preventer, and better station-keeping abilities. Plans also include an extensive science program for regional and site specific surveys and sample analysis. Primarily the drilling will be used on passive margins, especially those of the continental United States. Where feasible, the drill holes and their site surveys will be used to extend seaward land sea transects that might include continental drilling, CORCORP profiles, and continental drilling by U.S. Geological Survey or petroleum companies.

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Stratigraphy and Structure of Early Tertiary Orca Group, Prince William Sound, Alaska

The late Paleocene-early Eocene Orca Group records much of the depositional and deformational history of the Tertiary accretionary prism found in the subduction zone of the Pacific plate in south Alaska. The thick (?5,000+ m) quartzo-feldspathic sandstones and interbedded shales were deposited as a submarine fan complex. Paleocurrents show derivation of detritus from a northeastern source. Three facies belts are distinguished. A northwestern belt characterized by massive sandstones and strong deformation is thrust southeasterly over a central melange belt containing originally interbedded basalt and turbidites deposited on an ophiolite basement. To the southeast, the third belt comprises a classic turbidite sequence which may have been deposited upon imbricated offscrapings of pelagic Upper Cretaceous sedimentary rocks now exposed only in one faulted outcrop on southeast Montague Island.

The predominant structures of the Orca Group are steeply northwest-dipping thrusts and folds overturned to the southeast in harmony with northwesterly subduction of the Pacific plate. However, on Montague Island the neotectonic southeasterly overturned structures overprint early major northwesterly overturned folds. Along strike to the northeast, northwest-trending cross structures overprint the early folds. Structural analysis indicates that the structure of the late Tertiary offshore basin is complex.

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Oxidation-Reduction in Oakville Sandstone of South Texas—Implications for Uranium Mineralization

Three distinct oxidation-reduction zones have been identified within the uranium-bearing Oakville aquifer. An oxidizing zone with Eh values greater than 300 mv and with measurable dissolved oxygen occurs in areas of recharge and extends to depths as great as 800 ft (244 m). An intermediate zone with Eh values between 110 and 10 mv occurs downdip from the oxidizing zone. Eh in these waters may be controlled by ferrous-ferric mineral reactions. About half of the intermediate Eh waters contain low but detectable concentrations of hydrogen sulfide. In east Texas the deepest wells sampled (1,600 ft; 488 m) penetrate this intermediate zone. A reducing zone with Eh less than −40 mv and dissolved H_2S occurs in deepest parts of the Oakville in south Texas and also at shallow depths (300 ft; 91 m) associated with faults, which apparently provided conduits for the discharge of reducing, sulfide-rich waters from deeper formations. Present-day Eh is controlled by either the continued discharge of reducing water or the presence of pyrite formed by previous reduction.

Thermodynamic calculations show that uranium and selenium phases may precipitate within the intermediate zone, but that molybdenum and arsenic require more reducing conditions for precipitation. All four elements should occur together only where the oxidizing and reducing zones are adjacent without an intervening intermediate zone. Such areas can occur (1) where fault discharge has superimposed reducing, sulfidic conditions on an otherwise normal Eh gradient or (2) where a sharp Eh gradient separates highly permeable oxidized sediment from less permeable reduced sediment. Where oxidizing and reducing zones are not adjacent, uranium and selenium only should accumulate within the intermediate zone, and mineralization may be diffuse.

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Marine Petroleum Prospecting with Airborne Fraunhofer Line Discriminator

Natural oil slicks from the Santa Barbara Channel, California, have been imaged using an airborne Fraunhofer Line Discriminator (FLD). The imaged distribution correlates well with aerial photographs, visual observations, and simultaneous television monitoring. However, the areal extent of the surface film mapped by the FLD is larger than that determined by the other methods, suggesting that the FLD is more sensitive to exceptionally thin films. Digital image-enhancement techniques applied to multispectral FLD data may provide general compositional information. The FLD may be useful to explorationists looking for evidence of hydrocarbons in frontier marine areas.

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Possible Geometries of Sandstone Bodies as Reflected by Geomorphic Features on Modern Submarine Fans

Understanding the growth processes and geomorphic features of modern submarine fans will aid in the exploitation of potential hydrocarbon resources in deep-water turbidites. Surveys on four fans in the northeast Pacific using the deep-tow instrument package show a wide variety and size range of relief features. At least three types of channels can be recognized; (1) leveed valleys, common on the upper fan; (2) distributary channels that branch from the active valley; and (3) "headless" channels found at the basin slope and fan margin or along the edges of depositional lobes. All the channel types are associated with areas of active sand deposition. An abandoned distributary channel would likely become the site of deposition of pelagic and hemipelagic muds and occasional thin-bedded turbidites. A connection to the main channel may be maintained by

the sandy filling of the distributary channel. The distributary channels and their associated depositional lobes may serve as collectors and feeders of hydrocarbons to the main channel system.

Isolated depressions ranging from a few tens of meters to more than a kilometer across are seen on all fans that have been studied with the deep tow. On both Monterey and Navy submarine fans, large scour-shaped depressions are observed. In cross sections perpendicular to the fan gradient, these depressions resemble channels. Cores and reflection data show that these features are floored by sand and could be filled by sand or mud. Contrasting the interconnected nature of buried channel systems, the limited extent and continuity of sand-filled and buried depressions would suggest little potential as hydrocarbon reservoirs. Depositional lobes are also common on submarine fans and range in size from small (1 km wide) features associated with distributary channels to large fan lobes occupying tens of square kilometers.

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Lower Cretaceous Shelf Storm Deposits, North Texas

Many of the important features of shelf storm deposits are displayed in the Lower Cretaceous Washita Group in Grayson County, Texas. Proximal shelf sands are up to 2 m thick. They show channeled tops and abrupt lateral thickness variation and are stacked vertically or separated by thin, sparsely fossiliferous marine muds. Each sand unit has a scoured base and comprises a structureless lower interval that grades upward into hummocky cross-stratification. These features in turn are overlain by subhorizontal lamination, with an uppermost interval consisting of small-scale wave ripples containing abundant horizontal burrows and feeding trails. Distal shelf sands are thin (10 to 40 cm) compared to the intervening muds, and are comparable to modern storm deposits of the Texas shelf. A basal shelly lag, with a scoured base of upward-convex, disarticulated bivalves or current-aligned high-spired gastropods merges upward into subdued hummocky cross-stratification and subhorizontal lamination. Powerful bottom return currents, that in the modern Gulf of Mexico are generated by wind immediately prior to storm landfall, were probably the dominant mechanism of offshore sand transport. Storm waves operated contemporaneously and probably contributed toward sediment entrainment, as evidenced by hummocky cross-stratification. However, the disposition of fossils suggests that initially, at least, unidirectional currents were the dominant transport mechanism. Relatively shallow-water depths (50 m or less) are indicated by associated regressive deltaic sequences.

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Williston Basin—Reawakening of Giant Petroleum Province

The Williston basin, covering parts of Montana, North Dakota, and South Dakota, is one of the largest and most active petroleum provinces in the Rocky Mountains. Since the discovery of gas on Cedar Creek anticline in 1913 and oil in 1950, the basin has been the scene of several periods of intense drilling activity, the most recent beginning in the mid-1970s and continuing to the present. Early exploration in the basin centered around structural features with surface expression, such as Cedar Creek anticline, and shallow objective zones. As deeper Paleozoic zones were proven productive on these structures, seismic techniques became essential for defining structural leads with no surface expression. More detailed seismic data and more sophisticated processing techniques were necessary to define deeper and more subtle structures in remote parts of the basin. Existing technology was rapidly adapted by the petroleum industry to explore for these deeper traps.

Although a mature basin by some standards, the Williston basin still contains vast areas that are virtually unexplored. Intense competition by the industry and escalating land acquisition costs indicate that these parts of the basin will be the center of exploration activity in the future. The reserve potential of these areas should be at least as large as the proven reserves in the basin to date. Of equal importance is the exploitation of the more mature parts of the basin, including new pay zones.

Future exploration in the Williston basin must incorporate new exploration techniques and new exploration philosophies in the evaluation of new pay zones and unexplored parts of the basin.

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Intertidal Zonation of Recent Microbial Endoliths, Bermuda

Recent microbial endoliths have fine zonation within the intertidal and supratidal areas along the carbonate coast of Bermuda. This zonation correlates with a gradual change in the rock surface relief and color. The diversity and abundance of the endoliths were determined for seven sites with different degrees of slope and wave exposure around Bermuda. Within each site there is a gradual reduction in the number of species and a shift in the dominance of a species from subtidal to supratidal. By grouping of species, it is possible to identify community composition changes for each site and to establish the principal microbial endolith associations representative of the Bermuda Coast. A given assemblage of endolithic organisms occupies a certain relative position with respect to mean sea level and wave exposure, and is characterized by the microrelief of the biokarst. Preliminary work on the endoliths of Jamaica and Florida suggests that the endolith-community profile for Bermuda may be typical of the entire Caribbean area.

The microbial endolithic assemblages can be recognized on the basis of (SEM-studied) resin casts of their boreholes. Thus, by comparison with recent assemblages, fossil microborings can be interpreted.