SOLUBILITY OF PETROLEUM IN WATER AND ITS SIGNIFICANCE TO PETROLEUM MIGRATION

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ABSTRACT

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The aqueous solubilities of individual hydrocarbons, petroleum, and petroleum fractions increase with temperature, the rate of increase being gradual to 100°C and drastic thereafter; eventually cosolubility will be reached at high temperatures. Mass-balance calculations show that the formation of petroleum deposits can be accounted for by a molecular-solution primary-migration mechanism at temperatures greater than 180° C. Temperature decrease and salinity increase cause drastic exsolution of hydrocarbons from the aqueous phase. Thus the pronounced decrease in solubility of petroleum at higher salinities and lower temperatures present at shallow basin depths releases dissolved hydrocarbons during upward movement of deep-basinal waters. Faults provide the main pathway for this vertical movement. Eventually the fluids are collected into shallower sandstones when the fault becomes impermeable to further vertical fluid movement.

The model is supported by geochemical-geologic evidence. At depths of 14,000-18,000 ft. (4.27-5.49 km), 15-20 percent water remains in clastic sediments which is more than sufficient to carry the required volumes of petroleum. Experimental and field evidence has shown the almost total conversion of "kerogen" to extractable organic matter in fine-grained rocks at temperatures greater than 300° C. On the other hand, studies in Tertiary Mesozoic basins have shown that at depths shallower than where these temperatures are present the "kerogen" has not thermally degraded at all, and the extractable organic matter in shales is immature and unlike crude oil. Microspore and pollen particles in crude oils are derived from sediments much deeper in the section than where the oils are found. Thermodynamic equilibrium temperatures calculated for crude oils are much higher than reservoir temperatures and are in the range predicted by this model.

The model predicts specific geologic and geographic controls on petroleum occurrence. Examination of petroleum deposits and basins confirms the predictions and indicates that this model can be used as a powerful tool in petroleum exploration. Raw model's essence is a search for the first trap off a major fault into the area of greatest sediment thickness. The model can be used for exploration in Tertiary depocenters (Gulf Coast, Niger delta), wrench basins (Los Angeles), upthrust basins (Rocky Mountains), thrust basin (Western Canada), and shelf plays (Western Canada, Mid Continent).

Another implication of the model is the possible existence of a huge new energy resource – crude oil dissolved in hot deep waters of petroleum basins. The possibility exists of tapping these geothermal waters for heat as well as dissolved crude oil. Minimum estimates by mass-balance calculations put the reserves of this resource in range of the trillions of barrels.

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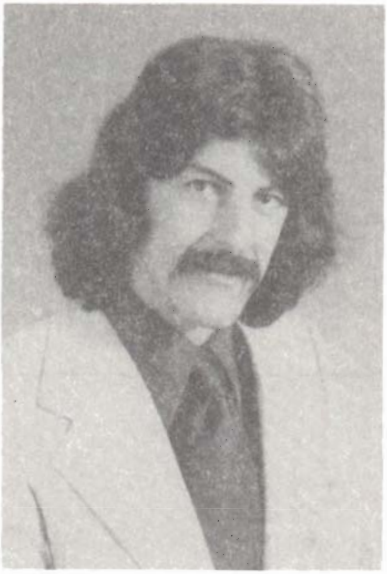

Biographical Review

Leigh C. Price attended the Colorado School of Mines and received a B. S. in Chemistry in 1966 and an M.S. and Ph.D. in Geology - Specialization in Geochemistry, in 1973 from the U. of California, Riverside. Dr. Price spent a year with Esso Production Research Co., Houston, and since January, 1974, has been associated with the U.S. Geological Survey, Denver.

His special interests are petroleum geology and geochemistry, low temperature metamorphism and hydrothermal mineralization.

Idea for the study came from a literature search on an unrelated possible thesis topic on hydrothermal mineralization. It was apparent that there was no lab data on the carrying capacity of hot water for petroleum and that there was a great need for such data to allow for evaluation of the possibility of primary migration by molecular solution in hot waters. After the gathering of the data, much background reading on petroleum geology and geochemistry was undertaken to allow an application of the data to the natural system and the construction of a model.

Dr. Price is a member of the A.A.P.G.