distal areas extending to the Carlsberg Ridge. The percent sand is higher and the number of thick sand beds is more common in the distal areas of the fan; Bouma turbidite sequences, T_{a-e}, are common. Two main sand lobes are distinguished in the distal fan—an extensive western lobe, derived through channels resulting from the branching of the western valley system, and a restricted, eastern lobe, derived from the eastern valley system. The distributions of these lobes coincide with areas of thick sediments as seen on seismic profile records, implying that sediment dispersal similar to that in the Pleistocene occurred in earlier times.

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USCHEM, Geochemical Data File of National Coal Resources Data System (NCRDS), Applied to Study of Appalachian Coal Bed

USCHEM, a geochemical data file, is a part of the U.S. Geological Survey's computerized National Coal Resources Data System, NCRDS. The purpose of this data file is to store and retrieve geographic, geologic, and chemical-analytical information for each coal and coal-related rock sample submitted for analysis to the USGS. Each sample is analyzed by the USGS for major-, minor-, and trace-element, and oxide concentrations; splits of coal samples are also analyzed by the U.S. Department of Energy for proximate and ultimate data, forms of sulfur, free-swelling index, ash-fusion temperatures, and Btu information.

Data for samples of the Waynesburg coal bed in the Appalachian region are useful to demonstrate the capabilities of USCHEM as an aid to geologic, geochemical, environmental, and technological studies. Available techniques for presenting and manipulating the data are: sorting, listing, mathematical redefinition, tabulation, statistical analysis, and graphic displays. Graphic displays include: plots of point locations, trend surfaces of single and multiple variables, isoline maps, histograms, and two- and three-dimensional graphs. Data in USCHEM can be used to delineate geographical areas that meet (1) specific individual criteria, for example, areas where arsenic is <10 ppm, or (2) multiple criteria, for example, areas where sulfur is $<3\%$, ash is $<10\%$, and Btu is $>10{,}000$. Trace-element data can be presented on an ash or whole-coal basis, and proximate and ultimate data on an "as-received" or " dry" basis.

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Diagenetic Features of Grand Rapids Formation, North-Central Alberta, Canada

The Lower Cretaceous Grand Rapids Formation of north-central Alberta consists of three massive sandstone units separated by shales and siltstones. Average thickness of the formation is approximately 90 m. In the subsurface these sandstones are impregnated with bitumen and form the Wabasca oil sands deposit, with resources estimated at 10.5×10^9 cu m (66×10^9 bbl).

The Grand Rapids sandstones are arkosic to lithic sandstones with a fairly heterogeneous mineralogy in which the predominant constituents are quartz, feldspar, chert, rock fragments, mica, glauconite, and locally siderite. They are poorly consolidated, the main cementing agents being authigenic clays. Kaolinite tends to be the dominant clay mineral in the oil-saturated sandstones while montmorillonite and Fe-rich chlorite predominate in the underlying water-bearing sandstones. Scanning electron microscope studies show that kaolinite occurs as booklets, irregularly scattered throughout the sandstone in a pore-filling habit. Montmorillonite and chlorite have both pore-lining and pore-bridging habits, while illite is mostly a pore-bridging clay. Montmorillonite-chlorite mixed layer clays are found in some samples. The clays in the sandstones all appear to be authigenic in origin.

Calcite is the only other common cementing agent. The calcareous cement formed early, apparently replacing most of the original matrix material and locally forming large concretions up to 5 m in diameter in the lower sandstone unit. Other authigenic minerals which may be local cementing agents include siderite, K-feldspar, pyrite, and zeolites(?).

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Investigation of Measurements of Heat Flow Regime in Oceans as Related to Hydrocarbon Generation

Geothermal gradients and conductivity measurements taken by shallow penetration gravity cores and used in calculating heat flow values are not necessarily indicative of the temperature regime and heat flow below. Any attempt to associate generation and maturation of hydrocarbons to heat flow values is erroneous. Geothermal gradients measured in wells cannot be compared with or against proximal shallow penetration heat flow values. Because of many near-surface effects, heat flow values are superfluous calculations unless deep penetration data are used and compared.

Attempts at relating heat flow values to hydrocarbon generation fail because values within and without sandstone bodies are of low magnitude, and the differences that are calculated are within the error of temperature and conductivity measurements; therefore, any differences will not be detectable near the surface.

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Early Porosity and Permeability Reduction in Deep-Sea Fan Sandstone and Shale By Authigenic Smectite and Carbonate Cement

A preliminary study of DSDP cores from deep-sea fan deposits off southern California and Baja California indicates that sandstone turbidites and interbedded shales can be rapidly and extensively altered at shallow burial depths. Their porosity and permeability are reduced or totally occluded by the early (commonly precompaction) formation of authigenic smectite and carbonate cements. As a result, many turbidite sands become tightly cemented at burial depths shallower than 400 m and thus lose their potential as petroleum reservoirs.

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,