Embracing Uncertainty: Integrating Geochronologic Data to Model Accurate Age Constraints for Triassic Earth-Life Events

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Abstract

Many subdivisions of the Triassic timescale and constituent key global events (e.g., extinctions, sudden climate change, perturbations in global biogeochemical cycles) remain poorly constrained by precise and accurate geochronologic dates. This has made it difficult to correlate key stratigraphic archives from different regions, and limited the ability to pinpoint the temporal relations of these global events to their hypothesized causes. During the past 20 years, an increasing volume of radioisotopic, magnetostratigraphic, and cyclostratigraphic data from Triassic sedimentary sequences have been made available, but it is not always clear how they should be best compared and integrated, given that they are based on different isotopic systems, analytical approaches, and standard materials, even though considerable progress has been made regarding their intercalibration. Using recent geochronologic data from Triassic non-marine sediments in North and South America, we present an ad hoc method to extract intercomparable and accurate radioisotopic ages from different geochronometers and techniques (i.e., 40Ar/39Ar, ID-TIMS U-Pb, and micro-beam U-Pb). We then integrate these and other data (e.g., magnetostratigraphic constraints) in Bayesian age-stratigraphic models that calibrate key Triassic paleoenvironmental and paleontologic records. Finally, we show how the inferred ages and uncertainties from these models can be used to identify discrepancies in stratigraphic correlation, and test hypotheses regarding biotic change (putative effects of hypervelocity impact), macroevolutionary patterns (e.g., origin of dinosaurs), and sudden climate change (e.g., Carnian Pluvial Episode). These approaches allow for more accurate age estimates, albeit with lower precision, by acknowledging realistic geologic and analytical uncertainty, ultimately leading to more robust hypothesis testing in deep time.

Keywords: Geochronology, Zircon, SIMS, LA, ICPMS, CA, TIMS

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