ogy 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-$\mu$ 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-$\mu$ 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