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URANIUM DISTRIBUTIONS IN RECENT SKELETAL CARBONATES

Fission-track analysis, used to map uranium distributions in sections at the ppb to ppm level, revealed considerable intraskeletal heterogeneities in corals and mollusks. In a layer next to the internal surface of the corallite in the corals studied, uranium is enriched in comparison with the inner parts of the skeleton; configuration and the factor of relative uranium enrichment of the layer differ among corals. The branching coral *Oculina diffusa,* in addition, exhibits alternating bands of relatively high and low uranium contents arranged subparallel with the external surface. In the mollusk shells studied, uranium concentrations vary between different layers of a given shell; further variations exist within a given shell perpendicular to the direction of accretion. These systematic heterogeneities result from variations in the processes of skeleton formation and growth. In all samples, apparently random variations were observed; they are superimposed on any distributional pattern which may exist. Trace-element distribution in carbonate skeletons is determined primarily by biologic processes and can be expected to change when affected by physicochemical diagenetic influences. Hence, the patterns of uranium distribution shown are potential indicators of uranium mobility during diagenesis and checks on the closed system requirement for uranium series dating of biogenic carbonates. This study also demonstrates that compositional complexities known from major elements are present on the trace-element level in skeletal carbonates.

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APPLICATIONS OF POTASSIUM-ARGON DATING IN OIL EXPLORATION

The dating of minerals and whole rocks by the potassium-argon method is now available to the petroleum industry on a low-cost, routine commercial basis. This service can provide valuable information regarding provenance of detrital material, and age correlations of volcanic rocks and nonfossiliferous strata. The method is particularly useful in distinguishing minor intrusives from basement. Application of potassium-argon dates is not restricted to long-term studies because modern analytic methods make possible the return of data in lengths of time consistent with decisions required by an active drilling operation.

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BETHANY FALLS LIMESTONE (MISSOURIAN) SEDIMENTATION AND DIAGENESIS, MISSOURI AND KANSAS

The Bethany Falls Limestone is a 15–30-ft-thick shelf deposit within lower Missourian rocks of the Mid-Continent region. In outcrop the lower Bethany Falls is typically an open-marine, faunally diversified, carbonate wackestone. The upper Bethany Falls consists of a wide variety of shallower water carbonate mudstone, wackestone, and grainstone. Cross-bedded oolitic grainstone and faunally restricted mudstone are perhaps the most distinctive rocks in the upper Bethany Falls. Cross-bed dip azimuths in the oolitic facies provide evidence that deposition resulted from 2 dominant current systems, one basically longshore drift toward the northwest and another essentially onshore tidal flow toward the north-northeast.

The sequence of open-marine wackestone succeeded by shallower water limestone resulted from rapid transgression. As progradation built the sea floor into the zone of agitation, oolitic "sand bars" developed. These bars restricted circulation in many interbar and backbar areas which became sites of the faunally restricted carbonate mud. Carbonate deposition ceased when progradation built to normal high tide.

Color mottling, ubiquitous in most upper Bethany Falls mudstone and wackestone, is a diagenetic effect related to selective bleaching of the original medium-gray or grayish-tan color. The bleaching apparently follows areas of initially high permeability. The controlling paths are commonly burrows or churned areas, "crumbly vugs" resulting from bioturbation and other processes, and microfractures formed by slumping and shrinkage. Grain diminution or removal commonly accompanies the bleaching, and many of the bleached areas exhibit microslump and convergence of laminae.

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PENNSYLVANIAN DELTAIC STRATIGRAPHIC TRAPS, EASTERN SHELF, MIDLAND BASIN, TEXAS

Hydrocarbon occurrence in Strawn (Pennsylvanian) sandstones in the West Tuscola field, near Abilene, Texas, is the result of stratigraphic entrapment in deltaic sandstone. The origin of the reservoir rock in the field area and the overall geometry and internal character of the deltaic complex were determined from the vertical sequence in numerous cores of the reservoir sandstone and associated units and from numerous E-logs of uncored wells.

The vertical succession of deltaic facies consists from base to top of a progradational sequence (prodelta and delta-front), an aggradational unit (delta plain, marsh, and interdistributary bay), and an overlying "transgressive" shallow-marine interval. Reservoir sandstones are present within the delta-front facies as stream-mouth-bar deposits, known locally as the "Grey sandstone."

The stream-mouth-bar sandstone in the West Tuscola reservoir is lenticular, highly irregular in outline, and has varied trends of porosity; these are characteristics common to deltaic deposits. Such features present problems in developing effective secondary-recovery methods and in predicting occurrences of other deltaic sandstones.

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CATIONIC BALANCE AND EARLY DIAGENESIS OF GLACIO-MARINE SEDIMENTS

Throughout the Quaternary, glaciers have provided considerable amounts of sediments to the oceans. However, little is known concerning the physical and chemical characteristics of these sediments. Rapid recession of glaciers during the past 100 years has deposited large amounts of glacial sediments in the fiords and inlets of southeast Alaska. These mechanically weathered, rapidly deposited sediments provide an unparalleled laboratory to study sediment-seawater

interaction and the geochemical characteristics of glaciomarine sediments.

Glaciomarine sediments in southeast Alaska consist predominantly of feldspar, quartz, illite, and chlorite. Kaolinite is not a weathering product in this area. Interstitial waters from bottom grab samples showed a substantial decrease in sodium ions compared with the overlying waters. Significant variations in Na^+ concentration with depth also were found in interstitial waters obtained from cores. Laboratory and field observations suggest that primary glacial clays are saturated with H^+ and Ca^{++}. During transport and early stages of burial in marine environment, cation exchange of H^+ and Ca^{++} from glacial and fluvial sediments for Na^+, K^+, and Mg^{++} of seawater is the major process causing changes in the interstitial water. No mineralogic alterations of clay were observed from the glaciofluvial to marine environment. Cationic concentrations in interstitial waters can be related to the bulk mineralogy and particle size of sediments, the environment of deposition, and the path length the sediments follow before deposition.

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EVAPORITE-CARBONATE RELATIONS IN BASIN DEVELOPMENT

Petrographic studies of marine evaporites reveal that the initial assemblages of evaporite minerals were generated in 2 distinctly different ways. Some grew or accumulated at the sediment surface where they were evidently precipitated from an overlying brine; others were emplaced within a preexisting, unconsolidated, host sediment, and were formed in response to conditions that prevailed beneath the sediment surface within the interstitial waters of the sediment itself. The latter mode of origin characterizes supratidal sabkha-facies evaporites, which have been found to be an essential constituent of many marginal evaporite complexes. In the sabkha environment there is no overlying body of brine and the evaporite minerals are emplaced within the sediment from marine-derived groundwater.

This same mode of genesis of evaporite minerals can be demonstrated for some of the anhydrite, halite, and potash deposits in several "basin-facies" evaporites. The possibility arises therefore that these units record phases of emergence and, as such, suggest that the whole evaporite assemblage was deposited in an environment of shoal water and emergent banks, and not beneath a deep body of brine as previously envisaged. In view of the evident relief within some of the basins, as inferred for example from the thickness of the carbonate reefs relative to the floor on which the evaporites were deposited, such an interpretation requires that profound changes in water level may have occurred within the basins.

The evaporites of the Middle Devonian Elk Point basin are reviewed in terms of the various modes of evaporite-mineral genesis, as a background to discussion on the carbonate-evaporite relations within the complex.

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SUBMARINE FORMATION OF BORED SURFACES (HARDGROUNDS) AND POSSIBLE MISINTERPRETATION IN STRATIGRAPHIC APPLICATIONS

Bored and encrusted surfaces, generally called "hardgrounds," are common in some ancient limestones. Proper identification of the environment of lithification in ancient hardgrounds is important because it can greatly influence the interpreted depositional history of the associated limestones. In addition, proper identification of the environment can determine the usefulness of hardgrounds as stratigraphic markers.

The presence of bored and encrusted Holocene submarine cemented layers in the Persian Gulf suggests that some ancient hardgrounds could have formed underwater and not by exposure to meteoric water. Holocene hardgrounds covering hundreds of square miles in the Persian Gulf commonly occur as multiples of bored beds (as many as 4 have been observed) interbedded with noncemented carbonate grainstone or mud. Each hardground bed is thoroughly cemented by fibrous aragonite and/or magnesium calcite at the upper surface and generally the degree of cementation decreases downward. Each hardground bed contains pelleted geopetal internal sediment which commonly lies on fibrous aragonite. Similar features, now altered by calcite, may be the key to understanding the origin of many ancient hardgrounds.

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GEOLOGY OF WESTERN CANADIAN CONTINENTAL SHELF

Shell Canada Limited geologists and geophysicists have made a study of the stratigraphy of the Tertiary strata in the Tofino and Queen Charlotte basins of Canada's Pacific shelf. Data was obtained from Mesozoic and Tertiary outcrops along the shoreline margins of the basins, 6 Richfield Oil Corporation wildcats on the Queen Charlotte Islands, Shell Canada's aeromagnetic, reflection, and refraction seismic surveys, and 14 offshore wildcats drilled between May 1967 and May 1969.

The pre-Tertiary framework of the shelf consists of a thick and complex sequence of Mesozoic sedimentary, metamorphic, and intrusive and extrusive igneous rocks. Little is known about the early Tertiary history but data from the Tofino basin suggest widespread early-middle Eocene submarine volcanic activity, initial uplift followed by subsidence in late Eocene time, distinct transgressions of Oligocene–early Miocene seas, followed by a middle Miocene period of crustal deformation, uplift, and regression.

There was a major transgression in late Miocene time and a lesser one in early Pliocene time followed by a regressive phase in late Pliocene-Pleistocene time. The early Tertiary volcanism in the Tofino basin spread northward and continued, at least sporadically, in the Queen Charlotte basin to the end of the Miocene and perhaps into the early Pliocene. Tertiary deposition in the Queen Charlotte basin began early in the Miocene and, although interrupted by perhaps 2 periods of uplift and erosion, continued through the Pliocene into the Pleistocene.

The maximum thickness of Tertiary strata is more than 15,000 ft. The strata range from deep-water, open-marine sequences of shale, siltstone, and sandstone in the Tofino basin, through both deep- and shallow-marine deposits in Queen Charlotte Sound, to a thick nonmarine sequence of sandstone, shale, siltstone, and coal in Hecate Strait and the Queen Charlotte Islands. The sandstones in both basins are composed primarily of feldspars and quartz, and those of the Queen Charlotte basin are characterized by high porosity and low permeability values.

There is a wide variety of structural styles including