

leum reservoirs. Microtidal flood-tidal deltas with highly bioturbated clayey sands to sandy clays would undoubtedly prove to be poor petroleum reservoirs.

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#### Intracrystalline Porosity—A Newly Discovered Pore Type in Dolomite Reservoirs and Implications for Dedolomitization and Pseudospiculites

Intracrystalline porosity consists of hollow dolomite crystals. It forms when anhydrite, which had replaced cores of dolomite crystals, was dissolved. Significant volumes of intracrystalline porosity have been preserved in subsurface Permian dolostones of the Permian basin and in outcrops of Lower Cretaceous dolostones of Texas.

Anhydrite can be seen replacing organic-rich cores of dolomite crystals in Permian and Jurassic (Smackover) dolostones. Dolomite crystals, which replace original carbonate, commonly appear cloudy because of organic inclusions. After dolomitization, continued flux of the dolomitizing fluid causes precipitation of clear rims on the "cloudy" crystals. Anhydrite tends to replace the organic-rich cores, leaving the clear epitaxial rims to form "pill box" structures.

When anhydrite was dissolved, many hollow dolomite crystals collapsed and fragments became transported as vadose internal sediment. Obtuse and acute angles of these hollow dolomite rims superficially resemble sponge spicules, and pseudospiculites are layers of vadose internal sediment in which numerous fragments of hollow dolomite rims have been deposited in solution channels. Hollow dolomite crystals and pseudospiculites constitute evidence for unconformity and also represent subtle indications of vanished sulfates.

In many instances, calcite cement was precipitated within intracrystalline pores and is misinterpreted as partial dedolomitization. Such calcite cement can be distinguished from dedolomite, because the calcite is not syntaxial with dolomite rims, as it would be in dedolomitization.

In some Permian dolomite intervals, intracrystalline porosity is the predominant pore type. Molds formed by dissolution of replacement porphyroblasts and nodules of anhydrite also commonly were formed along with intracrystalline pores and all represent tertiary (third order) voids.

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#### Emplacement of Nonevaporitic Sulfates in McKnight Formation, Maverick Basin, and Associated Complex Diagenesis

In the Maverick basin the so-called upper and lower anhydrites of the McKnight Formation (Edwards Group) predominantly consist of nonevaporitic anhydrite which was emplaced within limestones, dolostones, and dedolostones. Most nonevaporitic anhydrite has been emplaced within fossiliferous limestones, which had been subjected to freshwater diagenesis, leaching, and lithification, and in dedolostones.

Anhydrite was emplaced in many grainstone intervals, first as cement and then as replacement of grains. Nodular mosaics of felted-lath anhydrite, emplaced within limestones and dedolostones, closely resemble those formed as evaporites within dolomitic sediments of modern Persian Gulf sabkhas. The most abundantly represented morphology of replacive anhydrite is the blocky porphyroblast with stair-step outlines. Molds formed by dissolution of these porphyroblasts have been misidentified as molds of halite cube aggregates.

Much anhydrite in the McKnight represents a second or third generation, emplaced after dissolution of previous generations. The McKnight contains many dedolomite intervals which probably were produced during episodes of sulfate dissolution. McKnight diagenesis records multicyclic influxes of meteoric groundwater, dolomitizing, anhydritizing, and dedolomitizing fluids. Some McKnight intervals record the sequence of dolomitization, dedolomitization, and partial redolomitization of the dedolostones. Some examples of redolomitization of redolostones have been noted.

Nonevaporitic anhydrite layers do not occur below true evaporite

deposits, and so downward reflux of sulfate enriched brine cannot be invoked as a mechanism of anhydritization. The fact that anhydrite-bearing layers of the upper and lower McKnight alternate with anhydrite-free layers suggests that nonevaporitic anhydrites were emplaced by lateral discharge of calcium sulfate-enriched brines.

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#### Calcification of Encrusting Aragonitic Algae: Implications for Origin of Late Paleozoic Reefs and Cements

Encrusting aragonitic calcareous algae of the family Peyssonneliaceae are the largest group of calcified red algae except for the well-known Mg-calcite coralline algae. They are distributed worldwide, are most heavily calcified in temperate and tropical waters, and grow as prone but arched sheets on soft mud substrates, on hard rock surfaces, as extensive bridge-like networks between corals in reefs, and as concentric layers in nodules. Calcification is entirely aragonite, species specific, and both intracellular and extracellular below the thallus as a hypobasal layer. The hypobasal layer develops outside the tissue as an encrustation of small aragonite botryoids attached to the lower surface between rhizoids, and on living plants it may exceed the thickness of the thallus. Calcification ranges from nonexistent in some cold-water forms to thallus calcification only, to both thallus and hypobasal calcification, to species in which the thallus is noncalcified but there is a hypobasal layer of aragonite botryoids.

Although the confirmed fossil range of this family extends only to the Early Cretaceous, striking similarities between these aragonitic forms and some late Paleozoic phylloid algae suggest that they may be closely related. Their ability to grow on soft mud substrates and form structures composed of irregular arched sheets with extensive pore space, as well as their brittle nature so susceptible to fragmentation, are all characteristics of mound-forming fossil phylloid algae. The hypobasal layer of botryoidal aragonite, developed while the plant is still growing, could easily act as a nucleation site for further epitaxial submarine precipitation, thus explaining the common association of Paleozoic phylloid algae and extensive fossil reef cements that resemble botryoidal aragonite. The presence of hypobasal botryoidal aragonite on plants with a noncalcified thallus raises the possibility that some fossil reef cements may be related to now-vanished algae.

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#### Textural and Compositional Controls on Silica Diagenesis—A Case Study from Nugget Sandstone, Washakie Basin, Wyoming

Grain-size laminated quartzose sandstones ( $Q_{93}F_5R_2$ ) illustrate well-defined relations among framework grain size (GS), quartz type, silica cement (SC), and pressure solution (PS). The percentage of monocrystalline quartz grains with well-developed overgrowths (greater than 50% of grain not in contact with adjacent grains containing overgrowth) is related to grain size (71% coarse, 20% medium, 8% fine sand). Regardless of grain size, less than 10% of the polycrystalline quartz population exhibits well-developed overgrowths.

For medium sand-size nonundulose, undulose, and polycrystalline quartz, the portion of grains with well-developed overgrowth is 29%, 8%, and 2%, respectively. All other factors being equal, first-cycle quartzose sandstones derived from metamorphic source rocks will lose porosity and permeability, due to silica cementation, at a slower rate than those sandstones (nonundulose quartz rich) derived from other sources.

The silica cement present in the Nugget Sandstone is largely the result of pressure solution. Over the average grain size range of 0.22–0.35 mm, the volume represented by pressure solution can be depicted by the equation  $PS = -54(GS) + 26$  ( $r = -0.85$ ).  $SC = 99(GS) - 19$  ( $r = +0.80$ ) defines the relation between grain size and silica cement abundance. Sandstone intervals with an average grain size less than about 0.29 mm are characterized by an excess of silica, whereas for an average grain size above 0.29 mm the opposite is the case. Pressure-solution-produced silica mainly originated in finer grained units and migrated to coarser grained zones. When all grain sizes are considered, the volume of silica generated by pressure solution exceeds the amount of silica precipitated by overgrowths.