shot the first seismic survey the same year. These data were adequate to confirm a thick sedimentary section, and they contained sufficient structural indications to select the initial drill site. By 1974, four different seismic surveys had been conducted. More and more faulting became apparent with improving data quality. To resolve the structural pattern, a high-resolution seismic survey was conducted in 1976. These data first demonstrated the very complicated fault patterns now known to exist. Additionally, processing of this survey proved that migration is essential for fault definition, although dips are relatively shallow. Paradoxically, it was observed that the best seismic correlations across the many faults were predominantly low frequency. Consequently, a "low-frequency" seismic survey was initiated in 1979. Interpretation of this survey made it possible to correlate gross sedimentary units over large areas of the structure. These correlations were consistent with well control. In 1979, development plans were completed and a 3-D seismic survey was conducted prior to installation of permanent production facilities. This survey comprised 5,000 line-km of data with subsurface coverage of 25 m in the dip direction and 75 m along strike. Nonstandard processing techniques are being tested, both for Erawan field data and other structures in the Gulf of Thailand. Wavelet processing, utilizing a recorded far-field signature, has shown significant improvement in some cases. Migration before stack has significantly enhanced the data by better fault definition and improved correlations across the faults. Development plan for Erawan field consists of five platforms with 12 well slots per platform. Gas will be transported by pipeline to Bangkok and condensate will be separated and offloaded via a single point mooring system. Gas production of 250,000 mcf is planned with first production in the fall of 1981. The development program will continue to be heavily dependent upon detailed analysis of 3-D and other seismic reflection data for optimum positioning of boreholes in both horizontal and vertical dimensions.

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Depositional History and Dolomitization, Kirkuk Oil Field Host Rocks, Iraq

The modified lithostratigraphic framework of the Kirkuk (northern Iraq) carbonates shows that the Paleocene shoal/shelf facies graded northward into the nearshore dolostones and southward into the offshore (basinal) limestones. During Eocene time the shoal deposition covered the whole shelf area, with basinal equivalents present in the southwest. In contrast, the two major cycles of Oligocene sedimentation were controlled by shelf-edge bioherms (in-situ mechanical pilings of skeletal grains). In the Baba-Tarjil area, the bioherms grade laterally into mud flat (NW to NE) and basinal (SE to SW) facies.

Subaerial exposure caused cementation, dolomitization, and dissolution; moldic porosity being the dominant factor controlling the porosity development in the Kirkuk oil reservoir. The associated fine-grained dolostones of the Paleocene time show petrographic, chemical, and isotopic characteristics of the hypersaline (sabkha) type, whereas their coarse-grained Eocene and Oligocene counterparts resemble the diagenetic (Dorag) type dolostones.

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Present Thermal State of Western Canada Sedimentary Basin

The regional geothermal pattern of Western Canada sedimentary basin was studied using available temperature data from shut-in wells. Average heat conductivity was estimated with net-rock data from Canadian Stratigraphic Services. These data allow heat-flow estimations.

The geothermal gradient and heat-flow values for the basin are exceptionally high in comparison with the other Precambrian platform areas, especially in the northwestern part of the Prairies basin in Alberta, British Columbia, and most of southern Saskatchewan. Low-gradient areas are found close to the eastern limit of the Disturbed belt of Alberta and British Columbia. Neither the analysis of regional conductivity nor heat generation of the basement rocks based on U, Th, and K data after Burwash (1979) explains the heat-flow patterns. Certain hydrogeological phenomena do suggest the significant influence of fluid flow on geothermal features. Low geothermal gradient areas coincide with water recharge and high hydraulic head regions.

The phenomenon of upward water movement in the deep strata and downward fluid flow through much of the Cenozoic and Mesozoic strata seems to be the main influence on heat distribution in the basin. Analyses of coal metamorphism in the upper and middle Mesozoic formations of the Foothills belt and in the central Prairies basin suggest that pre-Laramide heat-flow distribution was different from the present. It is probable that the Foothills belt had a higher geothermal gradient than the central part of the Prairies basin, opposite to the present relationship.

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Hydrodynamic and Geologic Significance of Upper Jurassic Smackover Marine Oncolites—Evidence for Penecontemporaneous Lithification

Smackover oncolites from the Chalybeat Springs field, Columbia County, Arkansas, exhibit evidence for penecontemporaneous cementation. "Flower spar" cement, previously reported only in caliche and vadose pisoliths, has been found as thin ribbons within the oncolites. Bivalve and polychaete borings penetrate both the concentric algal laminations and the bioclastic nuclei of the nodules. Boreholes are found around the entire periphery of the nodules indicating that the oncolites were mobile at the time boring occurred. Some borings have their openings capped by subsequent layers of algally bound material, implying that the oncolites were periodically lithifying while still accreting. Foraminifera, serpulids, and bryozoans are seen to encrust the oncolites suggesting that the nodules were indurated at the time of encrustation.

Smackover oncolites are characterized by micritic and pelletal laminations and contain blue-green algal filaments attributed to *Girvanella.* Thus, they closely resemble modern marine oncolites with the exception that modern forms are unlithified. Recent lithifying blue-green algae are known only from freshwater and hypersaline environments.

The density of these large (5 to 35 mm), hard, cemented grains would be considerably higher than that of modern marine oncolites. If the cemented oncolites are assumed to have the same specific gravity as recent freshwater oncolites, current velocities exceeding 100 cm/sec would be required to initiate movement.

A survey of ancient oncolites suggests that virtually all Mesozoic oncolites show evidence of penecontemporaneous cementation.

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