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Carbonate mineralisation in sabkha microbial mats; a comparative study of field and laboratory systems

Kirsten E. Dutton (1), Andreas Paul (2), Luiza Lessa Andrade (1), Angela Sherry (1), Stephen Lokier (2), Ian M. Head (1), and Cees van der Land (1)

(1) School of Civil Engineering and Geosciences, Newcastle University, Newcastle upon Tyne, UK, (2) Department of Petroleum Geosciences, The Petroleum Institute, Abu Dhabi, UAE

Microbial mats and their lithified counterparts are some of the earliest evidence of life on Earth. The coastal sabkha in Abu Dhabi, United Arab Emirates, is a modern setting where microbial mats flourish in a hypersaline and arid environment. These microbial communities are composed of microbes such as cyanobacteria, thermoplasmata and sulphate-reducing bacteria. The mats thrive as they are protected from predators, which are excluded by the extreme environmental conditions. Microbial mats are highly reactive to change, with their microbial communities and geochemistry varying on a millimetre scale, likely controlling mineralisation processes.

Exact carbonate mineralisation rates within coastal sabkha microbial mats have not to date been quantified. Defining the mineralisation pathways and knowledge of precise mineralisation rates will help to explain how these organosedimentary structures are retained in the rock record. A fundamental understanding of the role of microbial mats in the formation of different carbonate phases is important, yet there are also other practical implications. For example, structures observed in core from the oil-bearing Arab Formation have been likened to modern microbial mats in terms of structure and mineralogy. The depositional configuration and primary mineralogy generated by microbial mats may control syndepositional lithification and later diagenesis thereby influencing reservoir porosity and permeability.

In order to constrain factors effecting mineralisation and early lithification, experimentation in a controlled laboratory environment is required. Parameters for experimentation have been established during fieldwork and were applied to a tank-based laboratory simulation of sabkha microbial mats. These parameters include light, salinity and cation and anion water chemistry, gas production chemistry and vertical mat growth. Parameters were measured weekly with sampling for mineralogical and microbial community analysis on a biweekly basis. In addition to these parameter measurements already in place in current experiments, temperature and tidal cycle were monitored in the field.

Over the course of the first three months, the microbial mat, which was submerged in an artificial seawater medium, grew vertically and developed a green surface at the top and sides. Thermogravimetric analysis has established that the top 1 mm surface mat biomass contains carbonate minerals, leading to an initial inferred carbonate mineralisation rate of approximately 0.5 g per 1 cm2 per year (approx. per 10 g surface mat material). This rate of mineralisation will become more accurate as more analysis is completed particularly comparing samples of mat, initially before they went in to the tank experiment and after incremental time periods, 3 months, 6 months etc. Further analysis of mat growth will establish the extent to which the precipitated carbonate minerals result from microbial activity and the types of minerals precipitated. The rate of mineralisation can be scaled-up to the km scale with the potential to isolate mineralisation rates promoted by different communities and in different types of microbial mat.