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Triassic Ichnofossils from the Fundy Basin: Early Dinosaur Locomotion and Behavioral Evolution

Dr. Nicole Patterson
Department of Geology, Dalhousie University

Prof. Mark Stevens
Institute of Ichnology, University of Alberta

Dr. Andrew MacLeod
Royal Ontario Museum, Toronto

Abstract

The Fundy Basin of eastern Canada preserves exceptional Triassic trace fossil assemblages documenting early dinosaur behavior. Analysis of 847 trackways reveals bipedal locomotion, social behavior, and size-related speed variations. Grallator and Eubrontes ichnotaxa indicate theropod diversity, while novel Atreipus tracks suggest early ornithischian presence. Biomechanical analysis supports cursorial adaptations in basal dinosauromorphs.

Keywords: trace fossils, ichnology, dinosaur tracks, Triassic, locomotion, behavior

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1. Introduction

Trace fossils (ichnofossils) provide unique insights into ancient animal behavior, paleoenvironmental conditions, and ecosystem structure that cannot be obtained from body fossils alone. The Cambrian Explosion, representing the rapid diversification of complex multicellular life approximately 540 million years ago, is documented not only by the first appearance of diverse body fossil assemblages but also by a dramatic increase in trace fossil diversity and complexity. This ichnological record reveals the evolution of animal behavior, bioturbation intensity, and sediment-organism interactions during this critical evolutionary interval. The transition from simple horizontal traces in Precambrian sediments to complex three-dimensional burrow systems in Cambrian rocks reflects fundamental changes in animal ecology and substrate relationships. Early Cambrian trace fossil assemblages document the evolution of infaunal lifestyles, predator-prey interactions, and the establishment of modern marine ecosystem structure. The ichnofossil record is particularly valuable because it preserves evidence of soft-bodied organisms that are rarely preserved as body fossils. The Wood Canyon Formation of the southwestern United States preserves exceptional trace fossil assemblages spanning the Precambrian-Cambrian transition. These deposits record the progressive colonization of marine substrates by increasingly complex animal communities, providing crucial insights into the ecological drivers of early animal diversification. This study presents a comprehensive ichnological analysis of trace fossil assemblages from the Wood Canyon Formation, integrating morphological, environmental, and statistical data to reconstruct early Cambrian behavioral evolution and ecosystem development. Our research focuses on understanding the relationship between trace fossil complexity and environmental factors, and the role of bioturbation in shaping early marine ecosystems.

2. Materials and Methods

2.1 Stratigraphic Framework and Sampling Trace fossil assemblages were systematically documented through 47 measured sections totaling 890 m of stratigraphic thickness in the Wood Canyon Formation across Nevada and California. Precise biostratigraphic control was achieved through trilobite and archaeocyath zones. Trace fossils were documented in situ with detailed stratigraphic and facies context. 2.2 Ichnological Analysis Trace fossil identification followed established ichnotaxonomic principles emphasizing morphological characteristics and behavioral interpretation. Detailed measurements included burrow diameter, length, depth penetration, and geometric complexity parameters. Bioturbation intensity was quantified using the ichnofabric index (ii) ranging from 1 (unbioturbated) to 6 (completely bioturbated). 2.3 Morphometric and Statistical Analysis Trace fossil morphological complexity was quantified using fractal dimension analysis and geometric morphometric methods. Diversity patterns were analyzed using rarefaction curves and non-parametric estimators. Assemblage composition was compared using multivariate ordination techniques including principal component analysis and non-metric multidimensional scaling. 2.4 Paleoecological Reconstruction Behavioral interpretation integrated trace fossil morphology with sedimentological and taphonomic data. Substrate consistency was inferred from trace fossil preservation style and sedimentary structures. Tiering analysis reconstructed vertical distribution of infaunal communities and intensity of substrate utilization. 2.5 Environmental Analysis Paleoenvironmental reconstruction employed sedimentological analysis, sequence stratigraphic interpretation, and geochemical proxies. Oxygen and carbon isotope analysis of associated carbonate phases provided constraints on water depth, temperature, and productivity. Storm bed analysis indicated wave base and depositional energy levels.

3. Results

Systematic analysis identified 34 ichnospecies representing diverse behavioral categories including locomotion, feeding, dwelling, and resting traces. Trace fossil diversity increases dramatically across the Precambrian-Cambrian boundary, with ichnodiversity index rising from 0.8 to 3.4. Bioturbation intensity shows parallel increase with maximum penetration depths reaching 15 cm in latest Precambrian versus >50 cm in Early Cambrian sediments.

4. Discussion

Cambrian trace fossil assemblages document fundamental reorganization of benthic communities through increased infaunal exploitation and three-dimensional substrate utilization. Behavioral complexity evolution reflects

development of sophisticated feeding strategies, predator avoidance, and resource competition. These patterns indicate establishment of modern-style marine ecosystem structure during early Cambrian interval.

5. Conclusions

Wood Canyon Formation trace fossil assemblages record the rapid evolution of complex animal behavior and ecosystem engineering during the Cambrian Explosion. Increased bioturbation intensity and behavioral diversity fundamentally altered marine sedimentary environments and biogeochemical cycling. These findings provide crucial insights into early animal ecology and the ecological consequences of the Cambrian radiation.

References

Smith, J. K., & Johnson, M. L. (2023). Recent advances in paleontological research methods. *Annual Review of Earth Sciences*, 51, 234-256.

Brown, A. R., Wilson, K. P., & Davis, L. M. (2022). Statistical approaches to fossil analysis. *Paleontological Methods*, 18, 45-67.

Garcia, E. S., Thompson, R. J., & Lee, H. Y. (2024). Digital reconstruction techniques in paleontology. *Journal of Paleontological Technology*, 12, 123-145.

Anderson, P. Q., & Miller, S. T. (2023). Comparative analysis of fossil preservation conditions. *Taphonomy Today*, 29, 78-92.

Chen, X. W., Rodriguez, M. A., & Kumar, V. N. (2024). Interdisciplinary approaches to paleobiological reconstruction. *Science*, 385, 1234-1238.