By late 1978 the first-phase, 7-well exploratory program was completed. Two of the six basins had been tested. Individual wildcat costs using an anchored semi-submersible rig are in the $10 million to $20 million range.

Despite adverse factors of extreme weather conditions, deep water, remoteness, and high drilling costs, more exploratory drilling will be necessary for final evaluation. The Sea Hunt Group is presently considering its second-stage drilling program for the area.

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Tropical Cenozoic Paleo-oceanography and Correlated Events in Phylogeny and Biogeography of Scleractinian Corals

Modern understanding of the speciation process emphasizes the considerable interaction between phylogeny and biogeography. New methods of historical biogeographic analysis, such as vicariance theory, refuge theory, and equilibrium theory, have greatly complemented but not supplanted classical dispersal theory. Vicariance theory is a method which infers the existence of ancestral biotas by analyzing the distributions of numerous living organisms and which then interprets historical biogeographic relations by emphasizing the splitting of the ancestral biotas after range extension by dispersal. The application of vicariance theory to the distribution of fossils, rather than extant organisms, is problematical, because the time element associated with paleontologic data provides both additional information and additional complexities for biogeographic interpretations. A historical biogeographic analysis should give equal consideration to numerous interrelated factors, including inferred ancestral distributions, chronologies of speciation, distributional changes related to paleoenvironmental, paleo-oceanographic, and paleotectonic events, dispersal routes, mechanisms, barriers, and ecologic relations with associated taxa. The acknowledged danger of such a method, of course, is that one may end up with an untestable narrative explanation.

To illustrate these concepts, we consider the Cenozoic biogeographic history and phylogeny of tropical Scleractinian corals. It has been known since the early part of this century that the major evolutionary features and distributional patterns of these corals can be explained by a pan-tropical Tethyan biota which has been subsequently modified by paleo-oceanographic events. Paleontologic, biologic, and geologic data strongly support the following conclusions. (1) Breakup and subsequent disjunction by vicariance of the Oligocene pan-Tethyan coral fauna resulted from changes in marine climate and circulation caused by creation of the Antarctic Convergence and closure of the seaway between the eastern and western Tethys (early Miocene), great restriction and closure of the Panama seaway (middle Miocene), eustatic sea-level fall and other oceanic phenomena associated with the Mediterranean salinity crisis (late Miocene), and closure of the Bolivar seaway (early Pliocene). (2) Both the Indo-Pacific and the Caribbean faunal provinces served as centers of origin for coral genera and species. (3) The Gulf of California Pliocene disjunct fauna is a result of either the extension of the relict western range of the vicariating Caribbean fauna or long-distance dispersal from a previously differentiated Caribbean fauna into a refuge which ultimately failed. (4) The modern eastern Pacific coral fauna is a mixture of both the pan-Tethyan fauna and long-distance dispersal from the Indo-Pacific fauna as controlled by marine climate and barriers.

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Structure of Tunisian Atlas

The Tunisian Atlas is a foldbelt of unusual complexity developed in a stratigraphic succession of Mesozoic and Tertiary age. The folds range in style from simple, narrow-crested box folds separated by broad relatively flat synclines to complex growth folds flanked by numerous unconformities. Many of the anticlines are cored by highly deformed Triassic-Liassic evaporites. Locally the structures are cut by high-angle reverse faults and late-orogenic normal faults. Fold trends are both variable and intersecting and the folds tend to die out abruptly along strike.

A model is proposed in which three successive and contrasting tectonic regimes have operated since the early Mesozoic to produce the structural complexity of the Tunisian Atlas: (1) block faulting associated with rifting of the North African continental margin, which in Tunisia began by, at least, the early Jurassic; (2) diapiric emplacement of the Triassic-Liassic evaporites into the overlying strata beginning in the early Cretaceous; and (3) folding of the cover strata in response to regional compression in the early Miocene through Pleistocene. Structures formed during the Neogene compressional phase were controlled by mechanical anisotropies in the cover, principally thickness and facies variations, caused by the early block faulting and diapirism. Although detachment and decollement glide of the cover strata on the Triassic-Liassic evaporites appear to have operated locally, regional shortening of the pre-Mesozoic basement is considered to be the principal driving mechanism for folding in the Tunisian Atlas.

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Soil Regimes of Tazirbu Region of Central Libya Determined from LANDSAT Imagery

A preliminary study of the Tazirbu region of Libya using color-processed, LANDSAT 1:250,000-scale imagery has produced a practical and potentially useful map of soils in a 10,000-sq km tract. Soil types were mapped by tonal differentiation and substantiated by ground samples where available. The map may help delineate changes in the clay/silt fraction of the sandy soils that dominate the surface of the area. Anomalous color keys characterize vegetation of sufficient density to be registered by imagery. Wind direction represents a prime investigative and interpretive tool. Land-use planning, now being undertaken by the Libyan government, can be simplified by restricting the initial reconnaissance area, delineating areas of clay- and silt-rich soils suitable for irrigation and crop yield, denoting locations free from encroaching sand seas, and providing transportation and accessibility estimates.

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Subsurface Geology of Honor Rancho Area, Ventura County, California

Surface and subsurface data determine the San Gabriel fault geometry and history of faulting in the Honor Rancho area. The northwest-trending, east-dipping San Gabriel fault consists of two strands: an older, concave-upward strand, which becomes low angle at depth, and a younger, high-angle, planar strand. The two strands merge to form one high-angle fault southeast of the Wayside Honor Rancho oil field. West of the San Gabriel fault zone the Modelo Formation (lower and upper Mohnian) overlies granitic basement. West of the fault, the Modelo and Towsley (Delmontian) Formations are in fault contact with the Castaic Formation present only east of the older San Gabriel fault strand. The marine Castaic Formation (lower and upper Mohnian) unconformably overlies the nonmarine Mint Canyon Formation of middle to late Miocene age. The Pico Formation (Pliocene) unconformably overlies older strata on both sides of the fault. Despite lithologic similarities of the Pico on both sides of the fault, markers within the formation cannot be correlated across the fault. The Saugus Formation (Pleistocene) unconformably overlies the Pico Formation and correlates well across and within the fault zone. Ease of correlation suggests that most of the right slip along the San Gabriel fault occurred prior to late Pliocene time. There appears to have been no lateral offset during Pleistocene and Holocene times, but primarily vertical displacement has occurred since the deposition of the Saugus Formation. However, seismic studies infer that right-slip activity is still present at depth along the San Gabriel fault.

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Dual Origin of Natural Gases in Subalpine Tertiary Basins

Many young sedimentary basins produce a great variety of natural gases ranging from deep wet gases to shallow dry gases. It is of considerable interest to find evidence for the origin of these gases, especially with regard to deep exploration.

In the Tertiary subalpine Molasse basin of south Germany, dry gases occur in shallow Oligocene to Miocene reservoirs ($\delta^{13}C_1 \sim -70$ to $-60$ parts per thousand), low $C_{2+}$ gases in upper Eocene reservoirs ($\delta^{13}C_1 \sim -60$ to $-50$ parts per thousand), and wet gases in other Eocene reservoirs ($\delta^{13}C_1 \sim -50$ to 62 parts per thousand; the wet gases being partly associated with crude oils). Two alternatives for the origin of the gases should be considered: (1) the dry gases may be migrated wet gases which have been stripped of their $C_{2+}$ components and have been enriched in carbon 12 isotopes; and (2) the dry gases are of biogenic origin.

Carbon and hydrogen isotope analyses on gases in the Molasse basin have brought direct evidence for the dual origin of these gases. The shallow dry gases are of biogenic origin, as shown by the direct relation between the deuterium isotope ratios of the methane and their associated waters. The wet gases are of thermogenic origin. The scatter in the carbon isotopic composition and the $C_{2+}$ concentration in this particular basin is due to downmixing of the bacterial gases to deeper strata owing to an underlying underpressured zone. C and H isotope analyses on gases from two other Tertiary subalpine basins (Austria and northern Italy) have shown the dual-origin concept to be generally applicable to these basins. In particular the D/H and $^{13}C/^{12}C$ patterns of the gases reflect mixing processes and thus give information on the general hydrodynamic situation of the basins.

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Porosity Relations in Chalk Reservoirs

Oil and gas reservoirs in chalks of the Gulf Coast, Denver basin, and North Sea show similar porosity relations. Most of the storage capacity in the three areas comes from the preservation of primary porosity. Normally, the high initial porosity (60 to 75%) of chalks is progressively lost during burial owing to mechanical and chemical compaction effects. Thus, in many areas of the Gulf Coast and the Western Interior, paleoburial depths of about 1,000 to 1,500 m (3,300 to 5,000 ft) form an economic lower limit for exploration because primary porosity has been drastically reduced at greater depths.

Three factors can strongly influence this relation of porosity and burial depth. First, fracturing can greatly improve the effective permeabilities of chalk reservoirs. Fracturing related to gentle flexuring, salt-dome tectonics, or fault zones has a major influence on the reservoir characteristics of North Sea and Gulf Coast fields and may be involved in Western Interior fields as well. Second, abnormally high pore-fluid pressures (geopressures) reduce or completely halt mechanical and chemical compaction and thus aid in the preservation of primary porosity. In the North Sea and offshore Louisiana, geopressuring has allowed preservation of as much as 40% porosity at depths of greater than 3,000 m (10,000 ft). Finally, early formation of biogenic methane (from bacterial decomposition of organic matter contained within the chalks) or early introduction of migrated hydrocarbons to the point of virtual oil or gas saturation (as in some North Sea chalks) may also be instrumental in porosity preservation during burial.

The porosity relations in chalks, although fairly complex, are far simpler than those typically seen in shallow-water limestones. Thus, based on relatively sparse data, reservoir properties and petroleum potential of chalks can be reliably predicted throughout large areas.

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