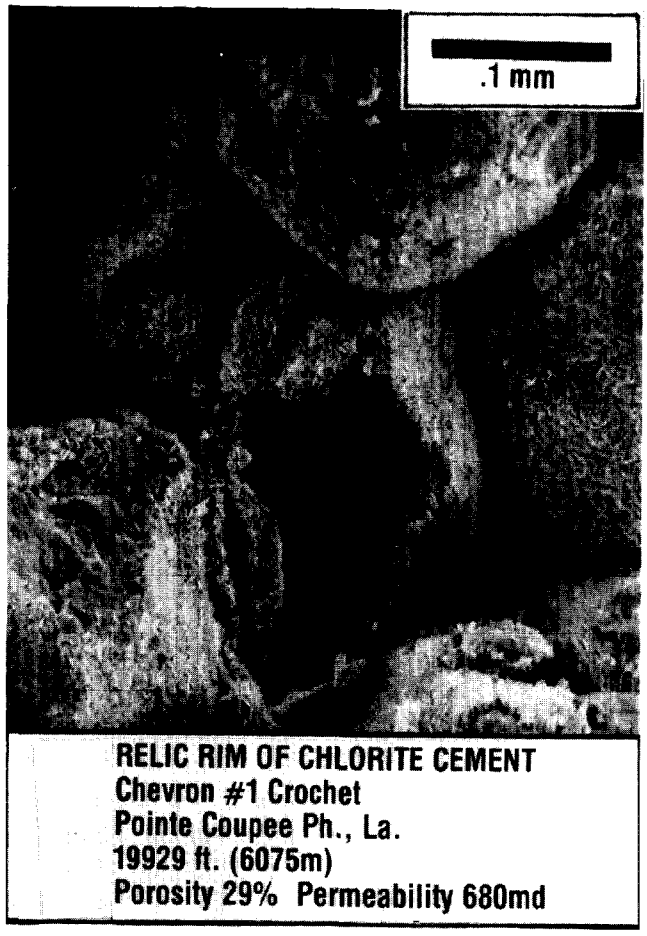

production from these deeply buried Tuscaloosa sandstones is dependent upon secondary enhancement of a reduced primary pore system and its subsequent maintenance by geopressure.

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Mineral Deposits at Shelf-Slope Break

Sedimentologic, geochemical, and tectonic processes, both past and present, in the vicinity of the shelf-slope boundary have created favorable conditions for the formation and accumulation of a range of mineral deposits. Phosphorites and authigenic sulphides are probably the most important but other deposits, including heavy mineral placers and aggregates, are of interest. The nature and formation of these deposits are reviewed with particular reference to the relevant processes which characterize the outer shelf and upper continental slope. These processes include the reworking of consolidated deposits which crop out on the outer shelf; authigenic sulphide formation in intra-slope basins or where the oxygen-minimum layer intersects the outer shelf or upper slope; the accumulation of heavy mineral placers along ancient strandlines and the subsequent reworking during the passage of the transgressing shoreline; authigenic mineral formation in relict sediments; and the bypassing of the outer shelf by recent, terrigenous sediment which might otherwise dilute the valuable minerals present.

An attempt is made to realistically appraise the economic potential of the mineral deposits found close to the shelf-slope boundary. Although at present they are nothing more than a gleam in the marine prospector's eye, strategic considerations, the availability of local markets for the commodities produced, and the depletion in the available land-based resources could make such deposits economically viable in the not-too-distant future.

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Petroleum Potential of Shelikof Strait Based on Outcrops in Katmai National Monument, Alaska

During the summers of 1979 and 1980, the U.S. Geological Survey conducted field work in Katmai National Monument to assess the reservoir and source rock potential of stratigraphic units which project into the Shelikof Strait outer continental shelf. Six stratigraphic sections and two traverses of Jurassic, Cretaceous, and Tertiary rocks were measured and sampled. Samples were analyzed for porosity, permeability, geochemistry, and fossil age dates.

Rocks with the highest organic contents are from the Upper Jurassic Naknek Formation (late Kimmeridgian) and from the Upper Cretaceous Kaguyak Formation (Maestrichtian). Organic-rich rocks of these ages found along Hallo Bay also have a strong petroliferous odor. These rocks are part of a large, complex anticline which plunges northeast into Shelikof Strait. The anticline is flanked by the Tertiary West Foreland Formation, with Middle Jurassic Shelikof Formation near the axis. Lower Cretaceous rocks were found between the Naknek and Kaguyak Formations, including discovery of Valanginian and Albian rocks on this part of the Alaska Peninsula. Several unconformities were observed in the area, the most notable of which is between the Upper Jurassic Naknek Formation and the Upper Cretaceous Kaguyak Formation.

Upper Cretaceous sandstones of good reservoir quality were penetrated by the ARCO Lower Cook Inlet COST No. 1 well. Onshore, source rocks were found in both the Naknet Formation (upper part) and the Kaguyak Formation. Mapping of these units should reveal promising exploration targets in the Shelikof Strait OCS.

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Subaerial Exposure Criteria in Modern Playa Mud Cracks

The playa mud flats of five closed basins in Nevada and California were examined to establish the characteristics of their ubiquitous mud cracks. The mud-crack patterns seen in plan view reflect local conditions of deposition, ground-water level, and exposure time. The purpose of this study was to determine how they appear in vertical cross section (as seen in rock outcrops or drill cores). Trenches and polished slabs of plastic impregnated surface samples reveal a variety of mud-crack cross sections, including: (1) sinuous, V-shaped fillings with lobate margins; (2) marked changes in width of a single filling; (3) branching fillings; (4) horizontal and obliquely dipping cracks; (5) breccia patterns created by mud-filled vertical and horizontal cracks; and (6) multiple crack fillings. These features are similar to characteristics used for identifying subaqueous shrinkage cracks in the rock record. Although subaqueous shrinkage is possible for the playa mud cracks, more important mechanisms for their formation are: (1) superimposed mud-crack patterns in areas of low sedimentation; (2) soil-like processes (internal drying, eluviation, clay expansion, and shrinkage); (3) partial erosion and mechanical slumping of mud-crack margins; and (4) plastic sediment flowage during

rewetting. These observations imply: (1) the criteria for recognizing subaqueous shrinkage cracks need reevaluation and (2) a careful study of mud-crack characteristics and their vertical and lateral variations in stratigraphic sections may provide detailed data on basin morphology, hydrology, and sedimentation rates.

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Early Diagenetic Controls on Allochthonous Carbonate Debris Flows—Examples from Egyptian Lower Eocene Platform-Slope

Many of the models that have been proposed for the origin of carbonate debris flows are based upon examples from ancient carbonate slope settings. Few ancient slope environments have been described, however, where submarine cementation processes were prevalent. This early diagenetic phenomenon, common on many modern carbonate slopes and platforms, can control the mechanisms by which debris flows are generated, as well as the ultimate form of the beds they produce.

Within the Duwi Trough of central Egypt, a basin to slope facies transition is preserved within the lower Eocene chalks and limestones of the Thebes Formation. Basinal facies are characterized by sequences of laminated chalks and limestones with thin, intercalated horizons of nodular limestone and limestone hardgrounds. Carbonate platforms developed on structural highs adjacent to the basin and periodically shed bioclastic detritus downslope in the form of fine-grained, skeletal turbidites. Nodular limestones and hardgrounds, that formed upslope, were in places dislocated and reworked into the basin as submarine debris flows. Individual debris flow beds preserved within the lower slope and basinal facies can be traced over 50 km down the trough axis and several kilometers laterally.

Nodular conglomeratic debris found within the flows range from 30 to 300 cm in thickness and are mud supported. Unlike most ancient debris flow breccias, larger clasts are unusually uniform in size and well rounded. This is not a reflection of textural maturity but a result of the primary nodular morphology of these clasts. Channels and basal scour features are poorly developed in these beds owing to the cemented (hardground) nature of the basin-floor during debris flow deposition.

Sites of nodular limestone bed dislocation are not recognized within the slope facies. Neither large-scale rotational slides, nor slump structures associated with translational slides are developed. The proposed mechanism for the detachment of these nodular horizons is one of relatively shallow decoupling of the early-cemented surface layer from the underlying, unconsolidated sediment. This process would have been accelerated by the presence of high pore fluid pressures owing to an impermeable surface layer (hardground) and loading, resulting from both sedimentation and cementation. Where submarine cementation was a continuous process, as on the upper slope, and uninterrupted sequences of nodular limestone were developed, sediments were stable and debris flows were not generated.

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Paleophosphate Determinations: Potentially Useful Paleo-Oceanographic Tool

Using recent hydrographic data from the Indian Ocean, we have derived an empirical relation that predicts PO_4^{3-} concentrations (μg - atoms/l) from the concentration of dissolved O_2 and temperature (°C), where PO_4^{3-} = 4.82 - 2.26 log T -0.30 dissolved O_2. The $\delta^{13}C$ and $\delta^{18}O$ of certain species of planktonic foraminifera have been demonstrated to be functions of apparent oxygen utilization (AOU = 205.0 − 100$\delta^{13}C$) and temperature (calculated from the $\delta^{18}O$ paleotemperature equation). Utilizing the down-core $\delta^{18}O$ and $\delta^{13}C$ of planktonic foraminifera, substituted into the equation above, permits determinations of paleophosphate concentrations for fossil oceans. In rewritten form: PO_4^{3-} = (43.5(16.0) − 7.43 log T) − (43.5 O_2 saturated seawater (ml/l) − 205.0 − 100 $\delta^{13}C$)/145.0. A comparison of the PO_4^{3-} values calculated from recent forams collected from 14 sites in the Indian Ocean with recent hydrographic values showed no significant differences (M = 0.91, B = 0.28, R = 0.89).

Having measured the isotopic concentrations of $\delta^{13}C$ and $\delta^{18}O$ obtained from 5 species of planktonic foraminifera from two cores in the Arabian Sea, we attempted down-core paleophosphate determinations. Foraminifera were collected from three time horizons in each core, the 0, 9, and 18 thousand years before present (KYBP) isochrons as determined from $\delta^{18}O$ ice-volume curves, using a linear age model. Our results indicate that the average surface and deep water (approximate O_2 minimum depth) paleophosphate concentrations for the three isochrons are, respectively: 0.575 and 2.07 at 18 KYBP, 0.205 and 2.30 at 9 KYBP, and 0.33 and 1.92 for the Holocene. These determinations may indicate greater productivity or upwelling at 9 KYBP relative to the Holocene at 18 KYBP.

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Isotopic Composition of Heavy ($C_{15}+$) Saturate and Aromatic Fractions of Crude Oils

One hundred and sixty oils from producing wells and drill-stem tests in the United States and around the world have been analyzed for the stable carbon isotope composition of the heavy ($C_{15}+$) saturated and aromatic fractions. Extreme reproducibility in the separation techniques and in the isotope preparation and measurement has allowed the plotting of the aromatic isotope composition versus that of the saturated composition with a very high degree of confidence. It appears that there is a linear relation between the isotopic composition of the aromatic and saturated fractions of oils of marine origin. A parallel relation, but with a more positive "y" intercept, seems to hold for oils of terrigenous origin. Oils which have undergone bacterial degradation show a different linear relation which can be extrapolated to the composition of the original non-degraded oil.

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Modern Depositional Analogs to Monterey Formation

The eastern Pacific Ocean encompasses three regions of modern sediment deposition that could be considered imperfect analogs to the depositional environment of the Monterey Formation. These are: (1) the shelf and slope areas off California; (2) shelf and slope areas off Peru-Chile; and (3) the basin margins of the Gulf of California.

All three regions lie within or near the influence of