Miocene and reflects a combinatyion of dextral strike-slip motion and oblique convergence. The proposed tectonic model suggests that most of the eastern Gulf of Alaska is underlain by early Tertiarty and older oceanic crust and that large-scale lateral displacement of the Yakutat block may not be necessary.

Late Tertiary convergence in the central Gulf of Alaska, or Yakataga district, has controlled the structural evolution of a complexly deformed, fold-thrust belt consisting of numerous subparallel folds and north-dipping thrust faults. Moving from north to south, deformation in this belt becomes progressively younger and less intense; most of the structures in the offshore part of the Yakataga district are late Pliocene to Pleistocene in age. Industry leased a number of these relatively young structures in April 1976, and subsequently drilled ten dry holes. The drilling results suggest that geopressures, resulting in part from tectonic stresses, low geothermal gradients, and poor sand development appear to be characteristic of these structures and contributed to the lack of success.

GALBRAITH, ROBERT M., Texaco Trinidad Inc., Pointe-a-Pierre, Trinidad, and ALISTAIR R. BROWN, Geophysical Service Inc., Dallas, TX

Field Appraisal with 3-D Seismic Surveys, Offshore Trinidad

The Southeast Coast Consortium block offshore eastern Trinidad contains four structures in each of which hydrocarbons have been discovered. Field appraisal to date had included two 3-D seismic surveys: the Pelican structure was surveyed in 1977 and, following its success, the Ibis 3-D survey was conducted in 1978.

The 3-D migrated data over both the Pelican and Ibis structures exhibit significant enhancement in the deeper part of the section and also improved fault resolution relative to previous 2-D control. On the north flank of the Pelican structure, primary dips have been recognized for the first time. As a consequence, estimated reserves have been increased by approximately 20%, thus substantially affecting development economics. Furthermore, the interpreted position of reserves in the minor reservoir sand has shifted from one fault block to another as a result of the revised fault interpretation. The acoustic nature of the stratigraphic boundary which may delimit this reservoir has been clearly demonstrated using seismic logs. Also the extent of this boundary has been manned from Seiscrop™ sections. The major change resulting from interpretation of the 3-D data at Ibis has been the definition of a much more complex fault pattern affecting all the reservoirs. This will have a significant impact on future field development plans. The 3-D seismic surveys are a useful tool for prospect evaluation in this area offshore Trinidad and should be considered prior to commitment to expensive offshore development programs.

GARRISON, ROBERT E., Univ. of California at Santa Cruz, Santa Cruz, CA, and K. A. PISCIOTTO, Scripps Inst. Oceanography, La Jolla, CA

Lithofacies and Depositional Environments of Monterey Shale, California

The Miocene Monterey Formation records the deep basinal phase of a major late Tertiary cycle of basin formation and filling associated with wrench fault tectonism. Over much of coastal California, Neogene facies show a progression from Oligocene nonmarine and neritic rocks to Miocene basinal shales and siliceous rocks and then to upper Miocene to Pliocene turbiditic and neritic clastic rocks. In many places the Monterey consists of a basal calcareous facies, a middle transitional phosphatic facies, and an upper thick siliceous facies composed of diatomaceous rocks and their diagnetic equivalents (cherts, porcelanites, etc). Hydrocarbon-producing turbidite sandstones occur in these basinal rocks in the southern San Joaquin Valley and in redeposited pelletal phosphorites in the central Coast Ranges.

By analogy with modern environments of phosphate formation off South America and Africa, Monterey phosphatic shales probably represent phosphatization of shelf-slope-basin muds near the boundaries of the oxygen minimum zone. Nodular and pelletal phosphorites may also have formed near the boundaries of the oxygen minimum zone, but on sediment-starved bank tops and shelves. The widespread siliceous facies represents rapidly deposited diatom ooze that records high plankton productivity spawned by late Miocene climatic deterioration and intensified upwelling. Abundant organic matter, ecologic inferences from faunal data, and sedimentary structures such as alternations of massive and laminated cycles indicate that these siliceous rocks also formed as basin, slope, and shelf deposits within or near the fluctuating boundaries of a well-developed oxygen minimum zone—a depositional environment similar to the present Gulf of California and western margin of South America.

GAUTIER, DONALD L., U.S. Geol. Survey, Denver, CO

Diagenesis and Methane Generation in Upper Cretaceous Gammon Shale, Northern Great Plains, United States

In the northern Great Plains, isotopically light methane is entrapped at shallow depths in marine rocks of Late Cretaceous age. Products of early diagenetic decomposition of organic matter in the Gammon Shale support the view that the gas is biogenic and formed at shallow depths early in the burial history of the sediments. This interpretation implies widespread gas occurrence and is consistent with a larger gas resource figure than alternative interpretations suggest.

The Gammon Shale was deposited offshore during a major regression of the Late Cretaceous epeiric sea. The sediment-water interface was oxygenated, and soft-bodied organisms burrowed the silt-clay sediment. Organic matter was sufficiently abundant for oxygen depletion at shallow depths. Bacterial sulfate reduction occurred quickly and resulted in the formation of framboids and octahedra of pyrite. Abundant concretions and discrete crystals of siderite began forming within tens of meters of the sediment surface. Interstitial waters became saturated with methane, and a free gas phase, held in siltstone layers by capillary forces, inhibited silicate diagenesis. Methane generation probably continued to burial depths of hundreds of meters. At the maximum burial depth (1,200 to 1,500 m), interstitial waters contained their maximum dissolved methane, and silt layers still contained free gas. Cenozoic uplift and erosion permitted gas exsolution. Exsolved gas combined with free methane already in the reservoirs to form the gas being currently explored and extracted.

GEALEY, W. K., Chevron Overseas Petroleum Inc., San Francisco, CA

Plate Tectonic Evolution of Southern South America–Scotia Sea–Antarctica Area

Jurassic, Cretaceous, and Tertiary stratigraphy is analyzed in relation to its plate tectonic significance. Based on the I. O. Norton-J. G. Sclater reconstructions for the breakup of southern Gondwana, a scheme is developed illustrating the plate tectonic evolution from Triassic to present that includes (1) opening of the south Atlantic-Indian Ocean areas, (2) the formation of a marginal basin in the southern Andes in Late Jurassic-Early Cretaceous and its subsequent destruction by arc-continent collision and attendant ophiolite obduction, and (3) interaction during the Tertiary of the convergent Pacific margin and a northward migrating RRR triple junction.

GEFFEN, T. M., Amoco Production Co., Tulsa, OK

Methods for Recovering More Oil from Known Fields

Waterflooding is the dominant fluid injection method used to recover secondary oil. It is economically attractive but leaves in the ground a large fraction (~50%) of the oil originally found. In the United States, for more than 30 years, research has been active in developing improved methods which are capable of producing a substantial part of the oil not recoverable by waterflooding (tertiary oil). The methods are usable in the secondary mode (instead of waterflooding) or in the tertiary mode (after waterflooding or natural water drive). Many methods are involved; most of them use water as a major injection constituent. The most promising methods for enhanced oil rcovery (EOR) involve either miscible displacement or thermal means to free the hard-to-recover oil. Although more than 400 field projects have been started with about 226 now (1-1-80) active in the U.S., and about 100 projects outside the U.S. (predominantly thermal type in Venezuela and Canada), the commercial use is now limited nearly entirely to secondary mode applications. Prospects in the tertiary mode have demonstrated technical operability. The economic potential, however, is uncertain, being related to changing price-cost relations.

A critical factor in the successful selection and operation of EOR applications is an understanding of the nature of the geologic makeup of subject reservoirs. Thus, the exploitation geologist is expected to contribute substantially to EOR activities.

GETZEN, RUFUS T., U.S. Geol. Survey, Menlo Park, CA, and RAYMOND T. LEVEY, Univ. South Carolina, Columbia, SC

Rigid-Peel Technique for Preserving Structures in Coarse-Grained Sediments

Low-viscosity epoxy was used to produce 30 × 120 cm peels of structures in unconsolidated sand. These peels have high strength and good visual impact, revealing both fine detail and gross features with several millimeters of relief. Epoxy was sprayed on vertical trench surfaces and heat-treated in situ using portable racks of heat lamps. Seventy-two peels were recovered out of 80 attempts in one trench.

The method is useful for gravelly sands and for fine-grained to very coarse-grained clean sands. The limiting size for vertical faces seems to be about 0.5 m high by 2 m long.

GIES, R. M., Canadian Hunter Exploration Ltd., Calgary, Alberta, Canada

Lateral Trapping Mechanisms in Deep Basin Gas Trap, Western Canada

The basic model for a Deep Basin gas trap is characterized by laterally extensive, low-porosity and low-permeability subsurface strata that contain gas downdip and water updip. No permeability barrier separates the two phases in the transition zone at the updip limit of the gas accumulation. Two other features of the model are significant: (1) the original gas and water phase pressures are about equal at the updip limit, and (2) there is no downdip gas/water contact.

In many respects, the Deep Basin trap is just the reverse of a conventional gas over water-type trap. In the conventional trap, gas has migrated to the highest structural position in the reservoir owing to its buoyancy in the ambient formation water phase; there is a downdip gas/water contact where original pressures in both phases are nearly equal and no permeability barrier is necessary to separate the two phases.

The physical principles controlling the Deep Basin water over gas trap are just as simple and straightforward as those long recognized for conventional traps. Because there is no downdip water phase or gas/water contact, the Deep Basin gas accumulation is not subjected to buoyancy forces as in the contentional trap. As long as pressures remain equal between both phases at the updip contact or transition zone, there will be no unbalanced forces present. As a result, the gas accumulation will remain in a state of static equilibrium. Similarly, in the conventional trap, equal pressures at the gas/water contact maintain the gas accumulation in a state of static equilibrium.

Evidence for these basic principles of Deep Basin trapping of hydrocarbons result from the study of abundant, high quality reservoir data derived from an extensive, ongoing development drilling program pursued by Canadian Hunter in the Elmworth gas field of northwestern Alberta.

GLASS, DOUGLAS E., Canada-Cities Service Ltd., Calgary, Alberta, Canada

Reflection of Topography on Pre-Cretaceous Unconformity Through Overlying Section in Central Alberta

Topographic highs and lows on the pre-Cretaceous unconformity of central Alberta are reflected as irregularities in the structure of overlying formations. In some places, the effects of large highs and lows can be seen directly on structure maps of the Cretaceous formations. For example, the Leduc reef chain, which itself is up to 1,000 ft (305 m) below the unconformity, causes anomalies in the structure of all overlying formations. The effect of the Leduc reef chain can even be seen in the present-day topographic surface through approximately 6,000 ft (1,829 m) of overlying sediment from almost every geologic environment. In many places, however, the irregularities on the unconformity are small and their effects are masked by the regional dip of the Alberta basin. They also become more diffuse on the upper formations.

Trend surface analysis on the structure of the overlying formations removes the regional trend from the data so that the more subtle highs and lows can be recognized. They can be seen, not only as differences between positive and negative residuals, but also as relative highs and lows within areas of positive and negative residuals.

Advantages of using residual maps of the structure of Cretaceous formations to locate highs and lows on the pre—Cretaceous unconformity include: (1) showing that some structural and stratigraphic traps are a direct result of irregularities on the unconformity; and (2) illustrating tht despite limited well control to the unconformity, highs and lows can be mapped using the more numerous shallow-well formation top values.