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In situ characterization and dating of sedimentary carbonates: case studies, process, and progress

MARJORIE CANTINE[1,2] AND AXEL GERDES[3]

[1]Goethe Universität Frankfurt
[2]University of Washington
[3]Goethe-Universität Frankfurt, Institut für Geowissenschaften
Presenting Author: cantine@uw.edu

Carbonate sediments are valuable biogeochemical archives with which we reconstruct ancient environments and biogeochemical cycles. However, their susceptibility to alteration during diagenesis and deformation mean that these records can be overwritten. This is a double-edged sword: although these processes can overwrite primary, environmental records, they can also be studied from the changes they induce in carbonate rocks. Ultimately, resolving the impact of primary and secondary processes on the proxy records carbonate rocks contain—and the timing of these processes—is critical for building a robust, useful record of change in Earth's environments in deep time. *In situ* analysis using laser ablation allows us to combine petrographic observations of carbonate phases with geochemical measurements to assess proxy records, and U-Pb dating of these phases can help elucidate the depositional and post-depositional history of the rock. However, laser ablation dating of carbonates, especially in sedimentary settings, is still in the early stages of development. Data may be misinterpreted.

In this contribution, we present a review of carbonate-derived U-Pb dates from published literature and highlight selected case studies from our own work from the Neoproterozoic and Phanerozoic in which we tie petrographic characterization of carbonate phases with U-Pb dating to inform interpretation. We also highlight the utility of in situ Sr isotope measurements in identifying well-preserved samples and tracking fluid influx and modification of samples. We conclude by highlighting potential analytical pitfalls in the interpretation of U-Pb carbonate data and making recommendations for best practices in future studies applying the technique.