Sedimentology and stratigraphy

Bacteria and dolomites *(January 2001)*

Production of carbonate rocks is one of the means of drawing down carbon dioxide from the atmosphere. During the Phanerozoic, times of "greenhouse" conditions were both induced and relieved by carbonate "factories" dominated by metazoans that secreted calcium carbonate in their hard parts. An excellent example is the Chalk of the late Cretaceous. Before the evolution of the metazoa some other means was needed. Precambrian sequences contain abundant carbonate strata, but a great many of them contain lots of calcium-magnesium carbonate or dolomite. The further back in time, the more dolomitic carbonates become.

Some of these dolomites contain mounds and cauliflower-like masses built of many thin laminae. By analogy with similar structures forming nowadays in a few rare environments that are too saline to support metazoans, sedimentologists have ascribed these stromatolites to the expulsion of toxic calcium from their cells by blue-green bacteria or cyanobacteria. Blue-greens are photosynthesisers that generate oxygen. Evidence from carbon-isotope analyses of fossil organic material in old Precambrian sediments supports them having evolved very early. Despite their antiquity and ability to break down water and release its oxygen, blue-greens were unable to build up oxygen in the Earth's atmosphere until about 2 000 million years ago. For half of life's history conditions were lacking in oxygen, and bacteria that consumed dead things had to subsist with metabolisms that employed other chemical tricks than the oxidation of organic matter to carbon dioxide plus water, for which oxygen is essential. One strategy is the reduction of sulphate (SO_4^{2-}) to sulphide (S_2^{2-}) ions (see *Slime to the rescue*, December 2000). That involves shifting of electrons so that the counterpart of a reduction is some form of oxidation, which such bacteria employ in their metabolism.

Modern environments devoid of oxygen encourage such organisms; hence their obnoxious odour from released hydrogen sulphide gas. One such habitat is a very salty lagoon in Brazil, and that is also a place where dolomite precipitates in abundance. A Swiss-French team of organic geochemists has shown experimentally that its sulphate-reducing micro-organisms actually encourage dolomite to leave solution (Warthmann, R. *et al*. 2000. Bacterially induced dolomite precipitation in anoxic culture environments. *Geology* v. **28**, p. 1091-1094; doi: 10.1130/0091-7613(2000)28<1091:BIDPIA>2.0.CO;2). Not only does that add to the ways in which modern carbon dioxide leaves the atmosphere on a long-term basis, but suggests that such bacteria played the key role in climate balance in the earliest Precambrian. The lack of oxygen before 2 000 million years ago would have made every niche available to them, for sulphate ions are continually added to sea water. They showed *in vitro* how bacteria from the lagoon sediments cultured in sulphate-rich water did precipitate dolomite in curious dumbbell-shaped grains that aggregated to cauliflower-shaped masses in zones around the cultures. By carefully isolating different species of bacteria, they found that sulphate reducers were the culprits. As well as helping account for the preponderance of dolomite in ancient carbonates, it expands our vista of organic diversity represented by them, albeit of a very lowly kind.