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Seals for Major Middle East Fields

The Middle Jurassic to Turonian sequence in the central part of the Arabo-Persian Gulf presents a concise and well-documented hydrocarbon habitat that demonstrates the controlling role of seal development and preservation in the spatial distribution of oil and gas accumulations.

Geochemical and geologic data indicate two source formations to be present within this sequence, the Upper Jurassic Hanifa, and the Aptian Shuaiba, where developed in intra-shelf restricted basinal facies. The terminal Jurassic Hith Anhydrite and the Albian Nahr Umr Shale are the two principal regional seals.

Hydrocarbon accumulations are concentrated in reservoirs located beneath the two regional seals. Where these are absent through non-deposition or are breached by faulting, oil has migrated upward and is now trapped beneath higher seals. Geochemical fingerprinting and maturation studies provide clues as to which source rock has generated the reservoir oils, and support the geologic inferences with regard to seal efficiency and its control on the distribution of accumulations.

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Simulation Model for Petroleum Exploration and Its Applications

A computerized simulation model was constructed to synthesize the processes of petroleum generation, migration, and accumulation under relatively simple conditions. The model successfully simulated petroleum accumulation in an existing anticlinal gas field, and was used to estimate the possibility of fault and stratigraphic entrapment nearby.

A geologic cross section of the area is divided into a series of vertical columns that are sectioned into rectangular cells representing successive intervals of time and corresponding strata. Four geologic processes are sequentially performed on each cell or pair of adjacent cells. First, sediment is deposited in a cell with its original thickness restored by removing the effects of compaction (deposition). Then, for each time-stratigraphic unit, the compaction caused by increasing time and depth of burial is calculated; the system also estimates the amount of petroleum generated, assuming it to be a function of temperature (compaction and petroleum generation). Primary migration is assumed to occur when petroleum saturation of source beds exceeds the residual amount normally present in thermally mature shale. Secondary migration is assumed to result from buoyancy alone; any petroleum which exceeds the hydrostatic trapping capacity of the shale seal is either allowed to migrate into a cell located along some upward path or escape to the surface (petroleum migration).

The model was applied to the anticlinal East Niigata field, Japan, using carefully selected input parameters. Results made it possible to estimate migration paths and timing of entrapment in each producing zone. The model may also be applied to exploration problems. For example, it was used to estimate the possibility of petroleum entrapment in strata near the East Niigata field. Results of this experiment show that the simulation method is potentially useful for estimating the possibility and places of entrapment, especially for stratigraphic traps.

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Seismic-Stratigraphy of Santa Monica Basin Fill, Southern California Borderland

Seismic-stratigraphic analysis of 3, 1, and 0.25 sec reflection records has permitted an interpretation of the depositional history in Santa Monica basin at several dimensions and time scales. The present form of the basin was established during orogenic episodes in late Miocene and late Pliocene time. Subsequent deformation of the onlapping Quaternary basin fill has been relatively minor. Beneath the basin plain the fill is 640 m thick and is divisible into two units. The lower unit (400 m) represents a pre-Pasadenan accumulation of sediment delivered to the basin through Hueneme, Mugu, Dume, and Redondo submarine canyons. Transport through Santa Monica canyon was inhibited by a structural barrier at the mouth of the canyon. Post-Pasadenan strata (240 m) represent overflow from the Los Angeles and Ventura basins. This latter stage of basin filling is characterized by a significant increase in the rate of sedimentation and extensive growth of the Hueneme and Mugu canyon-fans. During this time, sediment delivery to the basin through Dume and Redondo canyons was diminished, occurring only intermittently. The secular pattern of canyon activity and sedimentation appears to be tectonically controlled.

Glacio-eustatic effects have been secondary. Examination of high-resolution echo characteristics indicates a general southward decrease in the amount of surficial coarse-bedded sediment and that the major transport path since Wisconsinan time has been through Hueneme canyon. Large-scale mass movement, which is an important depositional process in several adjacent basins, is relatively unimportant in Santa Monica basin and is restricted to the canyons.

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Quantitative Investigation of Trapping Effect of Unfaulted Caprock

With the objective in mind to estimate the possible hydrocarbon columns, a statistical analysis has been made of 160 reservoirs in structural traps in several basins. Care was taken to assemble data in those areas where hydrocarbon charge is so abundant that underfilled structures imply seal deficiency. Likewise faulted anticlines and doubtful traps were avoided.

A multivariate statistical analysis was made by defining the dependent variable to be the differential pressure that the hydrocarbon column exerts at the culmination of the trap. This allowed the simulataneous analysis of data comprising oil, gas, and combined columns at different depths. Columns in reservoirs full to spillpoint were considered to indicate minimum (censored) values for the differential pressures. Other situations led to maximum values for the trapping efficiency, while in only a minority of places a column was believed to be in equilibrium with the sealing capacity and hence providing a real (uncensored) observation.

A special regression program that allows censored observations for the dependent variable has been used to relate differential pressure to a set of independent geologic parameters (X-variables). The important X-variables considered here are seal lithology, thickness, and depth of reservoir.