Recent exploration in the Capitol Reef National Park (CRNP) and Glen Canyon National Recreation Area (GCNRA) has revealed new sites of terrestrial and subaqueous vertebrate traces and is the oldest and most laterally extensive megatracksite surface documented in North America. Two different vertebrate track types (Chirotherium) and (Rhynchosauroides) and rare fish fin drag marks (Undichna) have been identified in the Torrey Member of the Moenkopi Formation (Early Triassic). Multiple vertebrate ichnological units are distinguished in the Torrey Member based on the stratigraphic occurrence of track sites within CRNP and GCNRA’s boundaries. Tracks are preserved as convex hyperreflected sandstone casts filling impressions in the underlying mudstones. Exposed tracks occur on the upper surfaces of resistant sandstone ledges where the mudstone has eroded away. The Torrey Member represents deposition on a broad, flat-lying coastal delta plain. Both nonmarine (fluvial) and marine (principally tidal) processes influenced deposition. Even-bedded mudstones, siltstones, claystones, and fine-grained sandstones containing abundant ripple marks and parallel laminations dominate lithologic types. Ichnites indicating swimming/feeding behaviors are associated with the walking trackways in CRNP and GCNRA. The water depth was sufficiently shallow to permit the vertebrates to touch the substrate with manus and pes when moving through the water.

Tracks form locally dense concentrations of toe scrape marks which sometimes occur with complete plantigrade manus and pes impressions. Fish fin drag marks are preserved with tetrapod swim tracks. In addition to vertebrate ichnites, fossil invertebrate traces of Palaeophycus and Fuersichnus, are abundant within the track bearing units. Lateral correlations of the ichnostratigraphic units identified in CRNP and GCNRA, will aid interpretations about the paleoecology of in the Western Interior during the Early/Middle (?) Triassic.

The Torrey Member of the Moenkopi Formation has been the subject of investigation for almost 50 years (Mckee, 1954; Smith et al., 1963; Blakey, 1973 and 1977; Stokes, 1980). However, these studies were more broad-based regional studies, and only recently has the Torrey Member been studied to investigate ichnological and ichnosediments on the extensive integrated track-bearing surfaces of pre-dinosaurian communities present within (Mickelson et al., 2000, 2001). Consequently, the track-bearing horizons are known to extend from west of Capitol Reef National Park and in as far south as northern Arizona. Currently, the Torrey Member vertebrate tracks are the oldest and most extensively recognized track site ever recorded.

Following the deposition of the Sinbad Member in a clear shallow sea, a change in tectonic and/or climatic conditions caused the progradation of a major delta succession into southeastern Utah. This delta complex is preserved within the track bearing horizons as a system of delta-front, and delta-slope facies. The track-bearing horizons are preserved within the delta-plan deposits.

Basal deposits of the Torrey Member include interbedded siliciclastic, dolomitic, and fine-grained sandstones that have been deposited in advance of the prograding delta. These deposits range from delta-front, and delta-slope deposits. The sequence commonly exhibits low-angle, cross-stratified sandstones with planar cross-bedding and ripple marks. Tetrapod tracks and fish fin drag marks are preserved within these deposits. The delta-plain facies includes channel deposits of large-scale, trough- and current-beded sand and mud. Tetrapod and ichnosediments are found associated with the channelized deposits and are most common in channelized sandstones. Channel deposits are also present within the fluvial-dominated reaches of the upper delta-plain. Tetrapod tracks have been identified in these channelized sandstones.

Also present are channel beds dominated by ripples in large-scale trough cross-stratification which are interbedded with sheet-beded sandstones and interbedded mudstones. The channelized deposits are large-scale with sigmoidal internal features and cross-stratified, and chevron cross-bedding. Tetrapod tracks and fish-fin drag marks are typically associated with these deposits. Small-scale horizons are common in the channelized sandstones and mudstones. These ichnological features represent the smallest delta plain expression of the sandstone-dominated Triassic.

The threefold lithofacies classification model (A) produced by Smith (1987) was adapted to describe depositional environments of the Torrey Member deltaic facies. Multiple internally consistent (B, C, D, and E) track-bearing horizons are identified within the track-bearing horizons. The ichnological information has been used to correlate the track-bearing horizons from east to west.
Peabody (1948) first described swim tracks from the Moenkopi Formation from several locations in Arizona. More recently, McAllister (1989) and McAllister and Kirby (1998) introduced criteria for identifying and describing tetrapod swim traces which indicate the presence of a fossil swim track and the body position of the trackmaker. The criteria that form the environmental interpretation should agree with the expected environmental trace fossil producers. Important differences between locomotion on land and in water can be attributed to buoyancy. In a floating animal the digits can extend farther posteriorly in the propulsive phase without impacting the water surface, and the propulsive force to be on a more horizontal plane and scrape instead of compressing downward into the sediment.

The Moenkopi tracks were originally impressed into a muddy matrix and later filled in with a fine sand. The swim tracks are elongated, striated scratch marks (produced by scales and nails) and occur laterally along their length and often on opposite sides of the tracks. These striated guides into subaerial traces formed by more typical terrestrial propulsions and demonstrate less buoyancy in the water because more shallow and digging at the trackmaker became fully buoyant. In addition, the subaerobic velocity at which the organism traversed the track is one of the criteria that the environmental trace fossil umbilical trace fossils.

Kick-off scours (C) occur immediately posterior to the traces. The sandstone cast unfilled the scour and is seen as the irregular positive relief behind the digitscapes. They represent the action of the water eddies created behind the digits as they pass close over the sediment. At the end of the propulsive phase (kick-off phase of Thulborn and Wade, 1989).

A. Chirotherium (pes)
B. Chirotherium (manus)
Chirotherium

Terrestrial Tracks, Dragmarks, and Skin Impressions for Chirotherium & Rotodactylus

Chirotherium

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Chirotherium

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Chirotherium

Rhynchosauroides

Arenicolites Paired Tubes

Rotodactylus

Chirotherium, Treise and Sarjent

Hypothetical Trackmaker: Boris (Ru. Leonardi, 1987)
Moenkopi Trace Fossil Assemblages

Invertebrate Traces

The Torrey Member of the Moenkopi Formation assemblage studied is considered herein as an example of the Glossifungites facies and commonly occurs with vertebrate swim traces. This ichnofacies has been restricted to firm but unlithified nonmarine and marine surfaces. The ichnofacies is characterized by low diversity and high density, and it is typically associated with the trackways of Rhynchosauroides, Palaeophycus, Arenicolites, and Skolithos.

The ichnogenus Rhynchosauroides is known from the Triassic of North America and Europe throughout the Triassic. It is characterized by elongate, slender trackways that are often associated with the trackways of vertebrates. The ichnogenus Palaeophycus is known from the Cretaceous of North America and Europe, and is characterized by elongate, slender burrows that are often associated with the trackways of vertebrates.

Arenicolites are very consistent in size, shape, and distance apart from each other. Interpreted as made by annelid worms. These small lacertoid footprints are generally characterized by deeply impressed manus and a faintly impressed pes. Trackways exhibit a relatively wide pattern with pentadactyl footprint relatively distant from the midline. The pes is slender and relatively longer in the pes than in the manus and both elements exhibit disarticulated claws.


References Cited

All track localities within Capitol Reef National Park and Glen Canyon National Recreation Area were identified with GPS locations, and a detailed map was provided to each park’s science research coordinator. This information allows for both local food resource management and path interpretation but also makes it possible to integrate the data into the Global Positioning System (GPS) network.