point microporosity of 5 to 10% are found within the fine-grained skeletal grainstones. Fracture porosity enhances permeability in several facies. Moldic and vuggy porosity types are generally secondary whereas intraparticle porosity may be preserved primary. Pinpoint microporosity is probably matrix related secondary porosity. Coarse equant calcite commonly occludes intraparticle, moldic, vuggy, and fracture porosities. Dolomitization within the "reef" limestones may have acted to create or preserve porosities.

Poor production from the Glen Rose reef trend has been attributed to the lack of structural closure. Use of all available electric logs and sample logs in conjunction with extensive core and thin section analysis should provide new insight on carbonate diagenesis and the relationship to porosity-permeability trends within the Glen Rose reef trend.

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Depositional Microfacies and Burial Diagenesis of Upper Jurassic Cotton Valley Limestone, Teague Townsite Field, Central Texas

The Cotton Valley Limestone, like the older Smackover, was deposited on a ramp where the monotonous regional topography was punctuated by salt-generated and basement highs that greatly influenced local depositional environments. Teague Townsite field is located above a salt ridge that was once divided into several domes where Cotton Valley grainstones were deposited. Open marine wackestones and packstones surrounded those oolite shoals and, updip, shaly wackestones were deposited in a more restricted environment. An overall increase upward in the carbonate grain/mud ratio resulted from a Late Jurassic regional regression. Nine smaller, shoaling-upward cycles are present in the study area; they probably reflect local salt movements. The reservoir at Teague Townsite field is mainly intraparticle porosity formed by early leaching of metastable allochems in the meteoric phreatic environment that was contemporaneous with several of the periods of local emergence. Interparticle porosity was filled early by equant and bladed cements. Neomorphism and replacement were common in early diagenesis. Subsequently, compaction, stylolitization, sparite cementation, and introduction of saddle dolomite occurred. Whole-rock analyses indicate that the present-day trace element distribution reflects (1) early cementation and flushing of porous zones; (2) comparatively less flushing of muddy zones; and (3) introduction of subsurface fluids. Whole-rock $\delta O^{18}/\delta C^{13}$ values plot within the range of published data for "typical Jurassic cements." The average δO^{18} values are -5 and the δC^{13} values are $+2.5$ PDB. A tendency toward "heavier" isotopic composition with increasing depth is interpreted to be the result of subsurface fluid influx during burial diagenesis.

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Storm-Generated Accumulation of Nummulite Banks in Eocene of Cairo, Egypt

Nummulite banks which are common in neritic and shelf-edge facies in many parts of the Tethyan Eocene have been mainly regarded as reef-type buildups so far. However, stratification and biofabrics of such banks in the middle Eocene around Cairo demonstrate the importance of physical processes in molding nummulitic sediment bodies.

Initiation of a nummulite bank at the Giza Pyramids Plateau is localized by a preexisting paleohigh, inherited from Late Cretaceous tectonism. On this "submarine swell" (about 1 × 1.5 km wide), ecological conditions were optimal for a flourishing *Nummulites gizehensis*-community, resulting in greater sediment production than in adjacent environments. Growth of the nummulite bank into a sediment body over 30 m (98 ft) in thickness and more than 1 km (.62 mi) in length is strongly enhanced by mechanical concentration of nummulite tests into coquinal packstones. These are interpreted to be a product of storm-generated winnowing. Paleoecological evidence shows that nummulite banks are largely an in-situ lag deposit. Periods of nummulite settlement are episodically disturbed by "catastrophic" storm events, which result in winnowing and local accumulation of the heavier bioclasts. Upward growth of the banks into shallower water is reflected by an increase in winnowed fabrics and by a cap of shoal calcarenites. During shallowing, patch reefs and a back-bank lagoon formed on the landward side of the bank.

This facies association may be regarded as a model for hydrocarbon reservoirs. The high intraparticle porosity in nummulite tests (54%) makes the banks a potential reservoir, while adjacent and overlying lagoonal mudstone and wackestone may serve as source and cap rocks.

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Origin and Genesis of Fracture Porosity in Viola Limestone (Ordovician)

Analysis of surface exposures of the Viola Limestone is important to understanding Viola oil and gas production trends in the Marietta basin of southern Oklahoma. Surface exposures of the Viola Limestone in the Arbuckle Mountains and Criner Hills of Oklahoma indicate a critical dependence of fracture development on structural position and lithology. Maximum fracturing occurs in tensional zones along fold crests, rather than in areas characterized by intense compressional stress. Fracturing also appears to be related to lithology. The basal, cherty unit has a fracture density approximately two to four times greater than that of the upper, more calcareous units. These relationships could be important to understanding oil and gas occurrence in the Viola Limestone, because the same controls may dictate distribution of fracture porosity in the subsurface.

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Textural Controls on Sandstone Diagenesis

Diagenetic alterations of sandstone occur in a continuous system. As a result, equilibrium thermodynamics cannot be strictly used to describe the equilibrium composition of the diagenetic system and the resulting course of diagenesis. If a geologist is to predict the course of diagenesis in a meaningful way, he must determine those factors which serve to control the various diagenetic pathways.

Geologic evaluation of sandstone fabric and texture is an integral part of most regional studies. These data are often critical in understanding diagenesis as well. Sediment grain size, roundness, sorting, and packing factors determine the ability of a sandstone to transmit fluid during the course of burial and diagenesis. These geologic factors can be used to evaluate the paleohydrology of the sand bodies under investigation, and provide insight to a major control of diagenesis.

The fluid flow rate through a sandstone controls the residence time of the various chemical components in solution. When the residence time is sufficiently long with respect to the time scale of the diagenetic reaction, the time invariant condition of a continuous system approaches chemical equilibrium. Thus it is possible to have different diagenetic reactions occurring within a sand body due to local changes in fluid flux (or flow velocity) and the resultant varying degrees of approach to equilibrium.

In systems where fluid flow is high and residence time is small with respect to diagenetic reaction rate, the fluid chemistry is largely controlled by the chemistry of external fluid source. This situation results in either introduction of new material (or minerals) into, or removal of existing material or minerals from the sandstone. If the fluid is saturated or nearly saturated with respect to some specific mineral this mineral is added. Conversely, leaching of material occurs when the fluid is undersaturated.

In systems where fluid flow is slow and residence time is large with respect to diagenetic reaction rates, the fluid chemistry is largely controlled by the chemistry of the host rock. In this case, chemical equilibrium is approximated and the material originally present in the rock is redistributed by solution/precipitation reactions. Only small amounts of materials are introduced to or removed from the host rock. Understanding this control on sandstone diagenesis is important in delineating trends in diagenetic alteration and projecting those trends into new areas, and in identifying the trends in differential cementation that produces some types of diagenetic traps.

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Role of CO_2 in Evolution of Secondary Porosity in Pennsylvanian Morrow Sandstones, Anadarko Basin, Oklahoma

The Anadarko basin is one of the most outstanding hydrocarbon producers in the North American continent. Examination of more than 50 cores from the Pennsylvanian Morrow sandstones reveals a complex diagenetic history. Although quartzarenite is the major lithology, shell fragments, glauconites, and clayey matrix occur in considerable amounts throughout the section. This diagenetic complexity is a function of depositional environment and burial and thermal history of the basin.

Most porosity in the Morrowan sandstones throughout the Anadarko basin is chiefly secondary. Such porosity results from the dissolution of clayey matrix, carbonate fragments and cement, glauconite, and quartz grains and their overgrowth.

Evolution of secondary porosity is related directly to the generation of hydrocarbons. CO_2 gas, with concentrations ranging from 0.3 to 4.7% by volume, was detected in more than 150 natural gas wells examined in the basin. Based on geothermal and geopressure gradients, and on experimental investigations of the solubility-potential of CO_2 in formation fluids under elevated temperatures and pressures, a good estimate of solubility of CO_2 in the Morrow Formation water may be attained. Because the concentration of CO_2 appears to increase with depth in the basin, secondary porosity should not be restricted to a particular zone or to particular depths, but definitely would persist with depth. Organic acids at shallow depths and H_2S in deeper zones may be important in enhancement of secondary porosity.

Amounts of porosity and the geometry of pore space are directly related to the original lithology. A better understanding of lithofacies is very critical in evaluating reservoir quality.

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Dolomitization and Late Secondary Porosity Development in Nisku Reefs (Late Devonian) of Alberta

Dolomitization and associated calcite dissolution are important controls on reservoir quality in coral reefs of the Nisku Formation. Average porosities of 13 to 15% and permeabilities of 3 darcys are recorded in the fully dolomitized reefs, while lower average porosities of 3 to 5% and permeabilities of 350 millidarcys are recorded in partly dolomitized reefs. The close correlation between dolomites and high porosity and permeability is best understood by examining the paragenetic sequence and spatial distribution of the dolomites.

Dolomitization occurred over a long period of burial and resulted in the formation of two major types of dolomites that are volumetrically significant. The first is characterized by matrix-selective, gray, cloudy, 20 to 150-μ crystals that grade from scattered subhedral and euhedral rhombs to interlocking crystalline mosaics. Matrix dolomites are slightly calcitic (51 to 53 mole % Ca), have a low iron content (less than 0.04 oxide wt. %), show a pronounced fabric selectivity toward micrite, and are abundant in all of the reefs. The second major type of dolomite is characterized by pervasive, brown, cloudy, 60 to 300-μ crystals that occur in the flanks of structurally updip reefs and throughout the downdip reefs. The pervasive dolomite exhibits similar chemical characteristics to the matrix dolomite and in some places replaces it.

Concentration of dolomite crystals and dissolution of individual rhombs along stylolites indicate that the matrix dolomite initially formed at shallow depths. As dolomitization progressed, dolomite recrystallization and cementation along with extensive calcite dissolution resulted in dramatic increases in porosity and permeability. Calcite dissolution continued after dolomitization ceased, but much of the dissolution is coeval with dolomitization. Evidence for the coeval relationship includes a complete gradation from partly dolomitized corals with dissolution of parts of the calcite skeleton to totally dolomitized rock with biomoldic porosity. Dolomite overgrowths, some of which are enriched in iron (up to 1.5 oxide wt. %), formed during progressive burial. Dolomite cements commonly extend into tension fractures that displace and are displaced by stylolites, indicating formation at greater depths than the precursor crystals. Matrix and pervasive dolomites exhibit values for ^{18}O from -2.5 to $-6.0‰$ PDB and ^{13}C from $+2.5$ to $+6.0‰$ PDB. The negative shift of ^{18}O values from those of modern dolomites formed at shallow depths may be the result of formation at elevated burial temperatures. Pervasive dolomites are the result of recrystallization of the matrix dolomite and possibly primary dolomitization of the reef-flank facies. Isotopic data support a strongly rock-buffered system.

Late dolomites and secondary porosity in the Nisku reef trend increase in abundance down structural dip, toward the southwest. Thus, much of the dolomite and late porosity is post-Devonian and probably formed during the late Paleozoic and early Mesozoic when the regional structure tilted to the southwest. Although all Nisku reefs form stratigraphic traps, late diagenetic overprints in some significantly enhanced their reservoir quality.

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Fine Structure of Radiolaria

Fine structure and physiological studies of major biological