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Death near the shoreline, not life on land: Ordovician arthropod trackways in the Borrowdale Volcanic Group, UK

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Shillito and Davies (2019) report new specimens of arthropod trace fossils from the late Ordovician Borrowdale Volcanic Group (BVG) of the English Lake District first described 25 years ago by Johnson et al. (1994), who observed that some 'were probably made in temporarily emergent conditions'. Shillito and Davies note that the trackways have been widely cited as the earliest unequivocal evidence for animal life on land, as in Davies et al. (2010) and Minter et al. (2016), a claim that goes far beyond any made by Johnson et al. (1994). Shillito and Davies conclude that the trackways represent near-shore arthropod activity during the early Paleozoic prelude to terrestrialization, confirming the major finding by Johnson et al. (1994).

The trackways discovered by Shillito and Davies extend our knowledge of the BVG trace fossils, but their significance has diminished with clear evidence of much earlier subaerial arthropod activity, although they are still interesting as an indication of the presence of myriapods (Shear and Edgecombe, 2010; Murienne et al., 2010). Arthropod trackways from the late Cambrian to early Ordovician Nepean Formation of Ontario (Canada) were made on eolian dunes (MacNaughton et al., 2002), and molecular clock methods indicate that subaerial arthropods originated in the late Cambrian (Rota-Stabelli et al., 2013) and presumably established communities. The paucity of body or trace fossil evidence for such arthropods is no surprise: non-marine environments of this age are rarely represented (Dunlop et al., 2013; Muscente et al., 2017) and subaerial arthropod trackways have a very low preservation potential.

Shillito and Davies observe that the BVG traces occur on dacitic tuff and argue that the 'claim' of Johnson et al. (1994) that the lithology is a sandstone is incorrect, ignoring their clear statements that the sandstone is volcanogenic (i.e., sensu Pettijohn et al., 1987) and a product of redistribution of the tuffs by aqueous sedimentary processes. Shillito and Davies interpret the transition from *Diplichnites* to *Diplopodichnus* as behavioral, rather than the result of changes in the property of the substrate, citing Wilson's (2006) observation that the imprints of the successive legs of a living millipede tend to cluster when it slows down. The primary difference between these ichnogenera is that *Diplopodichnus* shows little or no evidence of imprints, regardless of spacing (Brady, 1947), a property that may reflect the nature of the sediment (see Davis et al., 2007, their figure 12). Johnson et al. (1994) observed that the BVG *Diplichnites* overlies *Diplopodichnus* when the two are superimposed, compatible with drying out of the sediment. Such a change is consistent with Shillito and Davies's observation that the sediment varied from firm to unconsolidated and that, in places, trackways were only retained on the crest of wave ripples, which were drier than troughs, thus supporting the possibility of subaerial activity (Johnson et al., 1994).

Shillito and Davies appear to favor a marine origin for the BVG trace fossils. Johnson et al. (1994) acknowledged that a paralic environment was possible, but noted the almost complete absence of marine fossils through the 6 km thickness of well-exposed BVG (Millward, 2002, 2004), over an area of ~850 km^2. Shillito and Davies concede that there is no evidence to determine the salinity of the water. A lacustrine environment for the BVG arthropods remains likely.

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