

## SPECIAL NOON MEETING

### ORIGINAL AND SECONDARY PORES IN SEDIMENTARY RESERVOIR ROCKS: RELATIONSHIP TO $\text{CaCO}_3$ CEMENTS

By Gerald M. Friedman

Retention of original pore space, development of secondary pores, and precipitation of  $\text{CaCO}_3$  cement in pores of sedimentary reservoir rocks are the result of a delicate balance among organic processes, composition of water and migration of fluids, and the depositional and diagenetic history of calcium carbonate sediment particles and carbonate rocks.

In a high-energy marine environment, where waves and currents impinge on the sediment particles, original pore space may persist and thus may be available in subsurface reservoirs. However, in reefs, cements are precipitated early. Original pore space will be preserved only if hydrocarbons are introduced early, if shale seals off the reef from migrating fluids, or if the reef is invaded by meteoric waters undersaturated with respect to  $\text{CaCO}_3$ . Where reefs or ooids and skeletal accumulations are subject to leaching by meteoric water sub-aerially, in the subsurface, or on the sea bottom near leaks of meteoric water, leaching creates secondary (moldic) pore space while solutions are undersaturated with respect to  $\text{CaCO}_3$ . These new secondary pore spaces are added to the preserved original pores; they increase the total porosity. In corals leaching begins in sclerodermites. The newly created pores merge and form channels. In such leached corals porosity values may exceed the porosity values found in corals of unleached modern reefs. Hence conditions for developing maximum pore space include exposure of reefs or high-energy carbonate sands to meteoric waters. However, once meteoric waters become saturated with respect to calcite, calcite cement is precipitated in the pores. This cement progressively eliminates primary and secondary pores.

Under both surface and subsurface conditions, sulfate-reducing bacteria use sulfate from seawater, or from meteoric or formation waters as an oxidant for that part of organic matter which they oxidize for energy production. Calcite as a cement is formed when  $\text{CO}_2$  produced in the bacterial oxidation of organic matter combines with calcium.  $\text{CaS}$ , an intermediate product in sulfate reduction, hydrolyzes, because it is not stable in aqueous solution, and in this reaction the pH rises. At high values of pH not only does calcite cement tend to be precipitated, but also quartz particles tend to be peripherally corroded and ultimately replaced. Such cementation and replacement of quartz by calcite have been observed in subaerially exposed sandstones 10,000 years old, in subsurface reservoir rocks, and in modern beachrocks. Other bacteria form  $\text{CO}_2$  from methane, such as that found in lagoonal sediments or tidal marshes and this  $\text{CO}_2$  can trigger precipitation of carbonate cement in sediments lying on the sea floor or occurring in the subsurface.

BIOGRAPHICAL DATA:

Gerold M. Friedman

Born:

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Education:

1945 - B.Sc., University of London, England

1950 - M.A., Columbia University

1952 - Ph.D., Columbia University

Experience:

1950-1954 - Assistant Professor, University of Cincinnati

1954-1956 - Consulting Geologist, Sault Ste. Marie, Ontario, Canada

1956-1964 - Pan American Petroleum Corporation (Amoco), Tulsa, Oklahoma

1956-1960 - Senior Research Scientist

1960-1962 - Research Associate

1962-1964 - Supervisor of Research

1964-Present - Professor of Geology, Rensselaer Polytechnic Institute, Troy, N.Y.

Membership:

1971 - Vice-President, International Association of Sedimentologists

1964-1970 - Editor, Journal of Sedimentary Petrology

1970-1971 - Vice President, Society of Economic Paleontologists and Mineralogists,

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1966- - AAPG Continuing Education Program, Lecturer

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