

## Panel Discussion

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### Waterflooding of Carbonate Reservoirs

*Moderator, R. S. COOKE,  
Union Oil Company of California*

Members of the panel discussed operation of and problems associated with waterfloods in carbonate reservoirs. In addition to general flood performance, aspects discussed included the relation of pilot to full-scale results, analysis of injection well behavior and scale problems. A

question and answer period followed the panel presentations. A **brief** description of each topic, as outlined by each panelist, is included in this volume; however, the panel discussion was presented extemporaneously.

### Some Pilot Waterflood Results in Carbonate Reservoirs

*JOHN H. BUCKWALTER  
Ryder Scott Company, Petroleum Engineers*

A number of pilot waterfloods in carbonate reservoirs have been studied. There is a wide variation in the performance of these pilot waterfloods. The oil recoveries resulting from water injection have varied from negligible quantities of oil to more than one and one-half times primary oil production. In most cases, the expanded development of pilot waterflood projects do not follow the performance of the pilots. It is concluded that pilot projects in carbonate

reservoirs are not very reliable indicators of the oil production to be obtained from full-scale projects. Obvious reasons for the poor reliability of pilots are the wide variations in the geologic factors such as types of effective porosity, permeability and native reservoir fractures. In general, oil sand reservoirs do not have the wide variations of these geologic factors and therefore, pilot waterfloods in sands are reliable indicators of full-scale waterflood performance.

### Injection Well Analysis in Fractured Carbonate Floods

*JOHN R. GARRETT  
Pan American Petroleum Corporation*

In West Texas carbonate reservoir waterfloods, the problem of water channeling through open fractures can be acute, causing injected water to bypass large quantities of oil in the

rock matrix and produced water volumes to increase prematurely. Several injection well analysis techniques are available to determine such factors as the extent of fracturing, their most

probable orientation, their depth in the wellbore, and the injection conditions which cause the fracture to open. The injection well or wells, which are contributing this water, can be determined by reducing or shutting-in injection and observing the performance of offset or nearby producers. The use of several different types of tracer material in the injection water has also been helpful in locating the offending injection well. A pressure falloff test can be used to determine the flow capacity of the fractured area as well as that in the interwell area. This test will also provide a measurement of the reservoir pressure at the flow boundary and can be used for estimating the radius of the fracture. A

step rate test can be used to determine the injectivity conditions of rate and pressure, which cause the fracture to open. Other tests, such as the variable rate test, the two-rate test, and a plot of injectivity versus cumulative production, provide data on flow capacity and the skin condition at the wellbore. A water distribution profile survey can be used in conjunction with other tests to determine the location of the fracture in the wellbore, while oriented impression packers inflated across the fractured interval provide fracture orientation data. With these data in hand, the most suitable method of controlling channeling can be more readily determined.

## Waterflood Performance in Permian Basin Reservoirs

J. L. GOOLSBY

*Gulf Oil Corporation*

The types of reservoirs encountered in the Permian Basin are characterized by their geology and primary driving mechanisms. With this in mind, water injection case histories are of great value in the management of existing and future injection programs in similar reser-

voirs. Such case histories were presented in this extemporaneous presentation. This discussion also included several comments on data analysis and predictive procedures used in such water injection projects.

## Scale Problems Associated With Flooding of Carbonate Reservoirs

D. E. HEWITT

*Cities Service Oil Company*

To properly contend with scale problems in waterflooding carbonate reservoirs it is necessary to evaluate scale formation in both the producing and injection flow streams of the waterflood system. To realize the efficacy of such evaluations it is necessary to develop and

utilize procedures to eliminate these difficulties. Since the scale problem and attendant operational problems are varied and continuous it is also of importance to constantly study the problem and develop new and varied procedures to correct these situations.