used for recreation and bathing purposes. In 1890 a district geothermal space-heating project was initiated in Boise, Idaho, and in 1925 the first electric generation using geothermal fluids was accomplished in The Geysers area of California.

Geothermal energy is being investigated in many areas of the United States with most of the development occurring in the western states. Most of this development is oriented toward small, nonelectric projects such as space heating, greenhouses, and aquaculture, although several larger heating and industrial projects are being considered.

Electric generation using geothermal fluids is being done in California, Utah, and Oregon, with most effort in The Geysers and Imperial Valley areas of California. Considerable exploration and drilling has been done in Nevada for electric-grade geothermal resources, although institutional and economic problems have limited development at this time.

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Facies Analysis of Upper Jackfork Formation (Pennsylvanian), DeGray Dam, Arkansas

The DeGray Dam spillway cut displays perhaps the best exposed section of the upper Jackfork formation (Pennsylvanian) in the Ouachita Mountains of Arkansas and Oklahoma. Comprising more than 321 m (1,050 ft) of interbedded sandstone and shale, this deep-water succession was originally interpreted as a sequence of alternating proximal and distal turbidites, and subsequently as outer-fan depositional lobes. Recent detailed facies analysis, however, demonstrates that the succession represents a mid-fan association of channel and interchannel deposits.

Channelized intervals consist of stacked thinning-upward and/or amalgamated packages characterized by Mutti and Ricci Lucchi facies A, B, C, and G. Associated interchannel intervals consist of facies C, D, E, and G beds that are randomly interbedded or form thickening-upward packages that superficially resemble depositional lobes. These lobe-like packages, which are generally less than 4 m (13 ft) thick, are interpreted as crevasse-splay deposits. A similar association of channel and interchannel deposits can also be observed in nearby outcrops of the underlying lower Jackfork.

A longitudinal submarine fan system, analogous to the present-day Bengal fan, is visualized as the overall depositional setting for the Jackfork formation.

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Petroleum Resources in Powder River Basin

This updated geochemical-geologic appraisal of Powder River basin resources appreciably increases earlier estimates of generated and expelled Cretaceous oil and gas. However, volumetric estimates of trapped and preserved petroleum were not significantly revised.

Both hydrocarbon expulsion phases were evaluated in detail as follows. (1) *Oil-expulsion phase*—volumes of oil generated and expelled from each source rock, then trapped and preserved; also volumes of gas expelled with oil, then trapped and preserved, including gas generated with oil and minor quantities that resulted from incipient thermal cracking of oil. (2) *Gas-expulsion phase*—volumes of thermal gas generated, expelled, trapped and preserved after oil expulsions ceased, along with some gas formed from thermal cracking of unexpelled oil in effective gas source rocks which are fewer in number and areally much smaller than effective oil source rocks.

Gas derived from thermal cracking of oil in deep reservoirs, bacterial gas, and gas and oil generated beyond the geochemically defined limits of each effective source rock unit were not included in this appraisal. Volumes of biogenic gas and of gas formed by thermal cracking in reservoirs are minor, relative to gas expelled from source beds.

Expulsion efficiency appears to have averaged about 7% of generated oil. Most of the generated oil was retained in source beds, some of which was then expelled as gas. Although a high percentage of thermal gas was expelled, only a small quantity of expelled gas was preserved in traps.

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Devonian and Mississippian Stratigraphy and Depositional Environments in Big Hatchet Mountains of Southwestern New Mexico

In the Big Hatchet Mountains the Upper Devonian Percha Shale rests unconformably on the Upper Ordovician Montoya Formation and is overlain by strata referred to the upper part of Sabin's Portal Formation. To date, this is the farthest east the Portal has been observed. Devonian rocks record a shallowing-up sequence from the lower Percha (Ready Pay-Box Members) deposited in quiet water to the Portal grainstone deposited at or above wave base. The Portal contains Upper Devonian (Famennian) conodonts indicative of Sandberg's shallow-water *polygnathid-icriodid* biofacies.

Mississippian strata, represented by the Escabrosa Group, contain Early Mississippian (Osagean) conodonts at the base. Lower Mississippian strata record 2 Osagean cycles of submergence and emergence. Encroachment began in the early Osagean (*isosticha*-upper *crenulata* Zone) when the basal oolitic grainstones of the Bugle member of the Keating Formation were deposited. A shallowing-up sequence followed, culminating in the deposition of high-energy grainstones of the upper Bugle. The end of Bugle deposition is marked by a second submergence (lower *typicus-Anchoralis latus* Zone) when argillaceous wackestones were deposited. This deepening continued during deposition of the basal Witch member. Regression began during deposition of the Witch, as suggested by the vertical sequence from fine-grained mudstones to high-energy grainstones. This shallowing sequence continues into the lower Hatchita Formation.

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Results of Separation of Antarctica and Australia During Late Cretaceous

The U.S. Geological Survey research vessel *S.P. Lee* is investigating the area of continental breakup (90 m.y.B.P.) during which the Great Australian Bight separated from Wilkes Land, and Tasmania detached itself from the Ross Sea. Transform faults that formed along the Southeast Indian ridge are not perpendicular to the coast of Antarctica, but lie at an acute angle to it. This orientation indicates that the breakup followed a preexisting line of continental weakness. As new oceanic crust began to form after the breakup, the rift divided into a stairstep pattern of spreading axes and transform faults in harmony with the direction of separation. In places, the stairstep rifting created local basins of the continental-borderland type. Sediment flooded into the rifts from the two separated continents and lapped across stretched continental crust at the margins and onto newly formed and hot oceanic crust farther out. An optimistic scenario for petroleum formation in this area might be: (1) rapid sedimentation entrained organic petroleum precursors before they could decay at the sea floor, and (2) heat from the young oceanic crust below matured them. The favorable characteristics of rifted margins—silled grabens to reduce sea-floor oxidation, little reservoir-plugging volcanic ash, and rollover anticlines against curved growth faults—all make the area promising for exploration. Although petroleum is not known from the margin of Antarctica, analogous oil fields on the continental shelf near Tasmania suggest that the area has a resource potential.

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Sedimentology and Reservoir Characteristics of Tight Gas Sandstones, Frontier Formation, Southwestern Wyoming

The lower Frontier Formation, Moxa arch area, southwestern Wyoming, is one of the most prolific gas-producing formations in the Rocky Mountain region. Lower Frontier sediments were deposited as strandplains and coalescing wave-dominated deltas that prograded into the western margin of the Cretaceous interior seaway during the Cenomanian.

In this study, sedimentologic, petrologic, and stratigraphic analyses were conducted on cores and logs of Frontier wells from the Whiskey Buttes and Moxa fields. Twelve sedimentary facies have been identified. The most common sequence consists of burrowed to cross-bedded near-