The Pattern of Fossil Tracks in the Geological Record

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ABSTRACT

It has long been assumed by most creationist geologists that the terrestrial animals fossilised in the Mesozoic were animals drowned in the Noachic Flood. However, the Mesozoic is also the geological 'era' when bird and dinosaur tracks first appear Such evidence cannot be reconciled with the view that the Flood ended after the Mesozoic and indicates that the Mesozoic was laid down after the Flood.

INTRODUCTION

Live animals can walk, and leave footprints: dead animals can do neither. This paper applies these seemingly trivial propositions to the geological record. If the Earth suffered a life-destroying catastrophe such as the Flood, and the event left a geological record of its destruction, that record should be devoid of fossil footprints. Any attempt to explain Earth history in terms of a global catastrophe must take cognisance of, and be able to explain, the distribution of tracks in the geological record. Traces of the activities of ancient animals are far more abundant than their more familiar body fossils such as skeletons or bones: an organism has only one body to leave behind, but can make thousands of tracks. Under unusual conditions they may be, and often have been, preserved.

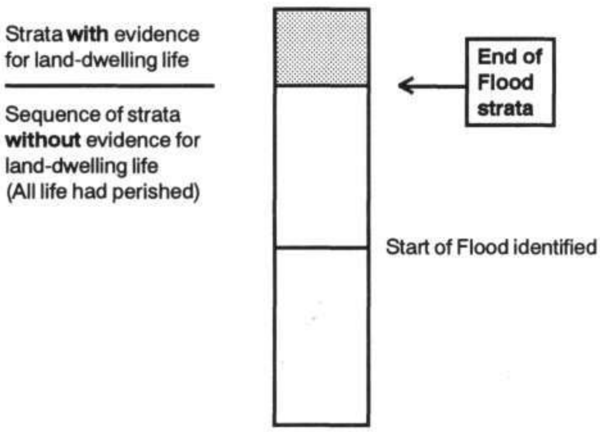


Figure 1. *Identification of the Flood/post-Flood boundary in strata from an imaginary borehole. If sediments from the beginning of the Flood can be identified, then above them should come Flood-strata lacking evidence of land-dwelling life. Near the top, evidence of living terrestrial animals (tracks, nests, coprolites) would show that the strata containing them were post-Flood.*

It will be suggested that the fossilised footprint evidence cannot be accommodated in the Flood model developed by Whitcomb and Morris.[1] The evidence demands a new model, built upon four assumptions which they and most other young earth creationists would accept:-

(1) as an historical event, the Flood must have had geological consequences;[2]
(2) the beginning of the Flood can be identified in the geological record;
(3) there was at least some geological activity after the Flood; and
(4) all land-dwelling, air-breathing creatures perished in the Flood.

Acceptance of these assumptions leads to an important expectation. Since land-dwelling creatures perished, Flood rocks should comprise strata which are devoid of evidence for contemporaneous life on the land. By contrast, later strata, originating from the time when animals from the Ark began to recolonise the Earth, may well contain evidence of land-dwelling creatures (see Figure 1). In other words, the Flood/post-Flood boundary should be definable by a junction: the absence/presence of live, air-breathing land animals.

The worldwide track evidence is summarised in Figure 2.[3,4] Amphibian tracks dominate the Devonian to Carboniferous, whilst reptiles are more abundant in the Permian. The Mesozoic track record is dominated by dinosaurs, but with significant numbers of turtle, crocodile and bird tracks. Mammals dominate the Tertiary record. This paper will focus on the Palaeozoic and Mesozoic track record.

EARLIER WORK

Fossil footprints are easily overlooked, and therefore it is not surprising that the first recorded observation of tracks was not made until 1802. A boy called Pliny Moody discovered bird-like tracks in the Connecticut valley, Massachusetts. Despite their size (the tracks were of a dinosaur) local opinion held that they had been made by Noah's raven — apparently a raven several metres tall! However, the tracks were not properly described until 1836,[5] when Hitchcock endorsed the opinion that the tracks were made by large birds. Because of this delay, the scientific study of fossil animal footprints may properly be said to have begun in Dumfrieshire, Scotland. The Reverend Henry Duncan recognised some fossil tracks there in about 1824, and published his account in 1831.[6] At the time they were interpreted as evidence of life from before the Flood.[7]

The Reverend William Buckland was sent some of the fossil tracks from Dumfrieshire, whereupon he arranged a demonstration for distinguished geologists of his day. Buckland wanted to show that modern turtles made impressions similar to the recently discovered tracks. Relates a witness of the scene:-

> ***'I went on Saturday last to a party at Mr Murchison's house, assembled to behold tortoises in the act of walking upon dough. Prof. Buckland acted as master of the ceremonies. There were present many other geologists and savants, among them Dr Wollaston. At first the beasts took it into their heads to be refractory and to stand still. Hereupon the ingenuity of the professor was called forth in order to make them move. This he endeavoured to do by applying sundry flips with his fingers upon their tails; deil a bit however would they stir; and no wonder, for on endeavouring to take them up it was found that they had stuck so fast to the piecrust as only to be removed with half a pound of dough sticking to each foot. This being the case it was found necessary to employ a rolling pin, and to knead the paste afresh; nor did geological fingers disdain the culinary offices. It was really a glorious scene to behold all the philosophers, flour-besmeared, working away with tucked-up sleeves. Their exertions, I am happy to say, were at length crowned with success; a proper consistency of paste was attained, and the animals walked over the course in a very satisfactory manner; insomuch that many who came to scoff returned rather better disposed to believing.'***[8]

A few years later, Fairholme[9] described animal footprints from strata a little below Carboniferous coal, which he considered was a late Flood deposit. Realising that land-dwelling animals should have perished by this time, he suggested that the tracks were made by amphibians which had been able to survive outside the Ark.

Whitcomb and Morris,[10] the pioneers of modern young-earth creationism, argued that at the beginning of the Flood some animals fled to higher ground. Most creationists have adopted their model and assumed that fossil tracks were made **during** the Flood by land-dwelling animals attempting to escape drowning.

John Morris, for example, tried to explain certain tracks in Texas by the suggestion that dinosaurs had taken refuge on high ground and from thence were able to walk across Flood strata more than a mile thick.[11] His is the best case study by a creationist and will be examined later. Morris understood the tracks as originating in the **earlier** part of the Flood. However, when Mehlert[12] commented on the **same tracks, he concluded, *'... I am inclined to believe that the prints are post-Flood... *** **Froede[13] implies that** the same Texas tracks are neither early- nor post-Flood but late-Flood!

Morton[14] questioned whether there was high ground at the time the animals in Texas made their tracks. He also queried whether the dinosaur tracks from Connecticut were the expression of animals about to perish in the Flood. Later[15] he stressed the violence of the early Flood and argued that track preservation was unlikely. He also noted[16,17] that the Connecticut tracks occurred at several levels, and 'shrimps' had burrowed into the dinosaur prints after they were made and before they had been buried. Morton called for more research to determine whether the whole sequence really could be accommodated within the Flood year. Whitmore[18] suggested that tracks in the Connecticut area were made by dinosaurs attempting to escape the Flood.

The need to clarify the Flood/post-Flood boundary prompted Garton[19] to highlight the significance of fossil tracks as a way of correlating events described in Scripture with geological evidence. He emphasised the violence at the **beginning** of the Flood. Flood strata would be characterised by the absence of fossil tracks of land animals (cf Figure 2), and therefore only the earlier, Palaeozoic strata could date from the Flood.

Oard,[20] while acknowledging that millions of fossil tracks are found around the world, often above thousands of metres of earlier sediment, claimed that they were reconcilable with the Whitcomb and Morris model. The problem, he acknowledged, was that even if track makers had survived until the fortieth day of the Flood, there would still not have been sufficient time to deposit the great thicknesses of sediment underneath the tracks. Oard therefore suggested that the destruction of life did not finish until day 150, thereby allowing more time to explain geological events before life was extinguished. Such a claim provoked a strong protest from Garner *et al.*[21] Among other criticisms, they considered that the extension of the period during which land animals could have survived was contrary to the biblical record.

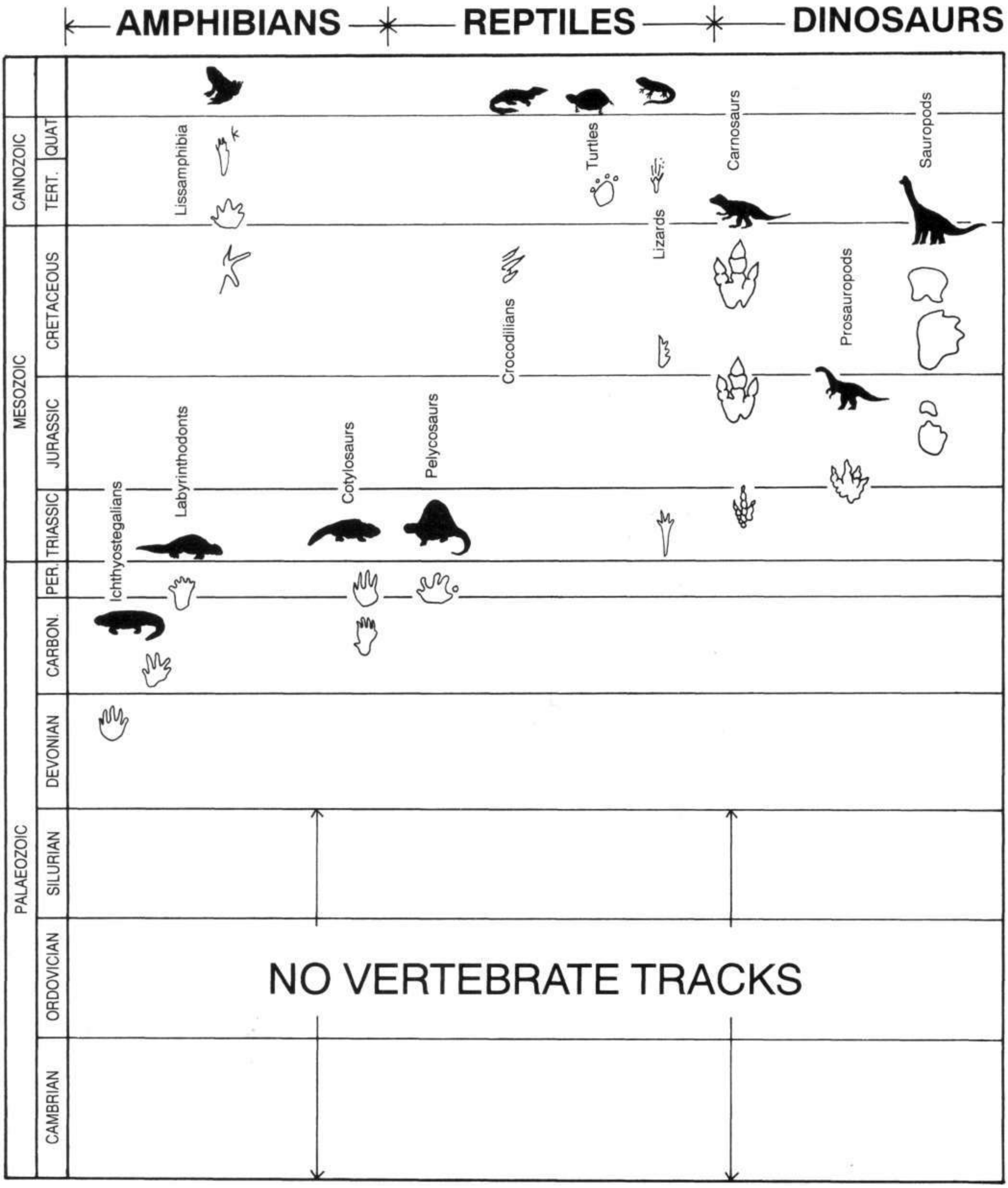
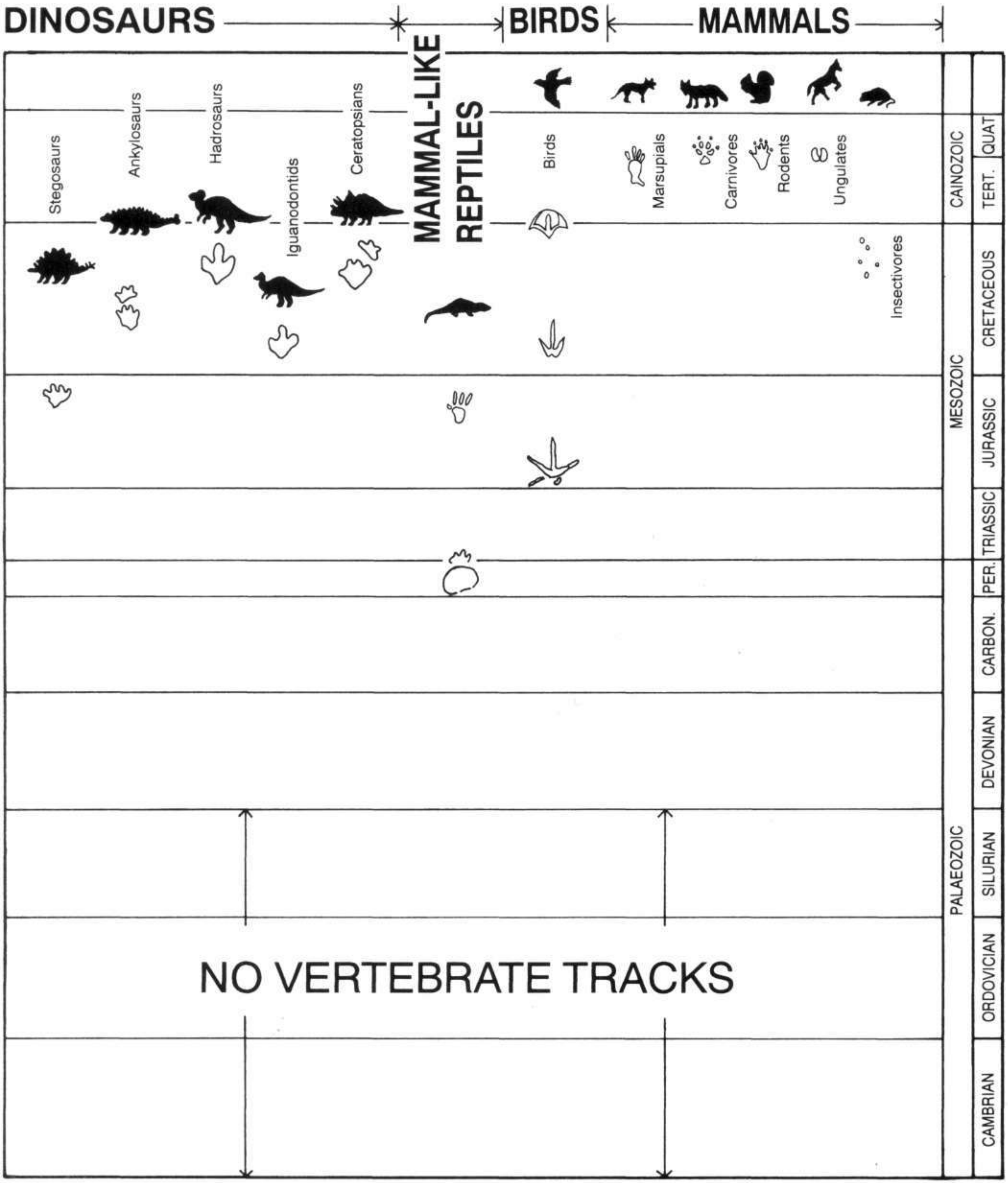


Figure 2. *Summary of the fossil track evidence made by vertebrates and known from most continents. Note the lack of vertebrate tracks in Lower Palaeozoic strata.*[3]


DINOSAURS
MAMMAL-LIKE REPTILES
BIRDS
MAMMALS
Stegosaurs
Ankylosaurs
Hadrosaurs
Iguanodontids
Ceratopsians
Birds
Marsupials
Carnivores
Rodents
Ungulates
Insectivores
NO VERTEBRATE TRACKS
CAINOZOIC
MESOZOIC
PALAEOZOIC
QUAT
TERT.
CRETACEOUS
JURASSIC
TRIASSIC
PER.
CARBON.
DEVONIAN
SILURIAN
ORDOVICIAN
CAMBRIAN

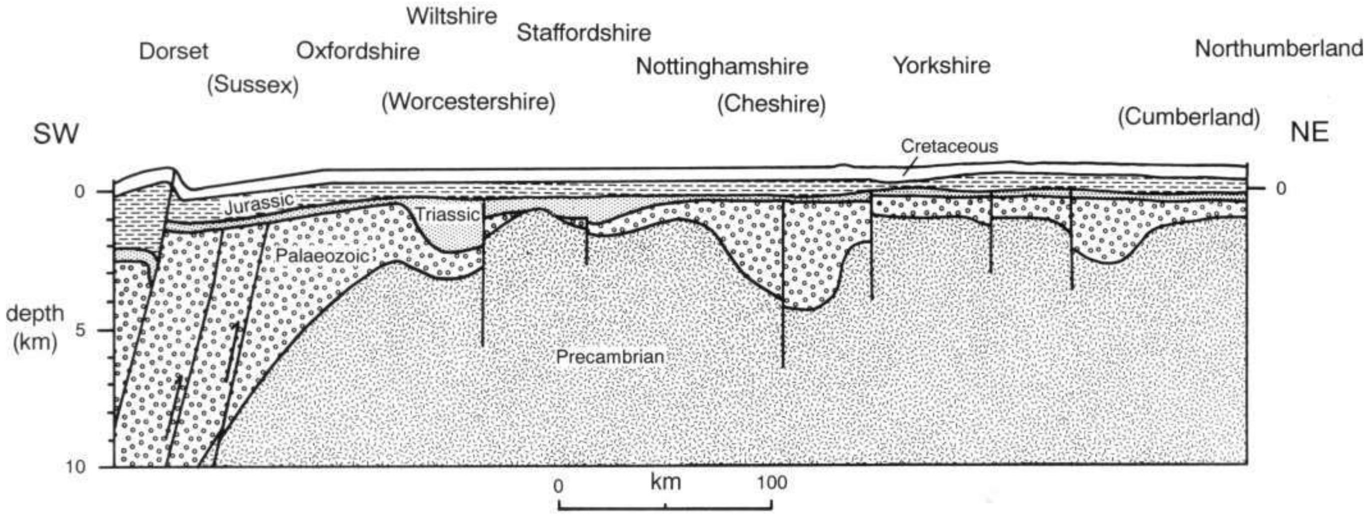


Figure 3. *A geological cross-section across England. Permian and Triassic strata were deposited on top of, and contain pebbles of, the underlying Palaeozoic, much of which had by then been deformed. The uppermost layers, first Jurassic, then Cretaceous, are continuous across the region and formed later. (The location of counties off the line of section are indicated in brackets.)*

Four case studies will present the evidence upon which further discussion will focus.

(1) GREAT BRITAIN

There are important reasons apart from historical precedent for including Great Britain. At a recent European creationist congress, it became clear that no sensible discussion about the significance of fossil tracks could be undertaken because creationists had differing opinions about the sequential nature of geological history. Some participants believed that Cambrian strata could well be younger than, say, Cretaceous strata; others agreed with the orthodox view (which I share) that Cambrian strata always predate Cretaceous strata.

A geological section through Great Britain enables us to avoid such confusion. Since the Palaeozoic, subsidence has been continual in the south-east, whereas most of the north-west has been rising. As one travels south to London, escarpment after escarpment is ascended, from Palaeozoic through to Tertiary. If a geological section is drawn across England from Yorkshire in the north-east to Dorset in the south-west (see Figure 3),[12,23] the lithostratigraphic succession corresponds to that part of the * geological column' which is of immediate concern (Precambrian to Cretaceous). It cannot be argued that, say, the Cambrian is later than the Cretaceous. The conventional geological sequence (without accepting the ages that go with it) can be shown to lie in a real sequence, corroborated by borehole evidence and free of any assumptions about evolution. A number of isochronous ash and tuff bands confirm the lateral equivalence of these layers.[24,25]

The footprint evidence is presented in two ways. First, the raw data is presented in Table 1 — the spatial position of the tracks geographically across the country and geologically in the strata they come from. Second, assuming the geological intervals to be approximately contemporaneous, Figure 4 summarises the data in an idealised sequence

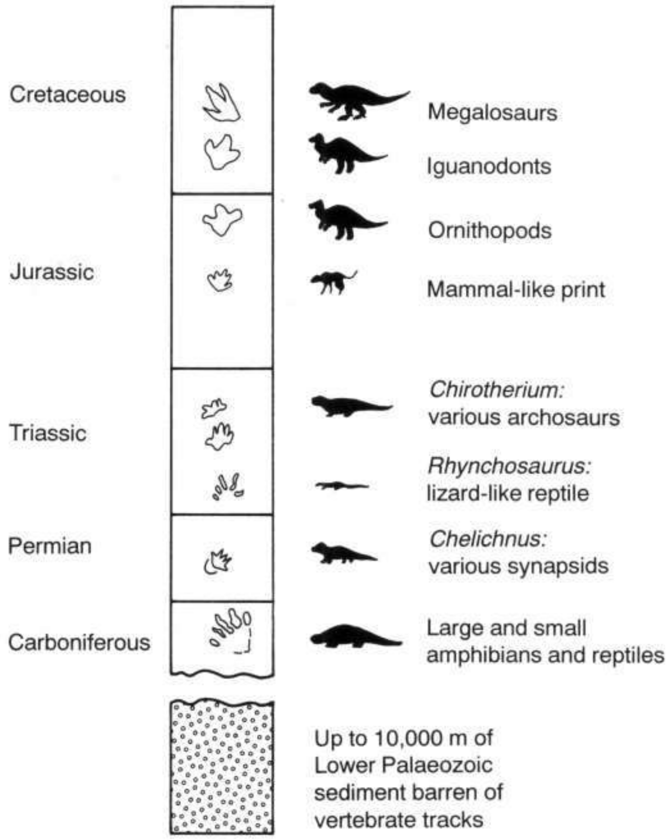


Figure 4. *Summary of the English fossil tracks shown in Table 1. The first prints, made by amphibians, lie on top of many thousands of metres of strata without vertebrate tracks. Amphibian tracks are succeeded by various reptile tracks before dinosaurs dominate the record above the Upper Triassic.*

	DORSET	(ISLE OF WIGHT)	(SUSSEX)	WILTSHIRE	SURREY
Cretaceous	*Iguanodon* *Megalosaurus* *Taupezia* *Purbeckopus*	*Iguanodon* *Megalosaurus* Antrodemids (carnivorous dinosaurs) webbed tridactyl	numerous *Iguanodon* (no other dinosaurs)		*Iguanodon*
Jurassic				lacertoid tracks	
Triassic					
Permian					
Carboniferous					
	(GLAMORGAN)	**WORCESTERSHIRE**	**OXFORDSHIRE**	**(BUCKINGHAMSHIRE)**	**WARWICKSHIRE**
Cretaceous					
Jurassic			*Pooleyichnus* (mammal?)	*Megalosaurus* (dinosaur)	
Triassic	*Gigandipus* (small carnosaur) *Anchisauripus* (coelurosaur)	*Chirotherium* aetosauroid coelurosauroid rhynchosauroid			*Cheriotherium* *Rhynchosaurus*
Permian					*Dromopus* (reptile)
Carboniferous					

Table 1. *The pattern of tracks in the geological record of Great Britain. (The location of counties off the line of section are indicated in brackets.)*

representative of English geology. Much of the sequence could be, and has been, proven in a single borehole in the English Midlands.

Below the lowest tracks there is a thick sequence of Lower Palaeozoic strata in Wales and the north-west of England: it is well in excess of 10,000 m. In view of the power of the volcanism and rapidity of the sedimentation, these layers may be readily correlated with the earlier stages of the Flood. They contain one of the earliest terrestrial tracks, made by a large arthropod (an invertebrate) in Ordovician strata. The track-maker was probably an aquatic myriapod-like animal,[26] which may have survived outside the Ark.

The footprint evidence summarised in Figure 4 begins in the Carboniferous. Most footprints appear to have been made by five-toed amphibians. To differentiate between amphibians and terrestrial reptiles is difficult on the basis of tracks alone, but amphibians do seem to dominate the Carboniferous track record, with reptiles becoming dominant thereafter. Most of the Carboniferous tracks are of small size, although Namurian prints from Northumberland (one of the earlier Carboniferous tracks known in Europe) suggest an animal which was about 1.5 metres long.[27]

Chelichnus tracks (see Figure 5)[28] are frequently reported from the British Permian, and include the first documented fossil tracks mentioned above. Sarjeant[29] suggested that the tracks were made by edaphosaurs, clumsy herbivorous reptiles; McKeever[30] suggested they were made by various pelycosaurs and anomodonts.

The fullest track record in Britain comes from Triassic strata. These tracks are different from those of the underlying Permian.[31,32] At that time, a varied reptile and amphibian fauna was alive in the area, including pseudo-suchians, coelurosaurs, rhynchocephalians, aetosaurs, lizards, cotylosaurs, thecodonts and salamander-like amphibians. The most common tracks are called *Chirotherium* (see Figure 6).[33,34] They are of small to medium size. There has been considerable discussion about the identity of the track-maker. A variety of archosaurs are now believed to have made *Chirotherium* tracks.[35] Dinosaur prints are extremely rare in the Triassic.

The varied reptilian fauna of the Triassic do not appear to have survived into the Jurassic and Early Cretaceous, where only dinosaur prints are reported. Numerous iguanodont tracks are known from the Early Cretaceous. Much of Britain was under water during the Late Cretaceous, when chalk was deposited. Therefore there was less opportunity for terrestrial tracks to be made and preserved, and none has been recorded. Environments were

	(SHROPSHIRE)	STAFFORDSHIRE	LEICESTERSHIRE	(CHESHIRE)	DERBYSHIRE
Cretaceous					
Jurassic					
Triassic	*Procolophonichnium* *Rhynchosaurus*	*Rhynchosaurus* *Chirotherium*	Chirotheroid	numerous *Chirotherium* rhynchosauroid small tridactyl	*Deuterotetrapous* (aetosaur)
Permian		*Ichnium/Amphisauropous*			
Carboniferous	*Anthichnium* *Batrachichnus* (small amphibians) *Limnopus* (labyrinthodont) *Dimetropus* (sphenacodont) *Ichniotherium* (edaphosaur)			*Chelichnus* (large amphibian)	

	NOTTINGHAMSHIRE	YORKSHIRE	(CUMBERLAND)	NORTHUMBERLAND	(DUMFRIESHIRE)
Cretaceous					
Jurassic		ornithopod dinosaur other dinosaur tracks			
Triassic	*Microsauropus* *Varanopus* *Brachychirotherium* *Coelurosaurichnus* *Swinnertonichnus* (reptiles and amphibians) saurischian dinosaur				
Permian	Chelichnus		*Chelichnus* *Laoporus* (caseasaur)		*Chelichnus* *Batrachichnus* (caseasaurs)
Carboniferous				*Baropezia* (large amphibian)	

Table 1 (continued). *The pattern of tracks in the geological record in Great Britain.*

equally unsuitable for track preservation in the Cainozoic; again, none has been reported.[36,37]

It will be apparent from Table 1 and Figure 4 that the British evidence accords with the summary of worldwide field evidence given earlier (see Figure 2). Two unusual and possibly anomalous tracks have been reported. In 1873, Barkas[38] described a small and broad quadrupedal trackway — which he attributed to a mammal — from Carboniferous strata. However, neither the prints nor the gait are distinctly mammalian. More recently, a small five-toed footprint has been described from Jurassic strata.[39] Since only a single print is known, its affinities remain conjectural, although it is '. . . *more likely to be the footprint of a mammal or a mammal-like reptile.*'[40]

Some may argue that amphibians and reptiles could have survived the Flood outside the Ark. Amphibians may have been able to survive, and various authors have suggested that certain dinosaurs were aquatic.[41,42] If amphibians and reptiles did survive, then they might have made tracks during the Flood. However, the aquatic nature of dinosaurs has not been established, and in creationist literature dinosaurs have almost always been described as perishing in the Flood.[43]

According to the Whitcomb and Morris model, after the start of the Flood animals fled to higher ground. They must have been on this high ground whilst thousands of metres of Early Palaeozoic sediment accumulated. However, there were times in the Early Palaeozoic (for example, the Early Silurian[44]) when most if not all the British region was under water.

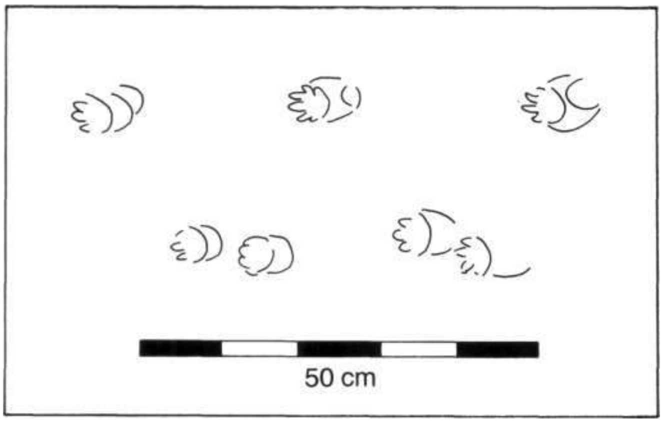


***Figure* 5.** Chelichnus, *one of the most common tracks from Permian strata in Britain. This particular track was the first to receive a scientific description, but the track-maker was wrongly identified (the name* Chelichnus *means tortoise track'). The tracks are thought to have been made by a variety of reptiles or mammal-like reptiles. In North America similar tracks are called* Laoporus.

Even supposing that high ground existed in the Early Palaeozoic, could land-dwelling animals have survived on it? Ordovician volcanism was on an unprecedented scale, not only in Britain, but on adjacent continents.[45,48] Creationists have emphasised the destructive power of the Mount St Helens eruption,[49] where one third of a cubic kilometre of material was ejected. How could any terrestrial life have survived the British Ordovician when so many volcanoes were continuously spewing out **thousands** of cubic kilometres of pyroclastic magma across the region?

Since the tracks continue through the Mesozoic strata, these strata too would have to have originated in the early Flood. Referring back to Figure 3, one has to allow sufficient time for the accumulation of thousands of metres of Palaeozoic strata, for subsequent mountain-building and erosion followed by deposition of the Mesozoic, including the development of some classic multiple hardgrounds.[50] It is unrealistic to suggest that this history can be compressed into the 40 (or 150) days of the early Flood period.

The British evidence establishes that:

(1) there is a real sequence of fossil tracks (without making assumptions about evolution);
(2) amphibians preceded reptiles, and reptiles preceded dinosaurs;
(3) tracks occur above thousands of metres of strata barren of vertebrate tracks;
(4) there were no refuges whilst these earlier strata were being deposited; and
(5) it is unreasonable to compress both Palaeozoic and Mesozoic history into the early Flood period.

(2) PALUXY, TEXAS

The Lower Cretaceous dinosaur tracks in the vicinity of the Paluxy River, Texas, are well known (see Figure 7). Tracks are widespread at the top of the Lower Glen Rose Formation, and are even more widespread — covering an area of 100,000 km^2 — on or near the top surface of the Upper Glen Rose Formation.[51] Most tracks known from the Cretaceous of Texas come from these two levels. Theropod, ornithopod and sauropod tracks are recorded. Up to 4,000 m[52] of Palaeozoic sediments were deposited first, underneath layers containing dinosaur foot impressions.

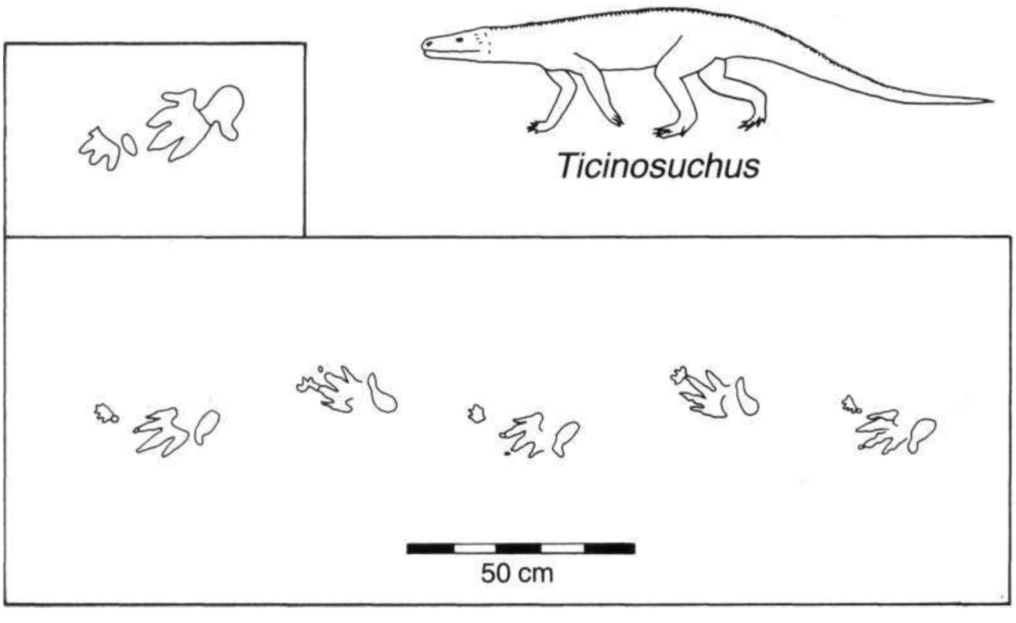
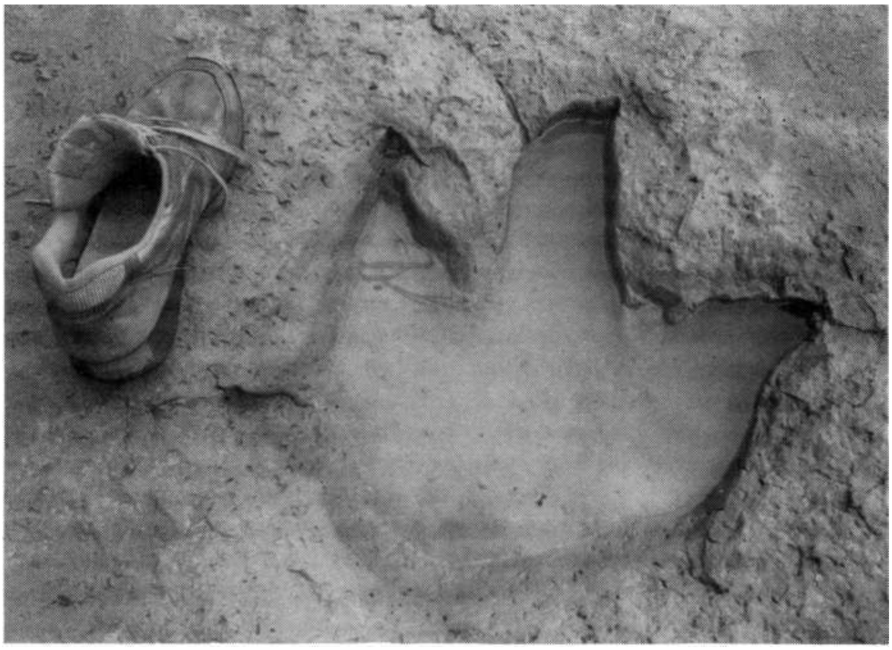


Figure 6. *Five digit* Chirotherium, *the most common track in the British Triassic. The isolated print is from similar impressions in the Moenkopi Formation of Arizona. Resembling little human hands, the name means 'hand animal'.* Ticinosuchus *is just one of a number of archosaurs thought to have made the tracks.*



A *well-preserved theropod dinosaur print in Lower Cretaceous strata, Paluxy riverbed at Dinosaur Valley State Park, Glen Rose, Texas. Author's shoe for scale.*

any distress. Indeed, the rarity, worldwide, of any track-makers showing evidence for running[55,56] is a strong argument against the Whitcomb and Morris model (see Figure 10). Neither is there any evidence for a preferred orientation in the Texas tracks. If only 'a few hardy souls' survived on the Llano Uplift, the rest must have drowned as the Flood waters rose. Where, then, are their bones? The first dinosaur bones in the Texas region coincide with the dinosaur tracks; dinosaur remains are not found in earlier strata.

Morris is presumably suggesting that the Flood waters reached their (furious) maximum at or soon after these beds were deposited. To adopt this view is tantamount to abandoning the biblical account of the Flood altogether, for the widespread shelf limestones of the Early Cretaceous suggest comparatively quiet conditions, not angry Flood waters at their zenith. Morris did not specify when in the Flood he expected the animals to have perished, but presumably it was within the first 40 days. To deposit 4,000 m of strata, sedimentation would have to have been very rapid, yet rapid sedimentation is unlikely for the Cretaceous, since sufficient time elapsed for

The track-bearing layers surround a contemporary island called the Llano Uplift (see Figures 8 and 9). As this Cretaceous island is approached, sedimentary units thin and facies change, suggesting very shallow water and then dry land. The tracks are closely associated with algal limestone, mudcracks and evaporites, suggesting that the dinosaurs were close to the 'Llano' shoreline. Some tracks appear to have been made on land, others in very shallow water, with the water depth seeming to have remained shallow for great distances. The track-bearing layers probably coincide with regression, which exposed broad areas of substrate.[53]

Morris suggested that dinosaurs left their refuge on the Llano uplift in a frantic search for safety elsewhere:

> *'The conclusion seems justified that the Llano Uplift was one of the last areas to be permanently inundated by the Flood. Certainly during the first few weeks of the Flood, as torrential rains poured down, as waters rose, as the earth shifted, and as areas flooded, men and the more mobile animals would have sought the highest ground for safety (which in this region would have been this great rock mass).'*[54]

Morris is of course following the Whitcomb and Morris model in advocating that animals found temporary refuge from the rising Flood waters. Although he speaks of animals leaving the uplift in a frantic search for safety, there is no evidence of dinosaurs moving quickly or in

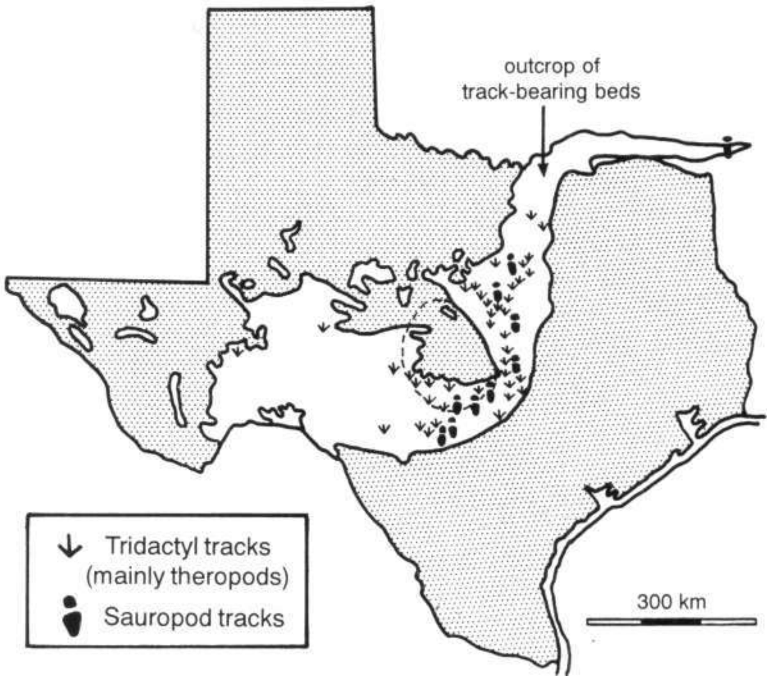


Figure 8. *Map of Texas showing the areal distribution of dinosaur tracks in the Early Cretaceous (Albian). The Llano Uplift is the central area enclosed within dotted lines. After Lockley and Hunt.*

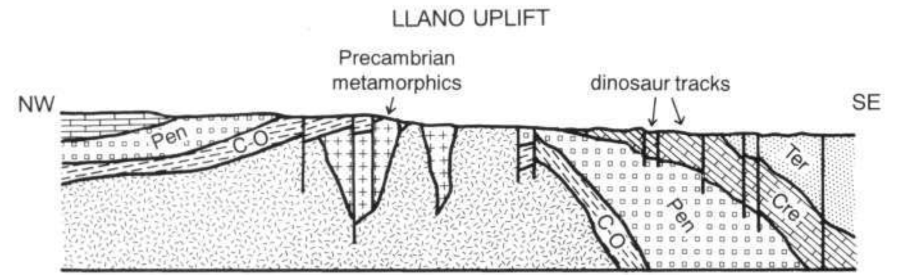


Figure 9. *Cross-section of strata overlying Precambrian granite around the Uano Uplift, Texas (redrawn from the A.A.R.G. geologic highway map of Texas, after Morris).*

extensive bioturbation by bivalves, including hard-grounds with pholad borings.[57]

Another great weakness in Morris's argument lies in its failure to embrace the geological history of the region prior to the footprint layers. Was the Llano Uplift always high ground, as Morris seems to imply? Creationist literature rightly acknowledges that 'all the high mountains under the whole heaven were covered', but there are no published studies attempting to identify this important stage of Flood geology. According to Morris, Texas was not fully submerged until the Late Cretaceous.

In geological literature the maximum inundation of North America is stated to have occurred in the Silurian, well before the track-bearing layers of the Cretaceous. *'Silurian land areas were a rarity'.*[58] In North America as a whole there are at least 15 'positive' areas like the Llano Uplift, which at some time stood as islands when parts of the continent were under water. In the Early Silurian, the Llano Uplift (along with most of the other positive areas) was certainly submerged; the only possible land areas were in northern Saskatchewan and along the east of the continent. Seas covered the Llano region in the Mississippian (Early Carboniferous).[59] Only in the Pennsylvanian did major uplift establish the permanently emergent feature which Morris seems to have assumed had existed throughout the Palaeozoic.[60]

If Morris wishes to advocate that, during the Flood, dinosaurs were on a Llano island in Cretaceous times, then he is obliged to explain where they were when most (and probably all) of North America was under water in the early stages of the Flood. If these Texas dinosaur tracks originated during the Flood, the animals must have first survived the most powerful phase of the Flood without the benefit of any refuge; they certainly did not survive by running to (non-existent) high ground in the Early Palaeozoic. It has been estimated that the Ordovician was deposited across a continental surface whose relief did not exceed 90 m.[61,62] 1 suggest that the lack of relief at this time corroborates Robinson's argument[63] that the Flood began suddenly and with extraordinary violence, planing the Precambrian land-surface and immediately destroying all terrestrial life.

The Lower Cretaceous tracks of Texas were made by dinosaurs. This case study suggests that:

(1) the idea of animals running to higher ground at the beginning of the Flood is misconceived;
(2) neither Cretaceous sedimentology nor track data is in accord with rapidly-deposited strata from Flood waters at their zenith; and
(3) some tracks coincide with regressing, not rising, Flood waters.

Moreover, if it is argued that the dinosaur tracks were made during the Flood, then:

(4) the sauropod, ornithopod and theropod dinosaurs had to be aquatic creatures.

(3) THE COLORADO PLATEAU

Vertebrate tracks are unknown in the pre-Carboniferous strata of western North America.[64] Tracks are first found in the Upper Carboniferous Supai Group[6567] (see Figure ll),[68,69] and they are thought to have been made by amphibians, reptiles and mammal-like reptiles. Again, differentiating between amphibians and reptiles is difficult. Most show four or five toes. Although the largest — *Anomalopus* — made impressions up to 10 cm long, most of the Carboniferous track-makers were much smaller.

Brand's attempt to show that the Permian Coconino Sandstone was deposited under water rather than in a desert[70] has been supported by creationists, but disputed by

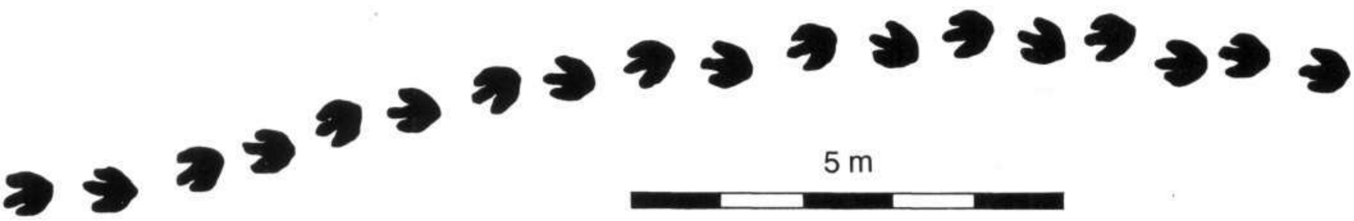


Figure 10. *If animals were in a frantic search for safety' as they fled from rising Flood waters, fossil tracks of running animals would be expected, but are rarely found. The above example is from a Lower Cretaceous bed at Barranco de la Canal Munilla, Rioja, Spain. The variable, closely-spaced, inward-pointing footprints are indicative of a slow-moving, large ornithopod dinosaur.*

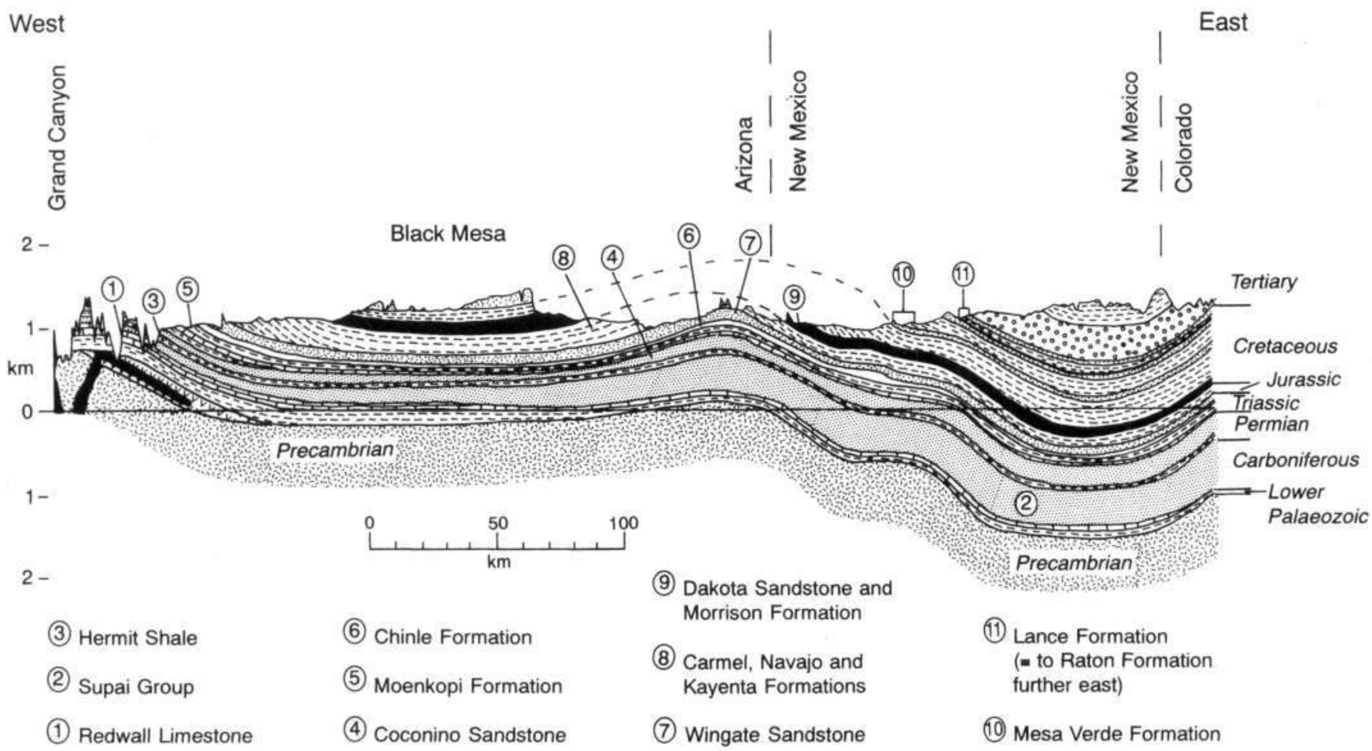


Figure 11. *A geological cross-section eastwards from Grand Canyon, showing the extent and position of the track-bearing stratigraphic units referred to in the text. Compared with the eastern United States or with Great Britain, the Lower Palaeozoic strata of the south-western states are much thinner.*

others.[71-73] The tracks are called *Laoporus.* Whatever their origin, *Laoporus* is morphologically the same as *Chelichnus*[74] (see Figure 5), which is widely reported in the British, and indeed European, Permian. The Hermit Shale, underlying the Coconino Sandstone, represents a different environment. Salamander-like (amphibian) tracks are called *Anthichnium,* whilst lizard tracks are termed *Dromopus.* Again, similar tracks are recorded from similar Permian strata in Britain and Europe (see Table 1).

Triassic tracks were made by reptiles. A few are attributed to mammal-like reptiles, some to lizards, most to archosaurs.[75] Of the archosaurs, only one kind is thought to have been truly aquatic, the crocodile-like phytosaurs. *Chirotherium* is the most abundant in the Triassic (see Figure 6), as also in the British and European Triassic, and is thought to have been made by archosaurs. As regards the Late Triassic, the Chinle Formation bears one of the best track records in the world, with most tracks occurring near the top of the Formation. In addition to *Chirotherium,* Rhyncosauroid (lizard) tracks are also abundant locally — so much so that they have been termed Triassic vermin'.[76]

Toward the end of the Triassic, in youngest Chinle Group sediments, small *Grallator* (theropod dinosaur tracks) appear in association with a diverse assemblage of other archosaur tracks. Then in some of the very youngest Chinle layers these *Grallator* tracks become the dominant track type, to the virtual exclusion of all other types. The impression given is that dinosaurs are taking over. In the overlying (Jurassic) Wingate Formation medium-sized *Grallator* tracks occur with few other track types.

After their first appearance in the Late Triassic the *Grallator tracks* steadily increase in size (see Figure 12)[77] into the Jurassic, a trend mirrored in prosauropod and sauropod tracks.[78] One exception to this trend is a large

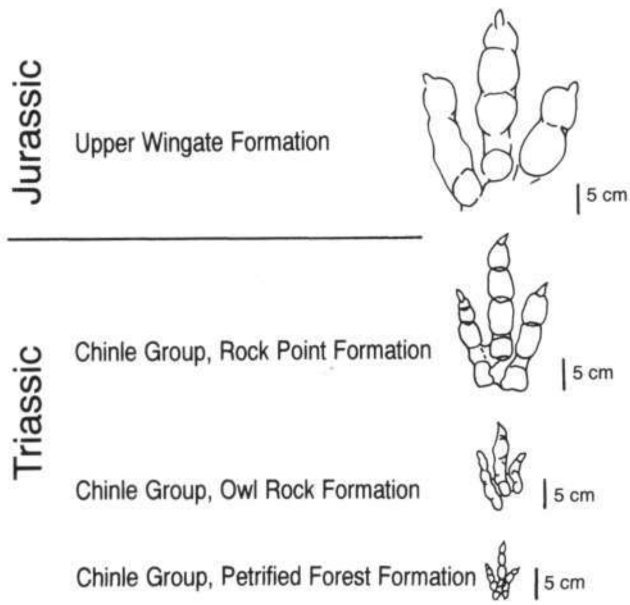


Figure 12. *Dinosaur tracks steadily increase in size near the Triassic-Jurassic boundary. After Lockley and Hunt.*

and rare theropod track from near the top of the Chinle. At over 25cm from claw to heel, it represents one of the largest three-toed dinosaurs known from the Triassic.[79]

The Jurassic track record is dominated by carnivorous, bipedal theropods. Sauropod dinosaur tracks also occur, along with crocodile and pterosaur tracks, mammal-like reptile and bird tracks. Amphibian and true mammal tracks are thought to be 'virtually unknown'.[80]

The oldest tracks attributed to birds come from the Early Jurassic Kayenta Formation. Bird tracks have also been reported in the overlying Navajo Formation, the Middle Jurassic Carmel Formation, a particularly large track in the Morrison Formation, and further prints in the Lower Cretaceous Dakota and Upper Cretaceous Mesa Verde Groups.

In the Middle Jurassic billions of dinosaur tracks are estimated to occur on the top surface of the Entrada Formation — the 'Moab Megatracksite', covering an area of about a thousand square kilometres.[81] The concentration of tracks at two levels in the Early Cretaceous, Texas, has already been noted, and these constitute two further megatrack sites. A fourth crosses the region near the top of the Dakota Sandstone (end of Middle Cretaceous) and is probably younger than the Texas sites.[82]

Much of the Early Cretaceous is missing. The ancient environment seems to have been characterised by low relief and shifting shorelines — conditions ideal for track preservation. Iguanodont tracks dominate the Middle Cretaceous record, with fewer medium-sized theropods. An ornithopod-dominated community must have covered a wide area, for similar tracks are found near the top of the Dakota Sandstone in Colorado, Oklahoma and New Mexico.[83]

In the Late Cretaceous, skeletal remains of hadrosaurs coincide with large, blunt, three-toed prints. Trackways on the roofs of coal mines in the Mesa Verde Group suggest that the hadrosaurs moved in herds. Early publications refer to well-beaten pathways, as though the dinosaurs were repeatedly using the same routes. Maps of the dense tracks and associated tree stumps have been cited as evidence that hadrosaurs were milling around in, and perhaps browsing on, dense vegetation.[84,85]

Hadrosaur tracks continue to dominate the record in the Raton Formation of the uppermost Cretaceous. Very close to the Cretaceous/Tertiary boundary, there are also prints attributed to the horned ceratopsians and tracks from a huge theropod with a foot almost 90 cm long. The only known dinosaur big enough to make this kind of track is *Tyrannosaurus.*

There is a prevalent myth in both popular and technical literature that tracks and bones do not occur together.[86] In creationist literature it has been stated that the majority of body fossils occur higher in the geological column than do their footprints.[87] Following a resurgence of interest in fossil tracks, more and more tracks are being found closely linked to body fossils of the track-makers. Such evidence does not support the notion that animals fled the rising Flood waters, leaving tracks first before their bodies were fossilised later.[88]

The footprint successions of Colorado and Britain share much in common. In both areas the track record begins above a remarkably similar Early Carboniferous limestone (in Colorado, the Redwall). Permian tracks in the Hermit Shale and Coconino Sandstone can be matched with similar prints in similar rocks of the British Permian. The most common track in the Triassic is also very similar. Dinosaurs are known above the same level in Late Triassic. British dinosaur tracks are only sufficiently common for meaningful comparison in the Early Cretaceous, and here the domination of iguanodonts corresponds. Creationists have already been challenged to recognise and explain the track succession of the Colorado Plateau. Godfrey notes:-

> *'As the Noachian flood was supposed to have killed all terrestrial four-footed critters except those in the ark, creationists must explain the presence of fossil trackways in many levels within the Colorado Plateau, as well as how they were made while the flood waters were raging.'*[89]

The most recent and comprehensive creationist account of the Grand Canyon[90] fails to address this aspect of the track question. In Austin's scheme Mesozoic strata, beginning with the Moenkopi Formation, correspond to a period beginning more than 150 days into the year of the Flood. The Mesozoic tracks must have been made by animals that somehow survived the most destructive phase of the Flood, despite what a straightforward reading of the biblical record demands, only to perish as the waters receded.

Although Austin's argument presupposes that all dinosaurs were aquatic, a variety of tracks cannot all have been made by aquatic animals.[91] Moreoever, birds certainly did not survive into the later part of the Flood. Although some Jurassic bird tracks may be questionable (the feet of some small dinosaurs made similar prints), bird tracks from the Early Cretaceous indicate that Austin cannot assign these strata to late in the Flood. They are either early Flood, or they tell us that the Flood ended before the Cretaceous strata, at the very latest.

The weakness of this model has not been lost on critics outside creationism. Heaton makes the point that Austin cannot reasonably

> *'attribute the overlying Mesozoic rocks, famous for their dinosaur trackways, to late in the Flood when all animals outside the Ark were supposed to be dead'*[92]

Two options remain: either the Palaeozoic **and** the Mesozoic are early Flood, or the Mesozoic is post-Flood.

The trend towards increasing size (cf. Figure 12) in a variety of groups of dinosaurs has long been noted,[93] and has been used to explain the sequence in which dinosaurs were fossilised.[94] Larger animals are said to have escaped the Flood waters longer, and therefore were fossilised later. However, the trend of increasing size does not hold good for all dinosaur groups, and does not apply to other animals. Moreover, the track evidence shows that for any group of dinosaurs (for example, Late Triassic/Early Jurassic prosauropods, Late Cretaceous hadrosaurs), there was a range of sizes. There is no evidence that all hadrosaurs of whatever size would have been more nimble than all prosauropods of whatever size. Only the largest dinosaurs could, perhaps, be expected to have survived the initial onslaught of the Flood. However, the track evidence indicates that amongst the last dinosaurs fossilised were herds of short-limbed, heavily-armoured ceratopsians[95] (see Figure 13).[96] Such animals would have been neither swift runners nor capable swimmers. Oard, in fact, surmised that they were probably **poor** swimmers.[97]

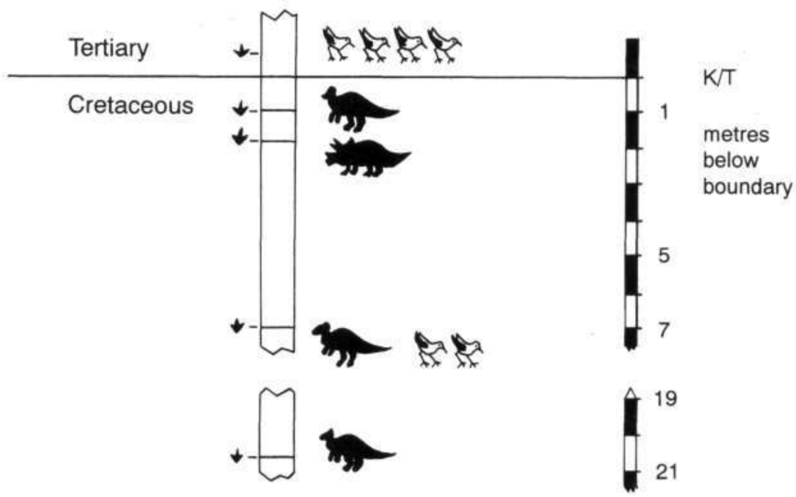


Figure 13. Trackways of birds, hadrosaurs and ceratopsians at five levels, straddling the Cretaceous/Tertiary boundary, Colorado. Tracks of the short-limbed, heavily-armoured ceratopsians suggest that herds survived until nearly the top of Cretaceous strata; ceratopsians were among the last dinosaurs to become extinct.

From the Colorado evidence I conclude that:

(1) the Mesozoic is either early Flood or post-Flood;
(2) the succession of track-makers cannot be explained on the basis of animals fleeing to higher ground; and
(3) the number and extent of the tracks corroborate other evidence for low relief and shifting shorelines.

(4) CONNECTICUT VALLEY

Fossil footprints were first recognised in the Hartford Basin, Connecticut Valley (see above). Although earlier work on these tracks is in need of revision, they are included here because their setting is rather different, and because they have been cited as evidence consistent with the Whitcomb and Morris model.[98]

The Hartford Basin is one of more than 15 sedimentary basins along the US east coast, all filled with Triassic strata of the Newark Supergroup.[99] Each basin is more or less bounded by marginal normal faults which have rifted the Precambrian, Palaeozoic or metamorphosed Palaeozoic, and so formed the depressions which were subsequently infilled. Palaeozoic strata on the eastern seaboard is extensively folded and deformed by Appalachian mountain-building. Since the rifts form a coherent suite and cut through these structures, these Mesozoic basins are obviously younger than the Palaeozoic strata and the events that deformed them.[100]

Each basin is infilled with coarse Triassic arkose and some, like the Hartford, contain finer-grained Jurassic sediments in which animal tracks are preserved. The prints were made by theropods of all sizes, small ornithopods and crocodile-like animals.[101] One track[102] appears to represent an animal walking in a rainstorm, crouching down and then continuing. The surrounding sediment is pock-marked with rainprints — except where the animal was lying — indicating that it remained crouched until the downpour had abated.

After dismissing radiometric, palaeomagnetic and palaeontological dating methods as having no validity, Whitmore[103] correlated the oldest strata within the Hartford Basin — that is, the base of the Triassic arkoses — with the beginning of the Flood. He was then free to suggest that the tracks in the overlying Jurassic also dated from early in the Flood year. However, these correlations seem difficult to reconcile even with Whitmore's own model, since the Hartford Basin rests on metamorphosed Palaeozoic strata, which must be still earlier Flood strata. Moreover, his conclusions have a bearing on the other basins of the Newark Supergroup, which, as he notes, are all strikingly similar in structure and sedimentology. With so many similar basins along the eastern seaboard, many of them bounded by the same fault systems, it is surely likely that they originated at the same time, in response to the same regional stress field that induced rifting parallel to the continental margin. I have already emphasised that this rifting must be post-Palaeozoic.

Consequently, Whitmore cannot correlate the Triassic with the beginning of the Flood, nor claim that the Triassic of the Hartford Basin is the same age as the Cambrian in the Grand Canyon. If the Jurassic tracks really are from the Flood, he must first explain how thousands of metres of Palaeozoic strata were formed, deformed and eroded during the Appalachian orogeny and then rifted in the Triassic — all in the early Flood, before the track-makers perished. A credible explanation does not seem possible.

Evidence from the Hartford Basin shows that:

(1) the Jurassic track-makers were preceded by a Palaeozoic history of sedimentation and subsequent mountain-building;
(2) it is extremely unlikely that all Palaeozoic and Mesozoic history can be compressed within the early Flood period;

(3) in the Triassic, eastern North America was rifted parallel to the margin of the continent; and
(4) the Triassic throughout eastern North America is of the same age and always comes after the Palaeozoic in the eastern states.

TRACKS AND THE GEOLOGICAL COLUMN

We have seen that tracks occur in a real sequence and that Early Palaeozoic strata precede layers with tracks. We must now consider the distribution of tracks in the geological record as a whole.

In Great Britain every system of the geological column is represented, and most systems (up to the modern-day surface) are represented in the areas examined in the other case studies. Even the strongest critics of the geological column acknowledge that all the geological systems usually occur in the sequence indicated by the column.[104] A real sequence of events has unfolded and could be divided into intervals corresponding to the geological systems. Isochronous ash bands were noted in Britain; they confirm the time equivalence of strata over tens to a few hundred miles. The megatracksite near the top of the Early Cretaceous Dakota Sandstone extends through three states, at least 420 miles (676 km).[105] Considered in relation to the facies preserving the tracks, any one track-bearing surface was probably made at about the same time, implying that there are approximate time-planes near the top of the sandstone.

To suggest that a geological period such as the Cretaceous may be everywhere contemporaneous does not entail accepting the geological timescale. Although each track layer indicates a pause in sedimentation, the tracks could have been made quickly, as shown even for sites where there is a high track density.[106107] The claim[108] that the Dakota Sandstone *'must have taken many thousands, even millions, of years for the multiple track-bearing levels to accumulate'* is without foundation, as is the assumption that sedimentation rates in the Cretaceous were slower than 0.3 mm/year.[109]

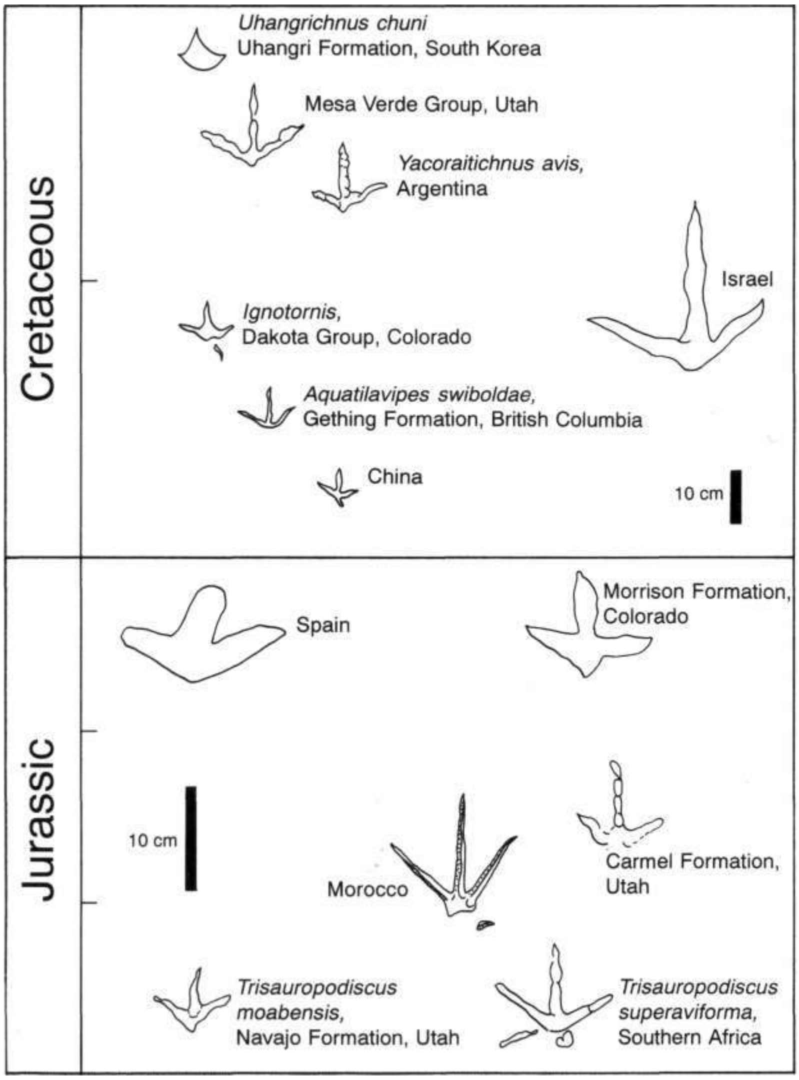


Figure 14. The stratigraphic position of fossil bird footprints from around the world. Prints on the right are drawn at half the scale of those on the left because they are much larger (about the size of a modern goliath heron).

On a broader and less precise scale, the Triassic in the basins of the Newark Supergroup, eastern North America, appears to be all of the same age, and there is a sequence Palaeozoic/ Appalachian Orogeny/Triassic/Jurassic which must be recognised. Extension and rifting affected the eastern seaboard only once, during the Triassic. Young-earth creationists should expect global correlations; it is therefore no surprise to note that the British (and European) Triassic is also characterised by rifting following Late Palaeozoic orogenesis, with similar sedimentation in similar environments. Likewise, there were few if any land areas in the Early Silurian, just as would be expected if Silurian rocks are of the same age around the world and correlate with Flood waters at their maximum.

The above four case studies — random ones insofar as they touch on the validity of the geological column — support the view that the geological periods are broadly isochronous. Using lithostratigraphy, early geologists gifted in spatial geometry established the validity of the sequence well **before** the theory of evolution was published.[110] Isochronous events such as ash fall layers or sea-level changes aid and often substantiate correlations.

Since very few young-earth creationists would dispute that pre-Carboniferous strata originate from the Flood, the crucial question is whether the Mesozoic also originates from the Flood. The case studies above have shown that

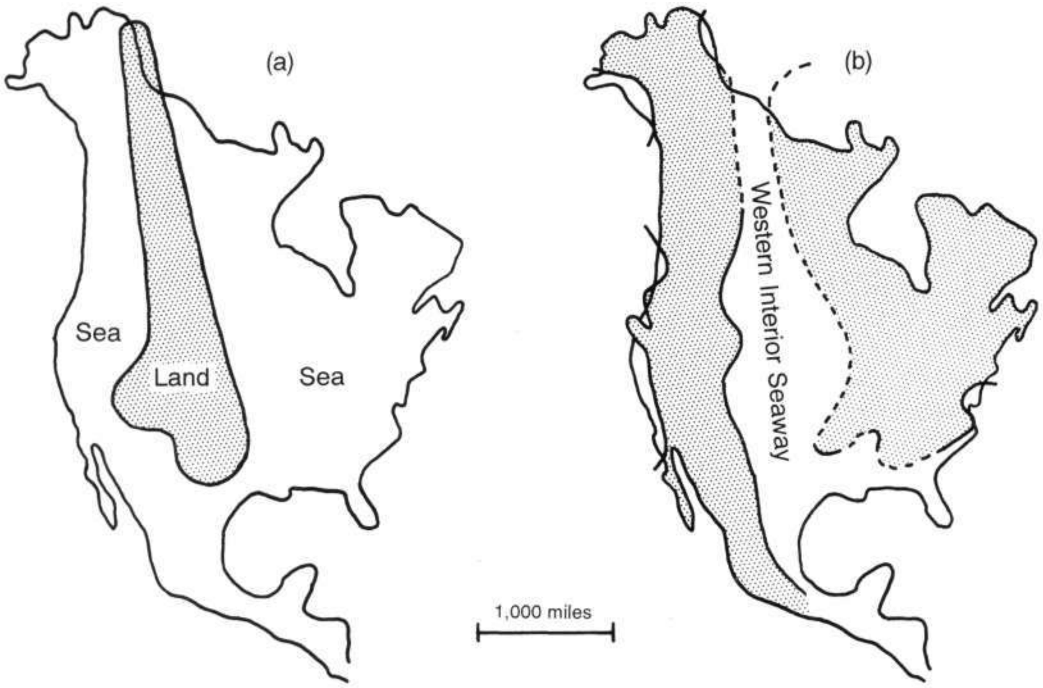


Figure 15. *(a) The strip of land which Oard hypothesised might have become exposed and repeatedly re-flooded during the first 150 days of the Flood; inferred from Triassic, Jurassic and Cretaceous dinosaur prints within the shaded area,*
(b) Completely contrary to Oard's hypothesis, the palaeogeography of North America during the Late Cretaceous, as inferred from distribution of marine and terrestrial facies.

the Mesozoic contains tracks of land-dwelling creatures that could not have survived the Flood, an observation further supported by Mesozoic bird tracks from around the world (see Figure 14):[111-113] birds did not survive the early stage of the Flood (Genesis 7:14, 21, 23). In addition to North America, bird tracks are now known from North and South Africa, Spain and various parts of East Asia.[114] In most of these localities, the conventional geological order is demonstrable because the tracks lie on top of characteristically Palaeozoic strata. The oldest bird tracks are from the Late Triassic/Early Jurassic of South Africa.[115] Birds were clearly alive in the Mesozoic; dinosaur tracks tell a similar story and are far more widespread.

PALAEOGEOGRAPHY

High sea-level stands around the globe have been inferred for the Early Palaeozoic, as has drainage of the continents in the Late Silurian/Devonian followed by a partial re-flooding of some areas, most extensively in the Late Cretaceous.[116-119] These sea-level changes are reflected in facies changes and the presence or absence of particular strata.[120] American creationists have paid little regard to Palaeozoic history (perhaps because, in contrast to most regions, major parts of it are not represented in the Grand Canyon). If dinosaurs were supposed to have looked for better refuges in the Mesozoic, would they not have done the same in the Palaeozoic? Why are there no dinosaur tracks alongside other tracks in terrestrial Devonian, Carboniferous or Permian deposits? Why did they not make tracks at all in the Palaeozoic?

Fossil tracks occur along the western mid-continent of North America from Alaska right down to Texas. Oard[121] adopted the Whitcomb and Morris model but recognised that these Mesozoic tracks must, in that model, date from the early Flood, when the waters were approaching their maximum. Since the tracks are terrestrial he postulated the existence of a strip of land whilst the rest of the continent was under water (see Figure 15a). He considered that thousands of floating dinosaurs might have embarked upon it and have run to and fro.

North American palaeogeography is reasonably well constrained by transitions from marine to continental facies, and indicates that much of the continent was above water in the Triassic and Jurassic. The highest Mesozoic sea-level occurred in the Late Cretaceous with the development of the Western Interior Seaway (see Figure 15b), and the palaeogeography of this period ought to correspond with Oard's model. It is almost the complete antithesis. A combination of low relief and relative changes in sea-level generated very extensive, changeable shoreline environments which were extraordinarily favourable for the preservation of tracks. Dinosaurs clearly frequented these shorelines and their tracks often indicate that they walked parallel to the shore, either on land or in very shallow water. However, the shallow, changing seaway was where Oard predicted the land to be, and the land was where the sea was supposed to be!

TRACKS AND THE FLOOD

There are conflicting arguments about which part of the geological record corresponds with the end of the Flood. In order to discriminate between them, it is important to differentiate essential from non-essential criteria. Non-essential, even misleading, criteria would include:-

(1) cessation of fossil formation (because catastrophism is likely to have persisted for a considerable period as a continuation of the geological upheavals associated with the Flood, until the Earth attained a new state of equilibrium);
(2) the end of a cycle of regression (since, as a result of continuing catastrophism, there could have been substantial re-flooding, without contradicting the promise in Genesis 9:11); and
(3) diminishing thickness and volume of deposits (post-Flood catastrophism is likely to have resulted in substantial deposition, although certainly the violence of events and rate of deposition are likely to have been of a lower order).

Among essential criteria, one of the most important would be an absence of tracks attributable to land-dwelling animals followed higher up in the geological record by growing numbers of such tracks, as the Earth after the Flood was recolonised.

The continents were submerged in the Early Palaeozoic. According to the Whitcomb and Morris model, the lack of dinosaur tracks in the Palaeozoic would have to indicate that the dinosaurs were alive in the water. Everyday examples of people drowned at sea reinforce the fact that land-dwelling creatures cannot survive anything more than a moderate swell. It must therefore concern all creationists that the model is being modified to include all dinosaurs (and presumably mammals) seeking refuge by swimming in the Flood waters at their most turbulent and surviving up to 150 days.[122]

There is an unexplained anomaly for those who have championed the swimming abilities of dinosaurs and adopted the Whitcomb and Morris model. Why did the dinosaurs perish before the mammals? Surely, on the Whitcomb and Morris model, large animals designed for both land and sea would have the best chance of surviving longest. Can we really argue that small or less agile mammals would be able to survive the deluge longer than large, strong animals which were at home on land and in the sea? Many creationists have noted the dinosaurian character of the animal described in Job 40 — a beast that was not frightened of the Jordan in flood. It is hardly consistent to go on to argue that dinosaurs were among the earlier animals to perish in the Flood.

Both Old and New Testaments describe the Flood as beginning suddenly and powerfully. Such catastrophic conditions, with water flooding the land from above and below, do not provide an environment in which tracks would be preserved (assuming that animals were in a fit state to make them). The absence of tracks in thick sequences of (early Flood) Palaeozoic strata supports the assumption that land-dwelling creatures did not leave a track record in the Flood. It would therefore be erroneous to suggest that there either was or could have been an inundatory phase to the Flood, characterised by the tracks of land-dwelling creatures fleeing the rising Flood waters.[123-126]

As noted above, the earliest fossil tracks which might be attributed to land-dwelling animals come from the Devonian. However, if the reptiles and amphibians making these tracks were animals which originated from the Ark, one would have to allow for a considerable period during which the animals — some of them of apparently ponderous locomotion — proliferated and spread to such an extent that their tracks were preserved in localities right across the globe. The period immediately preceding the Devonian is the Silurian, the period when more parts of the world were under water than at any other period in the Phanerozoic. To attribute tracks from the Devonian and Carboniferous to animals whose ancestors survived on the Ark is therefore not a tenable view.

Fairholme — one of the last geologists to maintain a diluvialist position before he too succumbed to Lyell's uniformitarianism — contemplated much the same problem in 1833, when, discussing certain Carboniferous tracks, he wrote:

> *'But it will naturally be asked, where was the animal to come from at a time when the whole living kingdom was in the act of being destroyed; or, (if the footmarks were made, as appears most probable, on the decline of the Deluge), when all had already perished? To this we reply, that we have here the most positive evidence, that all had not perished when these sandy formations were being so rapidly deposited. At whatever period of the Deluge this deposit took place, we see, that at least a few individuals, of the animal world, were lingering out a miserable existence, perhaps, preserved for weeks and months on those same vegetable islands which we have seen were being deposited in the immediate neighbourhood, and, now exhibited, in the form of coal. If the animals in question were of.. . an amphibious nature, we can have the less difficulty in finding a solution for this interesting problem; for, in considering the fossil remains of the natural inhabitants of the sea, we have before found it probable, that by no means a general destruction took place among this extensive class at the time of the Deluge.*[n21]

Robinson,[128] considering the problem in the light of Scheven's proposal that the Palaeozoic coal seams are the remains of pre-Flood floating forests, has independently come to a similar conclusion: the forests provided habitats for quadruped animals just as terrestrial forests do today, and when these 'vegetable islands' became grounded on the emergent deposits left by the Flood, the surviving animals disembarked and invaded the land. Later, as they

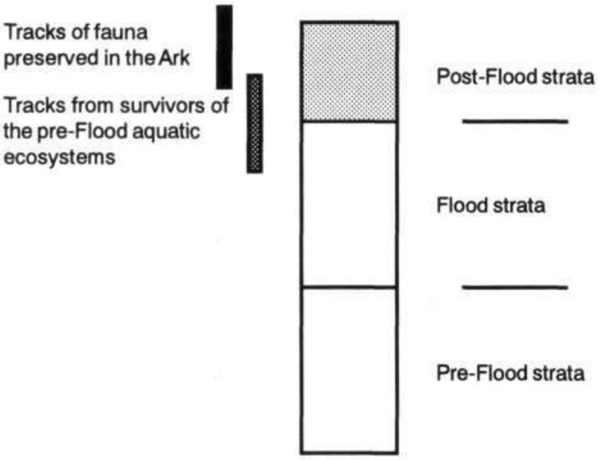


Figure 16. Fossil tracks as evidence for post-Flood colonisation. ***There are no tracks from before the Flood, nor tracks of any land-dwelling vertebrate in strata from the Flood itself.*** *The only tracks left during the Flood were made in the later stages by amphibian/reptile survivors from pre-Flood aquatic ecosystems. These track-makers were later superseded by tracks from land-dwelling fauna originating in the Ark.*

died out in this inhospitable environment, they were followed by the dinosaurs, birds and mammals radiating across a single, Permo-Triassic supercontinent from the Ark. The overlapping track records of these groups are indicated on Figure 16.

This interpretation would allow Devonian tracks to have been made at a time when some land was emergent, but before the end of the Flood year. Tracks from the Lower Carboniferous may also belong to this period. The precise dividing-line between Flood and post-Flood cannot, of course, be inferred from the track evidence, but — insofar as it can be drawn at all — must be determined by reference to those faunal and geological evidences which require more time than the closing stages of the Flood can accommodate.

CONCLUSION

Fossil tracks occur in a definite order, above Early Palaeozoic strata which are barren of tracks. Amphibians and reptiles characterise the Late Palaeozoic, reptiles the Triassic, and dinosaurs (with some birds) dominate the later Mesozoic. Since the Noachian Flood effected a total destruction of land-dwelling life, the event ought to be expressed in the geological record by strata which lack fossilised tracks from land-dwelling creatures — an essential consideration in any attempt to differentiate Flood from post-Flood sedimentation.

In the Whitcomb and Morris model, tracks might just be expected in soft sediments of the pre-Flood surface (always supposing that the Flood waters were not violent enough to erode them away), whilst later strata would be barren of tracks. In reality, fossil animal tracks are in the wrong place for this scheme, occurring too high in the sequence, often above many thousands of metres of Early Palaeozoic strata barren of tracks. Footprints are widespread in Mesozoic strata and record track-makers which would not have survived outside the Ark. If the Whitcomb and Morris model is to be retained, then Palaeozoic and Mesozoic strata must be accommodated within the early Flood period, before the time when track-makers perished. Under such a shortened timescale, it would be difficult to explain how thick sequences of Palaeozoic strata could have been deposited, suffer orogeny and then be overlain by Mesozoic strata, with their multiple hardgrounds and other stationary surfaces. Moreover, high sea-level stands in the Early Palaeozoic suggest that there was little or no high ground for animals to survive on before they left hypothetical refuges and made the Mesozoic tracks.

Mesozoic strata can more readily be accounted for after the catastrophe. The Noachian Flood began suddenly, with exceptional violence which quickly destroyed land-dwelling life. There were rapidly neither living animals to make tracks nor terrestrial conditions in which tracks could be made. Some fauna did survive outside the Ark, as part of a unique pre-Flood ecosystem of marine, floating forests, and these animals were the first to attempt to colonise the inhospitable land in the closing stages of the Flood. These pioneers were succeeded by animals and birds radiating out from the Ark across the single landmass of the Permo-Triassic.

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