tions should be recorded by the geologist himself to increase file reliability.

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Are Pennsylvanian "Freshwater" Limestones Actually Intertidal and Supratidal Deposits?

Previously, Upper Pennsylvanian carbonate rocks and associated strata in southeastern Ohio were interpreted as freshwater deposits. Detailed examination of these units has led to the recognition of depositional environments which include marine, intertidal, and supratidal.

Upper Conemaugh units contain an abundant marine fauna and grade upward into lower Monongahela sandstone, shale, and coal. Monongahela sandstones occur as elongate, lenticular bodies. Thin sandstone beds which extend from the lenticular sandstone and interfinger with green shale contain rip-up limestone fragments, stromatolites, and mudcracks. Middle Monongahela limestones and dolomitic limestones overlie these sandstones and shales and are interbedded with green shale. The carbonate rocks contain a sparse fauna of ostracods, gastropods, pelecypods and, locally, fish teeth and scales. Carbonate rocks are thick-bedded, brecciated micrites which contain bird's-eye structures, gypsum crystal molds, and stromatolites. Red-mottled claystones dominate the upper part of the sequence and are interbedded with thin, nodular, conglomeratic algal limestones.

Upper Conemaugh strata represent shallow-marine deposition offshore from a shifting Monongahela barrier-bar system. Behind these barrier bars, coal swamps developed which evolved into tidal flats on which dolomitic carbonate muds and clay muds were deposited. As tidal flats became more extensive, supratidal conditions developed, ranging from hypersaline to fresh water and subaerial, and clay and carbonate muds were deposited.

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Sverdrup Basin Response to Cratonic Events

Sverdrup basin is large (~520,000 sq km) and deep (~13 km), and was long lived (Early Carboniferous to latest Cretaceous). It belongs to a distinctive class of cratonic basins because it received great volumes of terrigenous clastic sediments, but never had a contemporaneous adjacent orogenic belt. Therefore, its stratigraphic record portrays responses to cratonic epeirogenesis unmasked by eccentricities of local orogeny.

Initial subsidence of the basin (Early Carboniferous) was along a system of grabens. During Carboniferous and Permian times, the axial region was relatively starved, whereas thick carbonate deposits and sandstones accumulated on the margins. In the Triassic the axial region received great thicknesses of fine-grained terrigenous clastics but basin-margin successions were thinner and coarser grained. Jurassic and early Neocomian deposits accumulated slowly. Aptian and later Cretaceous marine and nonmarine clastic deposits transgressed widely cratonward over the formerly well-defined basinal margins, and the structural basin lost identity in a broad continental-shelf and coastal-plain complex that existed until the area was fragmented in latest Cretaceous and early Tertiary time.

Mafic volcanism in the Carboniferous, Permian, Early and Late Cretaceous, and gabbro intrusion in the Jurassic and Cretaceous, indicate that crustal fracturing, accompanied by tapping of upper mantle fluids fashioned primary basin subsidence. Sedimentation in phases of accelerated subsidence appears to be dictated by the availability of detritus and the prevailing erosional gradient on the adjacent craton. The basin was relatively starved in the Carboniferous and Permian and relatively "stuffed" in the Triassic. Thick, widely distributed sandstones indicate vigorous erosion of the craton in the intervals late Norian to Sinemurian, late Valanginian to early Aptian, late Albian to Cenomanian, and late Campanian to early Tertiary. In contrast, black, laminated, marine shales mark early phases of marine transgression onto the craton in Leonardian, Griesbachian, Oxfordian, Valanginian, middle Albian, and Cenomanian-Turonian times.

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Cenozoic Clay-Mineral Stratigraphy in South Philippine Sea, DSDP Legs 59 and 60

On DSDP Legs 59 and 60, sites were drilled in the South Philippine Sea along an east-west transect at 17°N lat. Clay minerals from Cenozoic samples at DSDP sites 447A, 449, 450, 452, 453, and 454A were analyzed by X-ray diffraction methods. A semiquantitative determination of the percentages of clay minerals was made for each sample. In addition, illite crystallinities and relative iron contents in illites and chlorites were analyzed using X-ray diffraction data.

At site 447A, on the western flank of the Palau-Kyushu Ridge, the drill penetrated an undated surficial clay zone into underlying early Miocene pelagic clay. The clay is smectite-rich (averaging 95% smectite). The remaining percentage is almost evenly divided between crystalline illite, relatively low-iron chlorite, and kaolinite, all of which reflect detrital input from the Chinese mainland.

Site 449, on the eastern ridge flank, yielded a thick pelagic clay sequence ranging from an undated cover down through middle Miocene to upper Oligocene clays. An increase in smectite content during the late middle Miocene resulted from ash deposition due to volcanism on the West Mariana Ridge. Below this zone, in older middle Miocene clays, the content of chlorite, illite, and kaolinite increases considerably relative to smectite. The mineralogic change is associated with radiolarian-rich deposits of the same age. This change could mark a northward shift in the equatorial countercurrent associated with increased boundary-current circulation that occurred at this time.

Pelagic clays from the other sites in the Parece Vela Basin, Mariana Trough, and Mariana Trench are smectite-rich owing to the ash content of the sediment. However, stratigraphic interpretation of the Mariana Trough and Trench sediment is limited because the pelagic clay units consist only of thin Quaternary veneers.

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Geology and Development of Teak Oil Field, Trinidad, West Indies

The Teak oil field is located 25 mi (40 km) off the southeastern coast of Trinidad in the eastern part of the Venezuela Tertiary basin. The Teak field structure, discovered in 1968 from seismic data, is a broad asymmetric anticline located along a compressional foldbelt between the Caribbean and South American tectonic plates. It is broken by numerous transverse antithetic and synthetic normal faults which divide the producing reservoirs into many separate pools. Production is from depths of 4,000 to 14,000 ft (1,200 to 4,200 m) subsea in 17 upper Pliocene sandstones, ranging in thickness from 20 to 500 ft (6 to 150 m). The effectiveness of the faults as barriers to communication between fault blocks is demonstrated by variations in edgewater conditions, reservoir pressures, and gas:oil ratios. At the same time, migration of oil into the Teak feature may be related to deep-seated fault conduits communicating with underlying Miocene shales.

Production from the Teak field began in 1972 and is presently in its secondary stages, including waterflooding of some oil zones. Fifty productive wells have been drilled from five platforms with an additional 3 wells recently drilled for water injection. As of June 1, 1978, the field had produced 94 billion bbl oil and 153 Bcf gas.

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Distribution and Factors Controlling Foraminiferal Associations and Assemblages on Fringing Reefs During Winter, Mombasa, Kenya

Comparison is made between the distribution patterns of live and total foraminiferal assemblages using either a variety of cluster analyses techniques or a direct intuitive analysis. The former give quick, valid results; the latter brings out nuances of distribution not obvious in routine statistical analysis. The methods are complementary.

Contrasting physio-geomorphologic environments exist in the reef, on either side of the Ras Iwa Tine promontory. Trigon diagrams of the three foraminiferal suborders confirm the assessment of an open-marine foraminiferal environment. The miliolids dominate immediately north of the promontory, but decrease northward. Their abundance is inversely related to that of the rotalines, which dominate both the biocoenose and thanatocoenose of the southern sector. Thanatocoenoses have a high diversity in the lagoon channel and a low diversity in berm and reef-entrance regions, whereas the biocoenose has the highest diversity on the outer platform and the lowest in the channel. Total abundances and standing crops as directly related to gross environmental parameters are very variable in space.

Two hundred and six species have been identified (104 of them living) in marked contrast to the 465+ species and varieties identified by Heron-Allen and Earland farther south at Kerimba. Relative percentage occurrences, abundances, and rank occurrence delimit distinct species associations. The genera *Spiroloculina, Heterostegina, Ammonia*, and *Bolivina* are common in the north, but are locally restricted. Similarly, *Planorbulina, Epistomarioides*, and *Miliolinella* characterize the south. Live and total assemblages reflect the prevailing biophysical and edophic environments.

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Natural Gas Stability in Deep Subsurface

The trend from oil to gas with increasing reservoir depth is well established, but depth limitations on the occurrence of natural gas (methane) have yet to be determined. The controlling factor at depth is the chemical stability of the methane and its reactions with water and the rock matrix. This problem has been studied using a computer program which calculates the equilibrium composition in a multiphase, multicomponent system that simulates the rock-water-gas combination in a deep reservoir. The program accepts thermodynamic data, rock mineralogy, and gas-water ratios as input data. Within these constraints all possible combinations of compounds are considered and the equilibrium composition established using minimum free energy criteria.

Methane alone has considerable thermal stability but in the natural system it occurs in a water-wet environment that decreases its stability. At 30,000 ft (9,000 m) approximately 5% of the methane is destroyed, but for high geothermal gradients this can be as much as 40%. Reservoirs that contain methane derived from the breakdown of crude oil contain a carbonaceous residue. This residue can interact with the water in clastic reservoirs and produce increased amounts of methane along with considerable amounts of carbon dioxide. However, in carbonate reservoirs (or clastic reservoirs with carbonate cement), methane is destroyed with increasing depth, although carbon dioxide remains a major component in the gas phase. Free sulfur and many sulfur compounds dramatically reduce the stability of methane and generate high concentrations of hydrogen sulfide.

Computer calculations help define the role of rock composition in controlling the stability, and therefore the distribution, of natural gas in the deep subsurface. This understanding will become more important as the average well depth increases.

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Role of Temperature and Burial Depth in Development of Subnormal and Abnormal Pressures in Gas Reservoirs

The aquathermal-pressuring concept shows that isolated, water-filled reservoirs become abnormally pressured when temperature rises owing to increasing depth of burial. When reservoirs contain free gas, the situation is more complex and abnormal or subnormal pressures may develop depending on the gas/water ratio and the