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A Remarkable Mammal Trackway in the Uinta Formation (Late Eocene) of Utah

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ABSTRACT

The discovery of Eocene mammal tracks, spectacularly preserved as a series of ferruginous sandstone casts within a grey clay and exposed as discrete positive features by erosion, is described. This manner of preservation is without precedent in the geological literature.

The footprint casts occur within a grey mudstone in the Lower Member of the Uinta Formation near Myton, Utah. The trackmaker was certainly an ungulate (and probably a perissodactyl). Though the footprints do not accord with any described ichnogenus, the lack of detail precludes their erection as a new ichnotaxon.

INTRODUCTION

In the summer of 1994, possible mammal footprints were recognized by the first author in strata from the Lower Member of the Uinta Formation (Upper Eocene). They were discovered at a well location in the Monument Butte Oil Field, 10 miles south of Myton, Utah (Hamblin, 1994). During the ensuing fall, undoubted footprints (probably of large ungulates) were discovered in blocks of rock blasted from the pit during construction at the well location.

The three authors visited this track site together on 27th April 1995. While two of us were excavating a fossil turtle carapace from a dry creek-bed, the third author walked up the bank and found himself looking at a series of twenty-five plaques of ferruginous sandstone, arranged in an alternating left-right pattern (Plate 1) and set into, or lying upon, a surface of grey mudstone. Three further plaques, one broken, were exposed two days later by digging into the clay. The series of plaques was immediately recognized as representing sandy fillings of footprint molds made by a large ungulate, traveling across a mud-flat between streams during Uintan times, about 45 million years ago. The ferruginous sands, which had filled the footprints and had once overlain the clay, must have been afterwards largely washed away by a flash flood. However, the footprint fillings survived, and the hardened plaques, being much more resistant than the surrounding clay, were exposed as positive features by erosion. (Some small plates or nodules of the ferruginous sand have also persisted.)

So far as we are aware, the geological literature contains no reports of footprints preserved in such a fashion. Moreover, it should be noted that, unless such plaques are viewed from the right angle and their arrangement perceived, they would be merely dismissed as larger ferruginous nodules. (Indeed, the first author had traversed this locality several times without seeing them). Consequently, similarly preserved tracks should be watched for elsewhere in Tertiary Continental sediments.

GEOLOGIC SETTING

The footprint locality lies in the west central part of the Uinta Basin. This is a broad, east-west trending basin south of the Uinta Mountains covering approximately 31,000 sq. km [12,000 sq. mi.] with elevations ranging from 1,460 to 2,130 m [4,800–7,000 ft.]. The basin axis parallels that of the mountains, lying near the foot of their southern flank.

The principal drainage systems are formed by the west-to-east-flowing Duchesne River and its tributaries, and by the east-to-west-flowing White River and its tributaries. Both these rivers enter the Green River near Ouray,

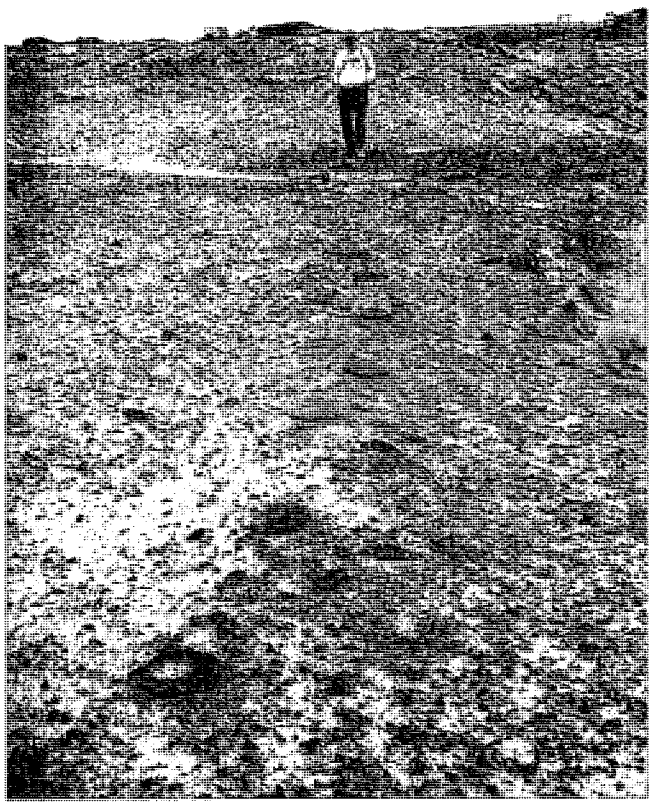


PLATE 1
Oblique view of the whole track, seen on the day of the discovery (27 April 1995) with David Spalding, its discoverer. (Photo: William A.S. Sarjeant).

Utah; the Green River itself flows south through the Book Cliffs and out of the Uinta Basin.

Rock exposures within the Basin consist predominantly of Middle to Late Eocene sediments which, in some areas, exceed 3,000 m [10,000 ft.] in thickness (Hintze, 1988). However, formations dating back to PreCambrian times are exposed in the Uinta Mountains to the north.

With the advent of the Laramide Orogeny in the Late Cretaceous (70 million years ago), the uplifts began which formed the Rocky Mountains. The largest Laramide structure in Utah is the Uinta Mountain Anticline (Hintze, 1988). Basins adjacent to this anticline were occupied by several large, freshwater lakes. On the south side of the Uinta Mountains, Lake Uinta constituted the environment in which the Green River Formation (Middle Eocene) and parts of the Uinta Formation (Upper Eocene) were deposited. Fluvial sediments intertongue with and overlie these lacustrine deposits.

By Late Eocene times, Lake Uinta had diminished in size. Depositional conditions fluctuated between lacustrine and fluvial, but tended to become increasingly fluvial as this epoch came to an end. The Uinta Formation, deposited during this period of changing conditions, is composed of beds of mudstone or claystone alternating with beds of siltstone or lenticular sandstone (occasionally of limestone); channel sandstones are also present. It is in these sediments that the bulk of Late Eocene vertebrate fossils is found in the Uinta Basin.

Uinta Formation

This is the only geologic formation exposed in the region of the footprint site. It forms an east-west band in the central part of the Uinta Basin, extending for about 130 km [80 mi.] and from 19 to 24 km [12–15 mi.] in a north-south direction. The Uinta Formation lies conformably upon the Green River Formation (Dane, 1954) and conformably beneath the Duchesne River Formation (Kay, 1934; Andersen and Picard, 1972).

The Uinta Formation was divided by Peterson (in Osborn, 1895) into three horizons, "A", "B" and "C". Somewhat confusingly, Osborn (1929) renamed the top part of "A" as "B_1" and called Peterson's "B", "B_2". Wood (1934) combined Peterson's Uinta "A" and "B" into a single member, calling it the Wagonhound Member (after Wagonhound Canyon in the White River area). Peterson's Uinta C was renamed the Myton Member (after the town of Myton, Utah).

More recently, Rowley, et al., (1985) and Bryant, et al., (1989) have divided the Uinta Formation into two parts—the Lower and the Upper Member. The first authors considered that the Lower Member generally corresponds to the "A" and "B" units of earlier descriptions. According to Bryant's map (in Bryant, 1992), only the Lower Member is present in the study area. He describes it as follows:

> Dark-greenish-gray and gray mudstone containing lenticular beds of yellowish-gray, gray and light-yellowish-brown sandstone as much as 6 m [19.7 ft] thick. Minor beds of grayish-red siltstone and brownish-gray to yellow-brown-weathering limestone. A few thin coaly beds. Dominantly fluvial in origin but contains some lacustrine beds. Interfingers with sandstone and limestone facies of the Green River Formation east of Duchesne.

The environments of deposition of the Uinta Formation thus vary from lacustrine to fluvial, at least part of its sediments being deposited during the waning stages of Lake

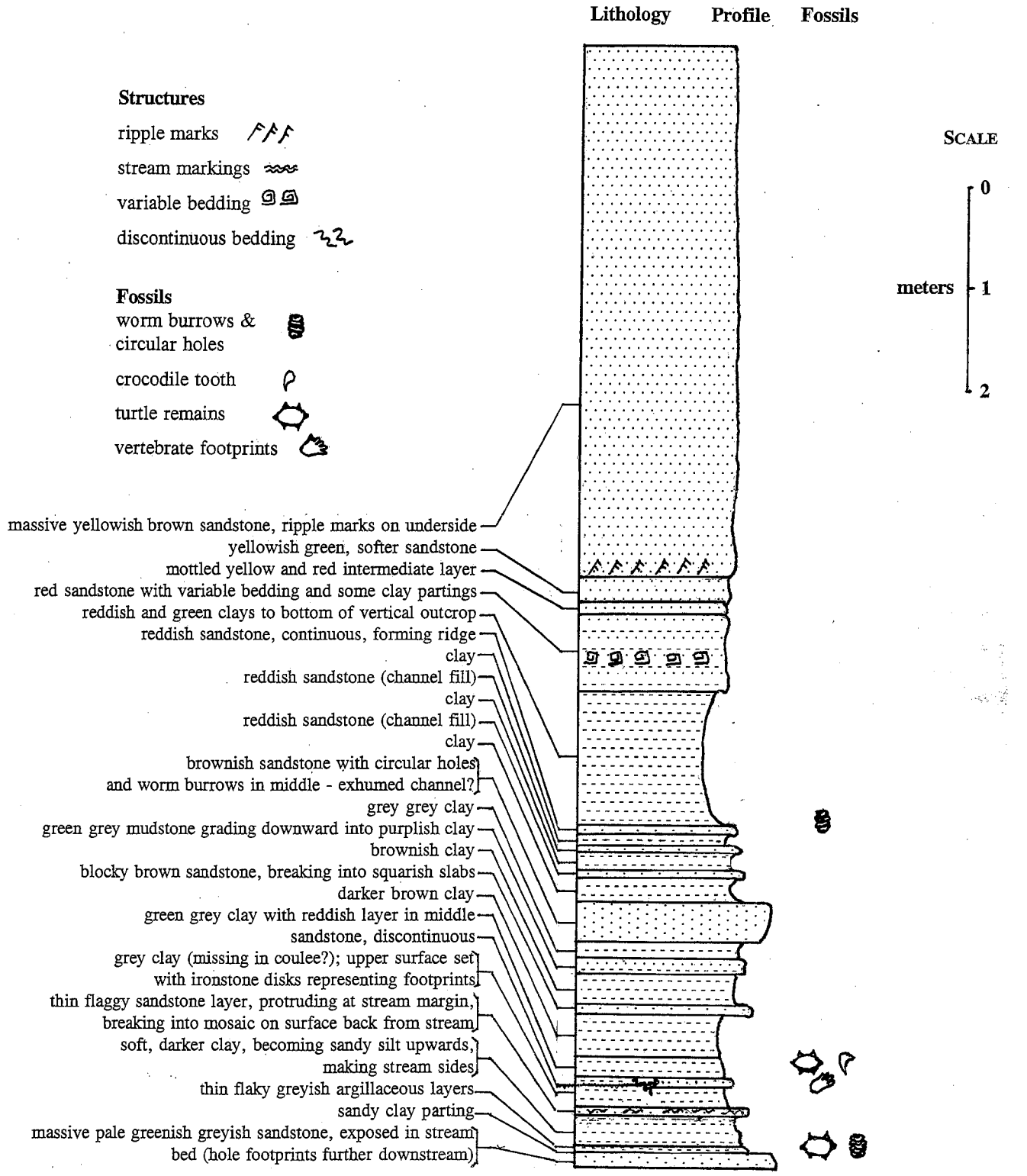
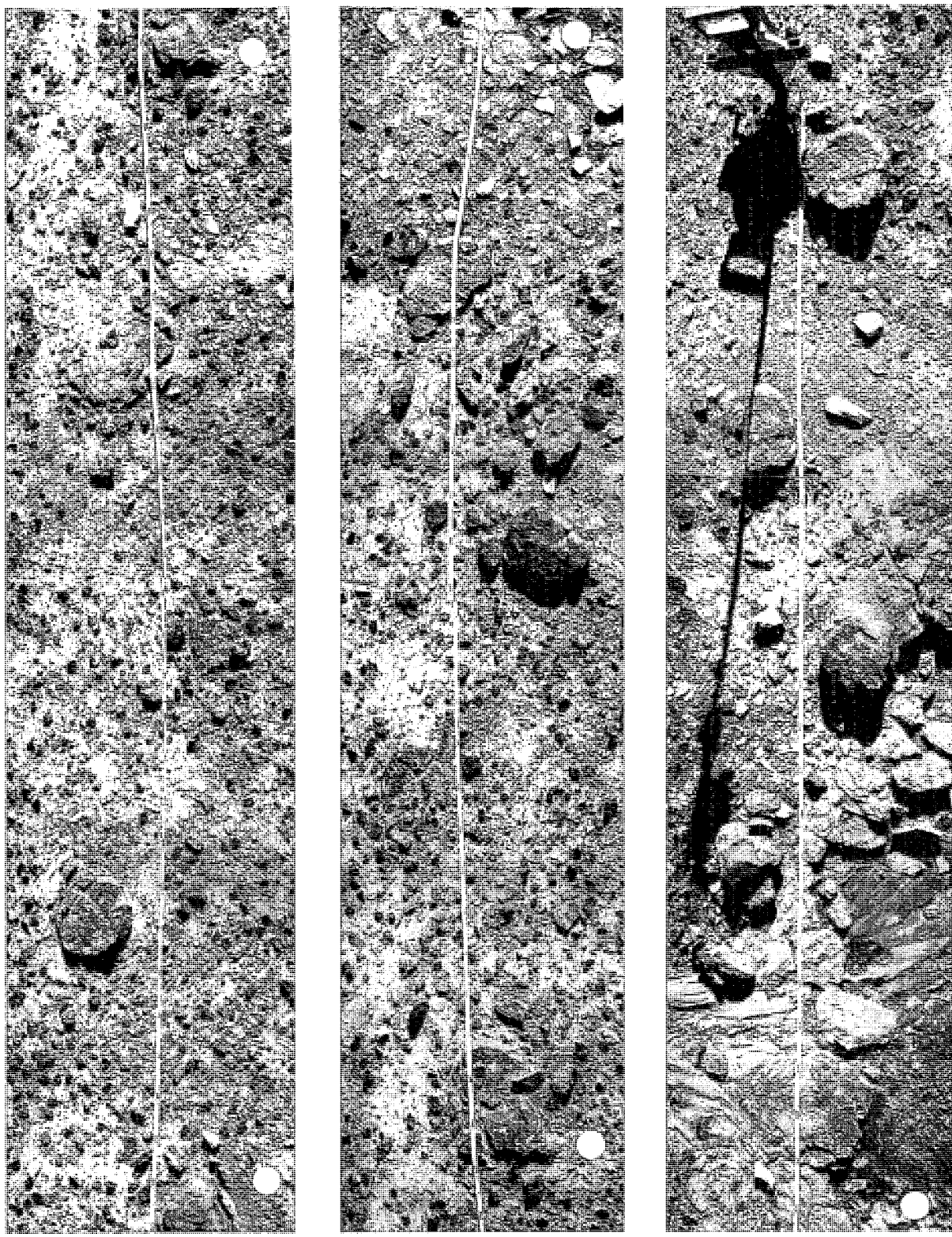
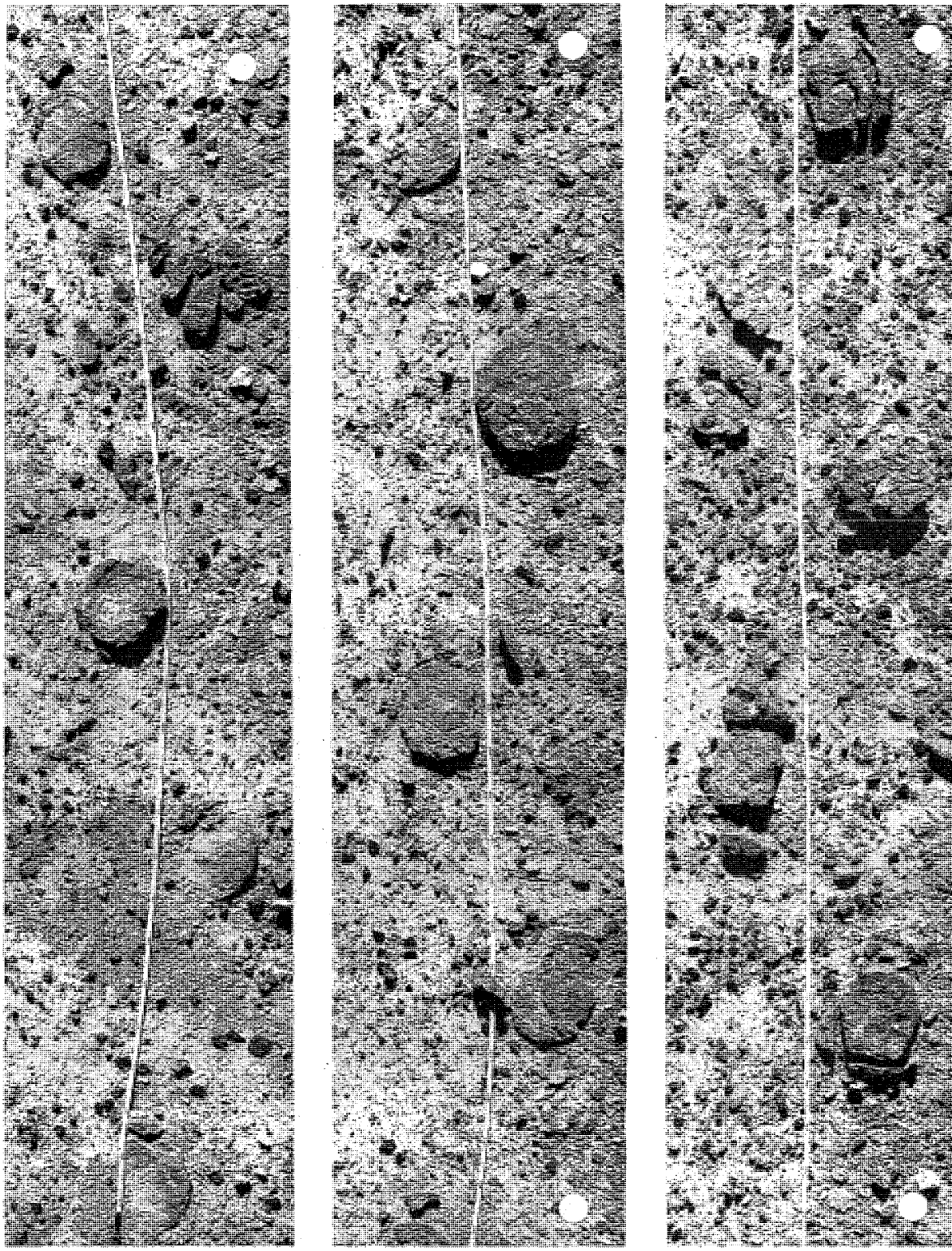


Figure 1. The geological section in the Uinta Formation at, and up section from, the footprint site.



PLATES 2–3

The footprint plaques in sequence, from northeast (lower left corner, pl. 2) to northwest (upper right corner, pl. 3); in vertical view. (Twenty six of the twenty eight casts are shown.) The yellow dots indicate the positions of overlap of the strips; the dry creek bed is seen at right on plate 3. (Photos: Alden H. Hamblin).



Uinta. The sediments are time-transgressive from east to west, the Lower Member being younger in the western exposures (Bryant, et al., 1989). The streams were flowing from east to west (Stegner, 1941; Bruhn, Picard and Isby, 1986: Hamblin, 1987); as Lake Uinta dwindled, they traversed an increasing breadth of mud-flats and delta plains to reach the ever-smaller remnant of the lake. Lake sediments, equivalent in time to eastern fluvial sediments, were included as part of the Uinta Formation by Dane (1954, 1955). Bryant, et al., (1989), however, reassigned these lacustrine sediments (which are of sandstone and limestone facies) to the Green River Formation.

The sediments exposed at the track site are characteristic of the Uinta Formation: they comprise interbedded claystones, mudstones and sandstones (Fig. 1). Some of the sandstones are thin-bedded, but massive, lenticular channel sandstones also occur. According to the log of the well adjacent to the track site (Insearch Corpn. 1, pers. comm. to AH), the top of the well is at an elevation of 1,600 m [5,250 ft.], while the top of the Green River Formation was encountered at an elevation of 1,430 m [4,700 ft]. The track site is thus at approximately 170 m [550 ft.] above the base of the Uinta Formation, within Peterson's unit B (B_1 of Osborn)—the Wagonhound Member of Wood (1934), the Lower Member of Bryant, et al., (1985).

THE FOOTPRINTS

The trackway comprises a series of 28 roughly circular plaques of ferruginous sandstone (some of them whole, others broken as consequence of erosion after exposure), forming a slightly curving line from southeast to northwest (Pls. 1–3; Fig. 2). At the southern end, the series is traversed by a wash, two of the plaques being loose but still in position (Pl. 3, center and right). In the middle part of the series, their degree of burial in the clay was variable, some being partially buried, some sitting directly on the clay surface, and some standing upon a low mudstone pedestal (Pl. 2, center and right; Pl. 3, left). At the northwestern end, the two plaques originally noticed were partially buried; digging revealed three further plaques, one broken, before the series passed from view beneath the surface. The position of the tracks is indicated on the sketch map (Fig. 3). It is possible that deeper excavation might reveal further plaques, but this has not been attempted.

The series of plaques represents casts formed within the footprints of a hoofed quadrupedal mammal. The exact shape of the plaques varies, but, while their southeastern margins approximate to a half-circle, their northwestern margins present a more rounded-conical outline, comparable to the backs of the footprints of living rhinoceroses (Walker, 1981, p. 128–129). It is considered that these were footprints of an ungulate having short, broad hooves, though the plaques did not allow differentiation of the hooves. If this interpretation is correct, then the trackmaker was progressing from northwest to southeast.

All the plaques were large, though the dimensions of some have been reduced by erosion of the margins subsequent to exposure. Because of the fragmentation of some plaques, accuracy in measurement is impossible in many instances; the measurements that follow are necessarily subjective. Even so, it appears that two size modes are exhibited, corresponding presumably to fore and hind feet. The smaller impressions—presumed to be forefeet, since the forefeet of most ungulates are smaller than the hind feet—are exemplified by that at upper left on Plate 2; they have a length of ca. 21.5 cm [ca. 8.5 in.] and breadth of ca. 17.5 cm [ca. 7 in.] (average of nine well preserved plaques). The larger impressions—the presumed hindfeet—are exemplified by that at upper centre on Plate 3; they have a length of ca. 24.5 cm [ca. 9.6 in.] and breadth of ca. 18.5 cm [ca. 7.3 in.] (average of ten well-preserved plaques). The thickness of the casts is up to 10 cm [4.3 in.], indicating an implantation into quite deep mud. The two footprint modes appear to alternate in pairs, a pattern characteristic of an animal running at moderate speed (cf. for example Rezendes, 1992, Fig. 3.69); however, the depth of the mud makes such a gait improbable and we cannot rule out the possibility that, in some instances, successive footprints were superposed.

The consistency of the animal's gait varied, as would be expected upon such a substrate. This is shown by changes in stride length, in step and pace angulation and, in particular, by the form and backward-sloping face of the cast at middle right on Pl. 2, suggesting that the right forefoot had slipped. The trackway is narrow, with an external width of ca. 50 cm [ca. 20 in.]. The step—the distance between the left and right feet in a pair—averages around 67 cm [26 in.]; the stride—the distance between the impressions of the same foot—is around 2.3 m [2.5 yd.]. The pace—the distance between one setting-down of a left or right foot and the next setting-down of the opposite foot—is ca. 1.6 m [ca. 1.75 yd] and the pace angulation (left, right, left or vice versa in the same pair of feet) is high (up to 167°). All these measurements suggest a highly mobile quadruped.

Since the footprint series is very vulnerable to vandalism or accidental destruction, it is to be collected and placed on display at the Utah Field House of Natural History in Vernal.

The variable nature of the sediments at the footprint locality (Fig. 1) indicates a region of rapidly changing conditions. When the footprint site is viewed from the nearest high spot—the bluff of red-brown sandstone at lower right in Fig. 3—something of the topography of Uinta times may be visualized. Lateral changes in sediment character indicate the position of two ancient stream

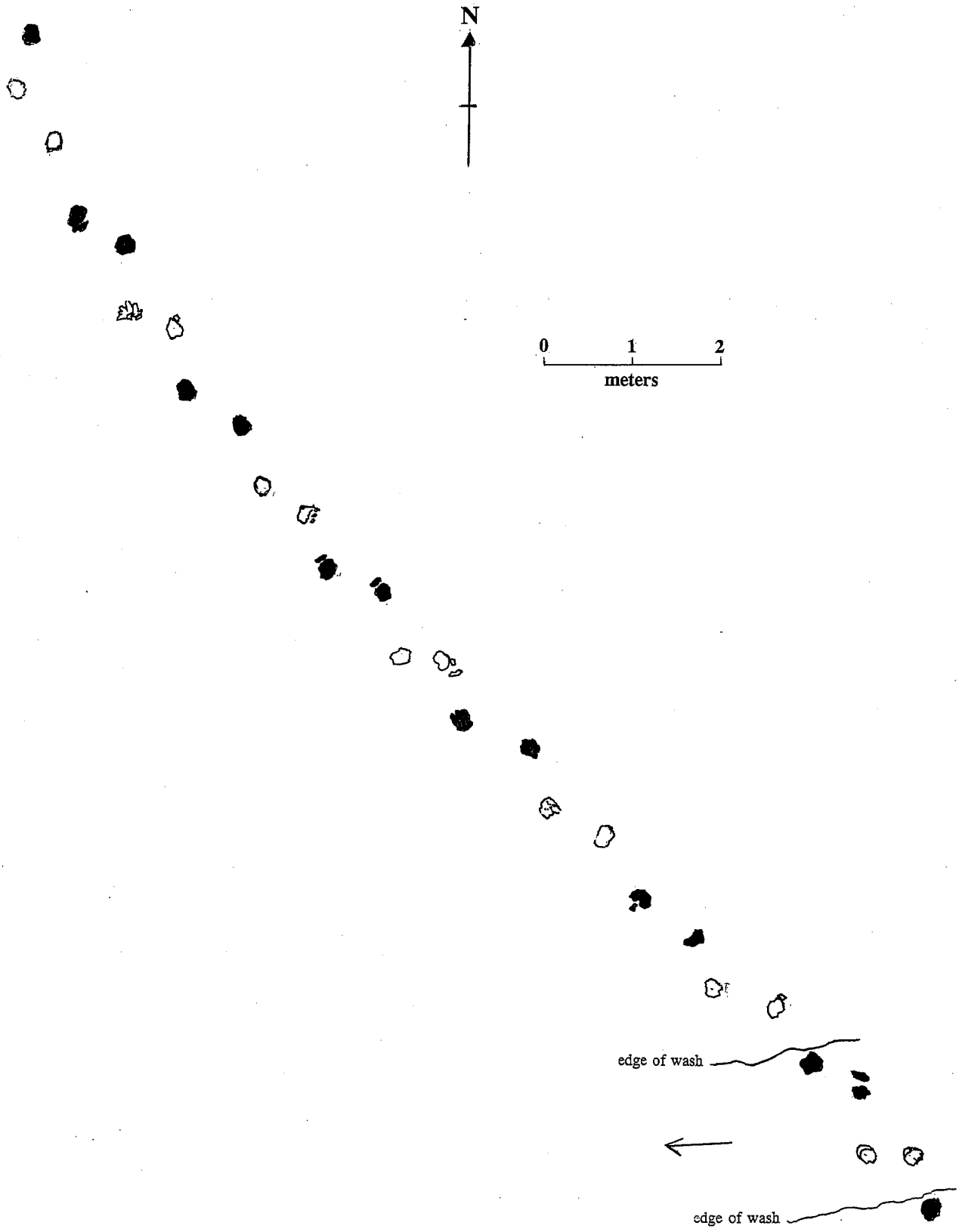


Figure 2. The pattern and direction of the track. Black shading indicates the larger casts (the presumed hindfoot impressions).

channels, one to the southeast of the tracks (just south of the present southern wash) and one to the northwest, close to the position of the present more northerly wash. The trackmaker appears to have been progressing quite briskly across a mudflat between these streams, at a time before the mud dried out and well before the flash flood that brought down the ferruginous sands to fill in its footprints. After a further interval, there must have been a second flooding event that eroded and removed the greater part of the sand, leaving only the footprint casts, and a limited amount of fragmental debris, to be incorporated into the base of the clay subsequently deposited.

A NAME FOR THE TRACKS?

The first discovery of fossil footprints in the Uinta Basin was made by Quey Hebrew of Shell Oil Co. in 1956, at Timber Creek in southeastern Wasatch County. They consisted of bird tracks and were situated within the Green River Formation, probably in the upper part of the Parachute Creek Member (Ray, Kent and Dane, 1956: Curry, 1957). By the time of the first published report of the discovery (Curry, 1957), the tracks of small reptiles and a single ungulate footprint (exhibiting three clear hooves of almost uniform size) had also been discovered. No suggestion was made as to the affinity of the latter.

Fossil footprints of size and overall outline comparable to the plaques here described have been reported from the Late Eocene (Chadronian) of west Texas by the second author (*Apoxypus tesselatus* Sarjeant and Langston, 1994, p. 36–37, Pl. 21, text-Figs. 35–37). They were considered probably the footprints of tapiroids. However, the manual impressions showed not three hooves, but four (II to IV); the hooves all have distinct points and the palm and sole impressions are much subdivided.

Another footprint type somewhat similar to the plaques was reported by Chaffee from the White River Oligocene of Wyoming (1943, Pl. 1, Fig. 2) and attributed to a member of the Family Rhinocerotidae. However, the three hooves were broader and asymmetrical, so the comparison is not close.

It appears, then, that these footprint casts are of novel character and potentially attributable to a new ichnogenus. There is precedent for naming tracks of equally simple morphology: Casamiquela (1974), for example, recorded almost ovoid imprints from Argentina and, after demonstrating the likely nature of the trackmaker, named them *Megatherichnium*, while Aramayo and Bianco (1987) employed similar arguments in characterizing two other footprint types of very simple morphology as *Neomegatherichnium* and *Mylodontidichnium*. However, it is a procedure that we deprecate, since it may result in imprints of comparable morphology being placed in the same ichnogenera, even when it is known that the name implies a wholly improbable trackmaker. (For an example, see Sarjeant and Langston, 1994, p. 3, 41). Consequently, we do not think it appropriate to give a new name to the footprint casts here reported, since we do not consider them to furnish adequate details to justify such a procedure.

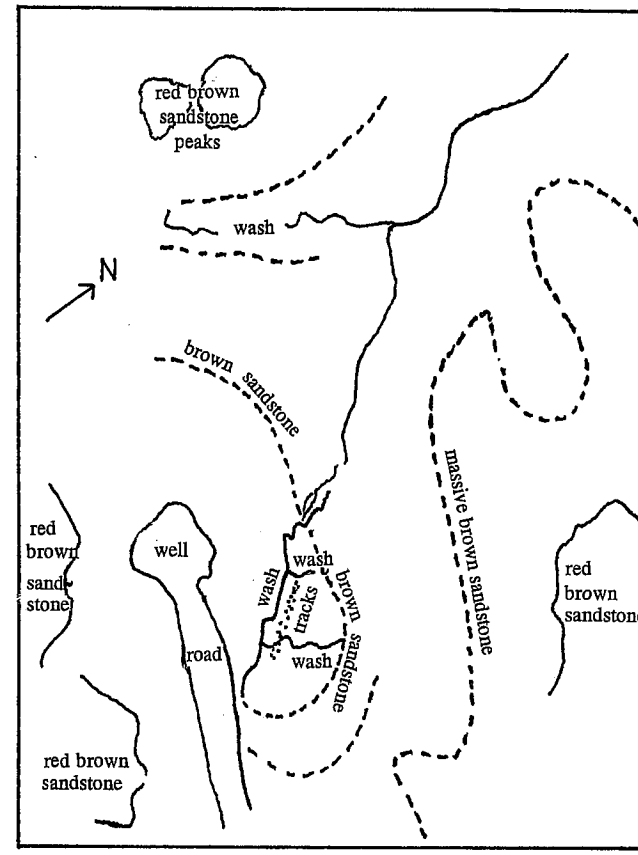


Figure 3. Sketch map of the region where the tracks were found. Not to precise scale.

POSSIBLE TRACKMAKERS

The animal making the tracks was, we believe, a herbivore, plantigrade to semiplantigrade in gait, having three hooves closely set and of fairly uniform size. The trackmaker was certainly of large size, with a narrow trackway and quite long stride.

Most, if not all, the osteological remains of large mammals in the Uinta Formation have come from the eastern (Coyote Basin, Kennedy Holes and Bonanza areas) and central (White River Pocket and Myton Pocket) parts of the Uinta Basin. The nearest documented Uinta fauna is the Myton Pocket fauna, 16 km [10 mi.] northeast of the track site. However, the Myton Pocket is 830.5 m [2,725

ft.] above the base of the Uinta Formation (Hamblin, 1987), in the lower part of the Myton Member (the Upper Member of Rowley, et al., 1985).

Recently, several small mammal bones (in addition to the remains of turtles and crocodilians) have been collected from the vicinity of the track-site, but these have not yet been identified to determine a correlation with Uinta faunas further east. No bones of large mammals have so far been found near the track-site. However, as mentioned earlier (p. 10), the Uinta Formation is time transgressive from east to west (Bryant, et al., 1989; Prothero and Swisher, 1992). Consequently, large mammals of the Uintan Fauna, from sites higher in the Uinta Formation in the eastern Uinta Basin, deserve to be considered as possible trackmakers.

There were a number of large hoofed mammals walking around during Middle and Late Eocene time when the Uinta Formation was being deposited. Most of these belong within the Order Perissodactyla. Brontotheres from the Uinta "B" horizon include *Dolichorhinus, Eotitanotherium, Rhadinorhinus* (Prothero, 1996) and *Protitanotherium* (collections of the Utah Field House of Natural History, Vernal, Utah). Several species of the amphibious rhinoceros *Amynodon* are also found in Uinta "B" (Prothero, 1996). As far as is known, all the animals listed above could fit the size range for the tracks. All had four toes on the manus and three on the pes, which would create a bimodal pattern if the tracks were not superimposed.

Other perissodactyls known from the Uinta Formation include the chalicothere *Eomoropus,* tapiroids and horses. *Eomoropus* would not have left comparable impressions, while the tapiroids and horses all appear to be too small to have made such tracks.

Since the nature of its feet is unknown, the mesonychid *Harpagolestes* cannot be ruled out as trackmaker, though one of us considers it likelier to have made footprints of *Corymbipes* type (Sarjeant and Langston, 1994, p. 31, 33–34). As for the uintatheres of that time (*Uintatherium* and *Eobasileus*), their five-hooved feet would be expected to make a broader imprint; though again, they cannot be ruled out (juvenile uintathere tracks might be considered more likely).

In summary, then, it seems likely that the trackmaker was a perissodactyl, possibly an amynodont or bronthothere. Much more information concerning the manual and pedal structure of the Uintan ungulates, and better track preservation, is needed before this hypothesis can be properly tested.

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