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Rocks, Pores, and Enhanced Oil Recovery — A Geological Challenge

The efficiency with which oil can be recovered during the advance of injected fluids is affected by a large number of variables which fall into three main categories: the properties of the rock-pore system, the properties of fluids, and the forces acting of the system. Of these, the rock-pore system is the most poorly known. Although the constituents of rock have been studied thoroughly, little quantitative information is available on the topology or geometry of pore systems. It is these systems which affected multi-phase fluid flow and influence the volume of oil which can be recovered economically.

Important pore properties include aspect ratio (pore to throat size ratio), connectivity (number of throats per pore), surface characteristics of the pore walls, and heterogeneity (degree of order or disorder).

Increasing order affects displacement efficiency adversely and a major difficulty of reservoir description is quantifying the degree and types of order-disorder on scales from a few pore diameters to dimensions approaching those of the reservoir. Degree or order may be related to depositional processes, as in stratification, but more commonly is related to diagenesis.

The relative importance of various pore characteristics can be assessed in relation to fluid properties such as wettability which are the result of fluid-rock interactions. Pore systems are best seen as pore casts folowing dissolution of the host rock. Selected characteristics of pore systems can be replicated, singly or in combinations, in transparent glass micromodels. Fluid displacements then can be conducted to determine a hierarchy of fluid and pore variables which affect displacement efficiency. Furthermore, displacements can be conducted in reservoir rocks with fluid properties and wettability similar to those of the reservoir but using fluids which can be solidified at residual saturations. Thin sections can be prepared and the form and distribution of multiphase fluids (water, oil, and gas) can be examined in relation to the mineralogical and textural properties of the rock. Conventional fluid displacement tests on core have provided data on the amount of residual oil but not on size, shape, or arrangement of populations of residual blobs. This information is required to understand oil entrapment and mobilization and provides a link between the petrographic observations of the geologist and the fluid displacement tests of the geologist and the fluid displacement tests of the engineer.

Fluids injected during enhanced oil recovery may react with solutions or minerals in reservoir systems and fluid compatability and formation damage problems can be minimized by use of geochemical-mineralogical information. This is another area where geologists can make an important contribution to reservoir production.