BIOTURBATION BEYOND EARTH: POTENTIAL, METHODS AND MODELS OF ASTROICHNOLOGY

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Traces – burrows, borings, footprints – are important evidences of biological behaviour on Earth, yet they received relatively little attention in the field of astrobiology. This study aims to discuss the application of ichnology (i.e. the study of life activity traces) to the search for past and modern life beyond Earth (i.e. herein called Astroichnology).

Organisms apparently represent a more direct evidence of life than traces. Consequently, why to look for traces (and trace fossils) is a central question. The reason is fourfold:

1) the Earth's ichnological record shows that traces record accurately the activity of soft-bodied organisms – from annelids to prokaryotes – that are comparatively underrepresented in the fossil record but that constitute the most part of the benthic biomass.

2) trace fossils are commonly the only preserved evidence of life in sediments that are otherwise unfossiliferous.

3) bioturbation and bioerosion change the physico-chemical properties of the substrate and leave (bio-)geochemical, petrographic and geotechnical signals that enable to relate with the presence of life.

4) the bioturbating activity of organisms commonly results in structures that are far more abundant and more visible/detectable than their tracemakers (e.g. several arthropods produce km-scale mounded topographies in aquatic and continental environments; cm-sized organisms shaped the geochemistry of the Earth's benthic ecosystem during the Cambrian Agronomic revolution).

With increasing availability of high-resolution imagery, the search for past and modern traces is possible for several terrestrial bodies, such as the Moon, Mars, Venus, Titan and Mercury. Nevertheless, finding ichnological evidences beyond Earth is still a significant challenge because of (a) resolution issues, (b) relative paucity of bedding-plane imagery, (c) lack of core data, (d) lack of method-specific instrumentation.

For these reasons, there is a great potential for developing tools that incorporate ichnology into an astrobiological framework. Specifically, tools for the analysis of sediment and/or rock cores are needed for observing biogenically-produced sedimentary fabrics (ichnofabrics) beyond Earth. Applied ichnology provides a vast set of practical tools (i.e. CT-scanning, borehole imagery) for studying ichnofabrics.

Finally, a question might arise: What to expect? Models of bioturbation beyond Earth are extremely complex and variable due to the variety of geodynamical conditions existing on solar and exo-planets. Nevertheless, burrowing and boring behaviours are expected to be a general pattern for life because they allow to face harsh surficial physico-chemical conditions (e.g. cosmic rays) and/or evolutionary pressures, both for mineralized or soft-bodied organisms. Identifying more precisely the forms and variation of Earth's traces in extreme environments and their evolutionary paths is likely to provide a more robust predictive model for bioturbation beyond Earth.