subsequent variation in degree and type of diagensis have yielded a remarkable range of ultimate lithologies. The Chalk of Northern Ireland is extremely hard (porosities of 1-10%), has oxygen isotopic values averaging −5.60°/oo, has low Sr concentrations and shows equant, blocky calcite micrite. Samples from Yorkshire have porosities of 18%, oxygen isotopes of about −4.00°/oo, and moderately extensive blocky calcite. Chalks from southern England (Dover, Thanet, Brighton) are very soft (porosities of about 43%), yield oxygen isotope values around −2.88°/oo, and show relatively slight recrystallization to blocky calcite. The Ekofisk chalk has an average porosity of 30% with oxygen isotope values averaging −0.42°/oo, high Sr concentration, traces of dolomitization, and common rounded crystal shapes.

These diagenetic variations appear related to the extent of freshwater diagenesis. Areas of continuing subsidence (North Sea basin) were not exposed to fresh water; cementation there was a function of burial depth and associated pressure solution-reprecipitation of calcite in marine or brine waters. In areas of increasing uplift (generally greatest near basin margins), progressively greater freshwater input brought about increasing diagenetic alteration of lithologic and petrophysical characteristics. These diagenetic facies are petrographically, as well as geochemically, recognizable.

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COMPARISON OF SLOPE AND BASINAL SEDIMENTS OF MARGINAL CRATONIC BASIN AND GEOSYNCLINE

The transition from slope to basinal facies generally is not so well exposed or understood as it is in the Pennsylvanian of New Mexico's Pedregosa basin and in the Liassic of Switzerland's Piemontais geosyncline.

The shape of the Pedrego basin is controlled by basement faulting; its trend is oblique to the Ouachita-Marathon geosyncline. During periods of stable sea-level stand, carbonate sedimentation prevailed in shelf areas, and bioherms built up at the shelf edge. Bioclastic foresets and huge slumps of brecciated material from these bioherms extended from the shelf edge into the basin, where deep-water carbonates were deposited. During periods of low sea-level stand, rivers cut through the shelf deposits and shelf-edge bioherms and eroded deep valleys on the slope. As sea level rose, the basin was filled mainly with shales, and valleys on the slope were filled with sand. The geometry of these sand bodies at the base of the slope is probably fan- or cone-shaped.

Normal faults in the Liassic slope sediments of the Piemontais geosyncline reflect the structural tension that persisted during early geosynclinal stages. Thick beds of structureless breccias accumulated on the downthrown side of these faults. In the downslope direction, the breccias grade into turbidite facies; farther downslope, thick wedges of turbidite thin at their distal edges. No evidence was found of channels or canyons that would serve as point sources for sediment dispersion down the slope. The turbidites grade upward into radiolarian chert.

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GEOLOGY AND DEVELOPMENT OF ATTAKA OIL FIELD, INDONESIA

Of particular significance in the Indonesia oil search was the discovery of the Attaka oil field, offshore East Kalimantan (Borneo), in late 1970. After confirmation drilling from September 1970 to February 1971, field development and facility installation began in early 1971. First production was achieved in November 1972.

This major field is in the Tertiary Balikpapan basin. Production occurs mainly from sublittoral to deltaic sands of the "Attaka Series," of Pliocene and Miocene ages. The age of the deepest bed penetrated in the field area is middle Miocene. Well logs and paleontologic data indicate a predominately regressive sequence of deposition. Highly permeable pay sands, 34 in number, occur at intervals from 2,000 to 7,800 ft measured depth.

The structure is a faulted anticline. Faults and stratigraphic variations in part control accumulation and affect fluid properties. The oil is very low in sulfur content, and has a range of gravity from 35 to 52°API. Both saturated and undersaturated reservoirs are present.

Development drilling was accomplished from 6 platforms with nearly all wells completed using dual tubing strings. After fluid processing at a production platform, further treating occurs at the onshore Santan terminal, where oil storage capacity is 2,000,000 bbl. Tankers are loaded at an SBM (buoy) anchored offshore. The maximum size of tanker that can be loaded is 125,000 DWT. With the completion of wells and facilities, it is anticipated that field production will exceed 100,000 BOPD during 1973.

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SEISMIC INTERPRETATION I AND II—RECENT ADVANCES IN SEISMIC EXPLORATION

This capsule review is a condensation of an SEG Continuing Education short course that is designed to present recent advances in seismic exploration from viewpoints based upon (1) a linear filter model and (2) a geometric model, with statistical communication theory unifying these two viewpoints.

Convolution of the source pulse with the earth reflectivity gives the seismic signal in the linear filter model. Absorption introduces the time variance. Horizontally traveling noise and random noise are additive processes that complete the filter model. Analysis of signal and noise in f-k (frequency-wavenumber) space leads to methods of noise suppression based upon spacial filters in the field and velocity filters in processing. Distortion of the source pulse by ghosts and reverberations is overcome by deconvolution, where the unknown and spacial varying source pulse is replaced by one that has constant and more desirable properties, such as zero phase.

The geometric model overcomes the one-dimensional shortcoming of the filter model, and allows for refractions and diffractions. Horizontal stacking to suppress multiples and increase signal-to-noise ratio requires accurate knowledge of the stacking velocity which is derived by analysis of normal movement.

Utilization of optimal aquisition and processing to preserve the amplitude and frequency characteristics of the underlying reflectivity, along with velocity estimates from strictly surface measurements, significantly improves interpretation in terms of lithology, stratigraphy, and fluid content, and demonstrates that the seismic method is more than a structural mapping tool.

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MULTISENSOR SYSTEMS REVEAL GAS SEEPS AND GAS-CHARGED SEDIMENTS

No abstract available.

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FACIES DISTRIBUTION OF TRACE FOSSILS IN JURASSIC-CRETACEOUS TRANSGRESSIVE SEQUENCE, NORTH-CENTRAL NEW MEXICO

In the southeastern part of the San Juan basin (north-central New Mexico), the upper Morrison, Dakota, and lower Mancos stratigraphic interval represents a transgressive nonmarine to marine, sedimentary sequence. Trace fossils, although quite sparse in the nonmarine sediments of the upper Morrison, are common in the marginal-marine deposits of the lower Dakota and are extremely abundant and taxonomically diverse in the nearshore-marine lithofacies of the upper Dakota and lower Mancos. The distribution of most trace fossils reflects strong control by substrate and environmental facies; however, several taxonomic and ethological variants of a few ichnogenera demonstrate a lack of such control.

The "Jackpile Sandstone" of the upper part of the Morrison Formation contains only a few trace-fossil structures; many of these can be ascribed to the ichnogenus *Planolites*, the only trace-fossil type present in all stratigraphic units investigated in this study. The paludal and strand-line deposits of the lower Dakota contain abundant *Skolithos* and *Planolites*, and *Ophiomorpha*, which displays transition in form to a small variety of *Thalassinoides*, "Reed(?) molds" also are common in the lower Dakota sandstones.

Shallow-water marine sandstones of the upper Dakota are intertongued with the lower Mancos shales and are characterized by an abundance of trace fossils. Well-developed *Ophiomorpha* and *Teichichnus* structures show transition in form to a small variety of *Thalassinoides* and are probably ecovariant forms made by the same organism. Additional ichnogenera studied include large polygonal *Thalassinoides, Asterosoma, Arenicolites, Zoophycos, Chondrites, Crossopodia, Gyrochorte, Pelecypodichnus, Planolites,* and *Skolithos*. The presence of *Zoophycos* is of particular interest because of its usual association with deep-water deposits. The large *Thalassinoides* and *Asterosoma* structures appear to be restricted to the deeper water sandstone deposits of the upper Dakota.

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TECTONIC FRAMEWORK OF MACKENZIE DELTA DETERMINED FROM GRAVITY DATA

The MacKenzie delta is the most exciting petroleum exploration area in North America. It is situated at the confluence of three orogenic belts: the north-trending Richardson Mountains; the northwest-trending British and Barnes Mountains; and the northeast-trending Aklavik arch-Campbell uplift. Within the delta are local and regional structures which correspond in strike to all 3 of these tectonic trends. A recently completed, extensive gravity survey clearly reveals these structures.

The main tectonic elements of the delta from the gravity data are: a large northeast-trending basement high and parallel system of growth faults that bound the delta on the east; the adjoining northeast-trending Kugmallit trough; the Campbell uplift on the southeast margin of the delta; the Aklavik-Tunnunuk arch; a regional basement high in the Beaufort Sea parallel with the coast; large, northwest-trending, anticlinal folds; faults bounding the major positive structures; and probable diapirs.

The present delta was a Cretaceous depocenter. Cretaceous sandstones, shales, and conglomerates thicken abruptly across faults into the Kugmallit trough. Oil and gas discoveries to date in the delta are from Cretaceous and Cretaceous-Tertiary sandstones on structures indicated by pronounced gravity maxima. However, Paleozoic rocks may be at drillable depths on some of the structures and are possible objectives. Numerous, very large structures prospective for hydrocarbons delineated by gravity data are of 4 types: (1) regional arch (regional gravity maximum); (2) large, linear fold, with a dense core (large linear gravity maximum); (3) large linear fold, with a low-density core (relatively small gravity maximum); and (4) probable diapirs (round to oval gravity minima).

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RELATIONS OF CRATONIC AND CONTINENTAL-MARGIN TECTONIC EPISODES

The Phanerozoic history of continental cratons is marked by repeated global episodes of 3 types: (1) oscillatory—generally elevated or oscillating with respect to sea level; marginal and submarginal areas subject to highly differentiated uplift and subsidence; periodicity of oscillations and uplifts 10^5-10^6 years; wave lengths of intracratonic tectonic elements 10^1-10^2 km; duration of episodes 10^7-10^8 years; (2) emergent—progressively elevated in time; without significant topographic relief; tectonically undifferentiated below wave lengths of 10^3; duration 10^6-10^7 years; and (3) submergent—progressively depressed below sea level to form widespread epicontinental seas; subepisodes (10^6-10^7 years) of differential subsidence to form basins and arches ($\delta = 10^2$-10^3 km); duration 10^7-10^8 years.

Time relations of cratonic episodes are (1) oscillatory—much of Cenozoic, including present and period from Pennsylvanian to Early Jurassic (time spans of Appalachian-Hercynian, Laramide and Alpine orogenies); (2) emergent—latest Precambrian, early Middle Ordovician, Early Devonian, *etc.* (lacunal intervals between accumulations of cratonic sedimentary sequences); and (3) submergent—time spans of Caledonian, Antler-Acadian, and Nevadian orogenies.

In plate-tectonic terms, the present is characterized by high spreading rates and by convergent boundaries of oceanic and continental plates relatively remote from cratonic margins. These probably were the prevailing conditions during times of oscillatory cratonic behavior. Emergent cratons, by historical analysis, appear to be related to quiescent episodes at continental margins, possibly reflecting spreading-rate minima. Submergent cratons would seem to coincide with times of active plate convergence involving oceanic margins of cratons expressed by obduction and subduction at such margins.

Differences in cratonal tectonic habit may represent responses to either or both time-variable factors in continent-margin tectonics: variation in lateral stress transmitted to cratons from their margins, and variation in thickness, and thus in flexural rigidity of the continental lithosphere.

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HALITE CRYSTALLIZATION IN SUPRATIDAL SALINA, OMETEPEC LAGOON, BAJA CALIFORNIA, MEXICO

Supratidal flats of the Colorado River delta are sites of active evaporite formation. Major evaporite minerals are gypsum and halite. Flooding of the flats by Gulf waters several times per year causes the Ometepec Lagoon to be covered by a standing body of water not deeper than 2 ft. After the initial stage of gypsum crystallization, halite forms until evaporation reduces the standing brine to a ground-water brine. The dominant growth mechanism of halite is a competitive upward growth of cubes which nucleate on the brine-pan floors. The upward advancing edges of the cubes produce chevron grains, an internal inverted V-structure caused by rapid alternations of fluid inclusion-rich and inclusion-free zones. Entrapment of brine inclusions represents a rapid growth stage, whereas the inclusion-free zones represent slow-growth periods. Very rapid fluctuations in growth rates seem necessary during crystallization of chevron halite. The very shallow depths of Salina Ometepec brines are extremely susceptible to rapid changes in growth-rate-control factors such as brine temperature, concentration, and rate of evaporation. These factors in turn are dependent on air temperature, humidity, wind, *etc.* If the assumptions are made that (1) inclusions are dependent on growth rate, and (2) growth rate is controlled by various combinations of the above factors, it is logical to conclude that chevron halite is a characteristic feature of halites produced in environments of rapidly fluctuating growth rates. Brine depths of these environments would be expected to be very shallow, as it is difficult to envision the necessary rapid fluctuations in a deep body of brine.

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