AAPG HEDBERG CONFERENCE
"MICROBIAL CARBONATE RESERVOIR CHARACTERIZATION"
JUNE 4-8, 2012 – HOUSTON, TEXAS

Composition, Distribution, and Diagenesis of Microbial Oncolite Beds Capping the Uplifted Atoll of Maré, Loyalty Islands, New Caledonia

Chelsea Pederson, Donald F. Mcneill, James S. Klaus

Division of Marine Geology and Geophysics, Rosenstiel School of Marine and Atmospheric Science, University of Miami, 4600 Rickenbacker Causeway, Miami, FL, U.S.A

The influence of microbes on carbonate textures is well known from studies of stromatolites that date back to the Precambrian. In the Phanerozoic, with the diversification of life forms, the dominance and influence of microbes in the marine realm has been largely relegated to niche environments. Microbial influence on carbonate textures and facies has been increasingly recognized, especially in the calibration of geological and reservoir models. This study contributes to the understanding of how microbial processes influence rock textures with the characterization of proposed cyanobacterial formed grains associated with the final stages of marine deposition and the onset of uplift-driven subaerial exposure. By characterizing the chemical and physical attributes of these microbial carbonates we will provide a better understanding of their formation and environment of origin.

GEOLOGIC SETTING

The island of Maré is located on a submarine volcanic ridge eastward of the island of New Caledonia in the Loyalty Island chain, 40 km west of the New Hebrides trench; the convergence of the Pacific and Australian plates. Volcanism on the island is thought to have occurred up until the middle-late Miocene (9-11 Ma), but has since been dominated by phases of carbonate deposition and diagenesis, with final atoll deposition projected to the mid-late Pliocene (Baubron et al., 1976, Guyomard et al., 1996). Maré is dominated by partially dolomitized, shallow-water limestone. Carriere (1987) suggests that a small fringing reef, intertwined with rhodolith beds ~40km wide, formed and back stepped as sea level rose, surrounding the central volcanic rock during the Miocene. During the early Pliocene an atoll rim developed on the rhodolith platform. Here we describe bedded oncolites that cap the reefal rim of the atoll (McNeill and Pisera, 2010).

PHYSICAL CHARACTERISATION OF MARÈ ONCOLITES

The diameter of the oncolite grains range from 1-10mm. The grains contain a microbial coating, and are classified as oncolites, defined as having diameters <10cm. The general composition of the oncolites consists of a minimum of three distinct layers (Figure 1a). The innermost layer is the nuclei, made of aragonitic skeletal fragments and intraclasts. Aragonitic mollusk shell fragments, some with their original nacre (mother-of-pearl) are common. Nuclei thickness ranges from 0.60-4mm. The second layer is a microbial coating (rind) surrounding the nuclei. Rind thickness ranges from 1.5-6 mm, representing 12-49% of the total oncoid diameter. While most nuclei are not well rounded, the encircling rind generally displays a more circular shape. The microbial rinds consist of 1-3 micron crystals, tightly packed, with low-permeability. These

crystals form an effective seal around the skeletal or composite nuclear grains. Possible microbial fibers in the rind indicate *in situ* biological formation (Figure 1b). These concentric grains are encased by a third layer of blocky calcite spar cement, typical of meteoric conditions. The boundary between the coated grain and these calcite cements suggest distinct environments of formation. The microbial rind promotes a rock fabric of well-preserved aragonitic nuclei.

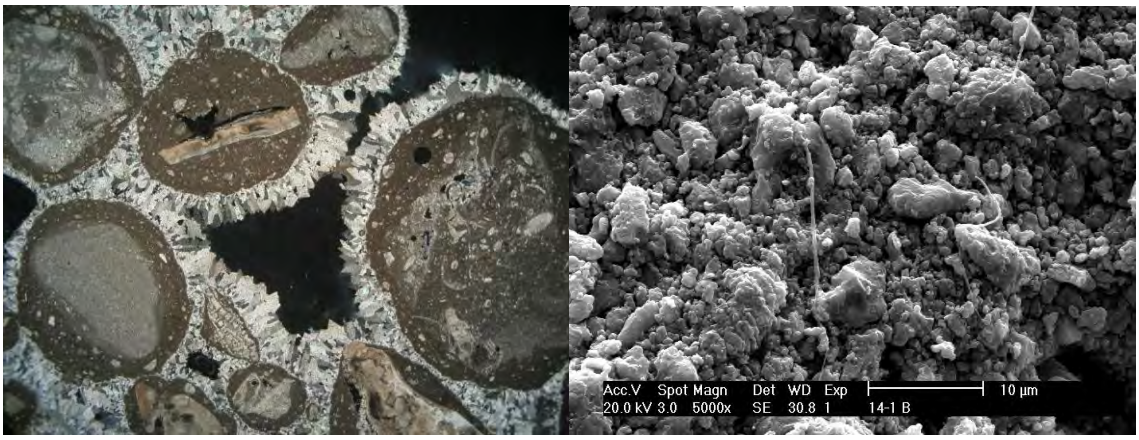

Figure 1 a) Thin-section photomicrograph of an oncolite sample taken from the top of a faro near the town of La Roche. b) SEM image of fine calcite crystals within the rind layer of an oncolite sample. Lightly etched with 5% HCl.

STABLE ISOTOPIC CHARACTERISATION OF MARÈ ONCOLITES

One key feature of the microbial rind is its influence on meteoric diagenesis. Unlike oolitic grainstones, the microbial rind inhibits nuclei dissolution and the formation of associated moldic porosity. MicroMill isotope sampling enabled the analysis of the minute layering within each oncolite. The average δ^{18} O signal for the nuclei, rind, and cement layers were -4.7, -4.9, and -5.6 respectively. The average δ^{12}C signal for the nuclei, rind, and cement layers were -6.7, -7.6, and -10.1. These stable isotopic results show a general trend toward lighter carbon and oxygen isotopes as you move from the nuclei to the cement. This trend records the transition from marine to freshwater conditions with progressive uplift. The permeability of the microbial rinds was sufficiently low at this early stage, to preclude freshwater access to the aragonitic fragments in both the nuclei and rinds. This exception to diagenetic sequence is well illustrated in thin section and SEM images and has important implications for the dissolution of aragonitic grains. Furthermore, the recognition of microbial textures, their formation, and distribution within existing facies models may be a challenge to the diagenetic paradigm.

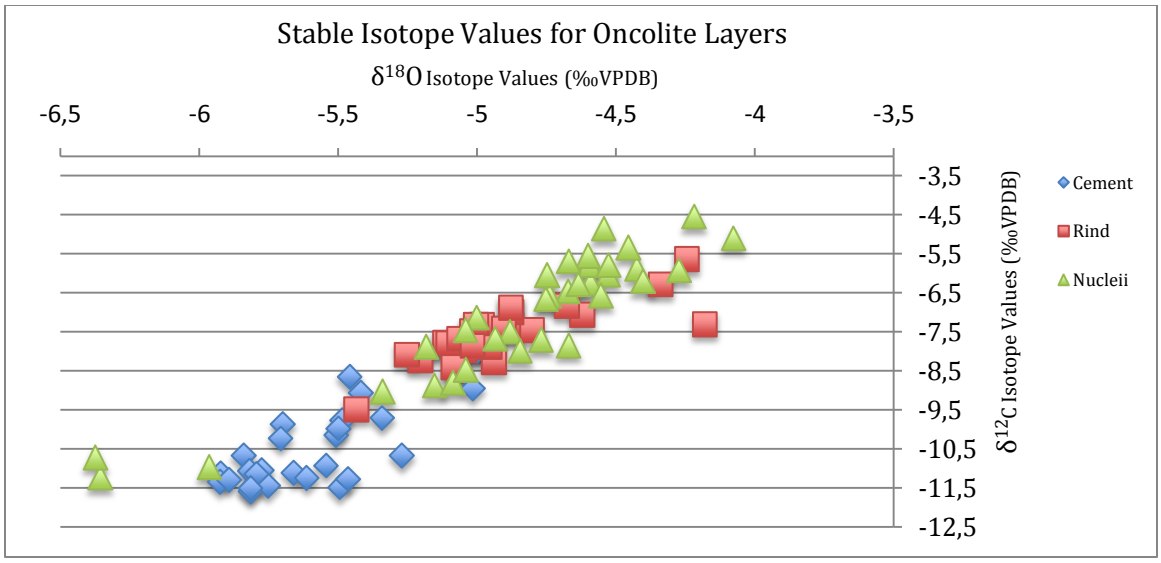

Figure 2 – Isotope results measured in ‰VPDB for the cement, rind, and nucleii layers.

REFERENCES

AISSAOUI, D.M., 1988, Diagenèse et géodynamique dans la formation des atolls: Îles Loyauté, Nouvelle-Calédonie: Académie des Sciences (Paris), Comptes Rendus, v. 306, p. 1241-1246.

BAUBRON, J.-C., GUILLON, J-H., AND RECY, J., 1976, Géochronologie par la méthode K/Ar de substrat volcanique de I'Île de Maré, archipel des Loyauté (sud-ouest Pacifique): Bulletin Bureau de Recherches Géologiques et Minières, IV, p. 165-175.

CARRIERE, D., 1987a, Sédimentation, diagenèse et cadre géodynamique de l'atoll soulevé de Maré, Nouvelle Calédonie: Le titre de docteur en science, Université de Paris-sud, Orsay, 369 p.

GUYOMARD, T, AISSAOUI, D.M., AND McNEILL, D.F., 1996, Magnetostratigraphic dating of an uplifted atoll, Maré Island, Loyalty Archipelago, S.W. Pacific: Journal of Geophysical Research, v. 101, p. 601-612.

McNEILL, D.F., AND PISERA, A., 2010, Neogene lithofacies evolution on a small carbonate platform in the Loyalty basin, Maré, New Caledonia: Cenozoic Carbonate Systems. SEPM Special Publication, v. 95, p. 243-255.