tional contact with Mississippi siliceous lutite.

The position and timing of alternating carbonate and fine terrigenous deposition, as well as the loci of carbonate buildups on the slope, must be affected and perhaps even controlled by the positioning of the Loop Current, a major precursor to the Gulf Stream which, depending upon factors as yet not totally understood, irregularly advances into or retreats from the eastern Gulf. When the loop is "up" and sweeps from north to south along the West Florida slope, it blocks or deflects Mississippi sedimentation. When the loop is restricted to the area of the Florida Straits, fines derived from the Mississippi River can be deposited at the base of the escarpment and even up on the slope.

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Palo Duro Basin, An Exploration Frontier in the Texas Panhandle

Recent oil discoveries in the northwestern and central Palo Duro basin have renewed interest in this sparsely drilled area. Production in the northwest, in Oldham and Potter Counties, is from Pennsylvanian granite wash and carbonates. These fields are located in a highly faulted area south of the Amarillo uplift, and traps are structural. Discovery wells here produce oil at rates that range from 150 to 650 bbl per day. Oil production in the central basin, in Briscoe County, is from Pennsylvanian carbonate. The reservoir is probably a Strawn shelf-margin buildup or a debris flow into the basin from a younger Pennsylvanian shelf margin.

The Palo Duro basin seems to contain potential reservoirs, traps, and source rocks; thermal maturity is probably the limiting factor for hydrocarbon production in the basin. The current geothermal gradient is relatively low, 1.1°F/100 ft (20°C/km), and it apparently has not been significantly different in the past. Vitrinite reflectance (R_o) measured in cores increases linearly with depth (temperature) by the relation: $R_o = 0.00003 \times$ depth (ft) + 0.36. R_o values seem to be in equilibrium with current depths and temperatures of the vitrinite. This suggests that (1) rocks in the basin are at or near their maximum burial depth, and (2) the geothermal gradient was not higher in the past. Shales of different ages that are at approximately the same depth have similar vitrinite reflectance values, an indication that increased time did not cause increased maturity in these Paleozoic samples.

Deeply buried shales, 7,000 to 9,000 ft (213 to 2,743 m), from Pennsylvanian and Wolfcampian basin facies theoretically should have reached temperatures sufficient to generate hydrocarbons. Recent discoveries provide evidence that oil actually was generated in the Palo Duro basin.

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Research in Geology Applied to Enhanced Oil Recovery

Geologists, working in close cooperation with engineers, have an important role to play in maximizing the recovery of oil and gas from producing fields and especially in implementing enhanced oil recovery (E.O.R.) projects. In order for this contribution by geologists to be useful, however, geologic descriptions of reservoir rocks must be quantified for inclusion in numerical models of fluid flow within the porous interval. In particular, research is needed in characterizing both large and small scale heterogeneities within porous reservoir rocks. In addition, research is needed in geophysical monitoring of E.O.R. processes in heterogeneous reservoirs.

At one scale are heterogeneities in the stratification of porous sedimentary facies. Thin shale beds, evaporite layers, cemented zones, and other features that affect the movement of fluids within a formation should be noted and made as important a part of reservoir description as is the nature of the porous rock itself. Numerical models for forecasting production commonly lack this kind of geologic input until development drilling is completed; so models of discontinuities in various clastic and carbonate facies are essential for accurately predicting reservoir heterogeneity with only a minimum of well control.

At a different scale are heterogeneities within the pore systems of reservoir rocks. Recent work by a few investigators has shown the importance of geometry of the pore system to entrapment and retention of nonwetting fluids. Observations by engineers and petrophysicists of differences in the capability of certain rock types to produce the fluids they contain have long been a basis for subdividing reservoir intervals for numerical modeling, but only recently has an understanding of the causes of these differences been gained through work with models and casts of actual pore networks. Further research is needed in this microscopic realm to link the description of rocks and their pores quantitatively with anticipated reservoir behavior.

Yet another field for future research is the chemical interaction of reservoir rocks with various non-native fluids to which they are exposed. Most petrographic studies stop with simple descriptions of pore-lining components of rocks, and only a few published studies provide empirical data on potential chemical reactions between these components and various acidic, caustic, and organic solutions in the subsurface environment.

Finally, another area of development that would be highly beneficial to E.O.R. projects is in our ability to monitor indirectly the progress of various fluids through the reservoir. Remote sensing of fluids of different compositions, through surface or borehole geophysics, without the need for numerous monitor wells between injectors and producers, would be desirable for control of the progress of an E.O.R. project and for reducing the cost of evaluating studies of pilot-areas.

Research of the kind mentioned is, of necessity, a multidisciplinary effort. Geologists or geophysicists working alone tend to stop short of seeing that the reservoir analysis they provide is adequate for answering the questions at hand; and engineers, without geologic guidance, tend to have an oversimplified concept of a reservoir. Either extreme is less than the desired result of which we are capable as a team, if all of the kinds of pertinent information are integrated and maximum use is made of them.

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Influence of Overthrusting on Maturation of Hydrocarbons in Phosphoria Formation, Idaho-Wyoming Overthrust Belt

The regional maturation history of the Phosphoria Formation in the Idaho-Wyoming Overthrust belt was determined from a suite of Phosphoria samples collected throughout the region. Samples were collected from both the footwall and hanging wall of as many thrust sheets as possible. The results of this study indicate that inclusion of the thermal effects of thrust faulting on the temperature history of the region is critical to a thorough explanation of the variations in maturity levels observed in the Phosphoria. A simple evaluation based only on the thickness of the overburden will not be sufficient to accurately interpret the maturation data. Instead, maturation models incorporating the thermal effects of thrust faulting with techniques developed by Lopatin are used to explain the geochemical maturation data.