First in situ Carbonate U-Pb Geochronology on the Ediacaran Sequence in Saudi Arabia: New Insights and Implications

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Abstract

The Ediacaran sequence in Saudi Arabia provides one of the most extensive exposures across the Arabian Plate, with more than 400 m thick of Precambrian mixed siliciclastic-carbonate sedimentary deposits. This sequence was deposited in an isolated, half-graben basin associated with the Precambrian Najd fault strike-slip systems. The carbonate-dominate sequence has been interpreted to host important biological and geochemical evidence related to the first appearance of soft-bodied animals and the presence of negative carbon isotopic excursion, termed as the "Shuram Anomaly". However, understanding these phenomena requires a robust geochronological framework, which is currently absent. While there have been attempts to resolve the age of this deposit by dating ash layers and zircon grains, so far, the results remain inconclusive, ranging from 625 My to 520 My. In this study, we explored the potential of applying the recently emerging techniques in in situ carbonate geochronology, using LA-ICP-MS to obtain the U-Pb ages directly from different primary carbonate phases, such as micrite and early marine cement. Our results, for the first time, exhibit two meaningful ages from the carbonate-dominated sequence, which yield a U-Pb isochron age of 592.9 ± 2.9 My at the base of the carbonate and 536.2 ± 4.5 My at the uppermost part of the carbonate sequence. These ages further refined and confirmed the age of the sedimentary deposit and indicated that the carbonate deposition coincided with the Shuram anomaly (573-562 Mya). Despite this, our high-resolution δ13C analysis does not reveal a strong negative carbon isotopic excursion as expected (ranging from -2‰ to +2‰), which may indicate either (i) pervasive diagenetic overprint or (ii) isolation from the global oceans. These absolute U-Pb ages provide a robust framework to correlate the worldwide Ediacaran sequence across the Arabian Plate and other sedimentary basins and understand the link between sedimentological, biological, and geochemical processes during this enigmatic period.