Authigenic smectite, recently reported to occur over large areas of the deep sea, forms in fan deposits as young as 0.4 m.y. at temperatures less than 10°C and has been found at burial depths less than 10 m. Scanning electron microscopy shows that crystallization of authigenic smectite is related to the progressive downhole dissolution of biogenic silica and volcanic glass. Sandstone cemented with only a few percent smectite retains high porosities (25 to 30%) but permeabilities are greatly reduced (<100 md).

Ancient sandstone turbidites commonly have their original interparticle pore space filled with carbonate cement. Textural evidence (few grain contacts, low grain density) indicates that, as in the DSDP cores, much carbonate cement in ancient sandstone turbidites is the product of an early pre-compaction cementation. At greater depths, these relatively uncompacted calcite-supported sandstones may once again become prospective petroleum reservoirs as decarbonatization generates secondary porosity.

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Thermogenic Hydrocarbon Gases in Unconsolidated Seafloor Deposits, Northern California Continental Margin

Modern unconsolidated sediment overlying a diapir-like structure in the Eel River Basin, offshore northern California, contains an unusual mixture of gas and gasoline-range hydrocarbons. Although concentrations of methane in a 2-m gravity core at a single sampling locality (water depth of 500 m) are in the same range as found in modern anoxic sediments, the concentrations of higher molecular weight hydrocarbon gases are anomalously high relative to background. For example, ethane, propane, isobutane, and n-butane are about 18, 5, 10, and 2 times, respectively, more abundant than the highest concentrations of these same hydrocarbons observed elsewhere in the same region. Associated with these high gas concentrations are anomalous contents of gasoline-range hydrocarbons. Much of the methane and part of the ethane appear to be derived from modern microbial processes. Most of the ethane and the higher hydrocarbons, however, probably have a thermogenic origin deep within the sediment of the Eel River Basin. These hydrocarbons may reach the surface through fractures in the diapir-like structure and seep into overlying unconsolidated sediments that are ponded locally within structural and bathymetric depressions on the surface of this structure. Thus, the hydrocarbons in these near-surface sediments may be derived from petroleum that has formed and accumulated in Tertiary sedimentary rocks of the Eel River Basin.

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Exploring for Niagaran Pinnacle Reefs in Southern Michigan Basin

The search for hydrocarbon-bearing Silurian Niagaran pinnacle reefs commenced when exploration technology became sufficiently advanced to accurately locate areally small reefs. Starting in 1947, gravity methods were used to locate 90 reefs in southwest Ontario and southeast Michigan but, as the reef trend was pursued westward, gravity data became unreliable owing to the presence of highly variable, surface glacial till. Initial efforts with single fold seismic were also unsuccessful for the same reason. It required the development of CDP seismic techniques with adequate surface static correction before exploration could successfully be expanded into the rest of the reef trend.

First, it was necessary to define reef seismic characteristics as it was not possible to see the reef directly. A synthetic seismogram study of known reefs in southeast Michigan indicated the initial indirect criteria: (a) thinning of seismic intervals above the reef and (b) pull-up below the reef interval. A CDP seismic survey confirmed these criteria and allowed optimization of field parameters.

The first prospect drilled satisfied the seismic criteria and, in addition, exhibited a salt-solution feature common above reefs in southeast Michigan. However, high-velocity infill material was drilled instead of a reef. A second prospect was selected with the additional criterion of an isochron thick around the reef interval. This feature proved to be a residual salt pillow inside the isochron interval. To reduce the risk of encountering salt features a third prospect was selected south of the salt limit (as defined by geologic mapping). The prospect was modeled with best fit of seismic data for the reef case. This resulted in the Mobil No. 1A Brown Niagaran discovery. Several similar seismic features were drilled confirming the reef seismic characteristics.

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Stewart Peak Culmination, Idaho-Wyoming Thrust Belt, as Compared with Other Fold-and-Thrust Belt Culminations

The Stewart Peak culmination, located in the northern Salt River Range of the Idaho-Wyoming thrust belt, is an anticlinorium in the hanging wall of the Absaroka thrust fault. The culmination is topographically and structurally higher than areas to the north or south and consists of the oldest rocks exposed in the thrust belt. Rocks from the lower part of the Absaroka thrust sheet, ranging in age from Middle Cambrian to Mississippian, are stacked by an anastomosing network of imbricate thrust faults. Fold geometries include kink, chevron, and open concentric forms which deformed by a flexural-slip mechanism.

Structural culminations are an important and predictable component of most fold-and-thrust belts. Down-plunge projections from culminations into adjacent depressions are often the key to unraveling complex structural relations. Several factors may contribute to the development of a culmination.

Surface geologic mapping, integrated with down-plunge projections and geophysical data, indicate that the Stewart Peak culmination is the result of polyphase uplift and arching of the Absaroka thrust sheet by motion on younger and structurally lower thrust faults, namely the Murphy and Firetrail thrusts. These younger faults are interpreted to sole into the overlying Absaroka thrust, forming a subsurface duplex zone which may have considerable oil and gas potential. In addition, magnetic data suggest that the Stewart Peak culmination may be positioned over the northwest continuation of the Moxa arch, an anticlinal flexure of authochthonous basement which formed contemporaneously with thin-skinned thrusting.

The Stewart Peak culmination is compared to structural culminations in the Canadian Rockies and the southern Appalachian orogene of Virginia and Tennessee. Culminations are prospective areas for oil and gas, and traps may be formed in a variety of geometric configurations.

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Carboniferous Conodonts

Our understanding of Carboniferous conodont faunas has been significantly advanced in the last several years because of increased interest in these microfossils. Although numerous biostratigraphic zonations have been proposed, especially in the lower Carboniferous, variations in taxonomic and zonal approach preclude a unified worldwide zonation at this time. Carboniferous conodont provincialism does not restrict correlation because globally distributed species occur at most levels in the system. However, paleoecological studies are just beginning and undoubtedly will receive considerable attention in the future. Although significant advances in upper Carboniferous multielement taxonomy have been made, few published attempts at lower Carboniferous conodont apparatus reconstructions have been proffered. Nevertheless, our comprehension of Carboniferous conodont evolution has reached a level where these microfossils will greatly influence decisions by international professional groups working on problems of boundary definitions and correlations, and will aid in paleogeographic reconstructions.

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Barrow Gas Fields, North Slope, Alaska

The Barrow gas fields, located a few miles south of Point Barrow, Alaska, on a northern extension of the Arctic coastal plain, constitute the most northerly producing area in the United States. The South Barrow gas field was discovered in 1949 under the exploration program supervised by the U.S. Navy. The East Barrow field proved productive in 1977, shortly before Congress transferred Naval Petroleum Reserve No. 4 (NPR-4) to the Department of the Interior and renamed it the National Petroleum Reserve in Alaska (NPRA).

The producing areas are regionally high near the intersection of two large structurally positive elements, the Barrow arch and the Meade arch. The section of sedimentary rocks above the metamorphic basement is thin in the producing fields, only about 760 m thick. The accumulations are structurally controlled and produce from a sandstone of Middle Jurassic age. The discovery wells were located on seismic anomalies that border a roughly circular "disturbed zone," of highly faulted rocks with erratic dips, that has been called an astrobleme or a cryptovolcanic structure. Additional untested seismic structures appear to be present in the area.

The older South Barrow field is the larger of the two fields, having original recoverable reserves of about 25 Bcf of gas. The newer East Barrow field has estimated recoverable reserves of about 12 Bcf of gas. The fields furnish fuel for facilities occupied by agencies of the federal government and the native village of Barrow. The costs of developing and producing the gas are high, but recent comparative studies have shown it to be the most economical fuel for the area.

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Development of Secondary Porosity in Reservoir Sandstones by Dissolution of Silicate Mineral Constituents

Although considerable pore space in reservoir sandstones may result from chemical removal of carbonate rock as cement or mineral replacements, significant porosity may develop by direct dissolution of silicate mineral constituents. Feldspar and volcanic rock fragments, in particular, appear highly susceptible to dissolution in many reservoir sands.

Dissolution of detrital feldspar represents a most important source of secondary porosity. Sanidine, orthoclase, and plagioclase occurring as discrete grains or constituents in rock fragments may undergo intense dissolution. Microcline and authigenic feldspar growths, however, are generally much less affected. Early unaltered carbonate cement (pre-feldspar dissolution) in some sandstones indicates that dissolution may occur under alkaline as well as acidic conditions. Although resultant pores may be moldic, most voids contain remnants of undissolved material. In feldspathic sandstones, extensive dissolution can cause weakening and subsequent readjustment of the detrital framework.

Dissolution of volcanic rock fragments (VRFs) may also account for considerable pore space in reservoir sandstones. Finely crystalline volcanic fragments and volcanic glass appear to be especially prone to dissolution. Voids resulting from dissolution of VFRs are commonly moldic appearing and may be characterized by a "skeletal framework" of straight to curvilinear shards and veinlets(?) resembling chert. In some specimens, chloritized VRFs appear to be more susceptible to dissolution than unaltered "fresh-appearing" fragments. As chlorite is relatively soluble under lower pH conditions, this possibly indicates that formation waters attending dissolution were somewhat acidic.

Although dissolution of silicate mineral constituents results in increased porosity, it does not necessarily result in enhanced permeability. In some places, the development of authigenic clay as a dissolution product may serve to constrict pore throats, resulting in a decrease in pore communication.