suring the ratio of known forms which inhabit different sonic scattering layers in mid-water. The lowermost layer represented in each fauna is in part a function of water depth, and also commonly indicates the boundary between water masses of sedimentologic importance.

The 4 zones detailed in this study are (1) mid-shelf; (2) cold bottom and epipelagic, or shelf-edge; (3) lanternfish, or oxygen minimum; and (4) bathypelagic, or Antarctic water. All these zones may be subdivided by later investigations.

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EMPIRICAL EVIDENCE FOR PETROLEUM MIGRATION IN SOLUTION AND DETECTION OF ALTERED CRUDE OILS

The volume and composition of light-liquid fractions in unaltered petroleum deposits are influenced by the salinity of associated formation waters. The implication is that low-molecular-weight hydrocarbons (boiling less than 200°C) are in a "dynamic equilibrium" with their accompanying waters. Hence, any significant variations in salinity could affect their relative solubilities and control their accumulation and escape.

The specific gravity of the light fractions in an unaltered crude is an approximate measure of the composition and relative abundance of the hydrocarbon components. A factor λ which normalizes the volume of light liquid fractions for variations in composition (specific gravity) is devised by dividing the volume (%) total plus naphtha, 10 times the specific gravity. The volume percent of the light fraction and the specific gravity are taken directly from U.S. Bureau of Mines Routine Crude-Oil Analyses.

If the volume of light fractions is salinity dependent, as zero-salt concentration is approached, the ratio of λ (%) to salinity (%) similarly should approach some limit. A log-log plot of λ divided by salinity versus salinity for 83 petroleum deposits of wide geographic distribution and geologic age shows a marked relation.

Evaporation, inorganic oxidation, through-put of relatively fresh water (water-washing), and microbial activity are known to affect appreciably the low-molecular-weight fractions of crudes, commonly resulting in oils that are in a disequilibrium with their formation waters (altered crudes). The low-carbon-number *n*-paraffins appear to be particularly biodegradable; biodegradation of a petroleum has been interpreted to be evidenced by a greatly reduced *n*-paraffin content, increased nitrogen content, and increased optical rotation of the remaining dense fraction. Detection of these effects requires relatively complicated laboratory procedures. Altered deposits show no systematic relation between λ divided by salinity and salinity, and this permits their ready identification. Laboratory analysis of a variety of oils corroborates the interpretation.

The nature of the data for unaltered crudes and theoretical considerations suggest an equilibrium relation in the form log λ equals 1 plus A times the square root of c, minus B times c, where c is the total concentration of solids in the associated formation water and A and B are empirically determined constants. A semilog plot of λ minus one divided by the square root of c, versus the square root of c, yields a straight line, suggesting that the volume and composition of the light liquid fraction in a petroleum are indeed salinity dependent.

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LATE PRECAMBRIAN-EARLY CAMBRIAN STRATIGRAPHY OF KELSO MOUNTAINS, EASTERN MOJAVE DESERT, CALIFORNIA

A detailed study has been made of several outcrops of late Precambrian-Early Cambrian strata in the southern Kelso Mountains. These strata, which are part of the predominantly detrital basal sequence of the Cordilleran miogeocline, previously have been described only in reconnaissance.

In the Kelso Mountains, these strata have been assigned to 5 regionally recognized formations. The late Precambrian Johnnie Formation, which lies unconformably on metamorphic basement, displays rapid lateral changes in lithology and thickness, perhaps due in part to infilling of uneven basement topography. Of 4 sections of Johnnie exposed, 3 are similar, consisting of 91-141 ft of quartzite and dolomite. Conformably overlying the Johnnie Formation are the late Precambrian Stirling Quartzite (186 ft thick, only the uppermost regional member is present), the late Precambrian-Early Cambrian Wood Canyon Formation (712 ft thick), the Early Cambrian Zabriskie Quartzite (75 ft thick), and the Early Cambrian lower part of the Carrara Formation (70 ft thick).

Comparison of these strata with equivalent miogeoclinal strata in the Providence Mountains 8 mi southeast and with Early Cambrian cratonic strata in the Marble Mountains 30 mi south shows that the northeast-trending craton-miogeocline boundary was not an abrupt break (an interpretation based on comparison in Nevada and Utah of thick allochthonous miogeoclinal strata with autochthonous cratonic strata), but rather a relatively broad transition zone of gradual thickening of strata from southeast to northwest.

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SEDIMENT TRANSPORT AND SHORELINE CHANGES ALONG ALASKAN ARCTIC COAST

Sediment-transport processes have been studied within a lagoon-barrier island environment on the Alaskan Arctic Ocean coast. In this area, active transportation is confined to the period from June to October. Analysis of aerial photographic surveys during the period 1949-1971 indicates accretion on one island (Thetis) at a mean rate of 2,580 sq m/year, whereas an adjacent island (Pingok) has been breached and eroded at both the western and eastern extremities. Recent studies of seasonal shoreline erosion demonstrate that more than 10 m may be removed within a single season. Erosion rates for the eastern end of Pingok Island are calculated to be at least 3,000 sq m/year. Littoral sediment transport along the northwestern and northeastern shores, landward of the lagoon (Oliktok Point), ranges from 0 to 38 sq m/day with current velocities of 0-75 cm/second. Most of the coastal spits and shoals in this area trend west. The prevailing winds are from the east and northwest. Overflow during breakup, thermal erosion of beach cliffs, normal fluvial and nearshore sedimentary processes, summer storms, and ice-rafting are the predominant mechanisms of erosion and deposition.

The more significant sediment movements here represent a net transport from east to west, especially on the barrier islands. These movements are considered to be due to the catastrophic effects of summer storms, for rates of littoral transport are lower, and the season for this transport is relatively short, in comparison with conditions in temperate areas.

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PALEONTOLOGIC EVIDENCE FOR MID-MIOCENE REFRIGERATION, FROM SUBSURFACE MARINE SHALE, LOUISIANA GULF COAST

The Harang facies, a regional, diachronic middle Miocene shale in Louisiana, has characteristics that can be interpreted as indications of deep-water or cold-water deposition. It consists of a seaward-thickening subsurface wedge of dark-gray to brown or black marine shale and clay with interbedded sandstones, containing a distinctive foraminiferal biofacies. The biofacies is characterized by an abundant and diversified benthonic foraminiferal fauna, including huge arenaceous forms

and a small percentage of planktonic Foraminifera. *Globorotalia fohsi, G. mayeri, G. menardii,* and other planktonic species are sinistrally coiled. The change from random to predominantly sinistral coiling coincides approximately with the inception of Harang deposition (±12-14 m.y. B.P.). The faunal assemblages indicate a muddy-water, outer neritic to bathyal environment, and suggest a cool water mass. The apparent anomaly of a cold-water fauna in this stratigraphic position in this area might be explained by upwelling, paleogeographic changes, and/or significant Miocene refrigeration.

During the time span that includes Harang deposition, continental glaciation in Antarctica, cold-water invertebrate faunas, cool-climate floras, and other evidences of cool climate in many parts of the world indicate mid-Miocene refrigeration. Although some conflicting evidence also exists, we conclude that the distinctive characteristics of the Harang biofacies are related to a cool water mass which was part of a worldwide cooling phenomenon.

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Recent work in the Canadian Cordillera has led to the formulation of several models for its tectonic evolution. These models can be tested by relating the structural evolution of the crystalline core zones and fold belts to the depositional record of the orogenic foredeeps and successor basins. They require a comprehensive understanding of paleodrainage. The arcuate geometry of orogenic belts places the principal structural constraint on the evolution of late orogenic drainage patterns. Like other mountain belts, the two orogens of the Canadian Cordillera (Pacific orogen in the west, Columbian orogen in the east) consist of a chain of structural salients and reentrants. During the growth of folds and thrust faults, the structural reentrants constituted the shortest connection between the rising core zones and the subsiding foredeeps and successor basins. Streams issuing through the reentrants, therefore, were the first to capture the longitudinal drainage which evolved during the growth of the fold belts and became the most important suppliers of clastics to the late-orogenic basins. This "reentrant principle" can be illustrated on a regional tectonic scale with the Peace, Liard, Eagle Plain, and Chukachida reentrants of the Columbian orogen. Local examples are used from near Crowsnest Pass, the Spatsizi Plateau, and the Fraser River. From the structural salients, predominantly small, though locally vigorous, streams issued directly into the late orogenic basins. Therefore, simple straight drainage lines connecting source areas and clastic basins were probably valid only for the earliest stages of uplift in the Canadian Cordillera. Later growth of folds and thrust faults produced curved or even U-shaped river systems, which merged near reentrants and effected thorough mixing of compositionally diverse sediment loads.

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RELATION OF INVERTEBRATE DEATH ASSEMBLAGES TO LIVING BENTHIC COMMUNITIES IN RECENT CARBONATE SEDIMENTS ALONG EASTERN YUCATAN COAST

The fidelity of the fossil record for paleoecological studies often is questioned. This investigation attempted to determine how well communities of living benthic organisms are represented by the assemblages of dead remains accumulating in the sediment, *i.e.*, future fossil assemblages.

Fifty quantitative samples were collected with a diver-operated suction dredge from various shallow-marine environments near Isla Cancun and Isla Contoy, Quintana Roo, Mexico. Virtually all the geologically preservable megafaunal remains in the sediment consisted of mollusks, and 290 molluscan species were identified in the samples. Although nearly three fourths of the species were collected only as dead shells, almost all live individuals were represented by dead shells of their species in the same sample.

A series of Q-mode and R-mode cluster analyses, utilizing 5 different similarity coefficients and data based on the presence or absence and relative abundances of species, demonstrates that the same general associations of samples and organisms occur, whether living animals or dead remains only are considered. Chi-square association tests between pairs of samples collected 5 m apart reveal that the death assemblages in both samples of each pair are similar, whereas the living communities are not.

The death assemblages apparently reflect the in-place accumulation of remains of living benthic communities during sedimentation as patchily distributed populations of organisms migrate across the bottom, leaving a record of their mortality behind them in the sediment.

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CHANNELIZED SUBMARINE CARBONATE-DEBRIS FLOW, CRETACEOUS, MEXICO

Carbonate platforms, fringed by rudistid reefs, rose to more than 1,000 m above contemporaneous basinal carbonates in the middle Cretaceous of central Mexico. The platforms are surrounded by halos of debris forming wedges which extend as much as 5-15 km from the platform margin. An exception to the wedge morphology is a breccia-filled channel exposed in section perpendicular to the paleoslope, 1 km from the marginal escarpment of the El Doctor platform, Querétaro, Mexico.

The main part of the channel deposit is 225 m wide and 16 m thick. Breccia clasts are 75% basinal components (pelagic limestone and chert) and 25% platform derived. The bedded clasts form flat plates up to several meters in maximum dimension. A few clasts are deformed, indicating that they were at most slightly lithified and presumably of low density; nevertheless, most are neatly stacked with little distortion. Unstable clast postures, with long axes approaching normal to bedding, and imbrication are common. Content of dolomitized muddy matrix is low; the deposit is grain supported.

The morphology of the breccia deposit and truncation of pelagic limestone at the channel edge demonstrate erosional competence of the depositional mechanism. Locally in the channel base an incipient slump of slightly folded pelagic limestone and chert indicates slope instability and suggests a mechanism for incorporating basinal carbonates in the breccias. In the top few meters of the deposit, breccia grades upward into fine-grained, skeletal-fragment packstone, which extends several hundred meters beyond the channel limits as thin, graded bed. At least 3 episodes of channel fill are suggested by internal structure.

This evidence places the following constraints on the depositional process—high competence (large clasts, erosion), high viscosity (unstable clast postures), low turbulence (slight deformation and platy form of unconsolidated clasts), high clast concentration (grain support, clast interaction) and channelization (form of deposit, multiple episodes). A high velocity submarine debris flow is suggested. The nonchannelized part of the last depositional episode is a typical turbidite.

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DISCOVERY AND DEVELOPMENT OF SAWTELLE OIL FIELD, CALIFORNIA

No abstract available.

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QUANTITATIVE PETROLOGY AND DEPOSITIONAL ENVIRONMENTS WITHIN ESSENTIALLY ISOCHRO-