana and other areas of Taunsa area and D. G. Khan District; Chachar-Maarri, Harand (Kaha), Sakhi Bor Bakhsh and other areas of Rajan Pur District; Draban, Domanda, Mughalkot, Shirani, etc areas of D. I. Khan District; Sham, Phailawagh, Beakar, Pirkoh, Habib Rahi, etc areas of Dera Bugti District; Lakha Kach Rakhni, Kofi, Nodo, Ishani, Gadumra, Bala Dhaka, Bahlol, etc areas of Barkhan District; Chamalang, Nisau, Bohri, Safed, Mawand, etc of Kohlu District; and Kingri, Drug, Zamri and other areas of Musa Khel District due to close existence of raw materials limestone, gypsum and shale can be provided in wheel belts. Due to location in central Pakistan, these cement industries will provide cement easily to Balochistan and every part of country and also for export.

References [4] [5] [25] reported gypsum 764 mt upto **50 m easily minable depth** and **28.5 billion tons** of estimated total reserves (measured, indicated, inferred and hypothetical) of Sulaiman foldbelt. The quality of gypsum is good as impurities are less than 2% based on chemical results of 125 samples. Chemical analyses show that CaO content varies from 30.84% to 32.24%, SO_3 from 45.75% to 48.36%, and H_2O from 17.62% to 18.62% [4] [5] [8]. There are 4 to 15 beds of gypsum in Baska Formation with cumulative thickness of 5 m to 25 m in Sulaiman foldbelt while one bed (0.3 m - 6 m) of gypsum in Domanda formation in only southern Sulaiman foldbelt. **Rajanpur District** hosts gypsum deposits of Giandari-Chachar-Kaha Harand-Sakhi Bor Bakhsh-Khaan gypsum belt about 2 billion tons/bt upto 200 m depth and 33 million ton/mt upto easy mineable 50 m depth. It hosts Late Cretaceous Fort Munro Limestone at Khan Sakhi Bor Bakhsh (1 bt), Paleocene Dungan Limestone at Chachar-Maarri (1 bt), Kaha-Harrand (1 bt) and Sakhi Bor Bakhsh (small deposits) areas, and Chacha-Beakar-Kalchas (3 bt) of western limb of Fort Munro-Maarri anticlinorium, and Eocene limestone of Drug, Habib Rahi and Pirkoh formations in eastern limb (30 bt) of Fort Munro-Maarri anticlinorium. It also hosts vast and huge deposits of shale/clay (see below) in Shaheed Ghat, Domanda and Drazinda formations and others at Chachar-Maarri-Kaha-Harrand-Sakhi Bor Bakhsh-Khaan areas. **Dera Ghazi Khan District** hosts gypsum deposits of Rakhi Gaj-Khandor gypsum belt estimated 1 bt upto 200 m depth and 22 mt upto 50 m depth and southern part of Zinda Pir anticlinal gypsum (U-shaped belt) deposits estimated 2 bt upto 200 m depth and 44 mt upto 50 m depth. It hosts limestone deposits 1 bt of Late Cretaceous Fort Munro limestone exposed at Rakhi Gaj, Girdu and surrounding areas, 1 bt of Paleocene Dungan Limestone at core of southern Zinda Pir anticline, 20 bt of Eocene limestones of Drug, Habib Rahi and Pirkoh formations in Rakhi Gaj-Khandhor area and 20 bt of southern Zinda Pir anticline. D. G. Khan cement industry is also using this Dungan Limestone. It also consists of huge and vast deposits of shale/clay (see below) in Shaheed Ghat, Domanda and Drazinda formations and others at Rakhi Gaj-Khandhor-Ronghan areas and southern Zinda Pir anticline. **Taunsa area** hosts gypsum deposits of northern Zinda Pir anticline gypsum belt estimated 2 bt upto 200 m depth and 44 mt upto 50 m depth, Sorra-Kachiwanga-Jisa Sharif gypsum belt estimated 1 bt upto 200 m depth and 22 mt upto 50 m depth and Manjhail Kharar gypsum loop estimated 3 bt upto 200 m depth and 66 mt upto 50 m depth. It hosts limestone deposits estimated 1 bt of Parh limestones (Early Cretaceous) exposed at Hinglun-Burg Pusht area, 1 bt of Dungan limestones at northern Zinda Pir anticline, 3 bt of eastern limb of Hinglun-Rarkhan thrusted anticline (Manjhail Pachadhi nala, Hinglun and Kachiwanga Luni areas), 3 bt of northern plunge of Fort Munro anticline (Hikbai, Mubarki-Sorra, Pir Gahno and Kharar areas), 20 bt of Eocene limestones of Drug, Habib Rahi and Pirkoh formations at Sorra-Kachiwanga-Jisa belt, 30 bt of Manjhail syncline, and 20 bt of northern Zinda Pir anticline. It also hosts vast and huge deposits of shale/clay (see below) in Shaheed Ghat, Domanda and Drazinda formations at southern Zinda Pir anticline, Manjhail and Sorra-Kachiwanga-Jisa areas. Sulaiman huge gypsum deposts is considered among the largest deposits in the Global World. Recently, Reference [46] compared the chemical analyses of Zinda Pir gypsum (Pakistan) with Iran, Türkiye and Spain gypsum. The XRD studies [46] revealed gypsum, anhydrite, magnesite and dolomite minerals of Zinda Pir gypsum deposits, however, they [46] mistyped the two beds (instead of 5 - 7 beds) reported previously from Zinda Pir, while in actual author MSM in 2000 paper mentioned the Zinda Pir gypsum beds varing thickness 1 – 4 m and later the reference [4] on page 60 mentioned 5 - 7 gypsum beds.

Ceramic mineral and clay resources: Vast clay/shale resources are found in the area. **Taunsa** district represents Shale reserves are 4 bt from Cretaceous Mughal Kot, Fort Munro, Pab and Vitakri formations, 5 bt from Paleocene Sangiali, Rakhi Gaj and Dungan formations, 300 bt from Eocene Shaheed Ghat, Drug, Baska, Domanda and Drazinda formations and 50 bt of Oligocene-Holocene strata. **Dera Ghazi Khan** district hosts Shale reserves are 4 bt from Cretaceous, 5 bt from Paleocene, 200 bt from Eocene and 50 bt from Oligocene-Holocene strata. **Rajanpur** district hosts Shale reserves are 1 bt from Cretaceous, 5 bt from Paleocene, 300 bt from Eocene and 100 bt from Oligocene-Holocene strata. Various types of Clay deposits are found from Ghazij, Kahan and Vihowa groups of Sulaiman Foldbelt. **Bentonite** is non swelling type of clay with white, grey and brown colors and high calcium %. To convert them into swelling type, it is converted into sodium bentonites by Base Exchange process. Bentonite derived from weathering and erosion of igneous rocks. Presently it is also observed in the Gadumra (Barkhan) and eastern foothills of Sulaiman range of Rajan Pur, D. G. Khan and D. I. Khan districts. It is used for drilling mud. **Fuller's earth** is nonplastic clay usually contain appreciable magnesia. The main producers are Taunsa area. Fuller's earth was formerly used for fulling or cleaning woolen fabrics and cloth, its absorbent properties causing it to remove greasy and oily matters. Its modern use is reefing of oil and fats. It is greenish grey, bluish grey and greenish brown clay with soapy feel. The D. G. Khan deposits show SiO_2

49.6%, 46.20%; Fe_2O_3 6.66%, 8.76%; Al_2O_3 11.94%, 22.86%; CaO 9.12%, 2.43%; MgO 3.13%, 1.94%; Na_2O 0.25%, 1.25%; K_2O 1.94%, 2.62%; and loss on ignition 16.18% and 12.65%, respectively [47]. This clay is relatively pure illite with a base exchange capacity of 50 compared with 40 for standard illite and 106 for English montimorillonite [44]. Reference [48] reported resistant, brownish yellow 1.5 m thick fuller's earth/volcanic ash on the contact of Litra sandstone and Chaudhwan mud from Zinda Pir Taunsa area, Its chemical results (wt %) show SiO_2 59.6%, Fe_2O_3 2.27%, Al_2O_3 16.98%, CaO 2.95%, MgO 2.91%, Na_2O 2.62%, K_2O 2.09%, TiO_2 0.15%, MnO 0.03%, P_2O_5 0.06% besides volatiles 9.32% [48]. Thick immense reserves of fuller's earth upto 30 m thick are observed by Hilal A. Raza in Domanda and Baska formations in Rakhi and Sebdi nalas. The deposits upto easily mineable depths 100 m are more than 1 billion ton of eastern Sulaiman foldbelt [35]. Fuller's earth is formed in the flood plains of Tertiary river channels. In recent years it is being utilized in oil refining and other industries in the country. With activation this clay may be used in vegetable oil and ghee industries. It is also being used in insecticide, foundries and steel industries. Its demands are being increased. Reference [35] collected samples of fuller's earth from Domanda and Drazinda shales of western (Zin area) and eastern limb (Mahoi area) of Zinda Pair anticline, Tehsil Taunsa, Dera Ghazi Khan District and their chemical results show SiO_2 50.86% to 64.01%, Al_2O_3 9.79% to 17.18%, Fe_2O_3 3.10% to 6.89%, CaO 6.41% to 12.20%, MgO 2.01% to 5.64%, P_2O_5 nil and loss on ignition/volatiles 8.87% to 12.60%. He estimated reserves of 10 mt upto 200 meter easily mineable depth in Zinda Pir anticline areas. Huge reserves of fuller's earth are observed in Domanda, Drazinda and Baska formations in eastern Sulaiman Range. Reference [25] shows its existence from Dera Bugti-Rajan Pur-D. G. Khan-Musakhel-D. I. Khan and Barkhan-Kohlu districts. **Fire clay** beds are associated with many coal horizons in the Sulaiman foldbelt. The possible Fire clay from Chitarwata, Rakhi Gaj, Vitakri, Drazinda formations and Vihowa group of eastern Sulaiman Foldbelt seems to be significant. Fire clay is resistant to shrinkage, abrasion and corrosion under high temperature and withstands thermal spalling. It is very low in iron oxide content < 2% and high in alumina (24% - 45%). It is being produced at Kot Kaisrani (Taunsa). In actual the fire clay and fuller earth deposits are same (mentioned in fuller earth) mined from many places at Kot Kaisrani, Mahoi, Zin, and other areas.

Quartzite, millstone and silica sand: The hard quartzose sandstone of Pab Formation is considered as Quartzite. Its vast deposits (into billions) are found in Mubarki-Fort Munro-Maarri anticlinorium and Hinglun-Luni-Andarpur areas. Due to its high hardness it was previously used for floor mill. Quartzite can be utilized by steel mill. Large deposits of silica sand in the sandstone of Pab Formation and Vihowa group (mostly in Chitarwata Formation of Zindapir and others).

Marble, dimesion stones, decorstones, gemstones and jewelry resources: South Punjab hosts significant decorstones, gemstones and jewelry resources. Large reserves of limestone (commonly used marble and dimension stones) are found in Koh Sulaiman. Fort Munro limestones in Rakhi Gaj and surroundings, and Dungan limestones in Harand, Maarri and Chacha-Beaker-Kalchas of Rajanpur, Rakhi Gaj, Khandor, Fort Munro, Bawata and surroundings and southern part of Zinda Pir anticline of D. G. Khan district, northern part of Zinda Pir anticline, Hikbai-Mubarki, Kharar, Ronghan-Sorra, Poadhi and Pachadhi nalals of Manjhail to Pir Gahno, Hinglun to Luni Kachiwanga and Burg Pusht areas of Taunsa can be used as dimension stones and tiles preparation. Beautiful pebbles, cobbles, chalcedonic silica like chert, flint, jasper and others are found as detritial in placer deposits like conglomerate and conglomeratic sandstone/gritstone of Vihowa and Sakhi Sarwar Groups and also in terrace and present day river/streams/channels in eastern Koh Sulaiman Range and its Daman areas. These can be used in jewelry which contributes a lot for the development of South Punjab. These deposits are easily accessible from D. G. Khan, Rajanpur and Shadan Lund railway stations.

Construction stones: Large deposits of construction stones like limestone, sandstone, shale, conglomerate, gravels, sand and muds found from Taunsa, D. G. Khan and Rajanpur districts (Koh Sulaiman Range and its foot mountains Daman areas). Vast sand of sands are found in Indus, Chenab and Sutlej rivers and also in Cholistan desert. The large limestone deposits (see above) are found from Fort Munro, Dungan, Drug, Habib Rahi and Pirkoh formations. The large sandstone deposits are found in Pab, Vitakri and Rakhi Gaj formations and Chitarwata, Litra and Chaudhwan formations. Further gravel, sand, silt and mud are found from Chaudhwan, Dada, Sakhi Sarwar formations, terrace, fan and present river gravel and alluvium deposits. The gravels from Dada and Sakhi Sarwar formations and in alluvial terraces and in river channels are being used in Sakhi Sarwar and Taunsa crushing plants. Like this crushing plants can be installed in Lundi Saidan, Maarri and Kaha Harrand areas. The limestone deposits are shown in cement resources (as above) and shale/clay deposits are shown in clay ceramics deposits (as above). **Taunsa** district represents Sandstone reserves are 250 bt from Cretaceous Pab and Vitakri formations, 3 bt from Paleocene Sangiali and Rakhi Gaj formations, 400 bt from Oligocene-Pliocene Vihowa Group (Chitarwata, Vihowa, Litra and Chaudhwan formations) and Pleistocene-Holocene Sakhi Sarwar Group (Dada and Sakhi Sarwar formations). **Dera Ghazi Khan** district hosts sandstone reserves are 250 bt from Cretaceous, 3 bt from Paleocene and 250 bt from Oligocene-Holocene strata. **Rajanpur** district hosts sandstone reserves are 200 bt from Cretaceous, 2 bt from Paleocene and 350 bt from Oligocene to Pliocene strata. These deposits are easily accessible from D. G. Khan and Shadan Lund railway stations.

Coal resources: Dera Ghazi Khan and Rajan Pur coal showings are reported from Late Eocene Domanda and Drazinda Formations and Oligocene Chitarwata Formation in Sulaiman Daman. Reference [49] reported coal from Domanda formation of Rakhi Munh area, Dera Ghazi Khan District. Reference [50] reported Domanda coal from Upper Tuso, Nabi Bakhsh Thal Nala and Khan BMP post area of Rajan Pur district, Mahoi and Zain BMP post area of D. G.

Khan district, Eocene Drazinda coal from Haft Gath/Shaheed Ghat area (Zinda Pir Ziarat area), Oligocene Chitarwata Formation coal in Khandor BMP post area of D. G. Khan district. Reference [49] reported chemical analysis of Rakhi Munh Domanda coal like moisture 11.19%, Ash 21.83%, volatile matter 34.63%, fixed carbon 32.35%, ADL 7.20%, Total sulphur 6.24%, heating value/BTU/lb 8617. Cholistan areas are significant and have vast areas for exploration and study of previous drilled holes if any for petroleum, water, etc. Further, in the west, Kingri-Aram-Gharwandi Coalfields (Latest Cretaceous coal), Kingri-Shikar-Tor Shah Coalfields (Early Eocene coal) and Toi Nala (Dewal-Ghoze Ghar-Savi Ragha) Coalfield (Early Eocene Toi Formation) have already described [5] [25] [28]. Further, the coal resources of area and surroundings were also reported [51] [52] [53] [54]. The drill hole log of Canteen area of Chamalang is shown in Figure 3 of [54].

Petroleum resources: Petroleum are being produced from the Dhodhak oilfield/gas condensate field (northern part of Zinda Pir anticline) in Jurassic Chiltan Limestone [46], Early Cretaceous Mekhtar, Goru and Parh formations (sandstone, marl and limestone), Late Cretaceous Mughalkot and Pab sandstones and Paleocene Rakhi Gaj sandstone and Dungan Limestone. Petroleum are also found in the drilled well of Savi Ragha and Jandran anticlines. The petroleum sources rocks like the Cretaceous Mughalkot and Sembar shales are widely found in Sulaiman foldbelt. The Mughalkot Formation have porcellaneous white to grey mudstone in the Rakhi Gaj and Girdu area which not seems to be sources of petroleum while in other areas it have blackish to grey and green shale which is significant for petroleum resources. Further, Mughalkot Formation acts as best host rocks because of shale and sandstone lithology, where shale is sources and sandstone act as reservoir rocks. That is the reason an oil spring found in Toi Nala of Mughalkot section. There are two Toi Nalas, one in the Mughalkot section and other southward located between the Toi Sar Thana area (Musa Khel) and Chitarwata area (Vihowa, Taunsa). The other major reservoir formations are Cretaceous Pab and Vitakri (as above), Paleocene Rakhi Gaj and Dungan, Habib Rahi and Pirkoh formation. The Rakhi Gaj Formation is well exposed in the eastern Sulaiman while in the west it has only shale deposits. Dungan Limestone is thin in the Mekhtar to Rakhi Gaj sections (poor reservoir), while it is thick in the north and also reasonable in the south (a good reservoir rocks). Habib Rahi and Pir koh limestones are relatively thin in the north (Drazinda and Domanda areas) and central (Rakhi Gaj area) and being increasing toward south especially in the Rajanpur areas and it is maximum thick at Dera Bugti areas and possibly in northernmost Sind Province. The Habib Rahi and Pirkoh being thick in the south can play significant role for the hosting petroleum reservoirs.

Radioactive mineral resources: Uranium can be explored from fluviatile cross bedded sandstones of the Oligocene-Pliocene Vihowa Group and Pleistocene to Holocene Sakhi Sarwar Group in Rajanpur, Dera Ghazi Khan and Taunsa areas. At present uranium is being exploited from the Miocene Litra sandstone in Dera Ghazi Khan and Taunsa areas. The uranium host Vihowa and Sakhi Sarwar groups traced along 200 km north south oriented outcrop along the Foot Mountains of Koh Sulaiman Range which host primary (uraninite, etc) and secondary (Tyuyamunite, carnotite, etc) uranium mineralizations. This significant uranium bearing rocks runs from Giandari (west of Rojhan) to Lundi Saidan to Sakhi Bor Bakhsh and Khaan (Rajanpur District) to Rakhi Gaj to Sorra to Fazla (Taunsa and Dera Ghazi Khan). Further, this host rocks can be found on the both limbs and plunges of Zindapir anticline. It may be explored in sandstones of Pab, Vitakri, Sangiali, Rakhi Gaj, Toi and Kingri formations in the Koh Sulaiman foldbelt. Iridium anomalies, REE and lithium can be tested in the Cretaceous-Paleogene boundary laterite, mottled muds and coal especially in the Fort Munro, Rakhi Gaj (and Kingri) and its vicinity areas.

Geothermal energy resources: Garmaf and Zinda Pir hot water springs of Taunsa area can be used for heating purpose during winter for nearby populations.

Forest resources and agricultural cultivation: The area is mostly barren of trees. Honourable Former Prime Minister Imran Khan Niazi started billion tree Project. Continuing this tree plantation and agricultural cultivation in barren lands and Daman areas of Koh Sulaiman Range and desert areas of Cholistan and Thal will shift the lands with greenery, rain will increase, pollution will decrease, weather will become better and income will increase which play major role for the development of these regions of Saraikistan area and ultimately for Pakistan.

Tourism: Fort Munro anticlinal peak areas from Mubarki to Hikbai to Fort Munro to Chitri to Dragal to Maarri belt can be used for tourism because of being elevated upto round about 7000 feet from sea level. Further, there are many mazars (tombs), forts and many other cultural heritages for tourism. Further, the locals and also foreigner can know and visit these tourism places and cultures. This tourism can play part of the development of the South Punjab and ultimately Pakistan.

Paleontology field museum and national and global geopark: Many famous paleontological sites fall in the Koh Sulaiman Range under the territory Taunsa, Dera Ghazi Khan and Rajanpur districts of South Punjab and adjoining Barkhan, Kohlu and Dera Bugti districts of Balochistan Province. These paleontological sites can be called as field museum of Cretaceous and also Cenozoic fauna and flora (see below). These sites are famous at international level because of discoveries of largest land mammals, largest marine mammals (walking to swimming whales), largest sauropods and theropod dinosaurs, mesoeucrocodiles, snake, pterosaurs and birds and other biotas. Many foreigner scientists like to work here. Their working here can be a source of foreign exchange. **A Paleontological Museum** should be established at Dera Ghazi Khan due to close occurrence of fossil host field sites. Further, the national and international visitors, researchers and scientists can visit and work easily at this museum and also can visit nearby field host sites. The shifting of fossils from field sites to museum will be relatively safe and breakage risk will be very low. Further, the **Vitakri Dome** of Barkhan District should be protected as National and Global Geopark because of being graveyard of latest Cretaceous biotas found just before the K-Pg Boundary extinction. This will save the destruction of exposed fossils, bones and host sites and horizon and will provide safe visits of national and international visitors.

South Punjab Secretariat and development-ease for peoples and Economic savings: Previous government lead by Former Prime Minister Imran Khan Niazi constructed the South Punjab Secretariat at Matital road, Multan and also at Bahawalpur. Further, make the functional South Punjab Civil Secretariat at Multan and Bahawalpur. Consequently, the transportation fuel, hoteling and other expenses were considerably reduced. Consequently ease of peoples of South Punjab started. Further extra burden on Lahore city and its pollution will be reduced. All these go to economic savings and the development of South Punjab and ultimately for Pakistan.

Water resources, smaller dams construction and energy resources: Rajanpur, D. G. Khan and Taunsa areas of South Punjab (Saraikistan) have vast potential of water resources because of mountainous areas with excellent topography, geomorphology and large catchment areas and also have downward vast barren plain but its needs proper preservation and increasing storage because significant portion wasted as flood. Storage as dams can also recharge the ground water of plain areas. South Punjab has mostly plain areas except north-south trended Koh Sulaiman Range. South Punjab has Indus, Chenab (include Jhelum river from Trimu and Ravi river from Sultan Baho/Garh More) and Sutlej (Source is Beas in Himachal) rivers. Sutlej and Chenab rivers join at Panjnand, and Chenab and Indus rivers join at Chachran/Kot-Mithan. These rivers got flood during summer after heavy rains. Koh Sulaiman Range has crossed numerous east-west trending streams/nalas/rudkohi which waste water as flood. Daman (foot-mountain) belt of Koh Sulaiman Range has vast barren lands more than 200 km north-south long and 10 - 30 km east-west wide. Here, smaller dams construction at mouth of streams like Kaura, Vihowa, Litra, Baathi, Kanwan, Sanghar (Sorra, Pachadhi and Poadhi Nalas of Manjhail/Kharar/Pir Gahno, Hinglun, Barthi/Hathi Mar), Luni, Drug, Sori-Zinda Pir, Dalana, Vidor, Mithwan, Rakhi Gaj, Khaan, Sakhi Bor Bakhsh, Kaha Harand, Chachar, Giandari and others can convert adjoining fertile barren lands into cultivation and greenery for sustainable development of South Punjab and ultimately for Pakistan. Further, these dams recharge the alluvial ground water resources which can be used during drought seasons. Honorable Former Prime Minister Imran Khan Niazi and Former Chief Justice Saqib Nisar initiated effort to start many large dams after previously long hibernation. On completion the peoples can get water for irrigation and cheap electricity, while previously thermal power plants run costly from coal (especially imported coal) and petroleum. Constructions of small water dams are vital due to congested and increasing population and large barren areas. Sutlej flood water should be diverted into Cholistan desert to increase the cultivation, drinking water and greenery for the development of poor local peoples. South Punjab has hot season best for solar energy and many large stream/ruds like Vihowa, Sanghar, Sori Zinda Pir and Kaha for small scale hydal energy via newly constructed dams to save costly thermal power supply and ultimately to reduce import of coal/petroleum which consequently save the foreign exchange. Coal, oil, natural gas, radioactive minerals, geothermal hot springs and geysers, etc. are exhaustable energy resources whilst solar, air/wind, terrestrial water, marine water/ocean, tides, waves, current, geothermal gradients of sea water, biomass, etc., are inexhaustable energy resources. Pakistan urgently demands the conversion of the non-conventional energy resources into those of conventional energy. Biomasses like crop residue (cotton stalk, wheat straw, rice husk), natural vegetation, trees, animal dung/manure and sewage are potential source of energy. These can be converted into energy by direct combustion and fermentation methods. The waste material is burnt in confined containers and heat is used for running boilers which produce steam to run a turbine generator. Biofuel like E-10 is a replacement of gasoline and can be produced by fermentation of biomass in digester tank by enzymes and decomposition in absence of air. Our global earth is receiving huge amount of energy from sun. Previously it was very expensive but now it is gradually becoming cheap. Nickel cadmium batteries can be used during night or cloudy days. The hydel energy is not sufficient due to increasing population; the development in construction of new dams and in **solar energy** is very necessary and vital in south Punjab and Pakistan.

3.2. Tabular Overview of Recently Discovered Biotas from Pakistan and Their Paleobiogeographic Link

These are presented as below.

3.2.1. Tabular Overview of Recently Discovered Biotas from Pakistan

History of discoveries of recently found biotas from Pakistan: The first ever bone of dinosaur from Pakistan was collected by MSM (present author) in early 2000. Later, on 100 bones/pieces of bones were collected with Philip D. Gingerich in Late 2000, pointing fossils on locality by MSM. About 1500 and 1200 bones/pieces of bones were collected by MSM during early and mid 2001, respectively. A large wood fossil and nautiloid were also collected by MSM. Many terrestrial bivalves were observed. The early history of discoveries of dinosaurs and other vertebrates during 2000 and 2001 were mentioned in detail ([19], pp. 108-109). About 400 recognized bones and a large wood fossil were published in series of papers [55]-[73]. Further walking whale fossils were collected during late 2000 under the supervision of Philip D. Gingerich [74]. Exploration and collection of titanosauriform 12 bones [6] [75], a few vertebrates and invertebrates fossils [7] [65] [69] [70] and a sauropod footprint [3] [6] [7] [70] from Kirthar Range (lower Indus/south Indus basin) Khuzdar district, Balochistan were done in 2001-2003. Later on fieldwork conducted by MSM for dinosaur bone exploration during January, 2005 and March, 2005 in different sections of eastern Sulaiman foldbelt. Only a few fossils were also collected during this field work, while numerous bones observed in this field were left in the intact field place. Fieldwork conducted by MSM for dinosaur bone exploration from February-March, 2006 in Ziarat (Balochistan), Surghar (Mianwali District, Punjab) and Salt Range (Punjab). Footprints were also discovered during this field work [6] [7] [61] [68] [69] [70] [76]. All the localities of Balochistan and South Punjab (visited above) lie in the Sulaiman Range (middle Indus/central Indus basin) while Surghar and Salt Range lie in the Kohat and Potwar sub- basins (Upper Indus/North Indus basin), respectively ([6] [7] and references therein). Further exploration and collection of about 100 basilosaurid fossil bones from middle Eocene Drazinda shale of Zamri area of Musa Khel District, Balochistan and 29 bones of large rhinoceros from Shagala area of Kamardin Kareez Tehsil, Zhob district and division was done in 2012-2013 [65] [69] [70] [77]. The exploration and collection of bones of large rhinoceros (*Buzdartherium gulkirao*) and crocodiles (*Asifcroco retrai*), and proboscidean (*Gomphotherium buzdari*) were done in 2013-2014 [6] [7] [65] [69] [70]. Footprints of late Cretaceous archosaurs from Sur Muzghai locality of Musafarpur, Qila Saifullah district, Zhob division, Balochistan was explored in 2013-2014 [6] [7] [63] [68] [69] [70] [71]. A footprint natural cast was discovered in 2018 from Maarri peak area of Rajanpur district, South Punjab [6] [7] [70] [78].

Recently discovered fauna and flora from Pakistan: Recent paleontological exploration during 2000-2023 yielded 52 new biotas (mostly by me and in a few I was partially involved) from the Paleozoic, Mesozoic and Cenozoic strata of Pakistan (**Tables 1-12**). These prehistoric biotas include 3 fishes (**Table 10**), 31 reptiles (**Tables 1-7** and **Table 12**), 9 mammals (**Table 8** and **Table 9**), 1 bird (**Table 10**), 7 invertebrates (**Table 11**) and 1 plant (**Table 10**) [6] [7]. Round about 3000 bones/pieces of bones were collected from Vitakri Formation. Among these well recognized about 400 mostly large sized (with some medium and small sized) bones were documented so far, while the remaining mostly recognized about 800 mostly medium sized bones/pieces of bones and mostly non-recognized about 1800 small sized bones/pieces of bones were not documented so far. The small sized bones/pieces of bones (1800) and medium sized bones (800) belong to 25 localities of Vitakri dome, Mari Bohri plunge, Dhaola, Pikal and Fort Munro ranges. About 30 bones of central Alam skeleton are documented while more than 100 medium sized bones of this assemblage are not documented so far. The documented bones distributed as Titanosaurs 330, theropods 40, crocodilians 16, pterosaur 2, snake 7, bird 7, and mammal 1. The majority of the bones recovered from south, mid, north and top Kinwa, Mari Bohri, lower and mid Sangiali, Bor and Alam localities. The many bone assemblages and numerous bones observed in the south Sangiali (just above the mid Sangiali), Bor, Kinwa (south, mid, north and east/top Kinwa), Alam 19, east Alam 18 and Dada Pahi localities. Further excavations are promising here for yielding articulated and associated skeleton and complete bones.

Table 1. Holotypic and referred materials of Poripuchia (Titanosauria, Sauropoda) found from Pakistan. Holotypic postcrania of *Gspsaurus pakistani* and *Maojandino alami* are same (see detail in text). H, h, holotyp. for holotype; R, r, ref, refer, referr for referred; elem for element; and Fm. for Formation used in all tables.

Region	*Pakisaurus balochistani*		*Sulaimanisaurus gingerichi*		*Khetranisaurus barkhani*	*Balochisaurus malkani*		*Marisaurus jeffi*	*Gspsaurus pakistani*		*Saraikimasoom vitakri*	*Nicksaurus razashahi*		*Maojandino alami*		*Khanazeem saraikistani*	
	H	R	H	R	H	H	R	H	H	R	H	H	R	H	R	H	R
Dermal skull	-	-	-	-	-	-	-	-	1	-	1	3	-	-	-	-	-
Lower jaw	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	1	-
Braincase	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-
Palate	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-
Teeth	-	-	-	-	-	-	-	-	+10	-	+23	6	-	-	-	5	-
Cervical vertebrae	9	-	-	-	-	5	5	-	6	-	-	4	-	6	-	-	-
Dorsal vertebrae	2	-	-	-	-	6	11	-	4	3	-	-	-	4	3	-	-
Sacral vertebrae	2	-	-	-	-	-	2	-	-	4	-	-	-	-	4	-	-
Caudal vertebrae	7	3	7	4	2	12	13	9	11	9	-	3	2	11	9	2	4
Ribs	-	1	-	-	-	5	2	-	-	3	-	1	-	-	3	-	1
Pectoral girdle	3	1	-	-	-	1	4	1	2	6	-	-	1	2	6	-	-
Humerus	2	1	-	1	-	1	3	-	-	2	-	1	-	-	2	2	-
Radius/ulna	3	2	-	-	-	1	1	-	1	-	-	-	-	1	-	-	1
Carpus + manus	3	-	-	-	-	2	9	-	-	-	-	-	-	-	-	-	-
Pelvis	1	1	-	-	-	1	1	1	-	-	-	1	-	-	-	-	-
Femur	1	-	-	1	-	1	3	1	1	1	-	2	-	1	1	2	-
Tibia + fibula	2	-	-	3	-	1	3	-	2	1	-	2	-	2	1	3	-
Tarsus + pes	1	-	-	1	-	2	1	-	-	-	-	-	-	-	-	-	-
Osteoderm	-	1	-	-	-	-	2	-	-	3	-	-	1	-	3	-	-
Coprolite	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-
Total cranial elements	-	-	-	-	-	-	-	-	14	-	26	9	-	-	1	6	-
Total axial elements	20	4	7	4	2	28	33	9	21	19	-	8	2	21	19	2	5
Total appendicular elements	16	5	-	6	-	10	25	3	6	10	-	6	1	6	10	7	1
Total osteoderm	-	1	-	-	-	-	2	-	-	3	-	-	1	-	3	-	-
Total elements	36	10	7	10	2	38	58	12	41	32	26	23	4	27	33	15	6
Total h + r elements	46		17		2	104		12	73		26	27		60		21	

Table 2. Statistical data and information of Titanosauriformes (Column 2) from the latest Jurassic-Early Cretaceous and Balochisauridae (Columns 3, 4) Poripuchian titanosaurs found from the latest Cretaceous (latest Maastrichtian) of Pakistan. The first appearance of the species name was not accompanied by proper diagnosis, designation of holotypic elements, or description (Row 2 where mentioned). Those names remained *nomina nuda* until they were formally defined following rules of the International Code of Zoological Nomenclature (Row 3). These last two sentences apply in Tables 2-12.

Titles	*Brohisaurus kirthari*	*Balochisaurus malkani*	*Marisaurus jeffi*
Informal description	-	[58]	[58]
Formal description	[75]	[7]	[7]
Holotype	Femur cross sectional parts GSP/MSM-86-K, GSP/MSM-89-K, GSP/ MSM-91-K and GSP/MSM-102-K; rib cross sections GSP/MSM-92-K, GSP/MSM-87-K and GSP/MSM-94-K; distal rib cross section GSP/MSM-93-K; proximal fibula GSP/MSM-88-K; neural spine GSP/MSM-95-K; and armor osteoderm ellipsoidal tubule GSP/MSM-98-K	Presacral vertebrae GSP/MSM-126-15 to GSP/MSM-130-15, GSP/MSM-822-15 to GSP/MSM-824-15, GSP/MSM-818-15; partial dorsal neuralarch GSP/MSM-323-15; caudal vertebraeGSP/MSM-43-15, GSP/MSM-44-15, GSP/MSM-44a-15, GSP/MSM-45-15 to GSP/MSM-48-15, GSP/MSM-260-15, GSP/MSM-505-15, GSP/MSM-834-15, GSP/MSM-325-15; cervical rib GSP/MSM-881-15; caudal neural spine GSP/MSM-324-15; distal rib/neural spine GSP/MSM-672-15, GSP/MSM-1056-15; proximal dorsal rib GSP/MSM-322-15; dorsal rib GSP/MSM-531-15; left sternalplate GSP/MSM-675-15; left proximal humerus GSP/MSM-245-15; distal left humerus GSP/MSM-174-15; left proximal ulna GSP/MSM-78-15; proximal metacarpal GSP/MSM-297-15; distal metacarpal GSP/MSM-750-15; left acetabulum GSP/MSM-166-15; left proximal femur GSP/MSN-168-15; distal left femur GSP/MSM-173-15; proximal left tibia GSP/MSM-246-15; distal tibia/ulna? GSP/MSM-227-15	Caudal vertebrae GSP/MSM-7-15, GSP/MSM-29-15 to GSP/MSM-33-15, GSP/MSM-815-15, GSP/MSM-808-15 and GSP/MSM-507-15; partial rights capula GSP/MSM-163-15; partial pubis GSP/MSM-165-15, GSP/MSM-164-15; proximal femur GSP/MSM-169-15; distal femur GSP/MSM-70-15
Holoty. elements	11	35	14
Type locality	Sun Chaku (27˚50'40"N; longitude 67˚09'66"E; Figure 1 of [75])	Mari Bohri (latitude 29˚41'57"N; longitude 69˚14'59"E; Figure 4 of [6])	Mari Bohri (latitude 29˚42'08"N; longitude 69˚15'08"E; Figure 4 of [6])
Referred material	Neural spine GSP/MSM-96-K	Cervical Centrum GSP-UM/Sangiali-1101, Cervicodorsal centrum GSP-UM/Sangiali-1176, Dorsal Centra (GSP-UM/ Sangiali-1102, -1123, Dorsal centrum GSP-UM/Sangiali-1176, Dorsal Neural Arch GSP-UM/Sangiali-1104, Caudal Vertebrae GSP-UM/Sangiali-1105-, -1106, and -1107; proximal left scapula GSP-UM/Sangiali-1108, proximal left scapula GSP-UM/Sangiali-1109, and left mid scapula GSP-UM/ Sangiali-1110; distal left scapula GSP-UM/Sangiali-1111; Coracoid GSP-UM/Sangiali-1112, right humerus parts GSP-UM/Sangiali-1113, -1114 and -1115; proximal left pubis GSP-UM/Sangiali-1116, left and right femur GSP-UM/ Sangiali-1118, -1119; distal femur GSP/MSM-1-1, left tibia GSP/Sangiali-1120, Proximal left fibula GSP/Sangiali-1121, Miscellaneous 49 pieces GSP-UM/Sangiali-1126 to GSP-UM/ Sangiali-1174	Caudal vertebra GSP/MSM-40-8

Continued

		Cervical vertebra GSP/MSM-359-2, cervicodorsal vertebra GSP/MSM-120-2, dorsal vertebrae GSP/MSM-121-2, GSP/MSM-122-2, GSP/MSM-123-2, GSP/MSM-124-2, GSP/MSM-125-2, GSP/MSM-441-2, a pair of sacral vertebrae GSP/MSM-135-2, caudal vertebrae GSP/MSM-41-2 and GSP/MSM-42-2, GSP/MSM-360-2, GSP/MSM-302-2, distal part of cervical rib GSP/MSM-187-2, distal thoracic rib GSP/MSM-301-2, neural spine GSP/MSM-792-2, distal rib/ neural spine GSP/MSM-784-2, prezygapophyses and postzygapophyses GSP/MSM-560-2; parts of sternal GSP/MSM-565-2 and sternal part GSP/MSM-1004-2, a coracoid GSP/MSM-560-2, humerus parts GSP/MSM-559-2, GSP/MSM-287-2, GSP/MSM-363-2, GSP/MSM-362-2; left and right ulnae GSP/MSM-573-2 and GSP/MSM-271-2, distal ulna GSP/MSM-852-2; proximal metacarpals GSP/MSM-295-2, GSP/MSM-279-2, GSP/MSM-685-2, GSP/MSM-566-2, GSP/MSM-278-2, GSP/MSM-686-2, GSP/MSM-1029-2, GSP/MSM-688-2; distal metacarpals GSP/MSM-277-2, GSP/MSM-1028-2, GSP/MSM-285-2, GSP/MSM-370-2, GSP/MSM-684-2, GSP/MSM-687-2, GSP/MSM-361-2, GSP/MSM-683-2, proximal ischium GSP/MSM-184-2, a femur (proximal half GSP/MSM-178-2 and distal half GSP/MSM-182-2), and metatarsals GSP/MSM-643-2, GSP/MSM-1031-2 and GSP/MSM-1030-2. Caudal vertebrae GSP/MSM-52-9, GSP/MSM-793-9, proximal humerus with prominent head GSP/MSM-694-9 and GSP/MSM-759-9, distal ulna GSP/MSM-252-9, transversely broad distal tibia GSP/MSM-75-9 and right astragalus GSP/MSM-752-9. Proximal right femora GSP/MSM-749-15 and GSP/MSM-167-15, Left distal femur GSP/MSM-170-15 from Pakistan [11]. A femur (GSI/WR/M/90/84) from Rahioli India referred due to same proportion and similarity with mid Sangiali femur (proximal GSP/Sangiali-1118 which was mistyped as GSP/Sangiali-13 on page 1054, and distal GSP/MSM-1-1), and a right humerus (GSI 20012) from Rahioli and a humerus from Bara Simla, India were referred due to matching with humerus GSP/Sangiali-1113 (mistyped as GSP/Sangiali-1124 on page 1054) [11]	
Refer elements	1	24 + 38 + 7= 69 (+49 Miscellaneous pieces)	1
Refer localities	Lakha Pir Charrow of Zidi Tehsil, Khuzdar District (Figure 1 of [75])	Mid Sangiali (top 6 lines), mid Bor last digit is 2 and Grut last digit 9, Mari Bohri last digit is 15 (Figure 4 of [6], Figure 1 of [7]) from Pakistan, and Rahioli and Bara Simla India [11]	Figure 1 of [7]
Tot. h + r elements	11 + 1 = 12	104 (+49 miscellaneous pieces)	14 +1 = 15
Total individuals	2	4 + 3 = 7	2
Horizon/ stratigraphic formation	Lower part of Sembar Shale	Vitakri Formation; Lameta Formation	Vitakri Formation

Continued

Age	Latest Jurassic-Early Cretaceous	Latest Maastrichtian	Latest Maastrichtian
Distribution territory; (basin) wise	Khuzdar District, Balochistan Province; (Kirthar Range and basin, Western Kirthar basin)	Barkhan District, Balochistan Province; (Sulaiman Range and basin; Sulaiman foldbelt; Sulaiman Basin/Middle Indus Basin/Central Indus basin); Rahioli, western India and Bara Simla, central India	Barkhan District, Balochistan Province; (Sulaiman Range; Sulaiman Basin)

Table 3. Statistical data and basic information of Gspsauridae (Poripuchia) titanosaurian sauropods from the latest Cretaceous of Pakistan. *Same as *Gspsaurus pakistani* except 2 skull pieces.

Titles	*Gspsaurus pakistani*	*Maojandino alami*	*Saraikimasoom vitakri*	*Nicksaurus razashahi*
Informal description	[63]	[66] [69]	[63]	[63]
Formal description	[6]	[7]	[6]	[7]
Holotype	Two associated cranial fragments including a partial dentary ramus, quadrate, and quadratojugal (GSP/MSM-79-19) and a partial vomer, palatine, and pterygoid (GSP/MSM-80-19); braincase/anterior caudal GSP/MSM-62-19; cervical vertebrae GSP/MSM-107-19, GSP/MSM-108-19, GSP/MSM-109-19, GSP/MSM-437-19, GSP/MSM-220-19, GSP/MSM-502-19; dorsal vertebrae GSP/MSM-110-19, GSP/MSM-111-19, GSP/MSM-112-19, GSP/MSM-617-19; caudal vertebrae GSP/MSM-113-19, GSP/MSM-114-19, GSP/MSM-115-19, GSP/MSM-116-19, GSP/MSM-117-19, GSP/MSM-218-19, GSP/MSM-219-19, GSP/MSM-221-19, GSP/MSM-696-19, GSP/MSM-777-19; vertebral fragment GSP/MSM-146-19; left and right partial distal scapula GSP/MSM-1100-19, GSP/MSM-217-19; proximal radius GSP/MSM-215-19; partial ilium GSP/MSM-216-19; proximal left femur GSP/MSM-213-19; distal left femur GSP/MSM-118-19; proximal left tibia GSP/MSM-119-19; distal left tibia GSP/MSM-569-19; distal right tibia GSP/MSM-710-19	Same as *Gspsaurus pakistani* except the cranial pieces	Snout GSP/MSM-142-4, consisting of articulated left and right premaxillae, left and rightmaxillae, dorsaland ventral palatal process, left and right dentary, and teeth	Jaw ramus with 6 teeth GSP/MSM-138-4n; cranial materials and teeth fragments in matrix GSP/MSM-315-4n and GSP/MSM-314-4n; cervical vertebrae GSP/MSM-381-4n to GSP/MSM-383-4n; cervical/dorsal vertebraGSP/MSM-212-4n; caudal vertebrae GSP/MSM-347-4n, GSP/MSM-348-4n; caudal chevron GSP/MSM-313-4n; humerus fragments GSP/MSM-380-4n, GSP/MSM-377-4n, GSP/MSM-379-4n, GSP/MSM-438-4n; proximal radius GSP/MSM-344-4n; proximal pubis GSP/MSM-1096-4n; left femur GSP/MSM-190-4n; right distal femur GSP/MSM-192-4n; right femur fragments GSP/ MSM-378-4n, GSP/MSM-270-4n; left and right distaltibiae GSP/MSM-346-4n, GSP/MSM-345-4n
Holotype	33	31*	1	22
Type locality	Alam (central Alam) (latitude 29˚41'0.7"N; longitude 69˚23'58"E; Figure 4 of [6])	Central Alam*	South Kinwa* (latitude 29˚40'57"N; longitude 69˚23'09"E; Figure 4 of [6])	North Kinwa (latitude 29˚41'16"N; longitude 69˚23'31"E; Figure 4 of [6])

Continued

Referred material	A pair of coosified sacral vertebrae GSP/MSM-137-16, dorsal vertebrae GSP/MSM-131-16 and GSP/MSM-132-16, caudal vertebrae GSP/MSM-34-16 and GSP/MSM-35-16, distal caudal vertebra GSP/MSM-153-16, a pair of left and right distal scapulae GSP/MSM-250-16 and GSP/MSM-176-16, a pair of left and right proximal ulna GSP/MSM-175-16 and GSP/MSM-240-16, distal ulna GSP/MSM-74-16, distal radius GSP/MSM-160-16, acetabulum in 2 pieces GSP/MSM-147-16 and GSP/MSM-148-16, proximal right tibia biconvex lense shaped GSP/MSM-73-16, left and right proximal fibulae GSP/MSM-76-16 and GSP/MSM-77-16, convex part of sternal GSP/MSM-1014-16, sternal part GSP/MSM-604-16, part of ilia GSP/MSM-557-16, part of ilia or spine with glenoid or wound mark GSP/MSM-150-16, vertebral process/distal rib/distal spine/metatarsal/metacarpal GSP/MSM-391-16, distal cervical ribs GSP/MSM-328-16, GSP/MSM-329-16, distal cervical rib GSP/MSM-767-16, mosaic type osteoderm GSP/MSM-83-16, mosaic type osteoderm GSP/MSM-1035-16, osteoderm or platy oval ungual or sacral vertebrae GSP/MSM-776-16; vertebral arch GSP/MSM-82-4, associated caudal vertebrae GSP/MSM-36-4, GSP/MSM-37-4, GSP/MSM-38-4, GSP/MSM-39-4, and GSP/MSM-39(a)-4, mid scapular blade with ridge GSP/MSM-838-4, right mid and distal scapula GSP/MSM-198-4, proximal and mid femur GSP/MSM-208-4, osteoderm ellipsoidal plate GSP/MSM-85-4; proximal humerus GSP/MSM-237-10 Proximal humerus GSP/Sangiali-1125; proximal tibia GSP/MSM-181-2 with associated proximal shaft GSP/MSM-850-2; from Pakistan [7] [71]. A caudal vertebra K20/317, a humerus from Bara Simla India and right and left humeri from Rahioli Gujarat and Chhota Simla limb skeleton from India [7] [71]	Same as *Gspsaurus pakistani*	-	Caudal vertebrae GSP/MSM-523-7 and GSP/MSM-524-7, scapula GSP/MSM-746-7 and osteoderm GSP/MSM-84-7
Ref. elements	42 from Pakistan; 10 from India	Same as *Gspsaurus*	-	4
Ref. localities	Top Kinwa, South Kinwa, Rahi Wali, east Bor and mid Sangiali (Pakistan) Figure 4 of [6], Figure 1 of [7], and Chhota Simla, Bara Simla and Rahioli (India)	Same as *Gspsaurus*	-	South Zubra (Figure 1 of [7])
Total h + r elements	85	1	1	26

Continued

Total individuals	6	6	1	2
Horizon/Fm.	Vitakri Formation; Lameta Formation	Vitakri Formation; Lameta Formation	Vitakri Formation	
Age	Latest Maastrichtian	Latest Maastrichtian	Latest Maastrichtian	
Distribution territory; (basin) wise	Barkhan District, Balochistan Province; (Sulaiman Range; Sulaiman Basin); Chhota Simla, Bara Simla and Rahioli (India)	Barkhan Distt, Balochistan; (Sulaiman Basin)	Barkhan District, Balochistan Province; (Sulaiman Basin)	Barkhan District, Balochistan Province; (Sulaiman Range; Sulaiman Basin)

Table 4. Statistical data/information of Pakisauridae poripuchian titanosaurs from Pakistan.

Titles	*Khanazeem saraikistani*	*Pakisaurus balochistani*	*Sulaimanisaurus gingerichi*	*Khetranisaurus barkhani*
Informal description	-	[58]	[58]	[58]
Formal description	[11]	[6]	[6]	[6]
Holotype	Dentary ramus and teeth GSP/MSM-143-2; caudal vertebrae GSP/MSM-16-2, GSP/MSM-793-2; left proximal and mid femur GSP/MSM-69-2; right femur including proximal GSP/MSM-294-2, mid-GSP/MSM-293-2, and distal sections GSP/MSM-266-2; partial humerus GSP/MSM-289-2; distal humerus GSP/MSM-180-2; proximal humerus GSP/MSM-288-2, mid humerus GSP/MSM-290-2; partial right tibia GSP/MSM-72-2; distal tibia GSP/MSM-186-2; proximal and mid left tibia GSP/GSP/MSM-286-2	Presacral vertebrae GSP/MSM-340-4, GSP/MSM-341-4, GSP/MSM-342-4, GSP/MSM-376-4, GSP/MSM-517-4, GSP/MSM-800-4, GSP/MSM-809-4, GSP/MSM-810-4 and GSP/MSM-1011-4; cervicodorsal vertebra GSP/MSM-133-4; partial sacrum GSPMSM-136-4; GSP/MSM-1008-4; caudal vertebrae GSP/MSM-11-4, GSP/MSM-12-4, GSP/MSM-13-4, GSP/MSM-14-4, GSP/MSM-207-4, GSP/MSM-763-4, GSP/MSM-1010-4; neural spine GSP/MSM-601-4; partial neural arches GSP/MSM-878-4, GSP/MSM-804-4, GSP/MSM-805-4, fragments pertaining to right and left scapulae (GSP/MSM-878a-4; GSP/MSM-318-4 and GSP/MSM-319-4; GSP/MSM-201-4; GSP/MSM-590-4; GSP/MSM-593-4; GSP/MSM-203-4; GSP/MSM-205-4; GSP/MSM-162-4); partial sternal plates GSP/MSM-355-4, GSP/MSM-598-4; proximal right humerus GSP/MSM-202-4; humerusparts GSP/MSM-268-4, GSP/MSM-210-4 and GSP/MSM-210a-4; distal humerus GSP/MSM-193-4; distal radius GSP/MSM-159-4; apair of proximal ulnae-left and right proximal ulnae GSP/MSM-603-4, GSP/MSM-600-4; shaft of proximal ulna GSP/MSM-211-4, GSP/MSM-678-4; partialmetacarpals GSP/MSM-280-4, GSP/MSM-970-4; partialilium GSP/MSM-971-4, GSP/MSM-972-4, GSP/MSM-594-4, GSP/MSM-806-4; right proximal femur GSP/MSM-595-4 and distal right femur GSP/MSM-200-4; proximal right fibula GSP/MSM-349-4; distal fibula GSP/MSM-580-4; proximal left fibula GSP/MSM-384-4; and partial metatarsal GSP/MSM-350-4	Caudal vertebrae GSP/MSM-17(a)-4, GSP/MSM-18-4, GSP/MSM-19-4, GSP/MSM-20-4, GSP/MSM-21-4, GSP/MSM-21(a)-4, GSP/MSM-22-4	Caudal vertebrae GSP/MSM-27-4, GSP/MSM-28-4

Continued

Holotypic elem.	14	56	7	2
Type locality	Lower Bor latitude 29.68700 and longitude 69.3771 (29˚41'12"N and 69˚22'37"E) (Figure 4 of [6])	South Kinwa (Southwestern Kinwa) 29˚41'05"N and 69˚23'05"E (south of foot track) including vertebrae and other bones), and at 29˚41'06"N and 69˚23'05"E (north of foot track) including complete diagnostic humerus and other bones) (Figure 4 of [6])	South Kinwa (Southernmost Kinwa) (latitude 29˚40'54"N; longitude 69˚23'04"E) (Figure 4 of [6])	Mid Kinwa (latitude 29˚41'04"N; longitude 69˚23'17"E) (Figure 4 of [6])
Referred material	Caudal vertebrae GSP/MSM-17-16, GSP/MSM-510-16 and GSP/MSM-154-16; prezygapophyses GSP/MSM-327-16; caudal chevron GSP/MSM-330-16 in 2, proximal ulna GSP/MSM-1032-16 from Pakistan. A femur from Rahioli, western India (ISI 622-623-624; Bandyopadhyay, pers. comm with Jeffrey A. Wilson; [13]) also possesses the slender proportions, proximolateral profile and inflected head present in lower Bor left and right femora [11]	Proximal pubis GSP/MSM-403-19n, proximal radius GSP/MSM-756-19n; distal ulna GSP/MSM-628-19n and caudal vertebra GSP/MSM-758-19n; fractured distal caudal vertebra GSP/MSM-523-3, distal caudal vertebra with horizontal groove on posterior cone GSP/MSM-151-3, proximal pubis with glenoid and fenestra GSP/MSM-366-3, ulna GSP/MSM-748-3, ungual GSP/MSM-152-3, and spongy thick armour spine GSP/MSM-150-3: proximal rib GSP/MSM-321-13; proximal right humerus GSP/MSM-195-4; caudal vertebraGSP/MSM-15-15 from Pakistan. Right and left humeri from Rahioli Gujarat India area (GSI type no 20008, GSI 20009) were referred from India [11]	Right proximal humerus GSP-UM/ Sangiali-1124, proximal fibula GSP-UM/ Sangiali-1117 and mid fibula GSP-UM/ Sangiali-1122; flattened tibia GSP/MSM-235-7, fibula GSP/MSM-253-7 and metatarsal GSP/MSM-296-7; caudal vertebrae GSP/MSM-24-15, GSP/MSM-25-15 and GSP/MSM-26-15; caudal vertebra GSP/MSM-23-3 from Pakistan. Left tibia K 20/321 and right fibula K 27/489 from Bara Simla, Jubalpur, India were referred to matching with its South Zubra exemplar's tibia and fibula	One vertebra like holotype was found on mid Kinwa (just west of foot track) and other bones (mostly caudal vertebrae and limb bones) found belong to *Balochisaurus malkani*
Referred elements	6	13	10	-
Referred localities	Top Kinwa (Figure 4 of [6]) from Pakistan [11], and Rahioli, Gujarat, western India	North Alam, Shalghara, South Kinwa, East Dolvahi, Mari Bohri (Figure 4 of [6], Figure 1 of [7]) from Pakistan, and Rahioli Gujarat, western India [11]	Lower Sangiali, mid Sangiali, Zubra peak, Mari Bohri and Shalghara. (Figure 4 of [6], Figure 1 of [7]) from Pakistan, and Bara Simla from India	Mid Kinwa (Figure 4 of [6])

Continued

Total h + r elements	14 + 6 = 20	56 + 13 = 69	7 + 10 = 17	2
Total individuals	1 + 2 = 3	1 + 5 = 6	1 + 4 = 5	1
Horizon/ formation	Vitakri Formation; Lameta Formation	Vitakri Formation; Lameta Formation	Vitakri Formation; Lameta Formation	Vitakri Formation
Age	Latest Maastrichtian	Latest Maastrichtian	Latest Maastrichtian	Latest Maastrichtian
Distribution territory; (basin) wise	Barkhan District, Balochistan Province (Sulaiman Range; Sulaiman Basin); Rahioli, western India	Barkhan District, Balochistan Province (Sulaiman Range; Sulaiman Basin); Rahioli western India	Barkhan District, Balochistan Province; (Sulaiman Range Sulaiman Basin); Bara Simla, central India	Barkhan District, Balochistan Province (Sulaiman Range; Sulaiman Basin)

Table 5. Statistical data/information of Vitakrisauridae theropod dinosaurs from Pakistan.

Title	*Vitakridrinda sulaimani*	*Vitakrisaurus saraiki*	*Shansaraiki insafi*
Informal description	[58]	[4]	-
Formal description	[6]	[6]	[11]
Holotype	Teeth GSP/MSM-1085-19, GSP/MSM-1089-19, GSP/MSM-1091-19, GSP/MSM-1092-19, GSP/MSM-1097-19, GSP/MSM-1098-19, GSP/MSM-1099-19 GSP/MSM-1100-19 and GSP/MSM-1101-19; Teeth cross sections GSP/MSM-1093-19 and GSP/MSM-1090-19; tall dorsal centra GSP/MSM-706-19 and GSP/MSM-765-19; left and right femora GSP/MSM-59-19 and GSP/MSM-60-19; distal femur cross section GSP/MSM-1039-19	Right hand/manus GSP/MSM-303-2; proximal ulna GSP/MSM-1076-2 cross section; partial vertebra GSP/MSM-780-2; humerus cross sections GSP/MSM-1044-2, GSP/MSM-984-2 and GSP/MSM-1027-2; one anterior caudal GSP/MSM-53-2 and two mid-caudal vertebrae GSP/MSM-54-2 and GSP/MSM-55-2	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
Holotypic elements	16	9	3
Type locality	Alam (central Alam) postcranial fossils were found at latitude 29˚41'00"N, and longitude 69˚23'58"E, and holotypic cranial fossils (teeth) were found at latitude 29˚41'01"N, and longitude 69˚23'59"E (Figure 4 of [6])	Mid Bor latitude 29˚41'12.8"N, and longitude 69˚23'07"E (Figure 4 of [6])	Shalghara latitude 29.68288 and longitude 69.38008 (N 29˚40'58"; E 69˚22'48") (Figure 4 of [6])
Referred material	tall anterior dorsal vertebra GSP/MSM-56-1, anterior caudal vertebra GSP/MSM-58-15, mid caudal vertebra GSP/MSM-282-15; GSP/MSM-1040-16 and GSP/MSM-1048-16; distal caudal vertebra GSP/MSM-149-16 of whiplash tail; teeth/metatarsals cross section II GSP/MSM-1041-16, GSP/MSM-1042-16; metatarsal III or tooth (GSP/MSM-1043-4)	Proximal femur GSP/MSM-1049-K, mid cross section of femur GSP/MSM-1055-K and part of peripheral bone of leg section GSP/MSM-1059-K	-

Continued

Referred elements	9	3	-
Referred localities	Sangiali 1, Eastern Kinwa (Top Kinwa) 16, Mari Bohri 15 and South Kinwa 4 (Figure 4 of [6]).	Karkh (Figure 4 of [6]).	-
Total h + r elements	16 + 9 = 25	9 + 3 = 12	3
Total individuals	5	2	1
Horizon/ formation	Vitakri Formation	Vitakri Formation	Vitakri Formation
Age	Latest Maastrichtian	Latest Maastrichtian	Latest Maastrichtian
Distribution territory; (basin) wise	Barkhan District, Balochistan Province; (Sulaiman Range; Sulaiman Basin)	Barkhan District, Balochistan Province; (Sulaiman Range; Sulaiman Basin) Khuzdar District, Balochistan Province (Kirthar Range)	Barkhan District, Balochistan Province; (Sulaiman Range; Sulaiman Basin)

Table 6. Statistical data and information of deep snouted Induszalimidae (Columns 2, 3), shallow snouted Sulaimanisuchidae (Column 4), broad snouted Mithasaraikistanidae (Column 5) fresh water riverine crocodiles, and *Khuzdarcroco zahri* (Column 6) marine crocodile found from the Cretaceous of Pakistan.

Titles	*Pabwehshi pakistanensis*	*Induszalim bala*	*Sulaimanisuchus kinwai*	*Mithasaraikistan ikniazi*	*Kuzdarcroco zahri*
Informal description	-	[64]	[4]	-	[67] [69]
Formal description	[79]	[6]	[6]	[6]	[7]
Holotype	Snout GSP/MSM-3-16 (GSP-UM 2000)	Rostrum GSP/MSM-155-19, caudal vertebrae GSP/MSM-65-19 and GSP/MSM-1084-19, proximal left tibia articulated with proximal left fibula GSP/MSM-1086-19, proximal left ulna GSP/MSM-1120-19, proximal left humerus GSP/MSM-1087-19, distal and mid left femur GSP/MSM-66-19, and ilium MSM-1088-19	Dentary GSP/MSM-63-4 and proximal humerus GSP/MSM-1094-4	Snout GSP/MSM-4-3, and dentary ramus GSP/MSM-139-3	A partial rib GSP/MSM-1057-K

Continued

Holotypic elements	1	8	2	2	1
Type locality	Top Kinwa/East Kinwa (latitude 29˚41'17"N, and longitude 69˚24'00"E) (Figure 4 of [6])	Central Alam (latitude 29˚41'01"N; longitude 69˚23'59"E) (Figure 4 of [6])	South Kinwa (latitude 29˚41'00"N; longitude 69˚23'10"E) (Figure 4 of [6])	Shalghara (latitude 29˚40'56"N, and longitude 69˚22'47"E) (Figure 4 of [6])	Khuzdar (27˚46'37"E; 66˚36'44"E) (Figure 1 of [7])
Referred material	Dentary GSP/MSM-6-3 (GSP-UM 2001)	dorsal vertebra GSP/MSM-64-15	-	-	One possible egg fragment GSP/MSM-1058-K
Referred elements	1	1	-	-	1
Referred localities	Shalghara (Figure 4 of [6])	Mari Bohri (Figure 4 of [6])	-	-	Pir Bari road, east of Karkh town (Figure 1 of [7])
Total h + r elements	2	9	2	2	2
Total individuals	2	2	1	1	2
Horizon/ formation	Vitakri Formation	Vitakri Formation	Vitakri Formation	Vitakri Formation	Goru Formation (Maroon Cretaceous marl and shale)
Age	Latest Maastrichtian	Latest Maastrichtian	Latest Maastrichtian	Latest Maastrichtian	Early Cretaceous
Distribution territory; (basin) wise	Barkhan District, Balochistan Province; (Sulaiman Basin)	Barkhan District, Balochistan Province; (Sulaiman Range; Sulaiman Basin)	Barkhan District, Balochistan Province; (Sulaiman Range; Sulaiman Basin)	Barkhan District, Balochistan Province; (Sulaiman Range; Sulaiman Basin)	Khuzdar District, Balochistan Province; (Kirthar Basin)

Table 7. Statistical data and information of recently named Eucrocodile, Gavial crocodile, Plesiosaur, Snake and Pterosaurs from the Mesozoic and Cenozoic strata of Pakistan.

Titles	***Asifcroco retrai*** **(Eucrocodile)**	***Sakhibaghoon khizari*** **(Gavial crocodile)**	***Zahrisaurus kilmoolai*** **(Plesiosaur)**	***Wadanaang kohsulaimani*** **(Snake)**	***Saraikisaurus minhui*** **(Pterosaur)**	***Imrankhanuqab qaeddiljani*** **(Pterosaur)**
Informal description	[67]	-	[70]	-	[62]	-
Formal description	[7]	[2]	[7]	[6]	[6]	Present paper

Continued

Holotype	Jaw GSP/MSM-46-Taunsa; vertebra GSP/MSM-41-Taunsa: armor bone GSP/MSM-42-Taunsa: proximal ulna GSP/MSM-43-Taunsa; proximal humerus GSP/MSM-44-Taunsa; bone fragment GSP/MSM-45-Taunsa	PCGU-40/22 jaw fragment	Trunk body with ribs GSP/MSM-99-K	Teeth (each tooth articulated with partial dentary) GSP/MSM-1102-19, GSP/MSM-1103-19, GSP/MSM-1104-19, GSP/MSM-1105-19, GSP/MSM-1106-19 and GSP/MSM-1107-19, and a vertebra GSP/MSM-1108-19	Dentary ramus GSP/MSM-157-16	GSP/Sangiali-1175
Holotypic elements	6	1	1	7	1	1
Type locality	Gulki Taunsa (latitude 30˚42'26"N; longitude 70˚29'16"E) (Figure 1 of [7])	Pachadhin (Sakhi Sarwar area) 30˚04'51" North; 70˚15'44" East (Figure 1 of [2])	Chotok Moola (28˚09'12"N; 67˚07'41"E) (Figure 1 of [7])	Central Alam (latitude 29˚41'01"N, and longitude 69˚23'59"E) (Figure 4 of [6])	Top Kinwa 29˚41'17"N, 69˚24'00"E (Figure 4 of [6])	Mid Sangiali latitude 29˚41'53.16"N; longitude 69˚23'55.39" E (Figure 4 of [6])
Referred material	Possible egg nesting GSP/MSM-47-Taunsa and GSP/MSM-48-Taunsa, armor GSP/MSM-49-Taunsa, armor GSP/MSM-50-Chamalang, tooth GSP/MSM-51-Kharzan Moola	-	-	-	-	-
Referred elements	5	-	-	-	-	-
Referred localities	Gulki Taunsa, Chamalang and Kharzan Moola (Figure 1 of [7])	-	-	-	-	-
Total h + r elements	11	1	1	7	1	1
Total individuals	6	1	1	1	1	1
Horizon/ formation	Chitarwata; Shaheed Ghat	Litra Formation	Chiltan Limestone	Vitakri Formation	Vitakri Formation	Vitakri Formation
Age	Oligocene and Eocene	Miocene	Late Jurassic	Latest Maastrichtian	Latest Maastrichtian	Latest Maastrichtian

Continued

Distribution territory; (basin) wise	Taunsa District (Dera Ghazi Khan District), South Punjab; (Koh Sulaiman Range; Sulaiman Basin)	Dera Ghazi Khan District, South Punjab; (Koh Sulaiman Basin)	Khuzdar District, Balochistan Province; (Kirthar Range; Kirthar Basin)	Barkhan District, Balochistan Province; (Sulaiman Range; Sulaiman Basin)	Barkhan District, Balochistan Province; (Sulaiman Range; Sulaiman Basin)	Barkhan District, Balochistan Province; (Sulaiman Range; Sulaiman Basin)

Table 8. Statistical data and information of recently named largest land and sea mammals from the Cenozoic strata of Pakistan which are among the largest land and ocean mammals of global world.

Titles	*Buzdartherium gulkirao*	*Pakitherium shagalai*	*Sulaimanitherium dhanotri*	*Gomphotherium buzdari*
Informal description	[65]	-	-	[65]
Formal description	[7]	[77]	[77]	[7]
Holotype	Cranial and postcranial specimens GSP/MSM-1-Taunsa to GSP/ MSM-37-Taunsa	GSP/MSID-201 to GSP/MSID-227 associated fossilized bones/pieces of bones of cranial and postcranial skeleton	GSP/MSID-1 to GSP/MSID-100 associated fossilized bones/pieces of bones of vertebral series	Proximal femur (mosaic of GSP/MSM-MSID-1 and GSP/MSMMSID-2), distal femur (mosaic of GSP/MSM-MSID-3 and GSP/MSM-MSID-5), and proximal tibia GSP/MSM-MSID-4
Holotypic elements	37	27	100 bones/pieces of bones	5
Type locality	Gulki (latitude 30˚42'26"N; longitude 70˚29'16"E) (Figure 1 of [7]).	Shagala (=Shagalu) area (latitude 31˚19'44"N; longitude 68˚40'19"E), (Figure 1 of [7]).	Zamri (latitude 31˚19'28"N; longitude 70˚11'11"E), (Figure 1 of [7]).	Mahoi (latitude 30˚42'12"N; longitude 70˚30'20"E) (Figure 1 of [7]).
Referred material	Limb elements (GSP/MSM-RA-38-Taunsa to GSP/MSMRA-60-Taunsa)	Right femur GSP/MSID-228, left femur GSP/MSID-229	-	-
Referred elements	23	2	-	-
Referred localities	Taunsa area	Same as type locality	-	-
Total h + r elements	60	29	100	5
Total individuals	2	2	1	1
Horizon/ formation	Chitarwata Formation	Shagala Formation	Drazinda Shale	Litra Formation of Vihowa Group
Age	Oligocene	Eocene-Oligocene	Early to middle Eocene	Miocene

Continued

Distribution territory; (basin)	Taunsa District (Dera Ghazi Khan District), South Punjab; (Sulaiman Range and Basin)	Kamardin Kareez of Zhob District, Balochistan Province; (Kakar-Khorasan sub-basin of Balochistan Basin)	Musakhel District, Balochistan Province; (Sulaiman Range and Basin)	Taunsa District (Dera Ghazi Khan District), South Punjab; (Sulaiman Range and Basin)

Table 9. Statistical data and information of recently named terrestrial and marine mammals from the Mesozoic and Cenozoic strata of Pakistan.

Titles	*Mirvitakriharan haji*	*Bolanicyon shahani*	*Kilgai moolakharzani*	*Artiocetus clavis*	*Rodhocetus balochistanensis*
Informal description	[70]	[65]	[70]	-	-
Formal description	[7]	[7]	[7]	[74]	[74]
Holotype	Angular and partial dentary GSP/MSM-141-4s	Lower jaw with teeth and angular (GSP/MSM-1068-Mach)	Fragmentary typical tooth GSP/MSM-1065-K	Cranium, astragalus and cuboid GSP-UM-3458	Manus and pes GSP-UM-3485
Holotypic elements	1	1	1	1	1
Type locality	South Kinwa (latitude 29˚41'00"N; longitude 69˚23'10"E) (Figure 4 of [6])	Gishtari area of Mach (possibly latitude 29˚48'24"N; longitude 67˚17'58"E) (Figure 1 of [7])	Kil locality of Moola Zahri area (28˚08'15"N; 67˚08'49"E) (Figure 1 of [7])	Kunvit locality of Lakha Kach syncline of Rakhni area of Barkhan District (30.059449N latitude, 69.479200E longitude)	Kunvit locality of Lakha Kach syncline of Rakhni area of Barkhan district (30.059449N latitude, 69.479200E longitude)
Referred material	A tooth GSP/MSM-1-Laki Bara	-	-	-	-
Referred elements	1	-	-	-	-
Referred localities	Bara section of Laki anticline, Jamshoro	-	-	-	-
Total holotypic and referred elements	2	1	1	1	1
Total individuals	2	1	1	1	1
Horizon/ stratigraphic formation	Vitakri Formation	Toi Formation of Chamalang Group	Possibly Shaheed Ghat shale of Chamalang Group	Transitional beds (dominant shale with minor thin marl beds) between Habib Rahi limestone and Domanda shale	Transitional beds (dominant shale with minor thin marl beds) between Habib Rahi limestone and Domanda shale

Continued

Age	Latest Maastrichtian	Early Eocene	Early Eocene	Early Eocene (Lutetian age 47 Ma)	Early Eocene (Lutetian age 47 Ma)
Distribution territory; (basin)	Barkhan District, Balochistan Province; (Sulaiman Range and Basin)	Bolan District, Balochistan Province; (Sulaiman Basin)	Khuzdar District, Balochistan Province; (Kirthar Range and Basin)	Barkhan District, Balochistan Province; (Sulaiman Range and Basin)	Barkhan District, Balochistan Province; (Sulaiman Range and Basin)

Table 10. Statistical data and information of recently named fishes from the Paleozoic, Mesozoic and Cenozoic strata; bird (avian) and a large tree (plant) from the Late Cretaceous strata of Pakistan.

Titles	***Muzaffarabadmachli abbottabadi*** **(Fish)**	***Kahamachli harrandlundi*** **(Fish)**	***Karkhimachli sangiali*** **(Fish)**	***Wasaibpanchi damani*** **(Bird/Ave)**	***Baradarakht Goeswangai*** **(Large plant)**
Informal description	[70]	[70]	[65]	-	[65]
Formal description	[7]	[7]	[7]	[6]	[7]
Holotype	One side of body GSP/MSM-1-Muzaffarabad	Body section GSP/MSM-2-Kaha Harrand	Body cross section GSP/MSM-1062-K	Teeth GSP/MSM-1111-19, GSP/MSM-1112-19, GSP/MSM-1113-19, GSP/MSM-1114-19, GSP/MSM-1115-19, GSP/MSM-1116-19 and GSP/MSM1117-19	A large stem wood fossil GSP/MSM-158-6
Holotypic elements	1	1	1	7	1
Type locality	Upper Chattar, Muzaffarabad (latitude 34˚20'47"N; longitude 73˚28'15"E) (Figure 1 of [7])	Kaha Harrand (N 29˚34'37"; E 69˚57'24") (Figure 1 of [7])	Karkh (27˚42'14"N; 67˚09'10"E) (Figure 1 of [7])	Central Alam (latitude 29˚41'01"N, and longitude 69˚23'59"E) (Figure 4 of [6])	Goes Wanga Pass (29˚43'35"N; 69˚30'59"E) (Figure 1 of [7])
Referred material	-	-	Body pieces GSP/MSM-1063-K and GSP/MSM-1064-K; and silicified tooth? (GSP/MSM-1-Laki Bara	-	-
Referred elements	-	-	3	-	-
Referred localities	-	-	Karkh (in Khuzdar District; Figure 1 of [7]) and Bara (Laki anticline; Jamshoro District) [11]	-	-

Continued

Total h + r elements	1	1	4	7	1
Total individuals	1	1	3	1	1
Horizon/ stratigraphic formation	Abbottabad Limestone	Pab Sandstone	Pab/Vitakri/ Sangiali/Rakhi Gaj Formations	Vitakri Formation	Dhaola Member of Pab Sandstone
Age	Cambrian	Maastrichtian	Maastrichtian or Early Paleocene	Latest Maastrichtian	Late Maastrichtian
Distribution territory; (basin)	Muzaffarabad District, Azad Kashmir, Pakistan; (Kohat-Potwar-Kotli Basin)	Rajanpur District, South Punjab; (Sulaiman Basin)	Khuzdar District, Balochistan Province; (Kirthar Basin)	Barkhan District, Balochistan Province; (Kirthar Basin)	Barkhan District, Balochistan Province; (Kirthar Basin)

Table 11. Statistical data and information of recently named invertebrates from the Mesozoic and Cenozoic strata of Pakistan.

Titles	***Moolatrilo chotoki*** (Arthropoda; Artiopoda; Trilobita)	***Nisaukankoil beakeri*** (Arthropoda; Myriapoda; Chilopoda)	***Phailawaghkankoil derabugti*** (Arthropoda; Myriapoda; Chilopoda)	***Mulastar zahri*** (Arthropoda; Echinodermata)	***Pakiring kharzani*** (Pelecypoda; Hippuritida?)	***Pakiwheel karkhi*** Mollusca; Cephalopoda; Nautiloidea	***Pakiwheel vitakri*** Mollusca; Cephalopoda; Nautiloidea
Informal description	[70]	[70]	[70]	[65]	[65]	[65]	[65]
Formal description	[7]	[7]	[7]	[7]	[7]	[7]	[7]
Holotype	Fossil shell GSP/MSM-1076-K	Skeleton GSP/MSM-1079-Siahkoh in block GSP/ MSM-Vit-13	Fossil skeleton GSP/MSM-1078-Siahkoh in block GSP/MSM-Vit-13	fossil shell GSP/MSM-1070-K	body fossil GSP/MSM-1073-K	Complete shell fossil GSP/MSM-1071-K	Complete shell fossil GSP/MSM-1072-V
Holotyp. elements	1	1	1	1	1	1	1
Type locality	stream channel in the Chotok Water Spring area (latitude 28˚09'12"N; longitude 67˚07'41"E) (Figure 1 of [7])	Nisau (Kohlu district) and Beaker-Phailawagh (Dera Bugti district) boundary on the northern plunge and axis of Siah Koh anticline locality (29˚34'11"N; 69˚29'13"E) (Figure 1 of [7])	Nisau (Kohlu district) and Beaker-Phailawagh (Dera Bugti district) boundary on the northern plunge and axis of Siah Koh anticline locality (29˚34'11"N; 69˚29'13"E) (Figure 1 of [7])	Kharzan-Karkh road, southeast Kharzan area (27˚59'19"N; 67˚09'50"E) (Figure 1 of [7])	Southern bank of a branch stream of Moola River located just 3 - 4 km north of Kharzan town (28˚04'22"N; 67˚06'38"E) (Figure 1 of [7])	Pir Bari road, Karkh Locality (N27˚43'19"; E67˚11'11") (Figure 1 of [7])	Lower Bor (N29˚41'21"; E 69˚22'33") (Figure 1 of [7])

Continued

Referred material	-	Referred skeleton GSP/MSM-1080-Siahkoh, GSP/MSM-1081-Siahkoh, GSP/MSM-1082-Siahkoh, and GSP/MSM-1083-Siahkoh	Fossil skeleton GSP/MSM-1078-Siahkoh found in block GSP/MSM-Vit-13.	-	Body sections GSP/MSM-1074-K and GSP/MSM-1075-K	A grave yard including many fossils found in volcaniclastic beds in Pir Bari road of Karkh	Many fossils in volcaniclastic beds in Lower Bor 2
Referr. elements	-	4	1	-	2	-	-
Referred localities	-	Exemplars at type locality (Figure 1 of [7])	Exemplar at type locality (Figure 1 of [7])	-	numerous exemplars from type locality (Figure 1 of [7])	Numerous exemplars from type locality (Figure 1 of [7])	Lower Bor
Total h + r elements	1	5	2	1	3	1	1
Total individuals	1	5	2	1	3	1	1
Horizon/ stratigraphic formation	Lower part of Zidi/Chiltan Limestone	Rakhi Gaj Formation	Rakhi Gaj Formation	Shaheed Ghat shale of Chamalang Group	Vitakri Formation laterite	Rakhi Gaj Formation	Rakhi Gaj Formation
Age	Permo-Triassic boundary?	Early Paleocene	Early Paleocene	Early Eocene	Latest Maastrichtian	Early Paleocene	Early Paleocene
Distribution. territory; (basin)	Khuzdar District, Balochistan Province; (Kirthar Basin)	Kohlu and Dera Bugti Districts, Balochistan Province; (Sulaiman Basin)	Dera Bugti and Kohlu Districts, Balochistan Province; (Sulaiman Basin)	Khuzdar District, Balochistan Province; (Kirthar Basin)	Khuzdar District, Balochistan Province; (Kirthar Basin)	Khuzdar District, Balochistan Province; (Kirthar Basin)	Barkhan District, Balochistan Province; (Kirthar Basin)

Table 12. Statistical data and information of ichnotaxa of Sauropods, Theropods and probably ornithischian/sauropod dinosaurs, and pterosaurs found from the Mesozoic strata of Pakistan.

Titles	*Malakhelisauroperus mianwali* Ornithopaonia	*Pashtosauroperus zhobi* Ornithopaonia	*Dgkhansauroperus maarri* Sauropaonia	*Chiltansauroperus nicki* Sauropaonia	*Samanadrindoperus surghari* Theropaonia	*Himalayadrindoperus potwari* Theropaonia	*Anmolpakhiperus alleni* Pteropaonia
Informal description	[76]	[63]	[70] [78]	[6]	[76]	[68]	[70]

Continued

Formal description	[7]	[7]	[7]	[7]	[7]	[7]	[7]
Holotype	Partial trackway GSP/MSM-1-Malakhel	Partial trackway GSP/MSM-8-Musaferpur	Natural cast of footprint GSP/NS-SJAN-MSM-13-Maarri	Footprint GSP/MSM-1067-K	A trackway GSP/MSM-5-Malakhel	trackway GSP/MSM-6-Malakhel	Partial trackway GSP/MSM-12-Musaferpur
Holotypic elements	1	1	1	1	1	1	1
Type locality	Baroch Nala, Malakhel (32˚55'50"N; 71˚09'01"E) (Figure 1 of [7])	Sor Muzghai, Musafarpur (30˚57'36"N; 69˚08'24"E) (Figure 1 of [7])	Maarri peak (29˚32'03"N; 69˚51'45"E) (Figure 1 of [7])	Madan Jhukur (28˚15'03"N; 67˚06'12"E) (Figure 1 of [7])	Baroch Nala, Malakhel (32˚55'50"N; 71˚09'01"E) (Figure 1 of [7])	Baroch Nala, Malakhel (32˚55'39"N; 71˚09'00"E) (Figure 1 of [7])	Sor Muzghai, Musafarpur (30˚57'36"N; 69˚08'24"E) (Figure 1 of [7])
Referred material	Partial trackways GSP/MSM-2-Malakhel, GSP/MSM-3-Malakhel; a footprint GSP/MSM-4-Malakhel	Partial trackway GSP/MSM-9-manus track Musaferpur; Manus track GSP/MSM-10-Musaferpur; with digit mark GSP/MSM-11-Musaferpur	-	-	-	A trackway GSP/MSM-7-Malakhel	Two tracks from type area (GSP/MSM-13-Musaferpur, GSP/MSM-14-Musaferpur) and partial trackway from Moharian
Referred elements	3	3	-	-	-	1	3
Referred localities	Baroch Nala, Malakhel (Figure 1 of [7])	Sor Muzghai, Musaferpur (Figure 1 of [7])	-	-	-	1	Sor Muzghai Musafarpur (Figure 1 of [7]) and Moharian, Salt Range, Khoshab)
Total h + r elements	4	4	1	1	1	2	4
Total individuals	4	4	1	1	1	2	4
Horizon/ formation	Samanasuk Limestone	Sor Member of Pab Formation	Dhaola Member of Pab Formation	Zidi/Chiltan Limestone	Samanasuk Limestone	Samanasuk Limestone	Sor Member of Pab Formation; Samanasuk Limestone
Age	Latest Jurassic	Late Cretaceous	Maastrichtian	Late Jurassic	Latest Jurassic	Latest Jurassic	Late Cretaceous; Late Jurassic respectively

Continued

Distribution territory; (basin)	Mianwali District, Punjab Province; (Kohat-Potwar-Kotli Basin)	Qila Saifullah District, Balochistan Province; (Sulaiman Basin)	Rajanpur District, South Punjab; (Sulaiman Basin)	Khuzdar District, Balochistan Province; (Kirthar Basin)	Mianwali District, Punjab Province; (Kohat-Potwar-Kotli Basin)	Mianwali District, Punjab Province; (Kohat-Potwar-Kotli Basin)	Qila Saifullah District, Balochistan Province; (Sulaiman Basin) Khoshab District, Punjab Province (Kohat-Potwar-Kotli Basin)

The fishes found are *Muzaffarabadmachli abbottabadi*, *Kahamachli harrandlundli* and *Karkhimachli sangiali* [7]. The reptiles so far found are as below; poripuchian titanosaurs (mentioned as below), abelisaurian theropods (*Shansaraiki insafi*, *Vitakridrinda sulaimani* and *Vitakrisaurus saraiki* of Vitakrisauridae), crocodiles (*Induszalim bala* [6] and *Pabwehshi pakistanensis* [79] of Induszalimidae, *Mithasaraikistan ikniazi* of Mithasaraikistanidae and *Sulaimanisuchus kinwai* of Sulaimanisuchidae), *Asifcroco retrai* [6] [7] and *Sakhibaghoon khizari* [2]. Pterosaur—the flying reptiles (*Saraikisaurus minhui* [6] and *Imrankhanuqab qaeddiljani*—new genus and species (see below) of Saraikisauridae, and large paleosnake (*Wadanaang kohsulaimani*) [6] [7], plesiosaur (the marine reptile) *Zahrisaurus kilmoolai* [7]. Mammals found so far are; possibly small mammal *Mirvitakriharan haji* [6] [7] based on posterior angular/dentary show close resemblance to Ausktribosphenids marsupial from Victoria (Figure 23(D) of [80]), walking whales *Artiocetus clavis* and *Rodhocetus balochistanensis* [74], swimming whale *Sulaimanitherium dhanotri* from Drazinda shale, and horse Hippomorpha *Bolanicyon shahani*, largest land rhinoceros (*Buzdartherium gulkirao*) and the Miocene Litra sandstone yielded the large proboscidean (*Gomphotherium buzdari*) [7] [65] [70] [77]. The Limb elements (GSP/MSM-RA-38-Taunsa to GSP/MSMRA-60-Taunsa; Figure 12 of [7]) of *Buzdartherium gulkirao* (large rhinoceros) were collected and hosted by Rao M. Ayub (belongs to Gujranwala, previously mistyped Khoshab) of Pakistan Atomic Energy Commission, Taunsa (Dera Ghazi Khan). A paleobird (*Wasaibpanchi damani* of Wasaibpanchidae) [6] [7] was reported so far, however it may be possible the synsacrum articulated with pelvis of *Imrankhanuqab qaeddiljani* (see below) may belong to bird. Recently reported invertebrates [7] [65] [69] [70] are arthropods trilobite *Moolatrilo chotoki*, centipedes *Nisaukankoil beakeri* and *Phailawaghkankoil derabugti* and Echinodermata (star fish) *Mulastar zahri*; mollusks nautiloid *Pakiwheel vitakri*, *Pakiwheel karkhi*, and bivalve pelecypod *Pakiring kharzani*. The Late Cretaceous (Late Maastrichtian) Dhaola Member of Pab Sandstone yielded the large stem fossil of paleotree (*Baradarakht goeswangai*) [7] [65] [69] [70].

Footprint of *Dgkhansauroperus maarri* and *Chiltansauroperus nicki* (**Table**

12) of Sauropaonia titanosaurian sauropod from the Maastrichtian Dhaola Member of Pab Formation and the Jurassic upper part of Chiltan Limestone, respectively; trackways/partial trackways of *Malakhelisauroperus mianwali* and *Pashtosauroperus zhobi* Ornithopaonia titanosaurian sauropod or ornithischian dinosaurs from the Late Jurassic Samanasuk Limestone and Late Maastrichtian Sor Member of Pab Formation, respectively; trackways of *Samanadrindoperus surghari* and *Himalayadrindoperus potwari* small and large Theropaonia (respectively) theropod dinosaurs from the Late Jurassic Samanasuk Limestone; and Pteropaonia *Anmolpakhiperus alleni* pterosaurs from Dhaola Member of Pab Formation [6] [7] [65] [68] [69] [70].

***Shansaraiki insafi* Theropod:** *Shansaraiki* is described by [11] but its best figures (**Figure 2**) and some description are provided here. The preserved medial side of dentary (GSP/MSM-5-3) has (preserved 2 teeth and one alveolus) consists of two large medial dental foramina (**Figure 2**). These foramina (located between two teeth) are large and more than 1 cm in diameter. These foramina approach to roots of teeth and used for nerve innervations and blood supply to dentary teeth, gums, muscles and tissues. These dentary foramina are among the autapomorphy of *Shansaraiki insafi*. Teeth are oval shaped and D-shaped asymmetrical (large size) to circular (medium sized). Large tooth have thick peripheral bone while small teeth show relatively thin peripheral bone while thickness vary in periphery. Further, teeth cavity of small and large teeth is almost same size. The teeth outer surface is wrinkled *i.e.* teeth outer bone periphery show long pipe type or hair type fibrous texture. The contact of teeth peripheral bone with core cavity is uneven and rough. The *Shansaraiki insafi* theropod dinosaur model (**Figure 2**, Row 3) was arranged by [81]. *Shansaraiki insafi* dentary from Pakistan has anterior weak symphysis closely match with dentary of *Australovenator wintonensis* from Australia [82].

A new pterosaur (flying reptile) from the latest Maastrichtian Vitakri Formation of Pakistan and further evidence of avian/bird evolution from pterosaur:

Systematic paleontology

Pterosauria

Pterodactyloidea

Saraikisauridae [2]

Imrankhanuqabinae new subfamily

Definition: *Imrankhanuqab*; their most recent common ancestor and all of its descendants.

Included species: *Imrankhanuqab qaeddiljani*

Diagnosis: Imrankhanuqabinae is a subgroup of Saraikisauridae. It is more pneumatic than Saraikisaurinae. Further, Saraikisaurinae is edentulous during latest Maastrichtian which makes it unique. Diagnosis is same as genus and species *Imrankhanuqab qaeddiljani* (as below).

Imrankhanuqab qaeddiljani new genus and new species (**Figure 2**)

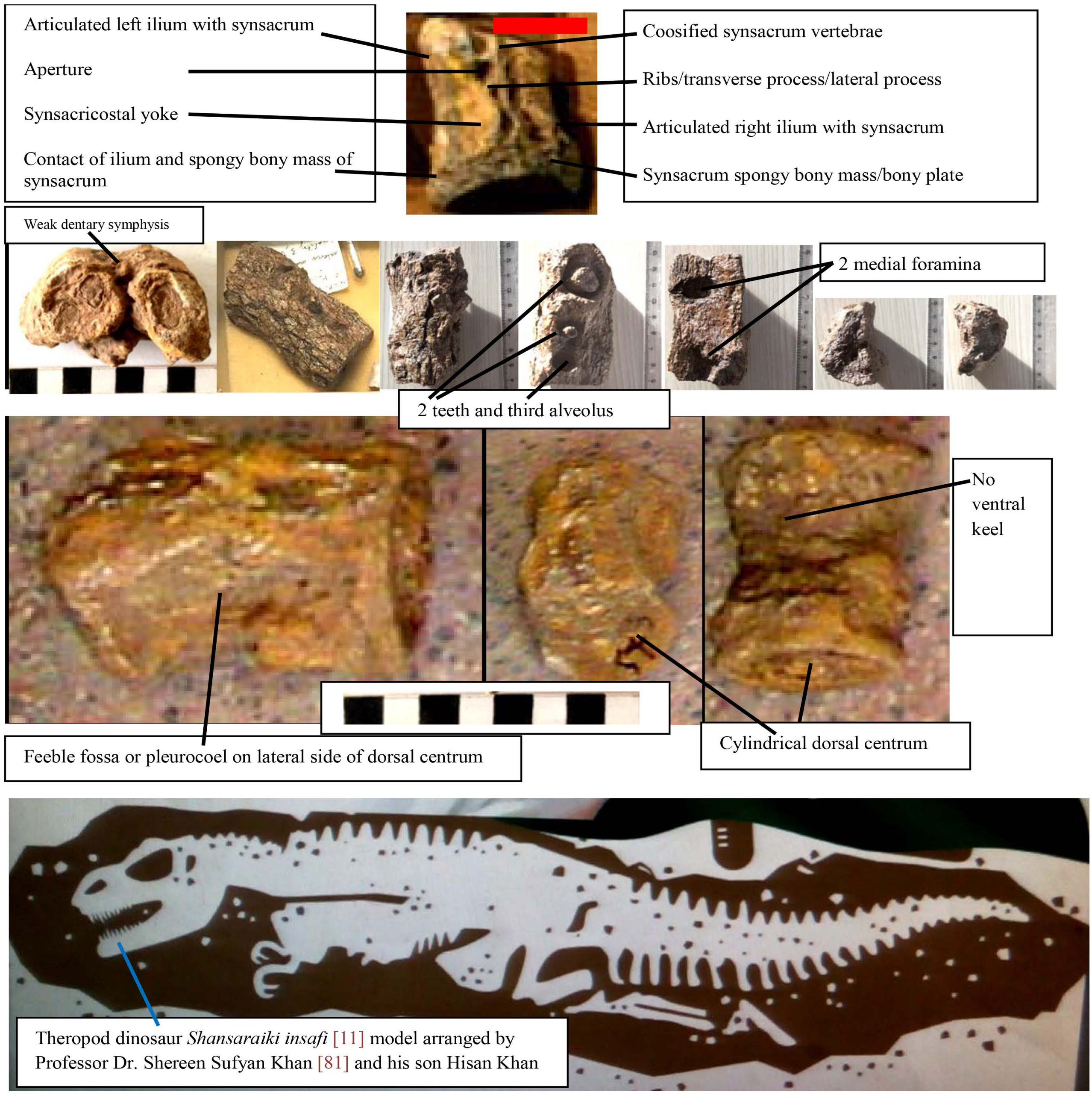

Figure 2. Holotype (Row 1) of *Imrankhanuqab qaeddiljani* new genus and new species of pterosaur (flying reptile) found from Sangiali type locality (Figure 4 of [6]) of Vitakri Dome (Vitakri Kali Kakor), Barkhan District, Balochistan Province, Pakistan. Holotype (Rows 2, 3) of *Shansaraiki insafi* [11] large size theropod found from Shalghara type locality (Figure 4 of [6]) of Vitakri Dome, Barkhan district, Balochistan Province, Pakistan. **Row 1**, coosified synsacrum articulated with ilia GSP/Sangiali-1175. **Row 2**, anterior dentary with weak symphysis GSP/MSM-140-3, and dentary ramus with two teeth and third alveolus GSP/MSM-5-3 in 6 views. **Row 3**, dorsal vertebra GSP/MSM-57-3 in 3 views. **Row 4**, tentative reconstruction arranged by Prof. Dr. Shereen Sufyan Khan and his son Hisan Khan [81] of *Shansaraiki insafi* large size theropod dinosaur from Pakistan. Scale bar (red bar) in Row 1 represents 5 cm; Scale, each black and white digit is 1 cm in Row 3 and Photo 1 of Row 2; Scale in Photos 3 - 7 of Row 2 is in centimeter.

Holotype: Articulated synsacrum, left and right ilia and coosified spongy bony mass GSP/Sangiali-1175 (Figure 2) belongs to a single individual. Fossil is housed in the museum of Geological Survey of Pakistan, Quetta (but at present it is in Museum of Paleontology, University of Michigan, for preparation).

Etymology: Genus *Imrankhanuqab* established in honor of Imran Khan Former Prime Minister of Pakistan and Imran Riaz Khan distinguishing journalist of Pakistan for supporting the poor peoples and development of Pakistan especially Saraiki and Balochi Koh Sulaiman area which is host of fossils, *uqab* in Urdu and Saraiki languages for bird/eagle/falcon which are powerful and have high speed flight. In short it is uqab of Imran Khan. *Imrankhanuqab* pronunciation is Imran Khan Uqab. Species *qaeddiljani* established as, *qaed* in urdu and Saraiki languages for leaders (e.g., Dr. Shahbaz Gil, Habib Akram, Azam Swati, Shereen Mazari, Sanam Javaid, Khadija Shah, Dr. Yasmin Rashid, Irfan Hashmi, Shaheed Arshad Sharif, Waqar Malik, Haider Mehdi, Dr. Moed Pirzada, Sabir Shakir, Adv. Aitzaz Ahsan, Adv. Latif Khosa, Adv. Abdul Ghafar, Sami Abrahim, Sidique Jan, Prof. Dr. Shereen Sufyan Khan, Hisan Khan and others) for supporting poor peoples of the area, *diljani* in Urdu and Saraiki languages for sweat heart. Species *qaeddiljani* means the sweat heart leaders. Species name can be pronunciated as Qaed Dil Jani.

Type locality, horizon and age: Holotype was discovered in mid Sangiali locality (Figure 4 of [6]), Barkhan District, Balochistan. The grid reference of type locality are latitude 29˚41'53.16''N; longitude 69˚23'55.39''E. The host horizon is the upper mud unit of Vitakri Formation of Fort Munro Group [6] [11]. Its age is the latest Maastrichtian [8] [9] [23].

Diagnosis and comparisons: *Imrankhanuqab qaeddiljani* shares with Pterodactyloidea as heavily fused small sized synsacrum. *Imrankhanuqab qaeddiljani* shares with Saraikisauridae as pneumatic bones and adult large size agreement. *Imrankhanuqab qaeddiljani* autapomorphies are as below. It consists of synsacrum and articulated both left and right ilia (**Figure 2**). Synsacrum consists of heavily fused and coosified 7 preserved synsacral vertebrae. The cranialmost five synsacral vertebrae have distinct slender and narrow ribs/transverse processes/lateral processes. Anterior 5 synsacral centra are long and narrow while 6th and 7th synsacral centra are reduced and short. Caudal to the fifth synsacral centrum, the size of centra seems to be reduced rapidly toward the caudal terminus of synsacrum. While this feature is different than *Muzquizopteryx coahuilensis* [83] where caudal to third vertebrae the size of synsacral vertebrae reduced rapidly toward caudal terminus of synsacrum. The caudal segments comprising of 6th and 7th synsacral vertebrae of *Imrankhanuqab qaeddiljani* formed the richly spongy bony mass. Its anterior 5 synsacral ribs are extremely slender and narrow anteroposteriorly. The first vertebral synsacral rib is anterolateral directed while the second synsacral rib directed laterally, the third synsacral rib directed posterolaterally, the fourth synsacral rib directed toward almost lateral and the fifth synsacral rib is directed posterolaterally. The sixth and seventh synsacral ribs and also centra are fused. The rib of first synsacral is longest and then decreasing gradually posteriorly. The distal portion of synsacral ribs formed synsacrocostal yoke which is contacted laterally with left and right ilia. The sacricostal yoke (contact of sacral ribs and ilium) is maximum thick transversely at the level of 4th

sacral rib. It decreases anteriorly and also posteriorly forming asymmetrical arc shape (convexing medially and concaving laterally). This feature of *Imrankhanuqab qaeddiljani* matches with *Coloborhynchus spielbergi* [84] [85]. The posterior limb of this arc of *Imrankhanuqab qaeddiljani* is relatively more inclined outward than *Coloborhynchus spielbergi* [84] [85] which have almost subparallel to vertebral axis. The plate like bony mass (posterior part of synsacral) of *Imrankhanuqab qaeddiljani* is more wide and expanded transversely than *Coloborhynchus spielbergi* [84] [85] posterior bony mass. The four large apertures are found between the synsacral ribs of anterior and mid synsacral vertebrae. Then these apertures are being reduced as very small in distal synsacral vertebrae/plate like bony mass. Ilia are long. The ilium is arc shaped (convexing medially and concaving laterally. Ilium represents acetabulum just lateral to second synsacral. Fused spongy bony mass/bony plate is highly pneumatic. Bony mass is short anteroposteriorly and wide transversely, which is contacted laterally with ilium. Its synsacral vertebrae which are diminishing in anteroposterior length toward posteriorly, this feature matches with *Pterodactylus* which has diminishing vertebrae anteroposteriorly [86]. Its synsacral ribs are narrow and thin anteroposteriorly while the *Huanhepterus quingyangensis* [86], *Vectidraco daisymorrisae* [87] and *Coloborhynchus spielbergi* [84] [85] have relatively thick anteroposteriorly sacral ribs/lateral processes. There are four large apertures between the synsacral ribs of *Imrankhanuqab qaeddiljani* while the *Muzquizopteryx coahuilensis* [83] has 2 large apertures, *Huanhepterus quingyangensis* [86], *Vectidraco daisymorrisae* [87], *Anhanguera* and *Coloborhynchus robustus* [87] have 3 large apertures and *Coloborhynchus spielbergi* [84] [85] have 4 large apertures. No any pterosaurs from India have synsacrum/sacrum for comparison.

Evidence of avian/bird evolution from pterosaur: The richly pneumatic and heavily fused synsacrum (**Figure 2**) with strongly thin and narrow synsacral ribs shows affinity to birds or evolutionary trend toward birds/aves. All the bones are pneumatic. Further, this coosified anatomy represents strong, powerful and speedy flight of *Imrankhanuqab qaeddiljani.* This fossil hosting strong coosified synsacrum with highly pneumatic bony mass (with articulated ilium) shows the early evolution of birds from pterosaurs. In this way, this can be expected as the *Wasaibpanchi damani* bird may be evolved from pterosaur *Imrankhanuqab qaeddiljani*.

3.2.2. Paleobiogeographic Link Known by Recently Discovered Biotas of Pakistan

A snout articulated with lower jaws and partial posterior of *Gspsaurus* and a snout articulated with lower jaws of *Saraikimasoom*, both these more advanced titanosaurs found from the latest Maastrichtian Vitakri Formation have no parallel in this age. *Gspsaurus* snout with V-shaped lower jaw is unique for Titanosaurian sauropods. Complete teeth rows of advanced titanosaurs are unknown so far while *Saraikimasoom* snout is unique anatomical wealth provide the dental Formula (4, 13/9-13). *Rapetosaurus skull* [88] material is disarticulated include incomplete maxilla. *Nemegtosaurus* [89] and *Quaesitosaurus* [90] skulls are older (not from latest Maastrichtian). *Tupuaisaurus* skull [91] is from Early Cretaceous. The first biconvex caudal of *Balochisaurus* and *Marisaurus* Balochisaurids from Pakistan matches with *Pellegrinisaurus* from Patagonia, Argentina and *Alamosaurus* from USA. The vertebrae and limb bones matches with both Gondwana and Laurasia showing Pangean distribution. The more stocky and transversely expanded proximal tibiae of *Balochisaurus* matches closely with late Jurassic *Lusotitan atalaiensis* from Portugal [92] and Late Cretaceous *Lohuecotitan pandafilandi* from Spain [93] and mid Cretaceous *Diamantinasaurus matildae* from Australia [82]. The robust tibia of *Gspsaurus pakistani* matches with *Saltasaurus loricatus* (Plates 45, 55 of [94]). The slender flat proximal tibia of *Khanazeem saraikistani* and *Sulaimanisaurus gingerichi* matches with the *Mendozasaurus neguyelap* from upper Cretaceous of Medoza, Argentina [95] and *Rapetosaurus krausei* from the Late Cretaceous of Madagascar [96] and *Igai semkhu* from Egypt [97]. The large oval shaped ellipsoid (GSP/MSM-85-4) of *Gspsaurus pakistani* osteoderm from South Kinwa locality of Pakistan matches with large osteodermal ellipsoid of titanosaur (Plate 77 of [94]) from Argentina, South America. The large oval shaped ellipsoid (GSP/MSM-84-7) armor bone of *Balochisaurus malkani* from south Zubra locality of Pakistan correlated with *Malawisaurus* [98] of Malawi. In short, the anatomy of Pakistani titanosaurs matches with Gondwana and Laurasian fauna showing Pangean distribution. Some elements of Pakistani titanosaurs are unique like the snouts of *Gspsaurus* and *Saraikimasoom*, and slender femora with inflected head of *Pakisaurus* and slender femora with concavity on proximolateral profile of *Khanazeem*, and diverse morphs of humeri.

The dentary of Pakistani theropod *Shansaraiki insafi* has anterior weak symphysis closely match with dentary symphysis of *Australovenator wintonensis* [82] from Australia showing affinity to Australian land of Gondwana but *Savannasaurus* sauropod [99] is contrasted having amphicoelous caudals while most of Pakistani titanosaurian are last most advanced Poripuchian titanosaurs which have procoelous anterior, mid, posterior and distal caudals. The Mesoeucrocodiles from Pakistan mostly matches with Brazil and Argentina (South America). Pterosaur from Pakistan matches with Asian and Gondwana showing global distribution (as shown above). However, the *Saraikisaurus minhui*, the edentulous pterosaur from the latest Maastrichtian of Pakistan is unique fossil in world. Some unique fossils are developed due to migration and isolation from other landmasses during Early to Late Cretaceous. Indo-Pakistan Plate was initially contacted with Asia/Eurasia at latest Cretaceous time which causes uplift and consequently the fluvial Vitakri Formation was deposited and terrestrial ecosystem evolved. Land bridges during latest Cretaceous formed on fluvial Vitakri Formation for land animals' migration like Dera Ghazi Khan (South Punjab) to Vitakri-Sanjawi to Ziarat to Sor Muzghai Musafarpur to Sor Tangi of Sor Kach Zhob to Waziristan to Afghanistan and Asia. Second land bridge started from Amri-Bara (Jamshoro, Sindh) to Zahri Range (Karkh-Moola; Khuzdar) to

Sor Range Quetta to Ziarat to Sor Muzghai Musafarpur to Sor Tangi of Sor Kach Zhob to Waziristan to Afghanistan and Asia. Due to these land bridges the well developed tracks and partial trackways of Ornithopaonia (and also Sauropaonia and Pteropaonia) are preserved on and around these land bridges [7] (**Table 12**). The close resemblance of partial and poorly recognized posterior dentary of *Mirvitakriharan haji* [7] [70] mammal from the latest Maastrichtian Vitakri Formation of Pakistan is found with the Early Cretaceous Ausktribosphenidae (Figure 23(D) and Figure 23(E) of [80]) possibly placental mammals from Australia. *Wasaibpanchi damani* (member of Wasaibpanchidae) is a giant terrestrial bony toothed bird once ruled the skies of Indo-Pakistan subcontinent just before the K-Pg extinction [6] [7]. Early evolution of walking to swimming whale started from Eocene and Oligocene whale found from Tethyian deposited marine strata of Pakistan. The Eocene and Oligocene largest land mammals evolved from Pakistan and migrated toward Eurasia or may be vice versa. The Mesozoic fauna shows affinity to both Gondwana and Laurasia (Pangea), while Cenozoic mammals show link to Eurasia.

3.3. Phylogeny and Hypodigm of Poripuchian Titanosaurs from Indo-Pakistan Subcontinent (South Asia)

The caudal vertebrae are most common collections from Pakistan. The variation in vertebral series is challenging [13]. The cervical, dorsal and caudal vertebral variations are reported on surface found vertebrae of different taxa from Pakistan [23] [59] [71] [72]. Caudal vertebrae used for higher level classification of titanosaurs from Indo-Pakistan according to [94]. Titanosauria are classified into derived and more derived clade Lithostrotia and most derived clade Poripuchia. The lithostrotians are derived and more derived having procoely in anterior, mid and posterior caudals (except farthest vertebrae being not procoelous) [100]. Poripuchia is a clade which considered most derived titanosaurs because of extended procoely in distalmost caudals [6] [7] [23] [71] [72]. Further, Poripuchian fossils found just below the Cretaceous-Paleogene boundary in Pakistan and also from India and being most derived nature, representing last most derived titanosaurs. Poripuchia include Pakisauridae [3] [6] (slender Poripuchia), Balochisauridae [3] [7] (stocky Poripuchia) and Gspsauridae [6] [63] (stocky Poripuchia, with V-shaped and U-shaped lower teeth row). The Pakisauridae was further subdivided into Pakisaurinae [3] (tall caudal centra without ventral reduction; *Pakisaurus balochistani*, *Khanazeem saraikistani*), Isisaurinae [3] (squarish caudals without ventral reduction; *Sulaimanisaurus gingerichi*, *Isisaurus colberti*), and Khetranisaurinae [3] (transverse ventral width at mid is more than dorsal transverse width; *Khetranisaurus barkhani*). Balochisauridae was subdivided into Balochisaurinae [3] (broad first biconvex caudal, strong ventral reduction of mid caudals; *Balochisaurus malkani*, "*Titanosaurus blanfordi*"), and Marisaurinae [3] (less broad first biconvex caudal, slightly tall and heavy mid caudals with somewhat ventral reduction; *Marisaurus jeffi*). The Gspsauridae [6] [63] [69] is further subdivided into Gspsaurinae [6] (stocky poripuchian, V-shaped lower teeth row; *Gspsaurus pakistani*, *Maojandino alami*) and Saraikimasoominae [6] (stocky titanosaurs, U-shaped lower teeth row, dental formula 4, 13/9-13; *Saraikimasoom vitakri*, *Nicksaurus razashahi*). Most of Poripuchian titanosaurs from Indo-Pakistan have procoelous farthest distal caudals while other are inferred and included on indirect features.

Poripuchian Titanosaurs from India

From India, the five titanosaur genera were named from latest Maastrichtian Lameta Formation are *Isisaurus colberti*, *Jainosaurus septentrionalis*, *Titanosaurus indicus*, *Titanosaurus blanfordi* and *Titanosaurus Rahioliensis*. *Titanosaurus indicus* and *Titanosaurus blanfordi* were named on 2 caudal vertebrae (each) by [101] [102], respectively. *Antarctosaurus septentrionalis* were named on braincase and postcranial bones by [103]. Reference [103] referred a few bones to *Titanosaurus indicus*, *Titanosaurus blanfordi* and *Laplatasaurus madagascariensis*. *Titanosaurus rahioliensis* was named on teeth (apparently one tooth) by [104]. *Antarctosaurus* was renamed as *Jainosaurus* by [105]. *Titanosaurus colberti* was named on associated postcranial skeleton by [106] and later on [107] renamed it as *Isisaurus colberti*. All these named Indian Lameta titanosaurs (except *Isisaurus colberti*) are un-official and informal as per standard set by the International Code of Zoological Nomenclature (ICZN), on the other side Pakistani Vitakri titanosaurs (10 taxa) are official and formal by the standard set by ICZN [6] [7]. *Isisaurus colberti* is represented by well diagnostic postcranial associated elements. While its hind limb missed from India. But from Pakistan its close relative *Sulaimanisaurus gingerichi* (based on caudals and typical humerus) have well diagnostic hind limb, e.g., caudals, humerus, femur and fibula from lower sangiali (size matches for single individual), and associated tibia, fibula and metatarsal from Zubra peak. *Jainosaurus septentrionalis* have well holotype/lectotype braincase and can be compared for other titanosaurs braincases, but its postcranial assignment show problems because the postcranial materials reported with braincase by [103] show taxonomic variation and chimeraic nature ([11], pp. 1072-1075; [23], p. 435). In this way, the [108] limb bones seems to be the second best association after *Isisaurus colberti* holotype. This limb bones with a caudals [108] [109] were referred to *Jainosaurus septentrionalis* based on key humerus [103] arises many questions for referral ([11], pp. 1072-1075; [23], p. 435). "*Titanosaurus indicus*" and "*Titanosaurus blanfordi*" have holotypic caudal vertebrae which are not diagnostic at species level [13]. The "*Titanosaurus indicus*" has one procoelous and one amphicoelous caudals showing chimeraic nature. "*Titanosaurus rahioliensis*" based on fragmentary teeth are also not diagnostic upto species level, however at higher level its assignment to titanosaurs seems to be best fit. Among these Indian titanosaurs the *Isisaurus colberti* and "*Titanosaurus blanfordi*" hosts procoelous distal caudal and can be predicted as Poripuchian where all caudal series are procoelous. Professor Dr. Ashok Sahni in 2001 presented a detailed overview of all dinosaurs (including titanosaurs) from India in his monograph [110]. Cranial and postcranial associations for *Isisaurus* and *Jainosaurus* are weakly established by many authors but not consistant. The

Isisaurus postcrania are well accepted but its referral of Top Kinwa braincase [111] is not suitable (no link). Further, this braincase was associated with the postcrania of *Gspsaurus* (stocky Poripuchia) which is well distinguished from *Isisaurus* (slender Poripuchia). If the braincase of *Jainosaurus* is accepted than its referral of diversed postcrania is again not suitable. *Isisaurus colberti* from India is diagnosed by medially inset dpc and not expanded radial condyle of humerus like the *Sulaimanisaurus gingerichi* from Pakistan. Further, *Sulaimanisaurus gingerichi* has hind limb like femur, tibia and fibula while *Isisaurus colberti* lack hindlimb. So, in future, the study of comparison of overlapping elements of *Isisaurus* and *Sulaimanisaurus* will solve this problem. Braincase crania of *Jainosaurus* are well diagnosed but its referral of limb elements arise problem.

Poripuchian Titanosaurs from Pakistan

Ten poripuchian titanosaurs were reported from Pakistan just below the K-Pg boundary as a graveyard type representing short duration K-Pg extinction. Pakistani Poripuchians were last titanosaurs (most advanced) found just before the Cretaceous-Paleogene (K-Pg) extinction. A skulls (articulated elements) of confirmed titanosaur (most advanced titanosaur) was first published in 2003 [57] while there was controversy on the assignment of *Nemegtosaurus* and *Quaesitosaurus* skulls to Titanosaurs, and *Rapetosaurus* skull materials including partial maxillae were not articulated. Further, *Gspsaurus* and *Saraikimasoom* snouts and skulls (with articulated elements) have no parallel on latest Maastrichtian age. *Saraikimasoom* preserves the complete lower and upper tooth rows (4, 13/ 9-13), while previously complete tooth row are not preserved in titanosaurs except the controversial taxa like *Nemegtosaurus* and *Quaesitosaurus*. A long standing problem (to know the morphology of skulls of titanosaurs especially most advanced titanosaurs) was solved by these recent discoveries from Pakistan. *Gspsaurus* and *Saraikimasoom* has shallow snouts (faces are moderately inclined about 40˚ slope; [71], pp. 450-451; [72], pp. 371-372), while camarasaurid has deep snout (face inclination are high about 60˚), and *Tupuaisaurus*, nemegtosaurid and diplodocid have very shallow snouts with low inclination. Teeth are frequent but have only higher level assignment (some times very difficult) to Titanosauria, and can not be differentiated for lithostrotian and Poripuchia. Three morphs of cranial materials attributed to *Gspsaurus*, *Saraikimasoom* and *Khanazeem* (see below in respective subtitle). Five morphs of caudal vertebrae are found from Pakistan but can not be used for taxa diagnosis because the vertebral especially caudal series variations are also challenging (Personnel communication by Jeffrey A. Wilson Mantilla; [13]). The unique trispinous distalmost tail vertebra is found in many poripuchian titanosaurs ([3], p. 53; [61], pp. 63-64). Among appendicular and limb elements the femora and humeri can be used for Hypodigm. Atleast two morphs of scapula (1st morph, proximal scapula is directed laterally, e.g., slender poripuchian *Pakisaurus* [23]; 2nd morph, proximal scapula is almost straight or slightly directed medially, e.g., stocky poripuchian *Balochisaurus* and *Gspsaurus* [71] [72]) are observed. Two morphs of coracoid are found (1st morph from Shalghara, coracoid glenoid has lip, e.g., slender poripuchian *Pakisaurus* and 2nd morph from Sangiali, coracoid glenoid has no lip, e.g., stocky poripuchian *Balochisaurus* ([11], p. 1049). The four morphs of humerus found from Indo-Pakistan are described and attributed to four taxa ([11], pp. 1062-1065). Atleast three morphs of tibiae are found from Pakistan ([23], pp. 433-435; [71] [72]) but question arises its ontogenic variation. Indo-Pakistani most of the tibiae belong to adult, so there is no ontogenic variation. Further, the *Balochisaurus malkani* has relatively smaller tibia from Sangiali and significantly larger tibia from Mari Bohri, both show more robust morphs (subequal transverse and anteroposterior widths), revealing no ontogenic variations. More than 2 morphs of femora (slender and robust/stocky) are observed. Among these the unique are slender femur with inflected head and a proximolateral concavity attributed to *Pakisaurus* and *Khanazeem* poripuchian, respectively. The stocky femora were attributed to stocky poripuchian, e.g., *Balochisaurus*, *Nicksaurus*, *Gspsaurus* and *Marisaurus* poripuchian. The laterally defleced proximal scapula of *Pakisaurus balochistani* is previously mentioned as distal scapula ([3], p. 55; [21], p. 83; [61], p. 67) created the more wide gauge locomotion in fore limbs while the inflected and obliquely oriented head of proximal femur created the more wide gauge locomotion in hind limbs of *Pakisaurus balochistani*. The stocky poripuchian showed less wide gauge locomotion ([3], p. 55; [21], p. 83; [61], p. 67). The diverse osteoderms were attributed to many poripuchian from Pakistan [23] [56] [71] [72]. In Asia, the titanosaurian osteoderms was first reported from Pakistan [56].

Gspsauridae Poripuchia (Titanosauria, Sauropoda, Dinosauria) from Pakistan

Gspsaurus pakistani: It is based on cranial and postcranial assemblage, has 4 exemplars from Pakistan and more than three exemplars (**Table 3**) from India [6] [11] [71]. *Gspsaurus* postcrania were found within about 10 m diameter and having same matrix coating seems to be associated as single adult animal [6] [71]. It is well diagnosed by slender long conical teeth with short spaced contact, while *Saraikimasoom vitakri* has relatively short and closely contacted teeth and *Khanazeem saraikistani* and *Mansourasaurus shahinae* has more widely spaced teeth. It has V-shaped lower teeth arcade and U-shaped upper teeth arcade (while *Saraikimasoom vitakri* have U-shaped lower and upper teeth arcade). Its snout is pneumatic and relatively larger than pneumatic small snout of *Saraikimasoom vitakri*. Its mid neck is heavy, stocky and strongly broad transversely. Among Poripuchian it is stocky and largest dinosaur. Its mid caudals are somewhat ventrally reduced with restricted posterior articular condyle, while distal caudals are cylindrical nature matches with vertebral series of *Alamosaurus* [112]. Its proximal scapula is almost straight (like *Balochisaurus malkani*) while *Pakisaurus balochistani* has laterally directed proximal scapula. Its proximal humerus has almost straight deltopectoral crest (dpc) situated medially inset, posteriorly plain surface just below the head and round shape of medial process, while the *Pakisaurus balochistani* has proximal humerus with posterior mid ridge and triangular shape of cross section just below the dpc, and almost straight and medially inset dpc, the *Balochisaurus malkani* has proximal humerus with posterior plain surface just below the head and quadrangular cross section just below the dpc, and sinusoidal and almost laterally inset dpc, and *Sulaimanisaurus gingerichi* and *Isisaurus colberti* have proximal humerus with posterior plain surface just below the head and slightly elliptical cross section just below the dpc, and sinusoidal and medially inset dpc. Its distal humerus has anteriorly expanded radial and ulnar condyles, while *Sulaimanisaurus gingerichi* and *Isisaurus colberti* have distal humerus which have no anteriorly expanded any condyles (radial and ulnar condyles). Its femur is robust (but long) with not obliquely oriented head like *Balochisaurus malkani* (has relatively small femur) and unlike slender femora of Pakisaurids (*Khanazeem saraikistani*, *Pakisaurus balochistani*) with inflected and obliquely oriented head. Further, its proximal tibia is robust and moderately transversely expanded (the anteroposterior width is slightly more than transverse width) while the proximal tibia of *Balochisaurus malkani* have subequal transverse and anteroposterior width showing strong transverse expansion, and proximal tibia of *Khanazeem saraikistani* and *Sulaimanisaurus gingerichi* have transversely compressed flat tibia having more than twice or thrice anteroposterior width than transverse width. Its distal tibia is transversely expanded with small astragalous fossa just front of short process.

Maojandino alami: It is based on cranial and postcranial assemblage. Its holotype is same as the holotype of *Gspsaurus pakistani* except the cranial 2 specimen GSP/MSM-79-19 and GSP/MSM-80-19 [6] [7]. It was considered junior synonym of *Gspsaurus pakistani*. Its diagnostic postcranial features are same as mentioned above in sub title of *Gspsaurus pakistani*. Reference [63] named *Gspsaurus pakistani* based on snout with one other specimen representing palate. References [66] [69] named *Maojandino alami* based on braincase/vertebrae and postcranial assemblage. Finding of snout and palate specimens close to postcranial assemblage from one Alam/central Alam locality, References [6] [71] considered both the cranial and postcranial assemblage seems to be associated, so all these bones were considered holotype of *Gspsaurus pakistani*. It is necessary to mention that the naming and bone assignment from 2014 to 2020 was informal as per standard set by ICZN. Only the *Maojandino alami* was formally published in 2021 as per standard set by ICZN. As a result, *Maojandino alami* was considered junior synonym of *Gspsaurus pakistani*.

Saraikimasoom vitakri: It is based on snout [6] [72]. It is well diagnosed by long slender conical teeth relatively more closely contacted (than *Gspsaurus pakistani* and widely spaced teeth of *Khanazeem saraikistani* from central Pakistan and *Mansourasaurus shahinae* from northern Egypt) and U-shaped lower and upper teeth arcade (while *Gspsaurus pakistani* have V-shaped lower and U-shaped upper teeth arcade). Its dentary rami are pneumatic, thin and small than dentary rami of *Gspsaurus pakistani*. Its dorsal palatal processes are relatively small and close to each other than dorsal palatal process of *Gspsaurus pakistani*. Its fore face shows 40˚ slope. Its dental formula is 4, 13/9-13.

Nicksaurus razashahi: It is based on cranial and postcranial assemblage [7], has one exemplar. It has small to medium sized slender teeth which are tightly contacted like *Saraikimasoom vitakri*. Broad caudal centra have strong ventral reduction like *Balochisaurus malkani*. Its distal tibia is transversely broad like *Balochisaurus malkani* and *Gspsaurus pakistani*.

Balochisauridae Poripuchia (Titanosauria, Sauropoda) from Pakistan

Balochisaurus malkani: It is based on postcranial assemblage and has 4 exemplars from Pakistan besides the referral of distal femur GSP/MSM-170-15 from Mari Bohri, and many vertebrae and limb bones from mid Kinwa and Top Kinwa [7] [11]. It has atleast 2 exemplars (**Table 2**) from India [11] [13]. *Balochisaurus* caudals are surface assemblage but matches well with the *Epachthosaurus* series [113] based on strong ventrally reduced middle caudal and elongated cylindrical posterior caudals. The *Balochisaurus malkani* has proximal humerus with posterior plain surface just below the head and quadrangular cross section just below the dpc, and sinusoidal and almost laterally inset DPC, while *Gspsaurus pakistani* has posterior plain surface just below the head and medially inset straight dpc, *Pakisaurus balochistani* has posterior mid ridge and triangular shape of cross section of shaft just below the dpc, and almost straight and medially inset dpc, and *Sulaimanisaurus gingerichi* and *Isisaurus colberti* have proximal humerus with posterior plain surface just below the head and slightly eccentric cross section just below the dpc, and sinusoidal and medially inset dpc. Its distal humerus has anteriorly expanded radial and ulnar condyles, while *Sulaimanisaurus gingerichi* and *Isisaurus colberti* have distal humerus which have no anteriorly expanded any condyles (radial and ulnar condyles). The *Balochisaurus malkani* has more robust tibia with subequal transverse and anteroposterior width showing strong transverse expansion (like proximal tibia of mid Cretaceous *Diamantinasaurus matildae* from Australia [82] [114], late Jurassic *Lusotitan atalaiensis* from Portugal [92] and Late Cretaceous *Lohuecotitan pandafilandi* from Spain [93]), while *Gspsaurus pakistani* proximal tibia is robust and moderately transversely expanded (the anteroposterior width is somewhat/slightly more than transverse width), *Khanazeem saraikistani* and *Sulaimanisaurus gingerichi* proximal tibiae have transversely compressed flat tibia with more than twice or thrice anteroposterior width than transverse width. Its distal tibia is transversely expanded with small astragalous fossa just front of short process.

Marisaurus jeffi: It is based on postcranial assemblage [7]. It's first biconvex caudal is less broad than *Balochisaurus malkani*. Its caudal ventral reduction is also less than *Balochisaurus malkani* and *Nicksaurus razashahi*.

Pakisauridae Poripuchia (Titanosauria, Sauropoda, Dinosauria) from Pakistan

Pakisaurus balochistani: It is based on postcranial assemblage, has major 2 exemplars from Pakistan [6] [11] [23] and atleast one exemplar (**Table 4**) from India [11] [13]. It has robust tall caudals while *Khanazeem saraikistani* has more robust slightly tall caudal and more slender tall caudal of "*Titanosaurus indicus*". Its distalmost caudal has median horizontal groove in posterior articular condyle. *Pakisaurus balochistani* has laterally directed proximal scapula while *Gspsau-*

rus pakistani and *Balochisaurus malkani* proximal scapulae are almost straight. *Pakisaurus balochistani* has proximal humerus with posterior mid ridge and triangular shape of shaft cross section just below the dpc, and almost straight and medially inset dpc (like humerus of *Diamantinasaurus matildae* from Australia [82] [115]), while *Gspsaurus pakistani* has almost straight and medially inset dpc, and posteriorly plain surface just below the head and round shape of medial process, *Balochisaurus malkani* has sinusoidal and laterally inset dpc, and posteriorly plain surface just below the head and quadrangular shaft cross section just below the dpc, and *Sulaimanisaurus gingerichi* and *Isisaurus colberti* have sinusoidal and medially inset dpc and posteriorly plain surface just below the head and elliptical shaft cross section of shaft. *Pakisaurus balochistani* distal humerus has anteriorly expanded medial and lateral condyles and more expanded radial/median condyle, while *Balochisaurus malkani* has anteriorly expanded medial condyle (ulnar condyle) and more dominantly expanded median condyle (radial condyle) shifted more laterally (than median condyle of *Pakisaurus balochistani*) and feebly expanded lateral condyle which mostly merged with the median condyle (radial condyle), and *Sulaimanisaurus gingerichi* and *Isisaurus colberti* have distal humerus which have no anteriorly expanded any condyles (radial and ulnar condyles or lateral, medial and median condyles). *Pakisaurus balochistani* has slender femur with inflected and obliquely oriented head (like *Khanazeem saraikistani*) while *Gspsaurus pakistani* and *Balochisaurus malkani* have large and small femora with robust nature. Its proximal fibula is large and anteroposteriorly more wide (like *Sulaimanisaurus gingerichi*) while *Gspsaurus pakistani* and *Balochisaurus malkani* have small and anteroposteriorly less wide fibula.

Khanazeem saraikistani: It is based on cranial and postcranial assemblage [11]. It has one exemplar from Pakistan [11] and atleast one exemplar (**Table 4**) from India [13]. *Khanazeem saraikistani* has more widely spaced teeth (like *Mansourasaurus shahinae* [97] from northern Egypt) while *Saraikimasoom vitakri* and *Nicksaurus razashahi* have closely tightly packed teeth, and *Gspsaurus pakistani* have moderate space between the two teeth. Its dentary rami is pneumatic and relatively thick and large with elongated subparallel lineation or small ridges oriented anteroposteriorly, while *Gspsaurus pakistani* has thick and large dentary rami and *Saraikimasoom vitakri* and *Nicksaurus razashahi* have relatively small and shallow dentary ramus. Its distal humerus has anteriorly expanded radial condyle unlike *Sulaimanisaurus gingerichi* and *Isisaurus colberti*. *Khanazeem saraikistani* femora is more slender (like *Pakisaurus balochistani*) and have inflected obliquely oriented head while *Gspsaurus pakistani* and *Balochisaurus pakistani* have robust femur and no inflected or no obliquely oriented head. Its proximal femora have concavity on the proximolateral corner while *Gspsaurus pakistani* and *Balochisaurus pakistani* have straight profile. The proximal tibia of *Khanazeem saraikistani* and *Sulaimanisaurus gingerichi* have transversely compressed flat tibia having more than twice or thrice anteroposterior width than transverse width, while *Gspsaurus pakistani* proximal tibia is robust and moderately transversely expanded (the anteroposterior width is slightly more than transverse width), and *Balochisaurus malkani* proximal tibia have subequal transverse and anteroposterior width showing strong transverse expansion. *Khanazeem saraikistani* distal tibia is anteroposteriorly expanded (like *Sulaimanisaurus gingerichi*) with large astragalous fossa (which is larger than astragalous fossa of *Sulaimanisaurus gingerichi*) located almost in the central position, while *Gspsaurus pakistani* and *Balochisaurus malkani* have transversely expanded distal tibia with small astragalous fossa just front of short process.

Sulaimanisaurus gingerichi: It is based on caudal assemblage, has 4 exemplars from Pakistan [6] and one exemplar from Bara Simla, India (**Table 4**). Left tibia K 20/321 and right fibula K 27/489 (Plate 1 of Figures 4, 5 of [103]) from Bara Simla, Jubalpur, India are referable to *Sulaimanisaurus gingerichi* due to matching with its South Zubra exemplar's flat tibia and larger size fibula (Figure 5 of [6]). *Sulaimanisaurus gingerichi* have sinusoidal and medially inset dpc (like *Isisaurus colberti*) and posteriorly plain surface just below the head and elliptical shaft cross section of shaft, while *Pakisaurus balochistani* has proximal humerus with posterior mid ridge and triangular shape of shaft cross section just below the dpc, and almost straight and medially inset dpc, while *Gspsaurus pakistani* has almost straight and medially inset dpc, and posteriorly plain surface just below the head and round shape of medial process, and *Balochisaurus malkani* has sinusoidal and laterally inset dpc, and posteriorly plain surface just below the head and quadrangular shaft cross section just below the dpc. *Sulaimanisaurus gingerichi* have distal humerus which have no anteriorly expanded any condyles (radial and ulnar condyles or lateral, medial and median condyles) like *Isisaurus colberti* while *Pakisaurus balochistani* distal humerus has anteriorly expanded medial and lateral condyles and more expanded radial/median condyle, *Balochisaurus malkani* has anteriorly expanded medial condyle (ulnar condyle) and more dominantly expanded median condyle (radial condyle) shifted more laterally (than median condyle of *Pakisaurus balochistani*) and feebly expanded lateral condyle which mostly merged with the median condyle (radial condyle). *Sulaimanisaurus gingerichi* has slender distal femur like *Pakisaurus balochistani* and *Khanazeem saraikistani*, while *Gspsaurus pakistani* and *Balochisaurus malkani* have distal large and small femora with robust nature. Its distal tibia is anteroposteriorly expanded (like *Khanazeem saraikistani*) with large astragalous fossa (which is less than *Khanazeem saraikistani*) located almost in the central position, while *Gspsaurus pakistani* and *Balochisaurus malkani* have transversely expanded distal tibia with small astragalous fossa just front of short process. Its proximal fibula is large and anteroposteriorly more wide (like *Pakisaurus balochistani*) while *Gspsaurus pakistani* and *Balochisaurus malkani* have small and anteroposteriorly less wide fibula.

Khetranisaurus barkhani: It is based on 2 caudal vertebrae [6] from mid Kinwa which are unique in Indo-Pakistan having transverse width more in ventral view than dorsal view of mid centrum. Many postcranial bones of *Balochi-*

saurus malkani in northern vicinity and *Gspsaurus pakistani* in southern vicinity of *Khetranisaurus barkhani* type locality were observed.

4. Conclusion

The saraikistan (South Punjab and surroundings) area of central Pakistan represents Triassic-Jurassic to Recent strata is mainly folded (with rare regional faults) by tectonic collision. The area hosts a large number of significant mineral deposits, their exploitation can play the best role in the development of Saraikistan area and Pakistan. The data of recently discovered biotas from Pakistan are tabulated for quick view of readers. Phylogenic classification and significant distinguishing features of Poripuchian titanosaurs from India and Pakistan (South Asia) are also provided.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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