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Ant-nest ichnofossils in honeycomb calcretes, Neogene Ogallala Formation, High Plains region of western Kansas, U.S.A.

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ABSTRACT

Two new ant-nest trace fossils are described from calcic sandy paleosols of the Neogene Ogallala Formation in western Kansas. The ichnofossils are preserved within and below calcrete beds weathering in positive relief as carbonate-filled casts or as cavities in negative relief. *Daimoniobarax* ichnogenus nov. is established for burrow systems composed of vertically tiered, horizontally oriented pancake-shaped chambers connected by predominantly vertical and cylindrical shafts ~0.8 cm in diameter. Ichnospecies of *Daimoniobarax* are differentiated based on differences in the plan view outline of chambers, shaft orientation, and junctions between chambers and shafts.

Daimoniobarax nephroides ichnospecies nov. is composed of an ~24–76 cm long vertical sequence of distinctly lobed chambers (~2–20 cm wide and ~1 cm high) arranged along sinuous to helical shafts. Chamber shape in plan view ranges from small teardrops to larger kidney- and U-shaped forms. Shafts intersect at chamber edges such that chambers appear to bud from the central shafts. *Daimoniobarax nephroides* is most similar to the nests of extant seed-harvester ants of the New World genus *Pogonomyrmex*. Such ants are specialized granivores and prefer sandy soils in arid to semi-arid grassland and desert regions.

Daimoniobarax tschinkeli ichnospecies nov. is ~30–80 cm in vertical extent. Chambers (~2–30 cm wide and ~1 cm high) are circular to elongate or pseudopodial in plan view. Vertical shafts are straight to slightly sinuous and intersect most often toward the center of the chambers. The generalized architecture of *D. tschinkeli* is similar to that of the nests or nest portions of several extant ant genera, though it does not closely resemble any known modern nest.

Ant ichnofossils provide valuable information on hidden biodiversity, paleohydrologic regimes, paleopedogenic processes, and paleoclimate during the time of nest occupation. Depth-related changes in chamber size and vertical spacing may also help interpret paleosurfaces and paleodepths, and serve as geopetal features.

1. Introduction

The Neogene Ogallala Formation underlies much of the North American High Plains region and is composed chiefly of fluvial and eolian sediments consisting of interbedded conglomerate, sandstone, mudrock, loess and their uncemented equivalents (Gustavson and Winkler, 1988, 1990). In the uppermost Ogallala Formation, pedocomplexes composed of multiple calcic paleosols with honeycombed to massive calcretes can be over 10 m thick (Gardner et al., 1992). Honeycomb calcretes (Stage III of Machette, 1985) were until recently thought to develop in calcified soils by the partial coalescence of carbonate nodules and pipy concretions to form a solid lattice-like framework surrounding less-indurated interstitial soil-material (Wright, 2007). Recent fieldwork in west-central and southern Kansas shows, however, that the sizes, basic structural elements, and architectural morphologies of many of the honeycomb structures in the Ogallala Formation are nearly identical to the nests of extant burrowing ants (Insecta: Hymenoptera: Formicidae).

This paper describes the morphology and paleoecological and paleoenvironmental significance of these newly recognized multi-chambered trace fossils and their interpreted tracemaking organisms. Interest in nests of subterranean social insects, particularly those of hymenopterans and isopterans, has focused largely on how nest architecture relates to such biological, behavioral, and ecological research topics as inter- and intraspecific interactions (e.g., Boulton et al., 2003), social structure and group-level behaviors (e.g., Langridge et al., 2008), and biogenic modification of soil properties (e.g., Cammeraat and Risch, 2008). Detailed information on the three-dimensional architecture of insect nests and their distinctly identifiable characteristics, however, is often lacking in these studies (Tschinkel, 2004). Our recognition of fossil ant nests in the Ogallala paleosols is due in large part to recent efforts to document the nest

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architectures of modern ants by casting them in plaster, metal, and concrete (e.g., Williams and Logfren, 1988; Tschinkel, 2003; Moreira et al., 2004; Tschinkel, 2004, 2005; Forti et al., 2007; Verza et al., 2007; Cerquera and Tschinkel, 2010; Halfen and Hasiotis, 2010; Tschinkel, 2010). Such comparisons are possible because the trace fossils of many soil-dwelling biota do not often differ significantly from the burrows and nests of extant species (e.g., Genise et al., 2000; Hasiotis, 2003; Duringer et al., 2007; Verde et al., 2007; Smith et al., 2008a; Hembree, 2009). Ichnofossils provide valuable information on hidden biodiversity in the absence of body fossils, paleopedogenic modification and processes, paleohydrologic regimes, and paleoclimatic conditions (e.g., Hasiotis, 2007; Smith et al., 2008b).

2. Geologic setting and background

The main study area is located in west-central Kansas where up to 53 m of the Neogene Ogallala Formation is exposed along the bluffs of Ladder Creek Canyon and in tributary draws in the northwestern portion of Scott County (Fig. 1). Additional Ogallala localities were examined in Ellis and Morton counties, Kansas. The formation consists mostly of gravel, sand, silt and clay of fluvial–alluvial origin, calcareous paleosols, and eolian silt and clay; local lenses of volcanic ash and lacustrine limestones are also present (Frye et al., 1956). Individual beds often grade laterally from one lithology to another and dramatic changes in thickness and bed continuity over relatively short distances are not uncommon (Waite, 1947). Calcareous paleosols occur with high stratigraphic frequency throughout the formation and are characterized by abundant carbonate nodules, pipy concretions, root traces, and irregular lenses and beds of ledge-forming calcrete (Fig. 2; Gutentag, 1988). Fossil mammal and floral assemblages (Thomasson, 1979, 1990; Zakrzewski, 1990; Martin et al., 2008) and tephrochronologic analyses of unaltered volcanic ash beds (Perkins, 1998) suggest that Ogallala deposits in Kansas range in age from middle Miocene to earliest Pliocene (Ludvigson et al., 2009). The Ogallala Formation is up to several hundred meters thick in western Kansas, but regional thickness varies greatly because of the uneven surface upon which sediments were deposited and post-Ogallala uplift and erosion (Leonard, 2002).

2.1. Devil's Backbone locality

The best-preserved and exposed ichnofossils are located approximately 1.6 km south of Lake Scott State Park in a road cut through an east–west trending ridge of Ogallala strata called the Devil's Backbone (Fig. 1). The road cut exposes ~23 vertical meters of rock composed chiefly of tan- to reddish brown-colored, moderately sorted, silty, fine- to very coarse-grained beds of arkosic sandstone (Fig. 3). Calcium carbonate pervades the section, mostly as fine-grained cement, but also

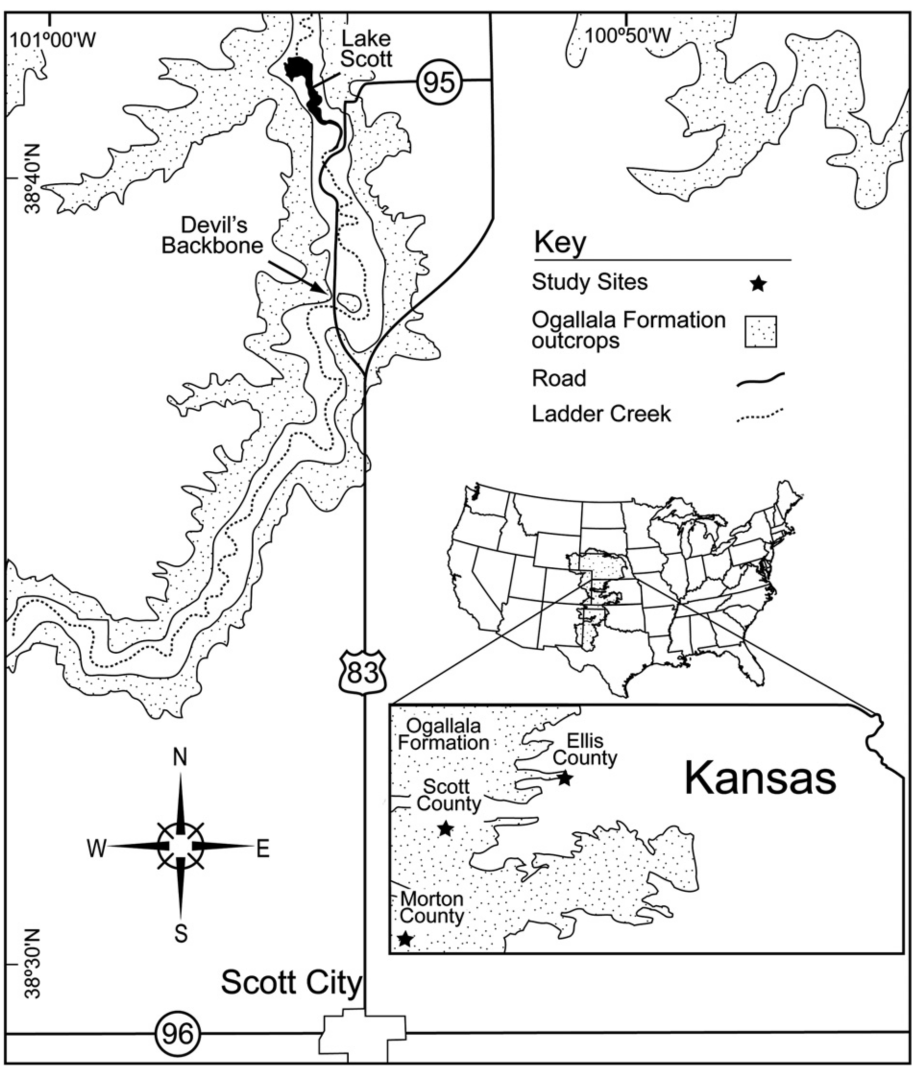

Fig. 1. Map of study area showing location of Ogallala Formation exposures and Devil's Backbone road cut in Ladder Creek Canyon, Scott County, Kansas. Inset map of Kansas shows the additional localities in Ellis and Morton Counties.