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Trackways evidence of sauropod Dinosaurs Confronted by a Theropod found from middle Jurassic Samana Suk Limestone of Pakistan

M. Sadiq Malkani

Paleontology and Stratigraphy Branch, Geological Survey of Pakistan, Sariab Road, Quetta, Pakistan.
E. Mail; Malkanims@yahoo.com

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Abstract

The temporal distribution of sauropod trackways generally parallels the record of sauropod body fossils. The oldest sauropod trackways are found in Lower Jurassic deposits of Africa, North America, and Asia; trackways are abundant throughout the rest of the Jurassic and Lower Cretaceous, but fewer are recorded in the Upper Cretaceous rocks. The foot structures of the various dinosaur groups are usually fairly conservative within those groups. Trackways are particularly promising records of dinosaur locomotion because they represent the trace of an act-a moment in time- and therefore can provide information that is usually unavailable from skeletal morphology alone.

Remains of a diversified paleobiota are found in the middle Indus basin, which includes plants (gymnosperm), mollusks, reptiles (cranial and post cranial bones). The commonest vertebrate fossils belong to sauropod and theropod dinosaurs, and mesoeucrocodilian fauna that occur a wide geographic area. Recently the author have found footprints of sauropod confronted with a theropod, in the middle Jurassic Samana Suk Limestone of Surghar Range, Mianwali district, Punjab Province, Pakistan. Five species of Late Cretaceous and one species of Late Jurassic titanosaurian sauropod, and one species of Late Cretaceous Abelisauran theropod dinosaur from Pakistan have already been established. But one new genus and species ***Malasaurus mianwali*** of middle Jurassic sauropod and one new genus and species ***Samanadrinda surghari*** of large bodied theropod based on only ichnofossils, are tentatively erected. Large pes foot print having length/width about 1 metre are diagnosed only for a large bodied sauropod. The manus footprints are totally overlapped by the pes prints. These tracks suggest the gregarious behavior of narrow gauge locomotors defending the attack of predatory theropod. This is the reason these are not referred to previously erected species of titanosaurs from Pakistan, because they may belongs to wide gauge trackways. These footprints are surely assigned to sauropod, but its assignment to lower level is difficult.

Three slender toed foot prints having maximum length about 2 feet and width about 1.5 feet are diagnosed only for a large bodied theropod. These footprints are surely assigned to Theropod, but its assignment to lower level is difficult. Both the sauropod and theropod genera erected are named only to refer for future research work regarding locomotion, behavior, soft and hard tissues. This ichnotype reveal the scenario of confrontation among a carnivorous ***Samanadrinda surghari*** theropod and the groups of herbivorous ***Malasaurus Mianwali*** sauropods.

This ichnocoenosis consists of exposed about 15 footprints, and 4 short trackways. Three trackways are interpreted as mainly produced by sauropods which are obliquely confronted by a track of large Theropod. They are indicative of a sauropod herd, composed of 3 or more individuals and furnish evidence of gregariousness (herd). The ichnofossils are usually deep footprints probably due to good granolometric sorting and the high plasticity of the limy substrate. In the vicinity, some foot prints of possibly birds/ small body theropod/coelorusaurs are also present. The ichnofossils of sauropod dinosaurs confronting a theropod of upper Indus Basin are a unique record of a middle Jurassic dinosaurian fauna which inhabited the north western margin of Indo-Pakistan subcontinental plate.

Keywords: Footprints, sauropods, confronted a theropod, Middle Jurassic, Pakistan.

1. Introduction

The temporal distribution of sauropod trackways generally parallels the record of sauropod body fossils. The oldest sauropod trackways are found in Lower Jurassic deposits of Africa, North America, and Asia; trackways are abundant throughout the rest of the Jurassic and Lower Cretaceous, but fewer are recorded in the Upper Cretaceous rocks (Lockley, Meyer, Hunt, and Lucas 1994 and references therein). The foot structures of the various dinosaur groups are usually fairly conservative within those groups; footprints shapes are also pretty generic within a group. One may be able to say that a given footprint was made by a large theropod, or a big ornithopod, or a sauropod, but it is seldom possible to say exactly which species of theropod, ornithopod, or sauropod we are dealing with (Farlow, 2000). If the formation having foot prints may host skeleton of dinosaurs then we can argue that it was a trackmaker but we can not be completely sure. Fossilized tracks and trackways (ichnofossils) are the only direct evidence of what extinct animals did when they were alive. They are like snapshot from the animal's life and can provide us important information about locomotion (e.g., posture, kinematics), behaviour (e.g., herding), and even soft tissues (e.g., foot scales, body features). The ancestral dinosaurs and herraresaurids walked with all four toes on the hind feet touching the ground, advanced carnivorous dinosaurs (the Neotheropoda) walked on only the middle three toes (digits 2-4).

Footprints and trackways were among the first dinosaur remains to receive scientific attention (e.g., Hitchcock 1836) and have seen a renaissance of study in recent decades as an increasing number and diversity have been discovered (see Lockley 1986; Thulborn and Wade 1989). Trackways are particularly promising records of dinosaur locomotion because they represent the trace of an act-a moment in time- and therefore can provide information that is usually unavailable from skeletal morphology alone (Alexander 1976; Thulborn 1982, 1989; Gatesy and Middleton 1996). Despite these potential benefits, however footprints have been of limited use because of difficulties in identifying the trackmakers. This problem is underscored in depositional settings where footprints are preserved better than body fossils, and estimates of taxonomic diversity must depend solely on these tracks. This problem is partially mitigated by a system of ichnotaxonomy that categorizes types (e.g., ceratopsian, sauropod, hadrosaur), but this system precludes examining footprint data at any lower taxonomic levels. As a result analyses that attempt to integrate skeletal and ichnological data (Farlow 1992; Lockley, Farlow, and Meyer 1994) must focus on these broad taxonomic categories and generally can not examine within group patterns of locomotor diversity (Wilson and Carrano, 1999).

A common pattern displayed by trackways at dinosaur footprint sites is for about half of the trails to be heading in one direction and the other half in the opposite direction. If we think about the conditions under which footprints are likely to be formed and preserved, the reason for this pattern will be apparent. Footprints require soft substrates in order to be formed, but some such soft substrate situations are more likely to preserve prints than others. Footprints can easily be made in dry sands well away from water courses, but likely fate of such prints is that they will eventually be gone with the wind. Footprints have a much better chance of survival if they are made in wet sediments, along the margins of streams, lakes, or seas, where they can eventually be buried beneath other sediments. The mirror image pattern could readily be generated if groups of animals were to move in either direction along the shore over time. The famous Early Cretaceous dinosaur footprint sites of the Paluxy River, in what is now Dinosaur Valley State Park near Glen Rose, Texas, provide a good example of this for one kind of trackmaker. The great majority of footprints displayed in the limestone bed of the river are big three toed jobs likely made by large theropods. The trackways of big theropods nicely show the mirror-image pattern. (Farlow, 2001).

Extrapolating from living crocodilians and birds, it is plausible that some dinosaur groups were family structures, consisting of a parent and its young, or a group of juveniles that had become large enough to get by without their parents but that stayed together, at least for a time, for mutual protection and foraging (Farlow 2001).

Paleontologists have faced the problem of associating tracks and trackmakers since the earliest discoveries of dinosaur tracks (Hitchcock 1836). In subsequent decades, a diverse ichnotaxonomy flourished alongside a comparatively poor understanding of trackmaker identity (e.g., Lull 1915). In recent years, however a renaissance in dinosaur ichnology has led to the application of theoretical biomechanics (Alexander 1976), the mechanics of trackmaking in extant vertebrates (Pardian and Olsen 1989), and the effect of different substrates (Farlow 1989) for discriminating and interpreting dinosaur tracks (Wilson and Carrano, 1999). Farlow (1997,1998) data from birds (extant dinosaurs) show that even under idealized conditions of preservation, the tracks of certain major taxonomic group (i.e., most ground dewelling birds) can be difficult to distinguish between lower level non avian dinosaur taxa. Temporal and spatial coincidence can be used to draw more general and reasonable conclusions about potential dinosaur trackmakers. For example, Schulp and Brokx (in press) described a wide gauge sauropod trackway from the Maastrichtian of Fumanya, Spain. The authors noted that titanosaurs were the only sauropods known from the Maastrichtian of Europe and cited this as evidence that titanosaurs were the makers of wide gauge trackways. This is consistent with the currently known geographic and temporal distribution of titanosaur body fossils, although this association remains coincidental. Although direct trackmaker-trackway associations are known in the fossil records, they are exceedingly rare (Wilson and Carrano, 1999).

2. History of Dinosaur Discoveries in Pakistan

The firstever discovery of dinosaurs from Pakistan was made by author during early 2000 from the Latest Cretaceous dinosaur beds (Vitakri) member of Pab formation in Vitakri area, Barkhan district, Balochistan. First time in Pakistan I found a fossil of distal femur of Titanosaurian Sauropod dinosaur and first reported by Malkani and Anwar (2000). Professor Philip D. Gingerich, University of Michigan congratulated the GSP for this first ever dinosaur discovery from Pakistan and requested to DG, GSP for the visit of dinosaur locality. During late 2000, Professor Phillip D. Gingerich visited the Pakistan for previously running project of Eocene whale. On his visit to Vitakri dinosaur locality, I showed him the in-situ fragmentary bones. About 100 bones/pieces of bones of dinosaur Vitakri locality no one, are sent to Museum of Paleontology, University of Michigan, USA. I collected further 1500 bones/pieces of bones from 25 localities in Sulaiman foldbelt, administratively located in the areas of Barkhan, Kohlu, Dera Bugti, and Dera Ghazi Khan districts, Balochistan and Punjab Provinces during early 2001. Dr Jaffery A Wilson, Museum of Paleontology, University of Michigan, USA visited the GSP museum during March, 2001 and Dr. David A. Krauss of Bostan College, USA visited the GSP museum and Vitakri locality during mid of 2001. Second time dinosaur fossils are reported by Malkani, Wilson and Gingerich, (2001). I collected further 1200 bones/ pieces of bones during mid of 2001, from Sulaiman foldbelt. Third time dinosaur fossils are reported by Malkani, (2003a,b,c). Then the collected fossils of dinosaurs from Pakistan are documented by a continuous series of research papers by Malkani, (2004a,b,c, 2005a,b, 2006 a-h). The research on a braincase of titanosaurian sauropod dinosaur discovered by me from the Top Kinwa Kali Kakor locality of Vitakri area are also documented (Wilson, Malkani and Gingerich, 2005; Malkani, 2006h). The research on Paleobiogeography of titanosaurian and abelisaurian dinosaurs from Pakistan, wide gauge locomotion argued from skeletal morphology of Late Cretaceous Pakistani Titanosauria, localities of dinosaurs from the Late Cretaceous Pakistan, and confrontation scenario between two theropod dinosaurs argued from the discovery of a rostrum of *Vitakridrinda* found from the Late Cretaceous Park of Pakistan (Malkani, in review). The research on the finding of trackways of sauropod dinosaurs confronted by a theropod found from the Middle Jurassic Samanasuk Limestone of Pakistan is presented here.

3. Geological and Stratigraphic Setting

The study area of Surghar range is located in the upper Indus Basin of Pakistan **(Fig.1).** Trackways (footprints) of sauropod dinosaurs and a theropod are hosted by middle Jurassic Samanasuk Limestone of Surghar Range. The sediments of the study area underwent considerable tectonic deformation during the collision of Asian and Indo-Pakistan continental plates that commenced in the Late Cenozoic. As a result dinosaurs' foot print hosted beds along with other formations have been folded and faulted **Table -1.**

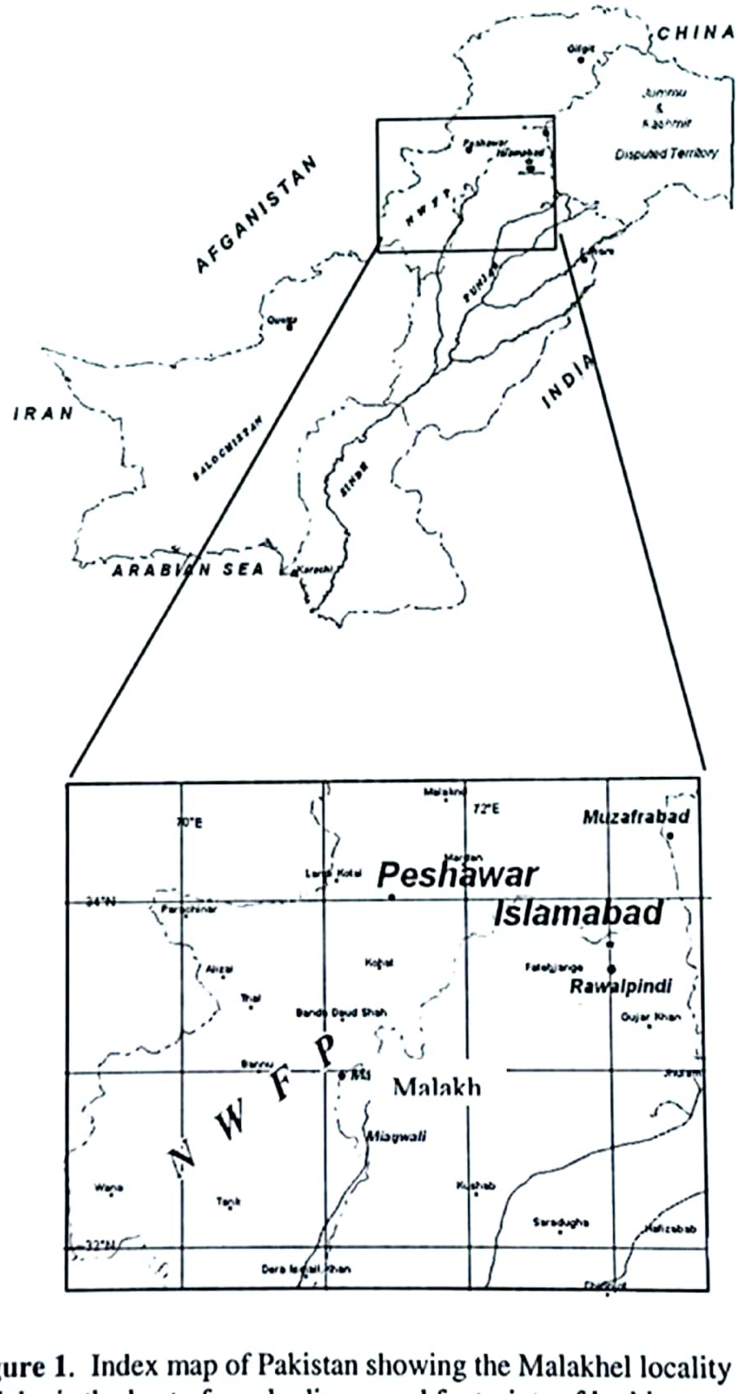

Figure 1. Index map of Pakistan showing the Malakhel locality of Mianwali District, which is the host of newly discovered footprints of herbivorous sauropod dinosaurs confronted by a carnivorous theropod dinosaur.

Table – 1: Stratigraphic Sequence of surghar range, Mianwali and Karak Districts, Punjab and N.W.F.P Provinces, Pakistan

Age			Formation	Lithology
CAINOZOIC	QUATERNARY	Recent	Modern channel deposits	Gravel, sand, silt and clay
			Sand, silt and clay deposits (cultivated lands)	Sand, silt and clay with minor gravel
		and	Sand, silt and clay deposits (non-cultivated lands)	Sand, silt and clay with minor gravel
			Colluvium deposits	Boulder, pebbles,cobbles,with sand silt and clay.
			Fan gravel deposits	Poorly consolidated gravel, sand, silt and clay.
		Sub-Recent	Terrace gravel deposits	Poorly consolidated gravel, sand, Silt and clay.
			-----Angular Unconformity-----	
	TERTIARY	Pliocene	Soan Formation	Clays, conglomerate and sandstone
			Dhok Pathan Formation	Clays with subordinate sandstone conglomerate
		Miocene	Nagri Formation	Sandstone with minor shale and conglomerate
			Chingi Formation	Red Clays, sandstone and conglomerate
			-----Disconformity-----	
			Kamlial Formation	Shale with subordinate sandstone and conglomerate
		Oligocene	Murree Formation	Sandstone, conglomerate and shale
			-----Disconformity-----	
			Habib Rahi Formation	Mainly limestone with marl and shale
			Kuldana Formation	Shale with minor sandstone and limestone
			Choregali Formation	Limestone and shale
		Eocene	Skesar Limestone	Limestone with subordinate shale and marl
			Nammal Formation	Marl with subordinate shale
			Patala shale	Mainly shale with marl
		Paleocene	Lockhart Limestone	Mainly limestone with minor shale
			Hungu Formation	Sandstone, coal, and shale
			-----Disconformity-----	
MESOZOIC	CRETACEOUS		Lumshiwal Formation	Sandstone & shale
			Chichali Formation	Glauconitic sandstone and shale
			-----Disconformity-----	
	JURASSIC		Samanasuk Formation	Mainly limestone with subordinate shale
			Shinawari Formation	Shale, limestone and sandstone.
			Data Formation	Mainly sandstone with minor shale
			-----Disconformity-----	
	TRIASSIC		Kingriali Formation	Dolomite and limestone with minor shale
			Tredian Formation	Mainly sandstone
			Mianwali Formation	Shale, limestone and sandstone
			-----Disconformity-----	
PALEOZOIC	PERMIAN		Chiddro Formation	Shale and sandstone.
			Wargal Limestone	Limestone and dolomite
			-----Contact not exposed-----	
PRECAMBRIAN			Salt Range Formation	Marl, gypsum, salt and shale

4. Materials and methods

Sedimentary strata of Pakistan are famous for Cenozoic vertebrate (Gingerich *et al.*, 2001). Recent dinosaur discoveries by me from Mesozoic of Pakistan have increased the temporal variation of its vertebrate fauna.

Remains of a diversified paleobiota are found in the middle Indus basin, which includes plants (gymnosperm), mollusks, reptiles (cranial and post cranial bones). The commonest vertebrate fossils belong to sauropod and theropod dinosaurs, and mesoeucrocodilian fauna that occur a wide geographic area. Five species of Late Cretaceous and one species of Late Jurassic titanosaurian sauropod, and one species of Late Cretaceous Abelisauran theropod dinosaur from Pakistan have already been established.

Recently I have found footprints of sauropod confronted with a theropod **(Figure 2-4),** in the middle Jurassic Samana Suk Limestone of Surghar Range, Mianwali district, Punjab Province, Pakistan. The research on these footprints and trackways of Sauropd dinosaur confronted by a theropod are presented here. The method applied here is the paleontological methods representing description, interpretation, discussion and conclusions.

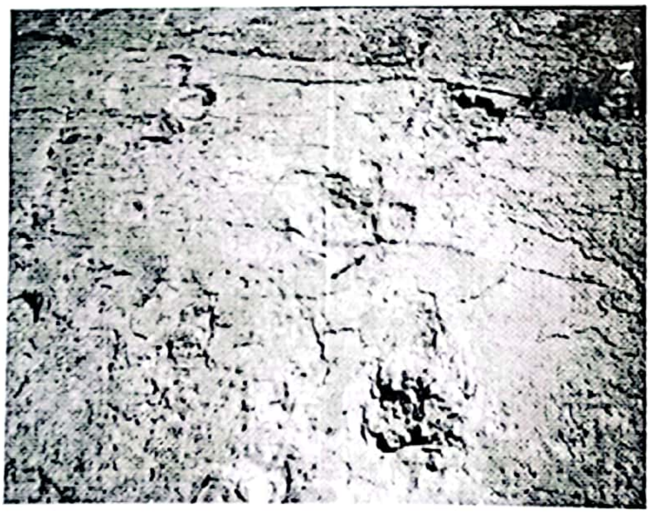

Figure 2. Footprint of herbivorous sauropod dinosaurs found from Malakhel area, Mianwali District, Punjab, Pakistan. For scale please see the hammer. Arrow shows movement direction.

Figure 3. Footprint of a large bodied theropod, found from Malakhel area of Mianwali District, Punjab, Pakistan.
For scale please see the hammer. Arrow shows movement direction.

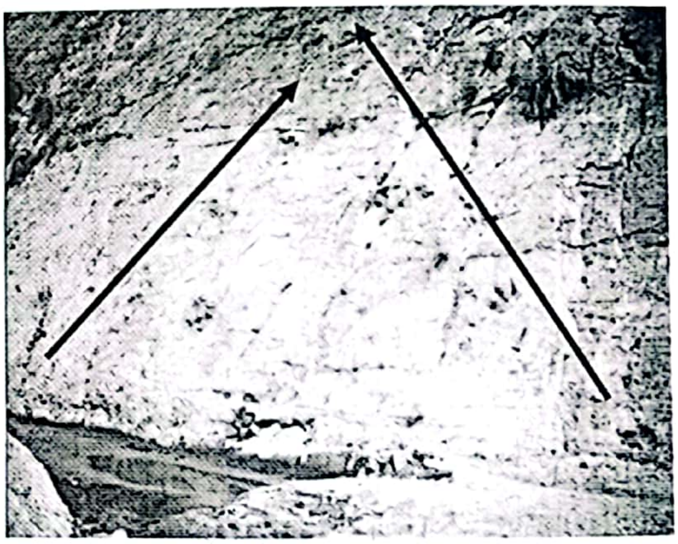

Figure 4. Footprints of sauropods confronted by a theropod,found from Malakhel area of Mianwali District, Punjab, Pakistan. Longer arrow shows the advancing movement of a Theropod, while the smaller arrow shows the advancing movements of sauropod dinosaurs. For scale please see the hammer.

5. Footprints of Dinosaurs

Sauropod trackways are notable in that they document distinct gauges. Variation in track and trackway morphology of other dinosaur clades appears to be circumstantial rather than systematic, serving to differentiate speeds, sizes, or individual ichnotaxa. For example, although hadrosaur trackways may preserve either bipedal or quadropedal locomotor habit, all hadrosaur taxa are thought to have been capable of engaging in either form of locomotion; other widespread differences between group of hadrosaur treacks are not apparent. The same is true for identifiable tracks of other ornithopods, theropods, ceratopsians,and prosauropods-none of these groups show systematic within group clustering of trackway variation (Wilson and Carrano, 1999).

Sauropod has an easily recognizable, conservative morphology. Manus impressions are generally U shaped, subtending an arc of approximately 270 degrees. The median axis of the print (passing through digit III) is oriented anterolaterally relative to the line of travel, and atrace of large pollex claw is occasional preserved. Pes impressions are always larger in an area than those of the manus, and the manus to pes ratio (referred to as heterodonty) ranges from 1:2 to1:5 in sauropods (Lockley, Farlow, and Meyer 1994). Additionally pes prints are characteristically subcircular in outline, with a well developed heel print and impressions of three or four laterally directed claws. The pes impression can partially or totally obscure that of the manus in sauropod trackways, as the pes was apparently often placed in the same location following removal of the manus from the substrate. This overlap is common in short coupled forms (Leonardi 1987).

Wide-gauge trackways have been defined as those in which manus and pes impressions are well away from the trackway midline, whereas those of narrow gauge tracks are close to or even intersect the trackway midline (Farlow 1992) (Fig.1). Farlow has identified several additional ichnomorphological correlates of narrow and wide gauge trackways. For example, whereas claw impressions are occasionally preserved in narrow gauge manus prints, they are not typically associated with wide gauge trackways. Additionally manus prints are positioned closer to the midline than are pes prints in wide gaudge trackways, where as the opposite is true of narrow gauge trackways. Farlow (1992) also described identifications in the manus prints of Brontopodus (wide gauge) that indsicate aseparation of digits II-IV from the marginal digits. The morphology is not known to occur in narrow gauge tracks.

Footprint sites of Queensland, Australia tells the story of more than 100 small bipedal dinosaurs from the early cretaceous that were seemingly stampeded into mass flight by the approach of a much larger bipedal dinosaur, probably a carnivore. The paleontologists who originally describe the site thought that the small bipedal dinosaurs represented two different species, one a theropod and the other an ornithopod. If true, the co-occurrence of the two kinds of trackway at the same spot suggests that members of each species tolerated the presence of the other, at least at times. However some paleontologists have suggested the two trackway types may belong to members of same species, so our behavioral interpretation must be rather tentative. (Farlow, 2000).

Caveats duly noted, we can now consider what dinosaur trackways suggest about their makers' social behavior. At the famous Early Jurassic locality at dinosaur State Park near Hartford, Connecticut, numerous theropod track makers traveled every which way, with no obvious pattern to their courses. Quite possibly these dinosaurs were loners. At other sites, the pattern is very different. At an Early Jurassic dinosaur tracksite near Holyoke, Massachusetts (New England), at least 20 bipedal dinosaur, all theropod, were moving together as a group. The Early Cretaceous British Colombia Canada locality where four igaunodonts appear to have moved as a unit, changing directions at the same time. One of the worlds' best known set of dinosaur footprints from the Early Cretaceous sauropod trackways from Texas. Since every individual trackway is in the same direction and in close association with others the probability that the makers were moving together is high. The past claims that the young were in a protective center have not borne out (Farlow, 2001).

At the Paluxy River site, prints made by enormous quadrupeds, with the hindfoot impressions a yard or more in length. These foot prints are made by sauropods, and at least a dozen of them moved across the main tracksites in the park. Unlike the theropod trails, which go in both directions along the inferred ancient shoreline, nearly all of the sauropod trails head in only one directions, it may representing migratory path (Farlow, 2001).

If sauropd moves in groups, then we might often expect to find monospecific bonebeds dominated by a single kind of sauropod. A few such occurrences have been reported, but most such monospecific sauropod bonebeds have only a few individual animals in them, nothing like the enormous monospecific death assemblages known for some hadrosaurs and ceratopsians. Most bonebeds that have sauropods generally contain more than one sauropod species (Farlow, 2001). Patterns in the temporal distribution of narrow and wide gauge trackways have been identified by Lockley, Farlow and Meyer (1994) and Lockley, Meyer, Hunt, and Lucas (1994). The narrow gauge tracks do form the majority of Jurassic sauropod ichnocoenoses, wide gauge tracks are well represented, particularly in the late Jurassic. Their data do, however support predominance of wide gauge tracks in the Cretaceous, as such tracks consititute atleast 96% of total trackways and 97% of total tracksites. The data of Lockley, Meyer, Hunt and Lucas (1994) suggest a more complex pattern; a mix distribution of Jurassic track types followed by increasing rarity of narrow gauge tracks through the late Jurassic and Early Cretaceous, culminating in the complete absence of narrow gauge trackways by the late Cretaceous.

Yuansheng *et. al.* (2001) mentioned semicircle/ new moon shape of the manus, and ellipse/inverse taper/ taper shape as pes impression of sauropod from the Gansu Province of China. The divarication from midline to 30 degree is also mentioned. High angle divarication shows the forward movement as splayfooted gait. He also mentioned the footprint with three strong digits and large divarication angle representing ornithopod, footprint with three slender digits having sharp claw and little divarication representing theropod, footprint with twidactyl represent also theropod and footprint with quadrupedal, tridactyl with outward rotation probably belongs to Lizard.

6. Footprints of Sauropod Dinosaurs Confronted by a Theropod found from Middle Jurassic Samana Suk Limestone of Pakistan

Remains of a diversified paleobiota are found in the middle Indus basin, which includes plants (gymnosperm), mollusks, reptiles (bone, teeth and ichnofossils). The commonest vertebrate fossils and ichnofossils belong to sauropod (Figure 2,4) and theropod (Figure 3,4) dinosaurian fauna that occurs a wide geographic area. Environmental interpretation of ichnofossil bearing lithofacies/strata allows reconstruction of sea shore marine limestone. Of all ichnofossil localities in Pakistan, one displays the theropod track. In this locality, the sauropod herd is flanked by a theropod on the right. There are four trackways of sauropod and one trackway of theropod, having about 15 footprints in a 1500 square feet area. Further exploration of footprints in the Sammanasuk limestone in the upper Indus Basin, Loralai and Chiltan limestone in the middle and lower Indus basin are encouraging and can reveal the best results. Malkani previously recorded one foot print of juvenile sauropod from the Mula area, Khuzdar district, Balochistan.

The fossil tracks are found on the limestone bed of Middle Jurassic Sammana Suk Formation.The footprint bearing strata are found in the upper successions of Middle Jurassic Sammana Suk Formation **(Figure 2-5).** The upper succession consists of marine limestone, possibly deposited near the sea shore. It is no doubt the footprint bearing limestone is marine and footprints show the slight regression of sea and area was exposed as near sea shore and already deposited lime clay received the dinosaur footprints. The sauropod and theropod ichnofossils of upper Indus Basin are a unique record of a middle Jurassic dinosaurian fauna which inhabited the north western margin of Indo-Pakistan sub continental plate. A gregarious behavior is deduced from the analysis of these ichnocoenoses. At the time of dinosaur extinction, all of the dinosaur and few of others biota becamextinct. The extinction may be due to catastrophic flood, droughts and volcanic eruptions.

Figure 5. Footprints obirds/Avian/theropod dinosaurs, found on the middle Jurassic limestone of Malakhel area, Mianwali District, Balochistan, Pakistan.

Malkani (2005a, fig.69) have reported a foot print of a juvenile primitive Titanosauria found on the fragment of Chiltan Limestone (middle Jurassic) of Jhukkur area, Mardan nala of Mula Zahri Range (lower Indus basin/ Kirthar foldbelt). It is an ellipse of about 15 cm diameter. It has well preserved three small digits. The manus print is partially overlapped by the pes print. Remains of a diversified paleobiota are found in the middle Indus basin, which includes plants (gymnosperm), mollusks, reptiles (cranial and post cranial bones). The commonest vertebrate fossils belong to sauropod and theropod dinosaurs, and mesoeucrocodilian fauna that occur a wide geographic area. Recently the author have found footprints of sauropod confronted with a theropod (Figure 2-4) found from the middle Jurassic Samana Suk Limestone of Surghar Range, Mianwali District, Punjab Province, Pakistan. Footprints of birds/Avian/theropod dinosaurs **(Figure 5),** found on the middle Jurassic limestone, in the vicinity of dinosaurs' footprints locality, Malakhel area, Mianwali District, Balochistan, Pakistan. Many visitors visit Baroch section of Malakhel area every year due to easy accessibility and best stratigraphic exposure. But the recent studies have broadened their distribution to the upper Indus Basin of Punjab Province, Pakistan.

Sauropod dinosaurs were the largest animals to inhabit the land. Sauropoda has a global affinity. Five species of latest Cretaceous sauropod (Malkani, 2004a, Malkani, 2005a) and one species of Late Jurassic sauropod (Malkani, 2003c) from Pakistan have already been established. But one new genus and species ***Malasaurus mianwali*** of middle Jurassic sauropod is hereby tentatively erected. The holotype/ ichnotype belong to three tracks consisting of exposed 10 footprints (Figure 4). Ichnotype/ holotype footprints are found in middle Jurassic Samana Suk Formation of Baroch nala, Mala khel area, Mianwali District, Punjab Province, Pakistan (32^0 55.50" N; 071^0 09.00" E). Age of the ichnotype foot prints is deduced from the host formation which is middle Jurassic after Fatmi (1977). The dip of host limestone strata is 52^0 west and strike is north 5^0 east. The dip of the strata is high and creates problem to take measurement of the footprints and trackways. This limestone is white brown as weathered, and white to light grey as fresh, thin to thick bedded, interbedded with light grey to greenish grey calcarious shale.

The name ***Mala,*** honoring the dinosaurs' host Malakhel area; ***saurus*** means reptile. The species specific epithet ***mianwali*** is deduced from the name of footprint host district. Large pes foot print having length/width about 1 meter are diagnosed only for a large bodied sauropod (Figure 2,4). The manus footprints are totally overlapped by the pes prints. These tracks suggest the narrow gauge trackways. That is the reason these are not referred to previously erected species of titanosaurs from Pakistan, because they may belongs to wide gauge trackways. These footprints are surely assigned to sauropod, but its assignment to lower level is difficult.

Carnosaurian dinosaurs were the largest carnivorous animals to inhabit the land. Theropoda has global occurrences while tyranosaurids have Laurasian affinity and abelisaurids have Gondwanan affinity. The eleven named species from the Lameta formation of India actually represent at least three large bodied theropod (*Rajasaurus, Indosuchas, Indosaurus*) and a fourth, small bodied theropod (*Laevisuchas*) (Wilson, et al. 2003). But from Pakistan, there are some evidences of two large bodied theropod, and one small bodied theropod of Late Cretaceous age. Malkani (2004a) reported one species *Vitakridrinda,* of large bodied theropod and the other large bodied theropod evidences are based on only two types of vertebrae and teeth. One type of vertebrae is tall and other type is cylindrical. One type of teeth is D shape while the other is oval. The small bodied theropod is only based on a hollow surrouded by thin bone found on cross section of bone. One new genus and species ***Samanadrinda surghari*** of large bodied theropod based on only ichnofossils, is hereby tentatively erected. A track consisting of exposed 5 footprints is considered as holotype/ichnotype (Figure 3,4). Ichnotype/ holotype footprints are found in middle Jurassic Samana Suk Formation of Baroch nala, Malakhel area, Mianwali District, Punjab Province, Pakistan. Age of the ichnotype foot prints is deduced from the host formation which is middle Jurassic after Fatmi (1977). The name ***Samana,*** honoring the dinosaurs' host geologic formation; and ***drinda*** is a Seraiki and Urdu word means beast. The species specific epithet ***surghari*** is deduced after the name of Surghar Range which is the host of ichnotype area. Three slender toed foot prints having maximum length about 2 feet and width about 1.5 feet are diagnosed only for a large bodied theropod (Figure 3). The other toed are not marked on footprints. These footprints are surely assigned to Theropod, but its assignment to lower level is difficult. Because until now, no theropod fossils from these strata are collected. Both the sauropod and theropod genera erected are purely tentative and named only to refer for future research work regarding locomotion, behavior, soft and hard tissues. This ichnotype reveal the scenario of confrontation among a carnivorous ***Samanadrinda surghari*** theropo and the groups of herbivorous ***Malasaurus Mianwali*** sauropods.

This ichnocoenosis consists of exposed about 15 footprints, and 4 short trackways. Three trackways are interpreted as mainly produced by sauropods which are obliquely confronted by a track of large Theropod. They are indicative of a sauropod herd, composed of 3 or more individuals and furnish evidence of gargariousness (herd). The ichnofossils are usually deep footprints probably due to good granolometric sorting and the high plasticity of the limy substrate. In the vicinity, some foot prints of possibly birds/ small body theropod/coelorusaurs are also present. The footprint bearing strata are found in the upper successions of Middle Jurassic Sammana Suk Formation. The upper succession consists of marine limestone, possibly deposited near the sea shore. It is no doubt the footprint bearing limestone is marine and footprints show the slight regression of sea and area was exposed as beach and already deposited lime clay received the dinosaur footprints. Further exploration of footprints in the Sammanasuk limestone in the upper Indus Basin, Loralai and Chiltan limestone in the middle and lower Indus basin, and other Mesozoic strata are encouraging and can reveal the best results.

The sauropod and theropod ichnofossils of upper Indus Basin are a unique record of a middle Jurassic dinosaurian fauna which inhabited the north western margin of Indo-Pakistan sub continental plate. A gregarious behavior of herbivorous sauropods defending the attack of predatory theropod is deduced from the analysis of these ichnocoenoses.

7. Conclusions

The sauropod and theropod ichnofossils of upper Indus Basin are a unique record of a middle Jurassic dinosaurian fauna which inhabited the north western margin of Indo-Pakistan sub continental plate. A gregarious behavior of herbivorous sauropods defending the attack of predatory theropod is deduced from the analysis of these ichnocoenoses.

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