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Can we date marine carbonates at high(er) precision with U-Pb ID-TIMS method?

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Uranium-lead geochronology of marine carbonates is very challenging, mainly due to the nature of the carbonate material (often having low U and high initial common Pb concentrations and being prone to diagenetic overprinting). Over the past 10 years this challenge has been successfully addressed by high-resolution spot analysis using the Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) technique, with a precision in the range of 2-5%, but remains less successful when applying the otherwise more precise Isotope Dilution Thermal Ionisation Mass Spectrometry (ID-TIMS) technique [1], due to excess data scatter. While LA-ICP-MS dating of carbonates is still in development [2, 3], the advantages of its spatial resolution make it the preferred method over ID TIMS, despite the risk of masking heterogeneities with its higher analytical uncertainty.

With this contribution we aim to assess whether the ID-TIMS technique applied at ~1 mm scale can achieve higher precision in carbonate dating and address some of the common problems in U-Pb dating of marine carbonates: mixing multiple chemical (or age) components, open system behaviour, variable initial Pb isotopic composition. We applied ID-TIMS techniques to two natural examples of marine carbonates: i) Early–Middle Pennsylvanian carbonates from a carbonate platform, NW Spain, and ii) Ediacaran carbonates from the Nama group, Namibia. Following detailed petrographic, mineralogical and geochemical characterization ($\delta^{13}C$, $\delta^{18}O$, XRD, SEM, clumped isotope thermometry, QEMSCAN, LA-ICP-MS) we were able to identify different carbonate phases and relate them to their pristine or diagenetic formation conditions. Our results show that accurate and successful dating of marine carbonates by ID-TIMS is achievable with a precision <0.1% in the case of marine carbonates with well-preserved botryoidal cements and remains a challenge in the case of more complex carbonates, such as micritic dolomite. The main prerequisite for successful dating of marine carbonates and assigning age significance to the U-Pb results, remains a thorough understanding of the field relationships of sampled material and its diagenetic history.

[1] Rasbury & Cole, 2009. *Reviews of Geophysics, 47, RG3001*; [2] Roberts, et al. 2020. *Geochronology, 2(1): p. 33-61*. [3] Guillong, et al. 2020 *Geochronology, 2(1): p. 155-167.*