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AN INTRODUCTION TO THUNDERBIRD FOOTPRINTS AT THE FLAG POINT PICTOGRAPH-TRACK SITE: PRELIMINARY OBSERVATIONS ON LOWER JURASSIC THEROPOD TRACKS FROM THE VERMILLION CLIFFS AREA, SOUTHWESTERN UTAH

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Abstract—The Flag Point Track Site, Vermillion Cliffs, SE Utah, reveals dinosaur footprints and nearby pictographs that provide convincing evidence that Native Americans depicted theropod dinosaur tracks that they must have observed in the Lower Jurassic Kayenta Formation and other geological formations in the region. However, despite being locally well-known and much-photographed, the track site has never been mapped or described. We herein offer a brief description of the tracks (*Eubrontes* and *Kayentapus*) and their stratigraphic context, that reveal a theropod-dominated assemblage typical of the upper part of the Kayenta Formation throughout much of southern Utah. Reported occurrences of track sites at the top of the Kayenta Formation suggest a regionally-extensive track-bearing zone or megatracksite at this level throughout much of southern Utah.

INTRODUCTION

The Lower Jurassic Flag Point Track Site, exposed near the top of the Vermillion Cliffs, east of Kanab, Utah (Fig. 1), is well-known, but has hitherto remained undescribed. However, it was briefly mentioned by Stokes and Bruhn (1960) and has been noted in a number of disparate publications, including those arising from official surveys of the Grand Staircase-Escalante National Monument (Hamblin, 1998; Foster et al., 2000). For example, Hamblin and Foster (2000, fig. 6) published a photograph of the site. A similar photograph of the site, accompanied by a photographs of one of the clearest footprints, the stratigraphic section, and an interesting pictograph of an "obvious" three-toed dinosaur track were used as a montage for the cover illustration of the January, 2001 issue of the journal *Utah Geological Survey Notes* (Allis, 2001). Similar photographs were used for a poster advertising Utah Prehistory Week (2006) sponsored by a dozen federal, state, and local agencies, including the Bureau of Land Management (BLM) and the National Park Service (NPS).

Hamblin and Foster (2000) noted four discreet Flag Point track sites that collectively yielded the theropod dinosaur tracks *Grallator*, *Eubrontes* and *Kayentapus*, as well as tracks labeled "?*Anomoepus*." They designated the best-known site, previously noted by Stokes and Bruhn (1960), as the "Flag Point Track Site." and the others as Flag Point II-IV. For consistency, we use this same designation. Despite the evidence that there are many sites in the area, and that the main site is well-known, none have been described in detail. The purpose of this paper therefore is to provide a preliminary summary of the main "Flag Point Track Site" which is locally famous and situated in a track-rich region that has yielded other significant sites, some of which are described elsewhere in various papers in this volume. The Flag Point Track Site has also been described by Thybony (2002) in a popular article and mentioned by Adrienne Mayor, the foremost expert on fossil legends (Mayor and Sarjent, 2001; Mayor, 2005). A photo of the dinosaur track pictograph site was also included in a popular book by Sadler (2005).

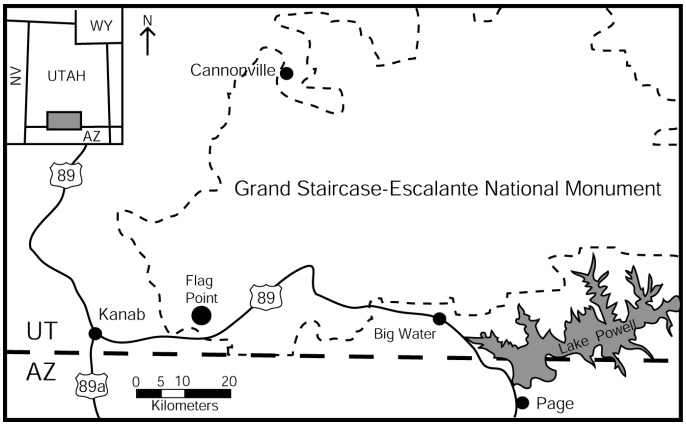

FIGURE 1. Locality map showing general location of Flag Point, about 25 km east of Kanab, Utah.

GEOLOGICAL SETTING

As shown in Figures 2-3, the Flag Point Track Site is situated at the top of the Vermillion Cliffs, very close to the contact between the Kayenta Formation and the overlying Lamb Point Tongue Member of

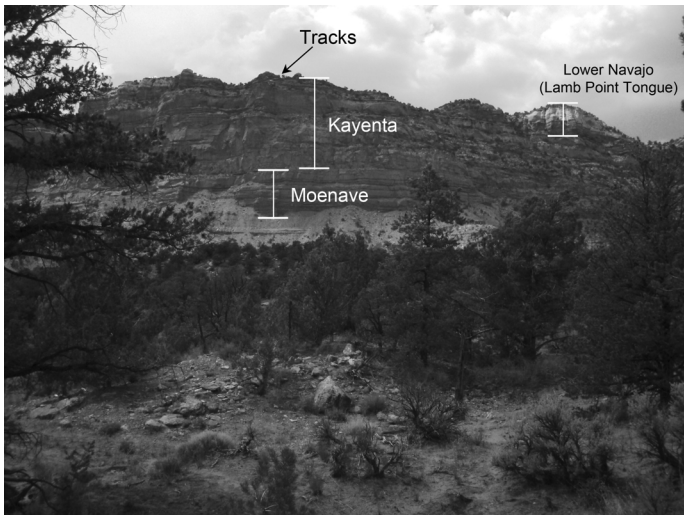

FIGURE 2. Photo of the Vermillion Cliffs looking north and showing the approximate location of the Flag Point Track Site. Access is by foot along steep, unmarked paths. The cliff is approximately 250 m high and comprises much of the Glen Canyon Group above the Chinle Formation (lower slopes hidden behind vegetation). Approximate boundaries of the Moenave, Kayenta and Navajo formations are marked. The white Lamb Point Tongue represents only the lower part of the Navajo Sandstone.

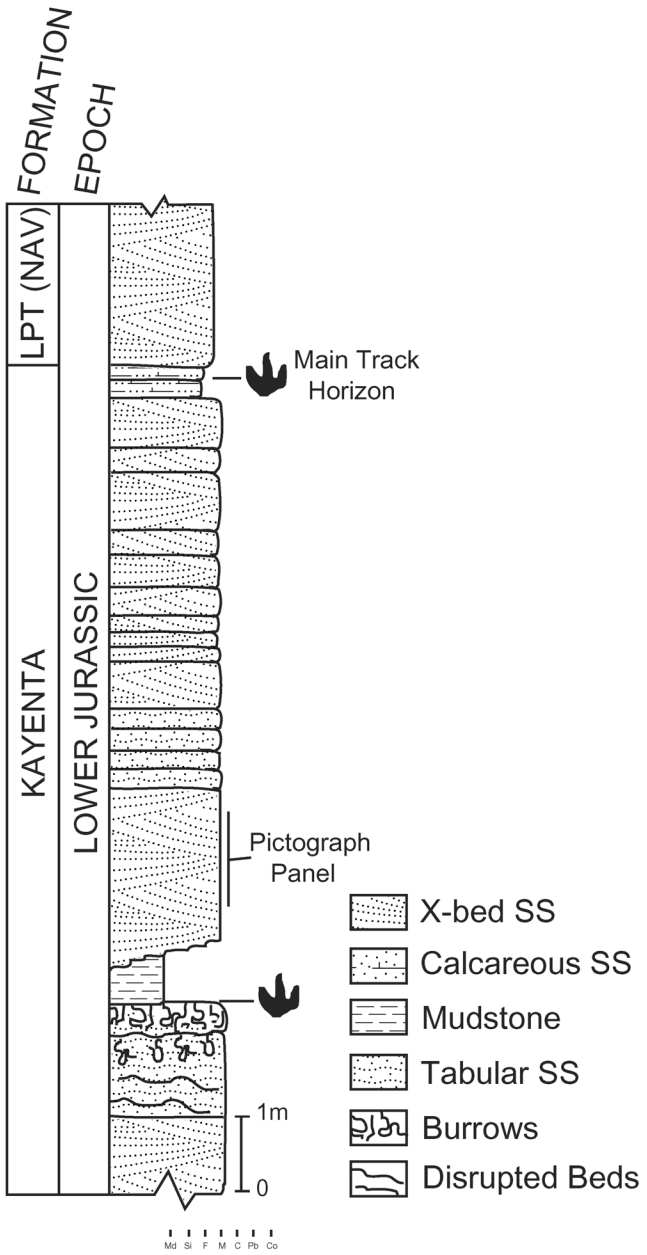

FIGURE 3. Detail of stratigraphic section showing the location of the main Flag Point Track Site at the boundary between the uppermost part of the Kayenta Formation and the basal member of the Navajo Sandstone (NAV). LPT = Lamb Point Tongue member.

the Navajo Sandstone (Averitt et al., 1955; Bush, 1983; Biek et al., 2000; Billingsley et al., 2002). The Lower Jurassic sequence in the study area consists of the Glen Canyon Group, divided into, in ascending order, the Moenave, Kayenta, and Navajo formations. Total thickness of Lower Jurassic rocks is around 830 meters, with the bulk of that thickness in the Navajo Formation (Doelling and Davis, 1989). The entire succession, including the track interval, is non-marine and dominated by reddish-colored mudstone and sandstone strata of eolian and fluvial origin. Track horizons occur consistently in the area below the contact of the Kayenta with the Lamb Point Tongue of the Navajo Formation, with the most extensive occurrence in a widespread carbonate rich siltstone of possible playa origin.

Tracksites are evidently abundant at this horizon at many locations in southern Utah. For example, Lockley and Hunt (1995) record sites at this level in the Moab area, and recently many sites have been recorded at this level in the Lake Powell area (Lockley et al., 2005). As noted in several papers elsewhere (Hamblin et al., this volume, Lockley and Gierlinski, this volume) there is growing evidence for regionally extensive tracksites or megatracksites at inter-formational boundaries in the Glen Canyon Group and other Mesozoic units in the greater Colorado Plateau region.

TRACK AND TRACK SITE DESCRIPTION

As shown in Figures 4 and 5, the Flag Point Track Site is easily identified by a prominent trackway of a large tridactyl theropod oriented WNW. This is the largest trackway at the site (number 1 in Fig. 5) with a pes length of about 44 cm and a step length of 155 cm (Table 1). There are at least 35 identifiable tracks in the mapped area and many others have been located at the same horizon both to the east and west. These other mapped tracks have been resolved into a minimum of 12 measurable trackways ranging in foot length from 27 to 40 cm (mean 34.9 cm) with a corresponding range of steps from 118 to 155 cm (mean 125 cm).

With the exception of trackway 1, all footprints are tentatively assigned to *Eubrontes*. Olsen et al. (1998) used the fairly arbitrary length of 25 cm to distinguish smaller *Grallator* from larger *Eubrontes*. This same size constraint was used by Thulborn (1990) to distinguish large from small theropods. Such differences are of dubious taxonomic significance, but nevertheless provide a rule of thumb that has been used by vertebrate ichnologists. It is well-known that *Grallator* and *Eubrontes* are very similar and there is little consensus on how they can be consistently distinguished (Olsen et al., 1998; Lockley, 2000). Nevertheless, *Grallator* is usually a narrower track in which the anterior toe extension of digit III beyond digits II and IV is more pronounced than in *Eubrontes*. According to Weems (1992), this anterior toe extension characteristic also helps to distinguish a third ichnogenus (*Kayentapus*) from *Grallator* and *Eubrontes*. Trackway 1 at the Flag Point Track Site is *Kayentapus*-like, and quite similar to *K. soltykovensis* from the Early Jurassic of Poland, Sweden and Hungary (Gierlinski, 1991,1996; Gierlinski and Ahlberg, 1994) in having wide digit divarication. The Polish *Kayentapus* samples from Soltykow reach the similar size like those in the trackway 1 (Gierlinski et al., 2004).

We have considered the possibility that this *Kayentapus*-like trackway (# 1) shows wider digit divarication and shorter digit III toe extension due to preservational factors or individual variation. However, this does not alter the fact that *Kayentapus* is a valid ichnogenus that has been widely recognized (Welles, 1971; Weems, 1992; Gierlinski, 1996; Gierlinski and Pienkowski, 1999; Lockley, 2000; Mietto et al., 2000; Gierlinski et al., 2004; Piubelli et al., 2005). Further study is required to

FIGURE 4. Photograph of the main Flag Point Track Site *sensu* Hamblin and Foster (2000). Compare with Figure 5.

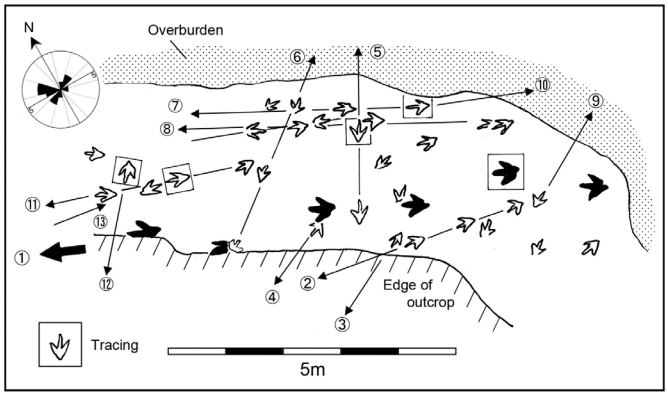

FIGURE 5. Map of main Flag Point Track Site showing at least 37 footprints comprising a minimum of 13 measurable trackways. Compare with Figure 4. Trackway orientations show in rose diagram top right. Large *Kayentapus*-like trackway (#1) shown in black. Tracks shown in squares correspond to tracings shown in Figure 6.

TABLE 1. Measurements for theropod dinosaur tracks from the Flag Point Track Site. Note that the mean stride is not calculated due to the small size of the sample of reliable stride measurements. Hip ht = hip height, estimated as foot length x 4.

Trackway #	Length (cm)	Width (cm)	Step	Stride	Hip ht
1	44.0	40.0	155.0	335.0	176.0
2	30.0	25.0	101.0	-	120.0
3	29.0	24.0	-	-	116.0
4	32.0	24.0	115.0	-	128.0
5	40.0	28.0	140.0	-	160.0
6	33.0	25.0	125.0	254.0	132.0
7	36.0	25.0	121.0	-	144.0
8	33.0	25.0	118.0	-	132.0
9	27.0	18.0	-	-	108.0
10	(35.0)	30.0	128.0	-	(140.0)
11	37.0	28.0	122.0	245.0	148.0
12	40.0	31.0	-	-	160.0
13	37.0	29.0	-	-	148.0
Mean	**34.9**	**27.1**	**125.0**	**-**	**139.4**

show the extent to which it differs from *Eubrontes*.

Hip height, based on estimates of 4 x foot length, fall in the range of 108-176 cm. Corresponding stride lengths suggest that all the trackmakers were walking at relatively slow speeds. Trackway orientations are variable but loosely concentrated about a bimodal E-W axis with a slight dominant trend towards the WNW.

INTERPRETATION OF THE PICTOGRAPHS

The Flag Point Track Site reveals a striking pictograph of a tridactyl dinosaur track on a vertical rock face below the main tracksite (Fig. 7). The pictograph shows a footprint about the same size as the average tracks. Its shape is very realistic, and actually shows wide digit divarication, more like *Kayentapus* than typical *Eubrontes*! The artists who drew these pictographs could not have missed seeing the dinosaur tracks, and we must assume that their depictions were accompanied by their own, unknown interpretations of the significance of the tracks.

According to Thybony (2002), the dinosaur track pictograph (Fig. 7) can be described as "the central figure of this rock art panel…a three-toed track painted red, about a foot long, and instantly recognizable. It clearly depicted one of the fossil tracks…seen above." Thybony (2002) suggests that "this ancient pictograph must be the oldest known recording of a dinosaur footprint in North America." It is one of more than 75 pictographs on the panel, and is clearly associated with two lines of figures on both sides of the track pictograph (Fig. 7). These figures number at least eight on each side of the track depiction and face towards the track with arms raised as if venerating it. The pictographs are probably of "Puebloan Cave Valley style." Thybony (2002) cited rock art expert Mary Allen for this opinion, which is at variance with the suggestion of Sadler (2005) that the pictograph can be attributed to " Fremont Indians." Puebloan culture began around 750 A.D. (Pueblo I phase) and continued through phases II-V beginning around 900, 1150, 1350 and 1600 A.D., respectively. The pictographs may represent the Pueblo II phase (900-1150: Marietta Eaton personal commun., 2006). In general, Fremont culture (450 -1350 A.D.) was distinct from Puebloan culture, despite overlap in time.

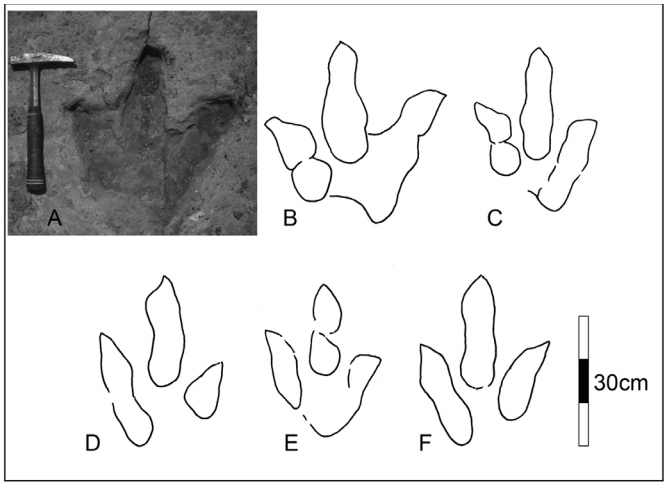

FIGURE 6. Detail of tracks from the main "Flag Point Track Site." **A** and **B**, Photo and tracing, respectively, of footprint from trackway 1. **C-F**, Tracings of tracks from trackways 7, 5, 11 and 12, respectively. See Figure 5 for location of footprints.

FIGURE 7. Photograph of pictograph of tridactyl dinosaur track located below main trackside. Note figures on either side, with hands raised as if in veneration. See text for discussion.

As noted by Thybony (2002), a dinosaur tracksite to the southeast (Irby, 1995) has the name "tsidii nabitin," which is Hopi for "bird tracks" and has been interpreted as the spoor of Kwaatoko, a powerful "man-warbird" or thunderbird, which had significance in various native American cultures (Cushing, 1981). It is outside the scope of this paper to discuss the possible significance attributed to these pictographs by the unknown artists who drew them. Such speculation would likely be highly conjectural. However, the Flag Point dinosaur footprint pictograph does seem to be a rare example of a large dinosaur track depiction closely associated with obvious dinosaur tracks, and distinct from small bird track depictions that occur on various panels that are not in known association with dinosaur trackistes (Thybony, 2002). A similar example of a large three toed track depiction in association with dinosaur tracks was recently documented by Ellenberger et al. (2005) from Lesotho.

This southern African example, attributed to the "San" bushman culture is also a pictograph that shows a three toed track facing downward. A European example of the dinosaur track association with rock art came recently from the Holy Cross Mountains in Poland (Gierlinski and Kowalski, this volume)

DISCUSSION AND CONCLUSIONS

The Flag Point Track Site is typical of many Lower Jurassic track sites in the Glen Canyon Group, which are heavily theropod dominated. Most reports of sites from fluvial facies of the Kayenta Formation show a dominance of *Eubrontes* and *Grallator* tracks, and indeed these tracks also dominate both the underlying and overlying formations (Moenave and Navajo, respectively) except in eolian facies. As noted above, the identification of *Kayentapus* has been the subject of debate (Weems, 1992; Gierlinski and Pienkowski, 1999; Lockley, 2000). Nevertheless, we consider that the main trackway (#1) more closely resembles *Kayentapus* than typical *Eubrontes*. Until a comprehensive study of the variation of digit divarication and toe extension in theropod tracks is undertaken, the ichnotaxonomic significance of such variation will remain obscure.

A significant conclusion that has not previously been explicitly stated is that the site is representative of a track-rich zone associated with the top of the Kayenta Formation. Not only did Hamblin and Foster (2000) report four Flag Point track sites that provide evidence that track distributions at this level can be mapped locally in the immediate vicinity of the Flag Point Track Site, but there is also growing evidence that these sites form part of a far more regionally extensive track zone or megatracksite.

We stress that this study is preliminary and purely descriptive. By mapping the site and obtaining basic size frequency, step, stride and trackway orientation data, we provide a few basic parameters that allow this site to be compared with others from the Glen Canyon Group described elsewhere.

The site is of special interest because of the close association of dinosaur tracks with a striking track pictograph. This evidently shows that at least one Native American culture, probably an early Puebloan phase, recognized these tracks and incorporated realistic depictions into their rock art.

ACKNOWLEDMENTS

We thank Marietta Eaton (Bureau of Land Management Office, Kanab, Utah) for her help with access to literature and her suggestions about the likely age of the pictographs. Jerry Harris (Dixie College, St. George, Utah) and Spencer Lucas (New Mexico Museum of Natural History and Science) provided helpful and prompt reviews of this manuscript.

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