Authigenic, euhedral tourmaline crystals are present in a core from a productive shallow gas reservoir in the Upper Cretaceous Eagle Sandstone of the Tiger Ridge field, north-central Montana. Detrital tourmaline is a common constituent of sands and sandstones, and although overgrowths on detrital grains have been reported elsewhere, discrete euhedral crystals of authigenic tourmaline formed in an unmetamorphosed sandstone have not been described. The tourmaline occurs as acicular or prismatic crystals of dravite which are 10 to 20 μ in length and 1 to 5 μ in diameter. The dravites usually occur in intergranular pore spaces and exhibit typical tourmaline crystal habit. An authigenic origin for these crystals is suggested by their (1) delicately euhedral morphology, (2) unabraded appearance, (3) occurrence in growth positions, (4) similarity to dravite overgrowths within the same rock, and (5) close association with other authigenic phases.

The presence of igneous rocks in the vicinity of the well, combined with the absence of tourmaline in several wells not associated with igneous rocks at Tiger Ridge field, suggests that Eocene volcanism in the Bearpaw Mountains was the source for boron, which facilitated tourmalinization. This interpretation has implications relative to the timing of gas emplacement in the Eagle Sandstone at Tiger Ridge. The gas was generated by bacteria during Late Cretaceous time; then adjacent Eocene volcanism caused tourmalinization. The gas was then remigrated into gravity-slide fault blocks in response to the Bearpaw Mountains intrusion and uplift.

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Mixing Zone Dolomite in Tidal-Flat Sediments of Central-West Andros Island, Bahamas

The central-west coast of Andros Island is a complex carbonate facies mosaic, deposited at or near mean sea level. The shore has prograded intermittently during the past 3,000 years to produce a seaward-thickening wedge of sediments up to 25 km wide and about 4 m thick beneath the present shoreline. Old channel levees and beach ridges have been preserved during progradation as topographically high ridges which allow the development of freshwater lenses beneath. These lenses show considerable seasonal variation, both in geometry and pore-water chemistry. Mixing zones, extending laterally a few hundred meters around the lenses and down to Pleistocene bedrock, separate the fresh waters of the lenses (with high alkalinity and low ionic concentration), from adjacent saline and hypersaline waters (with low alkalinity and high ionic concentration).

Fresh waters are generally undersaturated with aragonite, calcite, and dolomite, but calcite saturation may occur locally. The ends of aragonite needles, skeletal grains, and pellets are commonly corroded, although low-magnesian calcite crystals may locally enclose and replace aragonite by dissolution-reprecipitation.

Water in the mixing zone, between 2,500 and 15,000 ppm Cl^-, is undersaturated with respect to aragonite and low-magnesian calcite, but supersaturated with respect to calcium magnesium carbonates. X-ray diffraction (XRD) studies indicate small amounts ($<6\%$) of protodolomite (38 to 44 mole % $MgCO_3$) distributed in patches across whichever sedimentary facies are intersected by the mixing zone. The mixing-zone origin of the protodolomite is however equivocal, as similar compositions occur more rarely with saline pore waters not associated with present or past mixing zones. SEM reveals 1μm euhedral rhombic protodolomite crystals between and engulfing aragonite needles. The needles may later dissolve.

Chemical data from mixing zones indicate precipitation of a magnesium-rich phase frequently in excess of observed protodolomite concentrations; a huntite phase is indicated by considerations of stability, but is unsupported by XRD results.

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Porosity Examples from IAB Field, Coke County, Texas

IAB field produces oil from an Upper Pennsylvanian (Cisco-Canyon) carbonate buildup situated on the western edge of the Eastern shelf. The reservoir is approximately 6 mi (9 km) long, 2 mi (3 km) wide, and 300 to 1,000 ft (100 to 300 m) thick. The upper surface of this buildup is irregular with several pinnacles, probably caused by subaerial erosion that occurred during drops in sea level.

From examination of cores, 10 lithofacies have been identified and divided according to texture, sediment types, fossils, and mineralogic composition. Facies recognized are subtidal normal-marine deposits, ranging from relatively quiet-water skeletal wackestones to relatively high-energy, shallow-water oolitic grainstones.

Porosity consists of both primary and secondary types and is controlled by depositional fabric, dolomitization, and freshwater diagenesis. Five main porosity types are (1) primary interparticle and (2) primary intraparticle porosity, both in grain carbonate rocks, (3) secondary leached grain and moldic porosity in grain carbonate rocks, created during a drop in sea level, (4) secondary vug porosity in muddy or very fine-grained carbonate rocks, also created during a drop in sea level, and (5) secondary intercrystalline and vug porosity in dolomites.

Muddy carbonate beds had low initial effective porosities because of poor sorting, whereas grain-rich carbonate beds had high initial effective porosities owing to good sorting. Following deposition, sea level probably dropped, and the buildup was exposed to freshwater vadose and phreatic diagenesis. Solution of various grains and simultaneous precipitation of equant calcite cements produced secondary leached porosity and reduced primary interparticle and intraparticle porosity. Porosity preserved during this period of subaerial exposure and freshwater diagenesis was probably later reduced during deeper burial by additional cementation and compaction.