Name(s)

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Project Number

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Project Title

Implications of Climate Change on Marine Ecosystems: Using Big Data Mining to Analyze Bioturbation and Mass Extinctions

Abstract

Objectives

Bioturbation, the biogenic mixing of seafloor sediments by marine organisms, is an important ecological process that helps cycle nutrients in the ocean and maintain a functioning ecosystem. Changes in bioturbation illustrate the effects of evolutionary events on marine ecosystems throughout time, which is especially applicable to the modern oceans. Our goal for this project is to generate a complete evolutionary history of bioturbation, especially filling in the prominent literature gap between the Devonian and Triassic Periods. We hypothesize that the extent of bioturbation will generally increase over time, reflecting the increasing biodiversity of marine ecosystems. To test this, we quantified bioturbation using trace fossils, which are fossilized burrows/trackways that preserve the bioturbating behavior of seafloor organisms.

Methods

We assembled a large trace fossil database, grouping the trace fossil taxons into five reworking modes indicating varying levels of bioturbation. We then used this resource to perform data mining, using a machine reading method to find mentions of trace fossil taxons within GeoDeepDive, a database containing over eight million publications. To handle the large amount of papers, we adapted big data analytics with the Stanford Natural Language Processing tool, which parsed the papers into sentences to identify those containing mentions of trace fossils and their host stratigraphic units. These units could then be matched in the Macrostrat database to place them in chronological order.

Results

Our results show a rise in the extent of bioturbation, with increases in large-scale sediment mixing and decreases in shallower mixing. Our plots display a clear two-step increase in sediment mixing, exhibiting a pattern that is in line with documented evolutionary radiations. This pattern was likely caused by corresponding increases in oxygen levels and food supply, suggesting that these measures served as limiting thresholds.

Conclusions

Our plots filled in the literature gap with the two-step increase, improving scientists' understanding of bioturbation over time The impacts of mass extinctions can also be seen, as the End-Permian extinction marked a pronounced decline in bioturbation. We extrapolate that a man-made mass extinction will cause similar effects, drastically decreasing global bioturbation levels and inhibiting the circulation of oxygen and nutrients.

Summary Statement

Our project involved using a data mining method with natural language processing and the GeoDeepDive platform to determine the prevalence of bioturbation over time, which allows us to see the impact of mass extinctions on marine ecosystems.

Help Received

We completed our project during the summer as part of the Science Internship Program at UC Santa Cruz, so we received help in coming up with the idea from our mentor Professor Matthew Clapham and were able to use some of the equipment in his Paleobiology Lab to aid us in the project.