HEAVY MINERALS ADD WEIGHT TO NEOICHNOLOGICAL RESEARCH

ILYA V. BUYNEVICH

Temple University, Department of Earth and Environmental Science, 1901 N. 13th Street, Philadelphia, Pennsylvania 19122, USA
e-mail: coast@temple.edu

Vertebrate tracks offer important paleobiological and paleoenvironmental insights as indicated in the increasing number of studies of modern and fossil tracks in recent decades (Laporte and Behrensmeyer, 1980; Loope, 1986; McKeever, 1991; Platt and Hasiosits, 2008; Milán et al., 2007; and references therein). Whereas fine-grained sediments typically preserve the greatest detail, a track record of many organisms is archived in sand-rich strata representing paleo-shorelines, river banks, and dunes (Frey and Pemberton, 1986; Lockley, 1986). Despite the dynamic nature and coarse texture of sandy media (=substrates), many studies report abundant vertebrate and invertebrate tracks, from Paleozoic sandstones to Cenozoic depositional sequences (McKeever, 1991; Lea, 1996; Loope, 2006; Lucas et al., 2007). Aside from a few cursory investigations of vertebrate tracks in recent beach and dune environments, little research has focused on their distribution and preservation in unconsolidated sand-rich media (McKee, 1947; Loope, 1986; Lea, 1996). This is largely due to the difficulty of preserving the tracks and even greater challenge of detecting biogenic structures in coarse-grained sediments. New neoichnological research is underway that addresses this long-standing problem, making use of the combination of natural selective mineral sorting and the ability to image small-scale structures using geophysical techniques.

In many coastal and eolian settings, such lithological anomalies as heavy-mineral concentrations (HMCs) represent density lag formation during episodes of increased wave or wind activity (Komar and Wang, 1984; Smith and Jackson, 1990; Buynevich et al., 2007; Mange and Wright, 2007). Such lithological anomalies not only act as environmental indicators, but also accentuate vertebrate and large invertebrate tracks due to their darker color (Fig. 1; Van der Lingen and Andrews, 1969; Lewis and Titheridge, 1978; Frey and Pemberton, 1986; Neal et al., 2007). Even thin HMCs (1–3 mm) often accentuate the outlines of traces and associated sedimentary structures (Figs. 1A–B). For example, following storms, heavy-mineral concentrations may serve as distinct tracking media, which are in some way comparable to short-term omission or non-deposition surfaces. In addition, storm debris and stranded organisms provide ready food sources for scavenging birds and mammals, thereby increasing the number of traces produced on the HMC layer (López et al., 2008; Buynevich, 2010). Besides surface occurrences, heavy minerals also highlight small-scale structures in cross-section, as exemplified by a possible vertebrate track preserved in late Holocene dune strata (Fig. 1C). Image analysis of photographed exposures can be used for track analysis, although adequate sampling in unconsolidated sand remains a challenge. This can be partially overcome by in situ imaging using high-resolution geophysical techniques.

Such lithological anomalies as HMCs not only help in visual recognition of tracks, but also produce detectable signal in high-resolution geophysical instruments. This presents an opportunity for image buried tracks. Since many HMCs are enriched in such ferromagnetic and paramagnetic minerals as magnetite, ilmenite, garnet, hornblende, zircon, epidote, and tourmaline, low-field magnetic susceptibility (MS) can be used for in situ analysis of track and undertrack laminae. This method has high potential for mapping shallowly buried tracks in HMCs because of large contrast in bulk susceptibility (κ) between background quartz-rich sands and ferromag-