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Geochemical and stable isotope indicators of paleoenvironmental and climatic conditions from Cenozoic dolocretes in the Hamersley Basin of northwest Australia

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Extensive shallow groundwater carbonate deposits composed of dolomite (dolocretes) are ubiquitous within the semi-arid Hamersley Basin of NW Australia. However, dolomite is relatively rare within surficial terrestrial carbonate deposits as precipitation is strongly controlled by reaction kinetics and is inhibited at surface temperatures and pressures. The presence of dolomite within the Hamersley Basin carbonate deposits indicates that specific hydrochemical conditions occurred to overcome kinetic barriers to precipitation, namely elevated Mg/Ca and high salinity and alkalinity. We investigated the sedimentology, geochemistry and stable isotope compositions of dolocrete and groundwater chemistry from several locations in the Hamersley Basin to better understand dolocrete formation processes and produce a multi-proxy archive of the paleoenvironmental conditions. Petrographic and mineralogical analysis is consistent with channel dolocrete formation where dolomite has largely replaced host channel sediments. Authigenic palygorskite was also present in all samples, indicative of the Mg-rich environment. Modelling of the δ^{18}O of paleogroundwater from oxygen isotope compositions of carbonates revealed dolomite precipitated from groundwater with considerably higher δ^{18}O (median = -2.0‰) values compared to modern alluvial groundwater (-8.02 $\pm$ 0.83‰). As groundwater δ^{18}O values are strongly correlated (R^2=0.93) with salinity, this finding suggests that dolocrete formed from highly saline groundwaters and in an arid climate that prevailed for sufficient time to form dolocrete bodies of tens of metres thick. This ancient dolocrete formation can be constrained by host sediments ages to forming since the mid-late Miocene. In contrast, modern alluvial groundwater is relatively fresh and unlikely to precipitate dolomite. A further indication of a more recent (likely Holocene) shift to fresher waters is the dedolomitization and precipitation of calcite within shallow dolocrete (<5 m b.g.l) in the vadose zone as well as modern precipitation of calcite from fresh and brackish water within current drainage lines. These results demonstrate that stable oxygen isotope signatures of dolocretes can be used to reconstruct paleogroundwater salinity and by using a multi-proxy approach we can establish the groundwater processes and hydrochemical conditions occurring at the time of precipitation.