derground mining.

In 1977, coal production from seven strip mines amounted to 23 million tons or 50% of the state's total production that year. The Amax Coal Co. Belle Ayr mine alone accounted for 13.3 million tons. With expansion of the Belle Ayr mine to 17 million tons, the addition of three new mines, and the expansion of other existing mines, production in 1978 probably exceeded 39.2 million tons or about 63% of the state's 1978 production. Forecast annual production from the Powder River basin is 81.1 million tons by 1980 and 123.1 million tons by 1985. Of this tonnage, 95% is derived from the subbituminous Wyodak-Anderson coal bed, which ranges from 20 to 120 ft (6 to 36 m) thick in the east-central part of the basin.

In addition to conventional strip mining activity, two in-situ coal gasification projects are under way in the basin.

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Alluvial Fans and Their Deposits in Devonian Hornelen Basin, Norway

Conglomerate alluvial-fan bodies are well exposed around the fault margins of Hornelen basin. Detailed mapping of the bodies and of their internal facies variation together with logging of laterally equivalent profiles allows reconstruction of fan processes, geometry, internal cyclicity, and relation to contemporaneous flood-basin deposits. Of particular interest is fan-to-fan variation through Hornelen basin's 25 km succession, as illustrated by six examples from the northern and southern margins.

Some fan bodies, particularly with small radius (<2 km), and a rapid change in downfan maximum particle size (>30 cm/km) are entirely dominated by debris flows. The latter are commonly poorly sorted and massive or inversely graded. The ratio of bed thickness to maximum particle size in debris flows is usually less than 3. Other fans, usually thinner bodies, with greater radius (<6 km) and less abrupt downfan grain-size gradients, contain a significant amount of fluvial (braided stream) or sheet-flood deposits, which are usually concentrated in the middle or lower fan reaches.

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Mississippian Carbonate Shelf Margin Along Overthrust Belt from Montana to Nevada

A constructional carbonate platform and a generally north-trending shelf margin in Utah and southwestern Idaho were bordered on the west by a starved basin, flysch trough, and orogenic highland during Kinderhookian to middle Meramecian time. The Antler orogeny produced epeirogenic movements, which resulted in sea-level changes that caused the carbonate platform episodically to prograde and retreat. At different times the shelf was bordered either by a narrow foreslope or by a broad ramp. The sequential history is as follows: (1) Late Devonian thrusting raised the continental margin to produce the Antler orogenic highlands, which in earliest Mississippian time had a low eastern coastal plain that bordered a narrow, shallow marine basin lacking a distinct eastern shelf. (2) Widespread marine inundation of the craton on the east was followed by a stillstand, during which a low shelf margin that turned abruptly eastward in Montana was developed and deposition of clinoform micritic limestone beds occurred in moderately deep water across a very broad ramp. (3) Increased downwarping produced an incipient starved basin, separated by a shallow carbonate bank from the flysch trough on the west and by a broad ramp from the northeast-trending shelf margin on the east; coarse encrinites were deposited alternately with micrites on the ramp. (4) Maximum deepening and expansion of the starved basin were accompanied on the west by deepening of the carbonate bank and on the east by westward progradation of a carbonate platform with a narrow, steep foreslope. (5) Lowering of sea level produced a karst plateau on the former carbonate platform and caused cratonic sands to be carried westward into the basin. Meanwhile, filling of the flysch trough allowed an eastward spillover of distal flysch sediments into the basin. The starved-basin sediments, which have organic-carbon values as high as 7% in outcrop, are considered to be source rocks. Coarse sediments of the carbonate platform, particularly where dolomitized, may serve as petroleum reservoirs.

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Application of Nonmarine Mollusca to Paleoenvironmental Interpretation and Correlation of Paleogene Rocks

Nonmarine mollusks, the most consistently occurring element of Mesozoic and Cenozoic nonmarine macrofaunas, are abundant and locally dominant in many preserved terrestrial and freshwater "paleocommunities." Maximum interpretive potential of mollusk assemblages is derived from detailed analysis of several biologic and physical factors: (1) taxonomy based on modern malacologic and paleontologic concepts that include differentiation of genetic and nongenetic morphologic variability; (2) biostratonomy (the history of the faunal assemblage from death to final burial); (3) community structure; (4) time-space variability of assemblages relative to a detailed lithostratigraphic framework; and (5) rock types, fabric, and structures of the enclosing sedimentary rock. Collectively, these factors indicate whether the faunal assemblage was preserved in the original environment in which it lived. Failure to gather and/or interpret adequately these data has promoted the widely held misconception that mollusks are of little value in the interpretation of depositional environments, biostratigraphy, correlation, and age determination of nonmarine rocks.

Two examples of the interpretive value of Paleocene and Eocene nonmarine mollusks are (1) depositional environments and regional paleoenvironmental reconstruction of part of the Green River and Wasatch Formations, southwestern Wyoming and northwestern Colorado; and (2) biostratigraphy and correlation of part of the Tongue River Member of the Fort Union Formation, northern Powder River basin, Wyoming and Montana.

The Green River and Wasatch Formations are complexly intertonguing lacustrine and fluvial units that were deposited during early and middle Eocene time in Western Interior basins of Wyoming, Colorado, and Utah. The structure of nonmarine molluscan associations within these strata delineates littoral and sublittoral lacustrine, pond, fluvial, and terrestrial habitats. Littoral and sublittoral lacustrine habitats are characterized by a low-diversity association of prosobranch gastropods and unionid bivalves. Rank and relative abundance of taxa differ in these habitats. Ponds are dominated by a diverse association of aquatic pulmonate gastropods with sphaeriid bivalves. Lowland and flood-plain habitats are characterized by a locally diverse association of terrestrial pulmonate gastropods and a fluvial association dominated by unionid bivalves with prosobranch and aquatic pulmonate gastropods. Comparison with structurally similar molluscan associations from modern habitats, paleosynecology of fossil taxa, and lithostratigraphic data provide bases for paleoenvironmental interpretation. Analysis of paleogeographic and stratigraphic distribution of these Eocene molluscan associations, relative to a detailed lithostratigraphic framework, permits regional paleoenvironmental reconstruction within the Green River and Wasatch Formations.

In the northern Powder River basin, the Tongue River Member of the Fort Union Formation contains diverse, commonly excellently preserved assemblages of Paleocene nonmarine mollusks. Detailed study of the distribution of gastropods and bivalves in the stratigraphic interval from below the Wall coal bed to above the Arvada coal bed clearly indicates the value of mollusks in correlation of sedimentary sequences between the Wall, Anderson, Smith, Roland, and Arvada coal beds. Clinal morphologic variation in shell form and sculpture through time within a lineage of viviparid gastropods provides an additional method for correlation within part of the stratigraphic interval.

These studies clearly indicate the value of mollusks in the interpretation of depositional environments, biostratigraphy, and correlation of Paleogene nonmarine rocks.

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Alluvial-Plain Sediments of Nubia, Southwestern Egypt

Nubia sandstone strata of southwestern Egypt were deposited mainly on vast alluvial plains with a northward slope and range in age from Jurassic to latest Cretaceous. The unique aspects of the Nubia as compared to most published fluvial models are that: (1) the sequence is composed almost entirely of medium to coarse-grained sand through a thickness of 1,000 to 2,000 m, (2) the stream channels were relatively straight, commonly only 2 to 4 m deep, and occupied by sand-wave bed forms, and (3) the overbank deposits were thin, sandy, and contain fine kaolin clay plates introduced by infiltration of muddy flood waters.

The typical Nubia fluvial cycle is simple and of two parts. The lower part, commonly 2 to 4 m of porous clay-free sandstone, is composed of tabular sets of cross strata 20 to 100 cm thick, with consistent north dips. The upper part, only 1 to 2 m thick, is also sandstone but contains abundant kaolin platelets 1 to 2 μ in size. These clayey sandstones have numerous root traces and commonly lack primary lamination, although remnants of tabular sets are rarely partly preserved. The contact between upper and lower parts is transitional, with downward decreasing root-trace abundance. The basal contact of each cycle is an erosional surface with slight relief, and commonly eroded clayey sandstone clasts are reworked into the overlying sandstone.

Environmental reconstruction suggests that alluvial plains sloped northward from northern Sudan for hundreds of kilometers toward the Mediterranean. The climate was warm and humid or semihumid, judging from the flora. Streams crossing the plain were mostly fairly small, shallow, straight, but not braided. Interchannel areas were densely vegetated by plants typical of the Jurassic and Cretaceous. The sandstone is nearly pure quartz, although the source area is largely crystalline basement. This mineralogic maturity testifies to rigorous weathering and a long time span for fluvial recycling. Three alluvial plain sequences, each several hundred meters thick, are separated by thin marine or marginal marine muddy sediments deposited during extensive southward transgressions into Egypt.

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Oil and Gas Potential of Wyoming

Through 1978 Wyoming had produced 4.6 billion bbl of oil and had a year-end estimated 1.8 billion bbl in known fields (includes proved reserves, NGL, future extensions, revisions, new-pool discoveries, and enhanced recovery). Production and reserves are between 3 and 4% of United States totals. Approximately 55% of past oil production has been from Paleozoic rocks, primarily Permian-Pennsylvanian, and 35% from Cretaceous sandstones. Reserves in Cretaceous rocks probably are greater than those in Paleozoic rocks, but the importance of Jurassic reservoirs is increasing. Three-fourths of past discoveries have been in structural traps, but, with the exception of the thrust belt, future discoveries will be largely in stratigraphic traps.

Through 1978 Wyoming had produced 7.6 Tcf of natural gas and had an estimated 9.8 Tcf in known fields (includes proved reserves, future extensions, revisions, and new-pool discoveries). Production and reserves are between 1 and 2% of the United States totals and are concentrated in Cretaceous sandstones—Cretaceous rocks in stratigraphic traps will dominate future production.

Average annual oil production during the past 20 years has been 139 million bbl. With reasonable economic incentives, future discoveries should permit production at this level to continue to the year 2000.

Average annual gas production during the past 20 years has been 300 Bcf. Development of known gas accumulations and future discoveries should permit an in-