tion of time, temperature, solution composition, and exchange ion on the clay. Solution compositions ranged from 400 to 4,000 ppm potassium in all samples. Sodium concentration ranged from 0 to 9,400 ppm, calcium from 0 to 380 and magnesium from 0 to 10 ppm. Silica removal rate increased as the temperature increased from 200 to 350°C, decreased with time, and could be approximated initially by a parabolic rate law. Within the time range (from 1 to 10 days) approximated by the parabolic-rate law, comparison of rate constants allows quantitative evaluation of the effects of solution chemistry and exchange ion. Calcium-saturation of the clay reduced the value of the rate constant, relative to sodium-saturation, by about 50%. In all analyses, increasing solution concentration of an ion decreased the rate of silica removal. On an equimolar basis, magnesium was most effective at inhibiting dissolution, followed by calcium, sodium, and potassium. Reductions of the rate constant by 50 to 75% were observed for a Na-clay with 9,400 ppm sodium and for Ca-clay with 380 ppm calcium, relative to the sodium and calcium-free solutions. Activation energies for silica removal range from 3 to 12 kcal/mole. The highest values are associated with the largest concentrations of ions in solution, thus suggesting dissolution-inhibition by an ion adsorption mechanism. These results demonstrate that silica dissolution rate depends dramatically on solution composition. This relation should be incorporated into models constructed to describe sandstone cementation or porosity enhancement by dissolution and transport of dissolved silica from clays in sandstones or interbedded shales and sandstone sequences.

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Painter Reservoir Field—Giant in Wyoming Thrust Belt

Painter reservoir field is the largest of several recent Nugget Sandstone hydrocarbon discoveries in the Wyoming thrust belt province. The field is located in Uinta County, Wyoming, 5 mi (8 km) northeast of the town of Evanston. It lies on trend with the Clear Creek and Ryckman Creek accumulations, 5 and 10 mi (8 and 16 km), respectively, northeast. These features are also productive from the Nugget Sandstone.

The field discovery, Chevron-Federal 22-6A, was drilled in mid-1977 on a seismic anticlinal structure. The Nugget Sandstone was entered at 9,728 ft (2,918 m) and 1,355 ft (407 m) were penetrated to the total depth of 11,083 ft (3,325 m). After extensive testing, on October 22, 1977, potential of the well was 410 BOPD and 859 MCFGD, on 15/64-in. choke, FTP 1,275. Flow rates as high as 1,500 BOPD were recorded on larger chokes. Gravity of the oil is 48.4° API. Active development began immediately and is still in progress.

Field limits and structural configuration are not yet fully decided, but seismic and drilling data indicate an overturned fold associated with the hanging wall of the Absaroka thrust. Present drilling has established an oil and gas column of over 1,000 ft (300 m). The producing Nugget formation is a cross-bedded, quartz sandstone over 850 ft (255 m) thick with an average porosity of 12% and permeability ranging from 0 to 1,000 md. Analysis of the oil suggests a Cretaceous source.

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Detailed Temperature Logging as Useful Tool for Lithologic Interpretation

Data from an extensive drilling program conducted on the Atlantic coastal plain by the Department of Energy suggest that detailed temperature logs may be useful for interpretation of subsurface lithology and stratigraphy. Temperature was measured to ±0.01°C and was sampled every 0.5 m. Thermal gradients were computed, and compared to lithologic sequences as derived from drill cuttings collected every 3.0 m.

Examination of a vertical thermal-gradient curve reveals that breaks in the curve correspond to major grain-size changes. Many of these breaks correspond to stratigraphic boundaries that are associated with a grain-size change. However, stratigraphic boundaries that are not defined by a grain-size change are more difficult to recognize.

Preliminary results from the first hole at Fort Monmouth, New Jersey, suggest that the correspondence between thermal gradient and grain size is due to a direct correlation between local thermal gradient and the amount of sediment at that depth that is finer than 4.0 psi. This relation allows detailed interpretation of lithologic sequences. Trends within a stratigraphic unit, such as fining-upward sequences, can be readily identified. Also, thin lithologic units (1 to 2 m thick) that were recovered within sediment cores are recognizable on a thermal-gradient curve. These results suggest that detailed temperature logs can provide valuable, detailed information about subsurface stratigraphy and lithology.

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Deep-Sea Drilling: New Dimension in Our Approach to Oceanic Sediments

Over a century ago, when sedimentologists began studying deep-sea sediments, they could grab only small samples of mud from the seafloor. To study the evolution of sedimentation with time, it became imperative to add a vertical dimension and the first long-piston cores opened an entirely new field. When the seafloor-spreading and plate-tectonic hypotheses were developed, it was clear that the best test was to add the time dimension to the models. This combination of interests made the Deep Sea Drilling Project a logical step.

At first, the project aimed at verification and time-calibration of plate tectonics, but it soon became clear that oceanic sediments contain a wealth of information regarding the paleo-oceanographic evolution of the world ocean. One striking result of drilling is that, although the evolution of the oceanic crust appears rather continuous, oceanographic conditions have undergone abrupt changes that may reflect variations in the geometry of the ocean basins. Thus, the sediment record of the past 200 m.y. is both more diversified and more discontinuous than anticipated. For the first time, vertical sequences of cores allow a study of diagenesis of pelagic sediments from the incipient stage to the mature stage.

Oceanographic events, diagenetic effects, and lithologic boundaries related to the geodynamic evolution of the crust all affect large areas of the seafloor. Their imprints in the physical properties of the sediments can be recorded on seismic profiles over long distances between drill sites. Thus, for the first time, we can reconstruct the evolution of entire ocean basins from almost their time of creation and can separate basin-wide or even worldwide events from those that are only local in origin.

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Tyler Sandstones (Pennsylvanian), Dickinson Area, North Dakota—A 24-Million Barrel Soil-Zone Stratigraphic Trap

Approximately 24 million bbl of recoverable oil have been found in stratigraphic traps in the Lower Pennsylvanian Tyler Formation at the Dickinson, South Heart, and eastern Green River fields, Stark County, North Dakota. Production is from a multiple sequence of quartzose sandstones 5 to 18 ft (1.5 to 5 m) thick deposited as barrier islands along regressive shorelines. Where a shoreline sandstone is fully developed, a typical vertical sequence consists, in ascending order, of the following.

1. 1 to 6 ft (0.3 to 2 m) of black to greenish-gray, sparsely fossiliferous shale. Thin interbeds of fossiliferous carbonate mudstone may be present (shallow-neritic environment).

2. 1 to 6 ft (0.3 to 2 m) of very fine to fine-grained sandstone containing small, deposit-feeding burrow structures. Stratification is finely laminated to ripple cross-stratified. Thin interbeds of siltstone and shale are common (lower-shoreface environment).

3. 3 to 12 ft (1 to 3.6 m) of fine to medium-grained, well-sorted sandstone which commonly exhibits medium to low-angle sets of cross-stratification. These genetic units are the principal reservoir rocks (upper-shoreface environment).

4. 1 to 2 ft (0.3 to 0.6 m) of fine to medium-grained, well-sorted sandstone which commonly appears massive, but in a few cores exhibits parallel stratification. The upper few inches are clayey and mottled by root structures (foreshore environment).

5. 0.5 to 3 in. (2 to 7 cm) of coal (marsh environment).

In a landward direction (south) the shoreline sandstones interfinger with thin fossiliferous limestones, black shales, and oxidized mudstones which are interpreted to be lagoon, marsh, and mudflat deposits.

Throughout much of the subject area, porosity and permeability in the sandstones have been greatly reduced or completely destroyed by development of caliche paleosols. In the western part, the caliche consists of gray to brown limestone nodules or nodular layers of limestone in the sandstones and contains abundant pyrite. In the eastern part, the caliche has been strongly oxidized, and nodular to brecciated limestone in the sandstones is associated with reddish-brown to white clay, iron oxide cement, and scattered anhydrite nodules. It is estimated that the caliche destroys as much as 50% of the potential reservoir rock in the area and is an essential factor in the stratigraphic entrapment of the petroleum accumulations by providing an eastern (updip) barrier to migration.

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Isotopic and Trace-Element Geochemistry of Dolomite—State of the Art

Large variations in the stoichiometry, perfection of order, and substitution of iron for magnesium in sedimentary dolomite make precise interpretation of the trace-element and isotopic chemistry of this complex mineral difficult.

Redetermination of phosphoric acid fractionation factors yields values of of $10^3 \ln \alpha$ between 11.4 and 11.9 for most sedimentary dolomites (the redetermined value for calcite is 10.5). A few dolomite types apparently yield values of about 12.5, but the reasons are unknown.

Mathematical modeling of the diagenetic behavior of the trace element strontium, in conjunction with oxygen isotopic changes during the diagenesis of limestones, substantiates recent suggestions that experimentally determined partition coefficients for calcite may not apply under actual diagenetic conditions. Presumably, an analogous situation exists with respect to dolomite.

At the present state of the art, quantitative interpretation of absolute isotopic and/or trace-element values is tenuous at best. Qualitative interpretation of regional or stratigraphic gradients in either or both of these variables appears to be of far greater utility.

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Tracks and Substrate Reworking by Terrestrial Vertebrates in Quaternary Sediments of Kenya

Reworking of sedimentary substrates by terrestrial vertebrates, especially hoofed herbivores, has stratigraphic significance comparable to that of marine sediments by benthic invertebrates. Environmental analysis of the Pliocene-Pleistocene Koobi Fora Formation in northern Kenya reveals many vertebrate footprints and trackways in fluvial and lake-margin strata. Some beds are completely reworked by trampling of many animals, presumably ungulates, with subsequent disarrangement of primary grain fabric and sedimentary structures. Examination of footprints and game trails in similar modern Kenyan environments, and comparison with those in older sediments, indicate characteristics useful for their recognition elsewhere. Preservation is best in mud and sand interbeds of medium thickness where the animal foot punches out a plug of coherent surface sediment (usually mud) and presses it into underlying units of contrasting lithology (usually sand). Thicker and less coherent muds simply mold the foot. In both situations the print is flat to concave upward with a discontinuous rim that surrounds a low spot where later wind- or water-laid sediments and bone fragments may concentrate. Further trampling of coherent surface mud disturbs the ground surface allowing wind and water to remove the