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New ways to date old rocks: novel applications of in situ geochronology to constrain the sedimentary archive

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Ancient marine sedimentary rocks provide important insight into how the planet's surface environments have evolved through deep time. However, they can be difficult to date. This is particularly true for Precambrian sediments, where the lack of a diverse fossil record makes biostratigraphy inapplicable. Here, we display emerging in situ laser-based methods that have the potential to quickly and accurately define the depositional window of a sedimentary package.

The first method aims to date authigenic clay minerals in shales using Rb–Sr geochronology [2]. A gas in a reaction-cell laser ablation–inductively coupled plasma–tandem mass spectrometer is used to remove the isobaric interference between ^{87}Rb and ^{87}Sr. The sample's petrographic information is preserved with this approach, and zones can be targeted for analysis to give a more accurate age. The second method aims to date carbonate sedimentation using U–Pb geochronology via an image mapping approach [1]. Laser rasters are compiled into isotopic maps, and this spatial information is used to target subdomains within the sample. Detrital or altered regions can be avoided by monitoring chemical signatures such as low Si and Mn/Sr ratios, respectively. Pixels corresponding to the most authigenic domains are then subdivided into analyses that give the best spread of data on an isochron. This can yield a more precise result for samples that may exhibit poor isotopic spread under traditional procedures.

These techniques were tested in several case studies in basin systems across Australia. Samples were sourced from the Mesoproterozoic greater McArthur Basin, the Neoproterozoic Adelaide Superbasin, and the Cambrian Georgina Basin. Results from each sample were accurate to the expected age of their respective formations based on tuff dating or biostratigraphic correlations. As such, we show that these new in situ dating approaches are powerful tools to constrain the sedimentary archive.

[1] Drost, Kerstin, et al. "An image mapping approach to U–Pb LA–ICP–MS carbonate dating and applications to direct dating of carbonate sedimentation." *Geochemistry, Geophysics, Geosystems* 19.12 (2018): 4631-4648.

[2] Subarkah, Darwinaji, et al. "Unraveling the histories of Proterozoic shales through in situ Rb-Sr dating and trace element laser ablation analysis." *Geology* 50.1 (2022): 66-70.