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Dustin Perriguey
Corinne Myers

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PERRIGUEY, Dustin, Earth and Planetary Sciences, M.S. student and MYERS, Corinne, Earth and Planetary Sciences, Assistant Professor

Extinction has occurred throughout Earth history, with most of the focus on the largest in magnitude from the last ~540 million years (Myrs), or the Phanerozoic Eon. Extinction science has concentrated on the trigger and the recovery of these events. The largest extinctions have been linked to abiotic environmental forcing (e.g. massive volcanic events, extraterrestrial impacts, or climate change) that drove biota to extinction. Here, we investigate the impact initial environmental conditions had on elevated Phanerozoic extinction rates of marine genera.

To test hypotheses of how specific “initial conditions” of abiotic environmental factors may have impacted extinction rates, we compiled a ~540 Myrs record of five environmental proxies and two published marine faunal extinction rate datasets (Bambach 2006 and Alroy 2014) from an extensive literature review. The environmental proxies tested include: δ¹⁸O and δ¹³C stable isotopic records (climate variability), ⁸⁷Sr/⁸⁶Sr record (continental weathering rates), eustatic sea level (variability in area of shallow shelf habitat), and continental shelf area (habitable area). All proxies were subset to 2, 5, and 10 Myrs-prior bins, intervals of time, to test for time bin sensitivity. Multiple linear regression analysis was used to test our hypotheses and to estimate the relationship between environmental factors (individually and in concert) and extinction rates during 18 and 16 key intervals of elevated extinction identified by Bambach (2006) and Alroy (2014), respectively.

We find all six models, except the Alroy 5 Myrs-prior model, to weakly estimate the relationship between environmental proxies and extinction rates, and poorly explain the variation in extinction rates (<40%-60%). The Alroy 5 Myrs-prior model is statistically significant (p=0.001) and explains 78% of the variation in elevated extinction rates. Climate variability and continental weathering rates were the environmental proxies that contributed most to the Alroy 5 Myrs-prior model.

Our findings provide evidence that the most elevated extinctions may have been preconditioned for high extinction magnitudes. Identifying the role that pre-existing conditions play in promoting or inhibiting periods of elevated extinction are important for improving our understanding of Phanerozoic macroevolution and may positively contribute to improving projections of the consequences of the current biodiversity crisis.