AAPG HEDBERG CONFERENCE
"Microbial Carbonate Reservoir Characterization"
June 4-8, 2012 – Houston, Texas

Calcisponge-Microbialite Reef Facies, Middle Permian (Guadalupian), Northwest Shelf-Margin of Permian Basin, New Mexico USA

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Exceptional mimetic preservation of reefal fabrics in a dolostone subsurface core allows detailed observations of the significant microbial role in a calcisponge-microbialite reef facies of the Upper San Andres Formation (Early Guadalupian, Middle Permian). Microbialite encrustations and masses are by far the most important binding agent in the reef, and their major contribution to both the cohesion and volume of the reef has significant implications for the growth and character of other Middle Permian shelf-margin buildups, such as the Lower-Middle Capitan reef in the Guadalupe Mountains, which according to Yurewicz (1977) displays only 10-20% recognizable biotic framework elements but has common cavities that appear to be primary constructional features.

The reef studied here occurs in a subsurface core from the East Vacuum Grayburg San Andres Unit, Lea County, New Mexico, which was paleogeographically located along the Northwest Shelf margin of the Permian Basin. The shelf-margin reef is bordered shelfward by crestal shelf-margin grainstone-packstone shoal facies and seaward by basinal sandstones of the Delaware Mountain Group. This stratigraphic position of the reef immediately adacent to the basinal Delaware sands is reminiscent of the San Andres stratigraphic architecture described by Sonnenfeld and Cross (1993) from Last Chance Canyon in the Guadalupe Mountains of New Mexico. The cored section is composed of three thinning-upward depositional sequences. The calcisponge-microbialite reef facies comprises approximately 85% of the 175 ft thick section. The lower main reef exceeds 108 ft (base of reef not cored) of massive boundstones, and the overlying two thinner sequences are composed of interbedded reefal doloboundstones, fusulinid-skeletal-peloidal dolograinstones and dolowackestone-packstones, and reef talus dolorudstones. Karstic fractures and cavities penetrate the two upper interbedded reef sequences and are filled with breccia clasts, fusulinid packstone-grainstones, dark mudstones, and massive anhydrite.

The main components of the reef boundstone facies are: 1) a skeletal framework of abundant calcareous sponges; 2) a binding biota of thrombolitic, laminated, and micritic microbialite encrustations and masses, moderately common *Tubiphytes*, sparse fistuliporid bryozoans, and rare *Archeolithoporella* red algae; 3) sparse small botryoids of syndepositional originally-aragonitic radial fibrous cements; 4) a sparse reef dweller biota of gastropods, brachiopods, and crinoids; and 5) reef constructional cavities (up to several cm across) that are lined by thick isopachous layers of marine phreatic radiaxial cements, partly filled by geopetal sediments, and finally filled by anhydrite. The reef framework is dominated by the calcisponge *Guadalupia* and

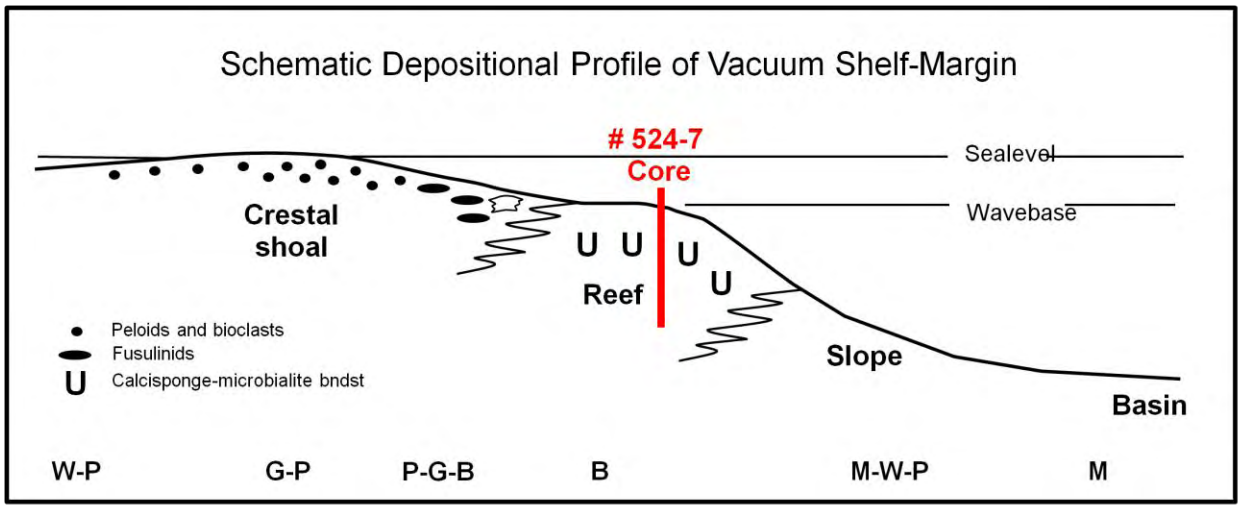
the closely-related *Lemonea*, with massive to tabular growth forms common throughout the reef, but branching growth forms dominant through the lower parts of the reefs. Associated smaller calcisponges include common *Amblysiphonella* and *Discosiphonella (Cystauletes)*, and sparse *Cystothalamia*. *Discospihonella (Cystauletes)*, and other smaller calcisponges, sometimes occur growing downward from the roofs of boundstone framework cavities.

Microbialites are ubiquitous encrusters of the calcisponge framework, as well as of other encrusting organisms. *Tubiphytes* and microbialite encrustations are commonly associated. On core slabs the microbialites are commonly mottled and microvugular. The fabric of the microbialites varies from homogeneous micrite to laminated to clotted and peloidal. Some microbialite occurs as nodular masses with concentric layers and fenestral-like microvugs that parallel the layering. The microbialites are the last stage of organic encrustation.

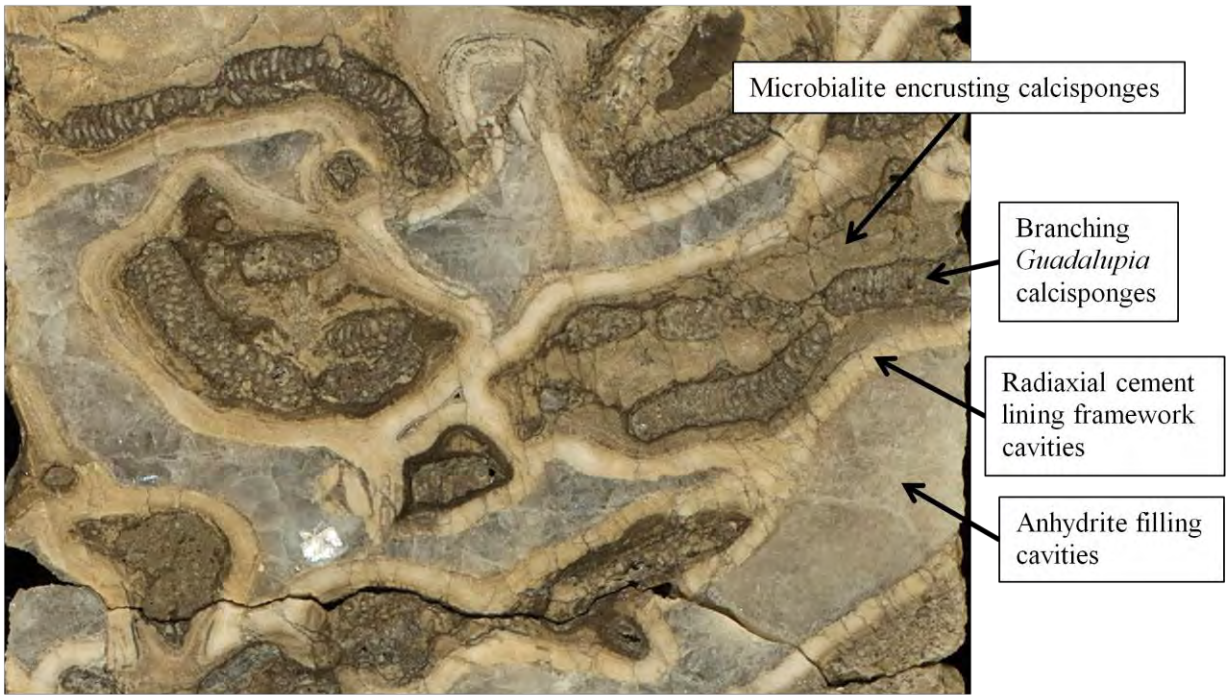
The exceptional mimetic preservation of the reefal fabrics in a dolostone core is the result of the fine-crystallinity of the dolomite, which resulted from early and rapid dolomitization by refluxing fluids superstaurated with Mg. There are also later-diagenetic sparse void-filling medium- to coarse-crystalline dolomite cements, rare calcite cements, and sporadic very small amounts of pore-lining bitumen. The paragenetic sequence appears to be: (1) reef growth with sparse syndepositional radial fibrous cements; (2) ubiquitous marine phreatic radiaxial cement linings and partial geopetal filling of reef framework cavities; (3) partial aragonite dissolution and karsting; (4) rapid mimetic dolomitization; (5) localized fracturing and spalling of cavity walls and emplacement of anhydrite into cavities; (6) burial and pressure solution; and (7) hydrocarbon migration.

Reef facies porosity is patchy in distribution and composed of mostly of intraskeletal skelmoldic porosity within the calcisponges, with lesser amounts of other skelmoldic porosity, intercrystalline dolomite porosity, some microporosity, and very sparse open fractures. The patchy distribution of porosity is increased by pore-filling anhydrite, which preferentially fills larger cavities and skelmolds.

The Vacuum Field reef section is correlated to the Guadalupian 9 sequence, which according to Kerans and Tinker's (1999) model for Guadalupian shelf-margin evolution in the nearby Guadalupe Mountains is in the transitional stage from sigmoidal ramp to rimmed shelf. This example of a 175 ft thick shelf-margin reef section located within 500 ft of basinal Delaware sandstone facies suggests that there was a relatively steep reefal shelf-margin at the time in the Vacuum area.



Depositional profile of Middle Permian carbonate facies along Northwest Shelf-Margin at Vacuum Field, Lea Co., New Mexico, showing location of studied subsurface core, and the growth site of the calcisponge-microbialite reef, which was downdip of crestal shelf-margin shoals and mostly below normal wavebase. Dominant carbonate lithologies along bottom of profile: M = mudstone, W = wackestone, P = packstone, G = grainstone, B = bafflestone-boundstone.



Polished core slab photograph showing framework of branching *Guadalupia* calcisponges encrusted by micritic microbialite, and framework cavities lined by marine phreatic radiaxial cements and filled by anhydrite.