Vertebrate burrows in deposits of an eolian system, Lower Jurassic Navajo Sandstone, Moab, Utah, area, U.S.A.

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Abstract:

Two types of vertebrate burrow morphotypes are preserved in stabilized interdune and dune deposits of the Lower Jurassic Navajo Sandstone in the Moab area of southeastern Utah. The Navajo Sandstone represents the largest eolian system preserved ever known. The burrow morphologies are similar to those of the ichnotaxa *Reniformichnus* isp. (subhorizontal to inclined tunnel, simple architecture) and Fractussemita isp. (complex, multicomponent architecture). The overall architectural and surficial morphologies and comparison to other ancient and extant burrows indicates the Navajo burrows were constructed by therapsids and mammals. The burrows are associated with interdune and fluvial environments associated with large-scale bounding surfaces.

Keywords: interdune, bounding surfaces, fluvial, mammals, paleosols

Introduction

Multiple examples of vertebrate burrows (Fig. 1) were discovered along extensive bounding surfaces that cross multiple depositional environments comprising the eolian system preserved in the Lower Jurassic Navajo Sandstone (Ss) in several localities in Moab, Utah, area. Vertebrate burrow occurrences are associated with bounding surfaces that exhibit various stages of pedogenic development. Two major types of burrow morphologies are documented: 1) Simple burrow systems: subhorizontal, inclined tunnel that likely terminates in a chamber >1.5x wider than the tunnel width and 3–4x longer than the width of the chamber; and 2) Complex burrow systems: short vertical shafts and/or a subhorizontal, inclined tunnel leading to a network of interconnected long and short tunnels, some of which likely terminate in an elliptical chamber 1.5–2x wider than the tunnel width and 2x longer than the width of the chamber.

Type 1 burrows: *Reniformichnus* (Fig. 1A, B)

Type 1 burrows are likely assignable to the ichnotaxon *Reniformichnus* isp., which represents large-diameter (~10–20 cm) burrows that exhibit subhorizontal orientation from a paleosurface with an elliptical to bean-shaped cross section containing a medial ridge in the burrow floor. Burrow walls and floors contain longitudinal scratches, whereas the burrow ceiling is often free of scratches. These features, however, are only preserved when the enclosing sediment is finer grained (siltstone and mudstone). A few of the burrows do exhibit a chamber at the termination that tends to be >1.5x wider than the tunnel width.

The Navajo Ss burrows can be placed within this burrow morphotype, with the majority of samples represented by partially preserved burrows in outcrop. The existence of a terminal chamber is currently unknown based on samples from which *Reniformichnus* was defined (KRUMMUCK & BORDY, 2017). Further exploration for additional complete specimens in areas adjacent to those outcrops may provide enough material to define a new ichnotaxon of burrow morphology that represent vertebrate behavior.

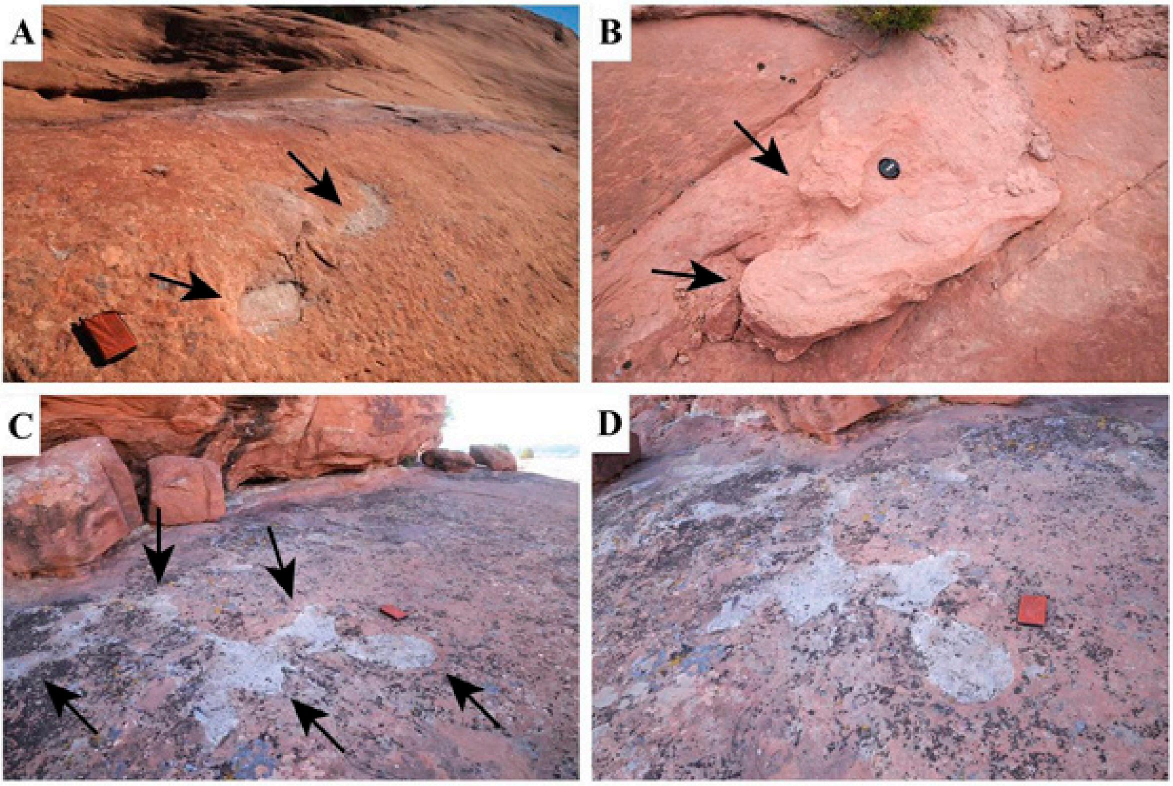

Fig. 1. Vertebrate burrows at a pedogenically modified complex surface, SFRA. Notebook 22 cm tall; lens cap 6.7 cm wide. A) Two examples of *Reniformichnus* isp. (arrows) in a moderately developed paleosol. B) Two closely occurring, different diameter *Reniformichnus* isp. (arrows) in a weakly developed paleosol; smaller burrow with medial ridge in the burrow floor; larger burrow with terminal chamber. C–D) Example of *Fractussemita* isp. (arrows) with multiple tunnels and chambers in a well-developed paleosol.

Reniformichnus in the Navajo Ss are interpreted to have been constructed by therapsids based on their elliptical, bean-shaped cross section. Similar burrow morphologies have been described from Triassic and Jurassic alluvial and fluvial floodplain deposits in Antarctica, Argentina, Poland, South Africa, and the United States (e.g., Hasiotis et al. 2004; Bordy et al. 2011; Talanda et al. 2011; Krapovickas et al. 2013). No body fossils have been found within any of those burrows, however, therapsid body fossils have been found in isolated terminal chambers in Antarctica (Sidor et al. 2008). Burrows assigned to Reniformichnus were likely used as seasonal to semipermanent dwellings to escape temperature extremes, as well as to rear young (e.g., Hasiotis et al. 2004; Bordy et al. 2011).

Type 2 burrows: *Fractussemita*

Type 2 burrows are likely assignable to a new ichnospecies of the ichnotaxon *Fractussemita* isp., which represents burrow systems composed of circular to subcircular, large-diameter (~10–20 cm) shafts (vertical orientation) and subhorizontal tunnels of low to high angle with respect to the paleosurface (Raisanen & Hasiotis, 2018). These burrow elements exhibit a variety of branching angles between 45–90° from the main tunnel and form an irregular boxwork pattern that extends several meters or more laterally in outcrop and to a depth of ~1 m. The *Fractussemita* isp. in SFRA exhibit a similar range in branching angles, but also exhibit one or more chambers associated with the burrow complex that are 1.5–2x wider than the tunnel diameter and ~2x longer than the width of the chamber. The SFRA burrows also tend to have larger diameter tunnels and shafts, do exhibit the irregular boxwork system, do not appear to contain the medial ridge on the burrow floor. They do exhibit a burrow system in which tunnels and shafts of different diameters are connected to a main subhorizontal tunnel.

Fractussemita are interpreted to have been constructed likely by mammals that exhibited some degree of social behavior, based on the complexity of the burrow system as well as the circular to subcircular diameter of the burrows. Similar burrow morphologies have been described from late

Paleozoic, Mesozoic, and Cenozoic alluvial and fluvial floodplain deposits in Antarctica, Morocco, South Africa, and the United States (see Voigt et al. 2011; Hasiotis et al. 2004). Burrows in Paleozoic deposits with similar morphology were likely constructed by therapsids or reptiles (see Voigt et al. 2011; Hasiotis et al. 2004). The SFRA *Fractussemita* burrow systems were likely the work of multiple individuals, all part of a social group. Such burrow systems required a great deal of work to construct, and maintenance was likely continuous or seasonal. Burrow networks were used for multiple purposes: protection from both predators and diurnal temperature extremes, food storage, foraging tunnels close to the surface to feed on plant roots and other soil biota, and denning to raise young.

Implications

Occurrences of the ichnotaxa *Reniformichnus* isp. and *Fractussemita* isp. in the deposits of the eolian system preserved in the Navajo Ss have several significant implications to paleoenvironmental, paleoecological, and paleoclimatic reconstructions, and the use and creation of ichnofacies. The overall architectural and surficial morphologies and comparison to other ancient and extant burrows indicates the Navajo burrows were constructed by therapsids and mammals. Both types of burrow morphologies reflect seasonal to semipermanent and permanent dwellings used to escape temperature extremes, as well as to rear young (*Reniformichnus*) and to forage and store food (*Fractussemita*), indicating abundant food, water, and stability of the local landscape to sustain the occupation populations of vertebrates in those areas. These ichnotaxa occur in association of large-scale bounding surfaces that cross dune, interdune, and fluvial environments within the Navajo eolian system, indicting a larger, more stable landscape likely produced by a shift of the climate to wetter and/or more humid conditions. This association is significant as the burrowing Navajo vertebrates did not have to contend with burial by migrating dunes across dry or wet interdune environments. The presence of lakes and rivers also indicates higher water table conditions, such that lakes produced carbonate deposits and rivers flowed through small valleys with associated floodplain deposits with the eolian system.

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