Ichnological Criteria for Discerning High-Latitude Conditions

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Summary

High-latitude settings show predictable trends in climatic conditions that exert controls on the distributions, behaviors, and sizes in some groups of tracemaking organisms. Resolving this signal in the ancient record, however, can be challenging, owing to the complex interplay of numerous environmental parameters, few of which have been tested neoichnologically.

Cold water results in lowered metabolism and elevated life spans in some organisms, commonly leading to gigantism (i.e., Bergmann's Principle). Additionally, due to increasing gas solubility in colder waters, dissolved oxygen contents are substantially higher in cold water versus warm tropical waters. The higher availability of oxygen in cold water has been positively correlated to animal size. These factors contribute to an adaptive landscape that favor larger body size that is expressed in Timofeev's proposition that body sizes increase along a declining temperature gradient.

The distribution of trace-making animals is greatly influenced by the severe conditions of high-latitude intertidal and shallow-water environments. Intertidal settings tend to preclude crustacean-colonization, resulting in markedly reduced occurrences of *Thalassinoides* and *Psilonichnus* in high-latitude tidal flats. Therein, Polychaete-generated structures are more common. The highest biomass in high-latitude settings resides within the mid- and outer shelf, a marked contrast to low and mid-latitude settings where biomass is highest in bays, estuaries, and the inner shelf. This results in the dislocation of the *Cruziana* Ichnofacies basinwards and likely suppresses occurrences of the *Zoophycos* and *Nereites* ichnofacies. Regarding specific ichnogenera, *Rosselia* abundances and morphologic complexities are heightened in cold-water settings. *Macaronichnus segregatis* occupying "toe-of-the-beach" positions occur in high-latitude

locales, and are effectively precluded from warm-water settings. Basinward displacement of echinoids in cold water favors robust and abundant *Scolicia*.

High-latitude settings are prone to high-frequency storms, favoring multiple re-equilibration of dwelling structures. *Rosselia* show stacked mud balls and spreiten-bearing dwelling tubes, *Lingulichnus* show upward re-adjustment, and *Diplocraterion* and *Rhizocorallium* have high proportions of retrusive spreiten, recording upward mobility of the tracemakers. Continued integration of neoichnological analyses with empirical-based observations from the ancient record is essential to elucidate the high-latitude signal.