Dolomite and Dedolomite in Mural Limestone, Lower Cretaceous, Arizona and Sonora

Three petrographically distinct types of dolomite occur in the upper member of the Mural Limestone, lower Albian, of southeastern Arizona and northeastern Sonora: (1) very fine to medium grained sucrosic dolomite occurs replacing lime mud fills of constructional reef cavities 5 cm to 2 m in diameter, emplaced along stylolites and in irregular patches of pressure-solved matrix in rudstones and floatstones, and replacing matrix in oolitic and skeletal packstones; (2) medium to extremely coarse ferroan baroque dolomite, characterized by curved cleavage and sweeping extinction, is an important void filling cement; and (3) euhedral, non-ferroan dolomite cement partly fills some late fractures.

Available evidence indicates that dolomitization occurred in four episodes. Petrographic and field evidence suggests that sucrosic dolomite in reef cavity fills and in coarse packstones preceded baroque dolomite cement. Baroque dolomite followed calcite rim cements and some blocky spar, and was followed by additional blocky spar. Fractures containing non-ferroan dolomite cement postdate all of these cements. Pressure solution-related dolomite formed still later, during middle to late burial diagenesis and tectonism.

Dedolomitization affected all dolomite types in the Mural Limestone. Nearly all sucrosic dolomite has been calcitized. The resultant fabric consists of calcite rhombs in a mass of anhedral calcite, stained by exsolved iron. Baroque dolomite cement is commonly partly calcitized. It alters to single crystals of "rusty" calcite in optical continuity with the dolomite, retaining the latter's curved cleavage and sweeping extinction.

Dedolomitization in the Mural is attributed to exposure to low-Mg fresh water under near-surface temperatures and pressures. These conditions have probably been in effect since the mid-Tertiary.

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Methane Measurement from "Saline Zone" Oil Shale, Piceance Creek Basin, Northwest Colorado

Oil shale from the Parachute Creek Member of the Green River Formation gives up methane in various amounts when penetrated by drilling or shaft sinking. The "Saline zone" from the base of the second salt to the base of the R-2 zone has been cored and drill-stem tested in 30-ft (9 m) intervals; the core has been sealed in PVC sleeves and the methane given off has been measured. The methane data have been correlated with the geologic section and the results have been presented for use in mine design.

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Wattenberg and Spindle Fields—Paleostructural and Stratigraphic Traps, Denver Basin, Colorado

The most important mineral resource activity in Colorado during the past decade has been the discovery and development of the Wattenberg gas field and the shallow overlying Spindle oil and gas field. Located north of Denver near the axis of the Denver basin, Wattenberg is estimated to have reserves of 1.3 Tcf of gas in the "tight" J sandstone (delta front) reservoir over an area of 600,000 acres (240,000 ha.), at depths of 7,600 to 8,400 ft (2,316 to 2,560 m). Spindle field, in the southwest part of the Wattenberg field, produces from two marine sandstone bar complexes (Terry and Hygiene Sandstones) in the middle part of the Pierre Shale. From an area of 30,000 acres (12,000 ha.), total production is in excess of 28,000,000 bbls of oil and 100 Bcf of gas at depths of 4,000 to 5,000 ft (1,219 to 1,524 m).

Although both fields are regarded as stratigraphic traps, paleostructural analysis of the area clearly shows that during middle Cretaceous the fields were located on an ancient structural high that was subsequently downwarped into the present low structural setting. Evidence for recurrent movement on the paleohigh are unconformities at the top of the J sandstone and at the base and top of the Niobrara Formation, and also thinning of shale intervals and localization of marine sand bars within the Pierre Shale.

The outline of the Wattenberg paleostructure is best shown by the area of truncation by erosion of the upper chalk of the Niobrara Formation over an area 10 mi wide × 50 mi long (16.1 km × 80.5 km). The east-west trend of the paleostructure changes to northeast and extends for more than 100 mi (16.1 km) into western Nebraska. Three other similar paleostructural trends can be mapped in the northern Denver basin.

Knowledge of paleostructural control on reservoir facies and petroleum migration provides new ideas for petroleum exploration in Cretaceous rocks and in the deeper Paleozoic section of the Denver basin.

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Dynamics of Unvegetated Tidal-Flat Muds

Process-oriented field studies of tidal-flat muds, together with satellite imagery and aerial photography, have provided new data for a synthesis of tidal-flat dynamics in low-, moderate-, and high-tide-range environments where vegetation is lacking in the intertidal zone. In the three areas studied since 1974 (coast of Louisiana, tide range 0.5 m; coast of Surinam, tide range 2.0 m; west coast of South Korea, tide range 5 to 9 m), intertidal exposures of mud measured normal to the shoreline range from less than 150 m (Louisiana) to over 50 km (Korea) width. Each area is blanketed by a layer of gelatinous fluid mud, several centimeters to over 1 m thick, which extends into the subaqueous zone seaward of the low-tide line.

Shallow-water waves in the nearshore zone are substantially attenuated when propagating over soft tidal-flat muds. Attenuation of wave height (without breaking) from a water depth of 15 m to 1 m indicates that there is an 87% energy loss (utilizing linear-wave theory) when waves propagate over a 40-cm thick fluid-mud bottom with a bulk density of 1.30 g cm^{-3}, and greater than 99% energy reduction over a 1-m thick layer of fluid mud with bulk density of 1.18 g cm^{-3}.

Tidal-flat muds are suspended and redeposited at wave and tidal frequency, provided bulk densities are less than 1.20 g cm^{-3}. Suspended-sediment concentrations in the nearshore region are typically 1 to 10 × 10^3 mg l^{-1}. Thickness of brown oxidized mud which overlies steel-gray muds beneath provides an indication of the depth to which suspension and redeposition occur.

In addition to serving as a storehouse for littoral sediments and as a buffer to wave attack, tidal-flat muds serve as a source of sediment for longshore transport processes. Because of high suspended-sediment concentrations, sediment transport rates can be enormous, even under relatively weak currents.

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Nearshore Marine and Continental Facies in Eocene of North-Central Pakistan

Stable-shelf carbonate sedimentation along the northwestern edge of the Indian subcontinent preceded the post–mid-Eocene Indian-Asian collision. The early Eocene section in Pakistan displays very rapid facies changes controlled by a cycle of regression and transgression. Beginning with the Paleocene Patala Formation in the Kohat area, quiet-water offshore dark shales grade up-section to include increasingly thick, extensive, and common marly limestones, becoming a foraminiferal limestone sequence. This section then becomes shalier with progressively thinner and more argillaceous micrites and grades upward into the unfossiliferous green Panoba Shale, which then passes into the nearshore, medium-energy, fossiliferous, and bioturbated limestones of the Shekhan Formation. The upper Shekhan beds are mud-cracked, festoon-bedded, channelform dolostones, presumably tidal deposits. The topmost dolostones contain zones of small disruptive anhydrite nodules and pass rapidly into gypsum laminated with varicolored clays. To the west, the Panoba Shale and the Shekhan Formation grade into a massive salt deposit; to the northeast they grade into deeper water limestone. The evaporites are interpreted as sabkha deposits. All are covered by the mostly continental, mammal-bearing Kuldana Formation red beds. Drowning of the coastline then caused rapid development of (1) local lacustrine dolomite and chert units, (2) oyster-rich lagoonal or estuarine limestones, and finally (3) open-bay nummulitic limestones and shales of the mid-Eocene Kohat Formation. The succession is truncated by a regional unconformity that records uplift, erosion, and dolomitization of the underlying carbonate rocks. The unconformity is then buried by continental Himalayan molasse.

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Uranium Mineralization in Hopi Buttes, Arizona

The Hopi Buttes dominate the landscape north of Holbrook, Arizona, rising to heights of ~1,000 ft (305 m) above the surrounding countryside. The buttes, erosional remnants of lava-filled diatremes and associated sediment-filled diatremes, are approximately 5 m.y. in age. The volcanic rocks of the diatremes are limburgite and monchiquite, which are distinguished from normal alkalic basalts of the Colorado Plateau in their extreme silica unsaturation, high water, TiO_2, and P_2O_5. Many trace elements are also unusually abundant, most notably Zr, Ba, Nb, Ce, and U (average value of about 4 ppm U compared to an average of 1 ppm for continental basalts). Many of the diatremes are filled with local maar lake sediments believed to have been deposited in part by rising thermal solutions. Limestone lake beds locally resemble travertine deposits and contain high concentrations of phosphate, sulfate, Ba, Sr, and As, as well as U and Se. Areas of high Se content are recognizable in the Hopi Buttes by the abundance of *Astragalus patersoni* ("loco weed").

Approximately 300 diatremes occur in the Hopi Buttes area. Of 79 studied during the past year, 35 contain lake-bed deposits with radioactivity exceeding background levels. Scintillometer traverses have shown 20 of these diatremes to have radioactivity exceeding 5 times background. An airborne gamma-ray survey shows sharp-peaked anomalies over all 20 of these diatremes. Hydrogeochemical sampling in the area also revealed anomalous concentrations of uranium in spring and well waters from the Hopi Buttes area. Uranium ore was mined during the 1950s from the Morale claim. Production records show the average grade for 186 tons of ore was 0.15% U_3O_8. Extensive drilling in this diatreme in October 1979 revealed intervals within limestone and siltstone maar lake sediments up to 20 ft (6 m) thick and 500 × 300 ft (152 × 91 m) in area containing an average of 0.015% U_3O_8. The potential for uranium in the Hopi Buttes is for low grade deposits within 50 ft (15 m) of the surface, some of which may contain on the order of 100 tens of U_3O_8 per diatreme.

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"Middle" Cretaceous (Albian-Turonian) Depositional Environments Along a Part of Eastern Margin of North American Epicontinental Seaway

In Iowa and bordering states the Dakota Formation, Graneros Shale, Greenhorn Limestone, and Carlile Shale were deposited along the eastern margin of the North American epicontinental seaway during the middle part of the Creteceous (Albian to Turonian). The pre-Cretaceous physiographic surface of northwestern Iowa consisted of ridges and valleys developed upon tilted Paleozoic rock. This surface profoundly affected the deposition of sediment. Detailed studies of surface outcrops, subsurface cores and cuttings, and gamma-ray well logs reveal that this part of the seaway was the scene of fluvial-deltaic deposition followed by an extensive marine transgression. The Dakota Formation commonly consists of a quartzarenite sequence which has a sharp basal contact and grades upward and laterally into clay shales. This sequence is commonly capped with organic-rich mudrocks, or lignite beds. Analyses of textures, sedimentary structures, and lateral relations indicate that these lithologies represent southwestward-flowing fluvial systems which floored topographic valleys. The Dakota Formation grades upward into fluvial-