rence. Marine minerals will in many instances provide a suitable alternative to terrestrial minerals, and their use will allow more time for technological development of a permanent, nondepletionary resource base.

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BIOGEOGRAPHIC SIGNIFICANCE OF EARLY CRETACEOUS FORAMINIFERA FROM BUDDEN CANYON FORMATION, NORTHWESTERN SACRAMENTO VALLEY, CALIFORNIA

A foraminiferal fauna of 189 species and varieties has been recovered from strata of Barremian-early Cenomanian age in the Chickabally Member of the Budden Canyon Formation. Calcareous perforate species, typified by the lagenids and rotaliids and, to a smaller degree, by the rotaliporids and buliminids, and among the arenaceous groups by the lituolids and valvulinids, constitute the major elements of the fauna.

The Foraminifera show close affinities with contemporaneous, medium-depth faunas widely distributed in the lower and middle latitudes of the northern hemisphere. Many lagenid and rotaliid species in particular appear to be conspecific with forms described from Europe and Trinidad. Common genera recorded for the first time from the Pacific Coast include *Falsoguttulina, Pseudosigmoilina, Reinholdella,* and *Spiroplectinata.* However, a persistent endemic element also can be recognized in the Chickabally assemblages, especially in arenaceous forms, the buliminids and the rotaliids. Resemblance of this microfauna to the marginal and neritic assemblages of the Gulf Coast and Alaska is less marked, and very little relation to the specialized brackish-water and quiet shallow-marine assemblages of the western interior is apparent. Regional correlations demonstrate that, during the late Early Cretaceous, benthonic Foraminifera favoring an offshore, medium-depth, muddy-bottom milieu were extant from Europe through North Africa, the Caribbean, and western North America, their distribution being facilitated by widespread tropical conditions and interconnected seaways.

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ROLE OF STORMS IN DEVELOPMENT OF ANCIENT MARINE RIDGE AND SWALE SYSTEM

Upper Jurassic (Oxfordian) sediments of Montana and Wyoming were deposited on a broad, shallow-marine shelf. Facies relations demonstrate that much of this shelf was characterized by a series of sand ridges separated by muddy swales. Ridges attain a thickness of about 12 m, an axial length of at least several kilometers, and a width measured perpendicular to crest less than 1 km. The crests of individual ridges are not parallel with one another or with the paleoshoreline. Analyses of directional features reveal multidirectional current vectors within individual ridges. The vertical sequence of internal sedimentary structures reveals that the ridges were constructed in distinct episodes, during which current flow was at least in the upper low-flow regime. Each episode is represented in the rocks by a unique style, scale, and vector of cross stratification. Storms are considered to be the main process responsible for the buildup of ridges, individual storms being responsible for each of the sedimentation units of which the ridges are composed. As sand supply, storm intensity, and wind direction varied from storm to storm, so the style, scale, and vectors of the resultant cross stratification varied. Fair-weather processes were minor factors in the development of the ridge and swale system.

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GLOBAL LOOK AT HIGH PRESSURES

Formation pressures higher than hydrostatic have been found in all parts of thw world during oil and gas drilling operations. The present paper analyzes the worldwide distribution of these high pressures. Data used include wells from western Europe, Hungary, Poland, Rumania, Russia, the Middle East, the Indian subcontinent, Australia, New Guinea, New Zealand, Japan, the Arctic, the African West Coast, the Red Sea, South America, and the United States. A statistical analysis to define the main geologic characteristics of high-pressure reservoirs was carried out using data from wells penetrating more than 5,000 reservoirs in the Gulf of Mexico, Santa Barbara Channel, and the Anadarko, Permian, and Uinta basins. The probability of finding high pressures in a given depth range for each of these basins has been established.

The main mechanisms responsible for the creation of these high pressures are concluded to be (1) gravitational compaction, (2) the montmorillonite-illite transformation, (3) wax seals, and (4) tectonic compression. Although in certain instances one of the mechanisms predominates, in most places a combination of them is responsible for the high pressures. Modeling of the geologic processes that have created a basin allows us to recognize in advance the type of pressures to be found there.

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SEDIMENTATION ASSOCIATED WITH TECTONISM OF ANCESTRAL ROCKY MOUNTAINS

During the Pennsylvanian and Early Permian, block-faulted tectonism created mountain ranges (Ancestral Rocky Mountains) as much as 5,000-10,000 ft in elevation in Colorado and adjacent areas. These mountain ranges and associated basins profoundly affected sedimentation; thick sequences (up to 20,000 ft) of Pennsylvanian and Permian strata, with abrupt facies changes and thickness variations, were deposited adjacent to the uplifted mountain blocks.

Early Pennsylvanian tectonic activity developed the general outlines of the north- to northwest-trending Front Range, Apishapa, Uncompahgre, Pathfinder, and Sawatch uplifts. Up to 2,000 ft of nonmarine, alluvial and coastal-plain deposits (Kerber, Sharpsdale, Flechado, and Fountain Formations) accumulated locally in narrow facies bands adjacent to these uplifts, but generally marine shale and carbonate deposition (Morgan, Belden, Casper, and Minnelusa Formations) prevailed.

During the Desmoinesian, 5,000- to 9,000-ft displacements occurred on many faults that bounded the mountain-block uplifts. Narrow bands of thick, coarse-grained arkosic detritus (Minturn, Maroon, Fountain, Sangre de Cristo, Alamitos, Cutler) surround all of the major uplifts; these arid-climate alluvial-fan and coastal-plain deposits change facies abruptly to marine carbonates (Hermosa, Morgan), evaporites (Paradox, Eagle Valley), and shales within short distances from the mountain uplifts.

During the Late Pennsylvanian and Early Permian, the area of alluvial sedimentation expanded onto the mountainous areas and laterally from them, and filled the adjacent basins with up to 3,000 ft of red, arkosic sandstone and shale (Fountain, Maroon, Sangre de Cristo, and Cutler). Local relief of the Ancestral Rocky Mountains became subdued by Guadalupian time, and erosion of low-lying land area or marine deposition (Lykins, Park City, Kaibab) prevailed.

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PALEOBATHYMETRY BY FISH OTOLITHS

Four distinct faunal zones are present in otolith assemblages of bottom muds from the eastern Gulf of Mexico, between depths of 300 and 2,000 ft. At least 2 more zones can be projected on the basis of the literature and known water-circulation patterns in the Gulf, and the outer limit of workable faunas may be far out on the abyssal plain. Within the documented depth range, surprising precision is obtained by mea-

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