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Bacterial role in deep-marine dolomite formation within the Gulf of Cadiz contourite depositional system, IODP Expedition 339

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The nature and formation of dolomite in deep marine sediments is very poorly understood. Here, we present new data from three separate dolomite layers that occur within the Pliocene-Quaternary contourite succession of the Gulf of Cadiz continental slope, drilled during IODP Expedition 339. These deposits provide a unique opportunity to understand dolomite formation uncomplicated by meteoric, shallow marine or deep burial influences. We use a novel approach by investigating the organogenic components extracted from the dolomites.

The Cadiz contourite depositional system, between 500-1500 m water depths, was developed under the influence of bottom currents caused by the Mediterranean Outflow Water, which has been active since the early Pliocene. At least four regional hiatuses in the sedimentary record have been identified, and represent periods of time when highly energetic bottom current activity prevented sediment accumulation. These episodes were most likely linked to tectonic adjustments to seafloor morphology and/or to dimensions of the Gibraltar oceanic gateway. The most prominent hiatuses are the late Pliocene Discontinuity (around 3 Ma) and the early Quaternary Discontinuity (around 2 Ma). At one of the sites drilled, these hiatuses have combined to yield a gap in sedimentation in excess of 1 My. The thickest dolomite layer is associated with this hiatus.

The succession is characterised by highly bioturbated, mud, silt and sand contourites of mixed siliciclastic (dominant) and biogenic (minor) composition. The three dolomite layers (10-50 cm thick) occur at present-day burial depths of 450 to 630 m, although their formation most likely occurred close to the seafloor, associated with development of the hiatuses, and also linked to the influx of formation waters escaping from depth with the sediment column. The changing patterns of fluid migration within the sediments is likely related to tectonic activity. Dolomite crystals show a distinctive pattern of oscillatory zoning, with up to 30 separate zones. Both rhombic and non-rhombic crystal shape and zonal accretion are evident, which can be related to pulses of highly alkaline fluids.

Nucleic acids were extracted from ground-up dolomite and mud samples and DNA was used for 16S rRNA gene amplicon sequencing. Microbial community analysis revealed that the DNA extracted from the dolomites is dominated by Arthrobacter. Members of this genus are known to induce dolomite crystallisation in a suitable medium of high Mg/Ca concentration. Although the dolomites at the two sites investigated are associated with different hiatuses and show varying crystal morphology, they share a similar bacterial community. It is inferred that microbes played an important role in the precipitation of dolomite through increasing pH and alkalinity, and possibly providing nucleation sites for the carbonate crystallisation.