Trace fossils: a fundamental framework and basic unit for quantifying ecosystem change

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Organisms and their environments have been interacting and modifying one another since life began. The modification of an environment by one organism such that it affects other organisms is known as ecosystem engineering and such modifications can result in long-term changes that have evolutionary consequences. Behavioral interactions between organisms and sediments are one such type of ecosystem engineering and the importance of the effects were first realized by Charles Darwin. The results of behavioral interactions between organisms and sediments are recorded as trace fossils. As yet, trace fossils are an underutilized resource for studying environmental and ecosystem change and are largely underappreciated by those outside of the ichnological community. Here, I propose that trace fossils provide us with a fundamental framework and the basic unit for quantifying such changes. Just as there are many versions of the same play with different actors, we can still identify the play by the roles that are being performed and the same is true for trace fossils in that we can characterize an ecosystem regardless of the animals present. Unlike ecological studies involving body fossils, which are often temporally and spatially restricted, trace fossils enable us to compare ecosystems through time and across environments. The application of existing methods such as cluster analysis and the development of new numerical techniques for quantifying ecosystems based on trace fossils will allow us to tackle questions relating to ecosystem engineering through time, the colonization of different environments and the recovery from mass extinctions. It will also open up the use of animal traces in modern habitat mapping. Together, these will provide insights for future challenges to society in predicting the impacts of environmental change on ecosystems and biodiversity.

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