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"Linking the Geosphere & Biosphere to Understand Dolomite Formation"

Judith A. McKenzie
ETH-Zürich, Geological Institute, 8092 Zurich, Switzerland (sediment@erdw.ethz.ch)

Reflecting on almost two centuries of carbonate research reveals that varying scientific trends regulate the approach sedimentologists use to interpret the sedimentary rock record. New concepts develop with the introduction of the latest methods and technologies to a scientific field and propel evolving scientific trends, which often tend to cycle back on themselves with new advances. The study of dolomite formation since the recognition of its unique mineralogy more than 200 years ago has been no exception to this rule.

Although dolomite is found throughout the geological record, especially in Precambrian carbonate rocks where it is abundant and often found associated with microbial structures, it is rarely found forming in modern carbonate sediments. Because of its rare occurrence in modern environments, as well as the apparent inability to synthesize it under low-temperature conditions in the laboratory, the origin of dolomite has remained a longstanding enigma in carbonate sedimentology, often called the "Dolomite Problem". Dolomite bodies are often significant hydrocarbon reservoirs, and, as a consequence, much emphasis has been placed on the development of dolomite models to define the physico-chemical and hydrologic parameters involved in dolomitization. Nevertheless, these models, such as the mixing-zone model or reflux model, have not been adequately calibrated for real-world circumstances because it was not possible to synthesis dolomite in the laboratory at Earth's surface temperatures.

Since 1995, a microbial factor has been incorporated into geochemical models to better represent the process of dolomite formation under Earth's surface conditions. It is now generally appreciated that microbial activity under specific environmental conditions can mediate the precipitation of dolomite at low temperatures. With the recognition that specific microbes can mediate dolomite precipitation, it is possible to conduct culture experiments under controlled conditions to better define boundary parameters. The results of these experiments provide new information to interpret the conditions required for dolomite formation during carbonate diagenesis and necessitate a reinterpretation of currently applied models. Factors, such as the optimum growth temperature for particular microbes under defined chemical conditions, are essential considerations for dolomite nucleation. In addition, geochemical proxies that have been used to interpret the paleoenvironment of dolomite formation, such as stable isotopic fractionation, are being redefined with these experimental studies. Furthermore, revisiting classic areas of modern dolomite formation, such as the coastal sabkhas of Abu Dhabi (U.A.E.), demonstrates that the microbial factor plays an important role in dolomite precipitation in these extreme environments.

Ultimately, microbes appear to be a powerful driving force behind carbonate diagenesis and must be included in any new model paradigm for dolomitization. Applying molecular biology methods and technical advances in microscopy, it is now possible to view the carbonate world through the microbial window. Indeed, a new scientific trend in carbonate sedimentology linking the geosphere with the biosphere has already begun. How this microbial mediation of a biomineral can be translated into the production of gigantic structures, such as the Dolomite Mountains, remains unclear, but the influence of these microorganisms can no longer be ignored.