A reassessment of ichnofacies, with emphasis on those present in nonmarine strata

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In the 1960s, Adolf Seilacher observed that, within several globally selected rock sequences, certain trace fossils commonly occurred in association with one another. Where recurrent, these trace-fossil associations (ichnocoenoses) were considered, from the environmental interpretation of co-occurring physical sedimentary structures, to be diagnostic of particular marine bathymetric zones. Accordingly, these recurrent ichnocoenoses were identified as 'ichnofacies' (specifically, from deep to shallow water, the *Nereites*, *Zoophycos*, *Cruziana*, and *Skolithos* ichnofacies, though the bathymetric relationships have since been recognized to be a generalization). Regrettably, Seilacher subsequently looked at nonmarine strata and, failing to identify potentially recurrent ichnocoenoses and the plethora of nonmarine environments that actually exist, placed all the disparate ichnocoenoses within the *Scoyenia* ichnofacies.

We have attempted to correct this inconsistency first by identifying, from selected nonmarine sequences including, in particular, the Carboniferous of the Maritimes, globally recurrent ichnocoenoses, and then by equating them with various nonmarine environments through the environmental interpretation of accompanying sedimentary structures. Six categories of recurrent ichnocoenoses are considered to be present in these nonmarine strata, five of which are sufficiently recurrent for modelling as distinct ichnofacies. These ichnofacies appear to indicate particular combinations of a few major controlling environmental factors: (a) hydrodynamic energy and/or degree of desiccation of the environment; (b) substrate organic-content; and (c) the stability or predictability of (a) and, or, (b) in nonmarine environments.

The *Skolithos* ichnofacies, which is extended from the marine to nonmarine realm, remains indicative of environments of essentially continuous (i.e., predictable) high energy (or desiccation or other stressful environmental conditions), which means that the substrate would be lacking in organic detritus and frequently subject to erosion. The newly introduced *Diplichnites* ichnofacies is indicative of environments of low, generally stable hydrodynamic energy where, for whatever reasons, organic detritus does not accumulate (the ichnofacies representing environments of low, generally stable hydrodynamic energy and abundant organic detritus, equivalent to the *Zoophycos-Nereites* ichnofacies, is not well documented in nonmarine strata). The *Scoyenia* ichnofacies, as emended, reflects conditions where hydrodynamic energy is likely high but yet unpredictable (?seasonal), and the organic content of the substrate continuously low. The *Mermia* ichnofacies, as emended, is indicative of fluctuating hydrodynamic conditions that can interrupt the normal, low energy conditions where organic detritus can accumulate in the sediment. The *Cruziana* ichnofacies, also extended into the nonmarine realm, can be considered a mega-ichnofacies comprising components of several others. Fluctuations between the extremes of high organic accumulation (with low energy and desiccation), and high energy and/or desiccation (with low organic content) in the substrate would be the environmental conditions reflected by this ichnofacies.