

sequence usually including thin, marine sandstones which form a transition into the overlying limestones. Many of these limestones display remarkable lateral continuity. In the outcrop area of southeastern Missouri and southwestern Illinois, the Aux Vases, Renault, and Yankeetown Formations are primarily clastic units which interfinger with one another and probably make up a single depositional package. The massive sandstones, called the Aux Vases, occur at different horizons within the sequence and interfinger with shales which have been variously assigned to either the Renault or the Aux Vases. Furthermore, the Aux Vases differs from other Chesterian sandstone units in that it does not contain coal beds anywhere, and it displays prominent herringbone-type cross-beds. In some places, the sandstone contains marine fossils. However, the Renault, which is usually considered to be a limestone unit, in many places does not contain limestone, and when marine limestone lenses are present they are highly discontinuous. The Yankeetown is a thin, highly continuous unit that typically contains characteristic cherty sandstones along with sandstones like those found in other Chesterian sandstone units, as well as shales and limestones. Some of these strata also contain marine fossils. Thus, the Aux Vases differs from other major Chesterian sandstone units in showing strong tidal influence and in lacking both coals and rooted zones, but is similar to other Chesterian sands in showing widespread marine influence.

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#### Geologic Structures and Horizontal Stresses—Their Impact on Petroleum and Coal Production in Illinois Basin

Knowledge of subsurface structures and stress is important to the petroleum and mining industries. These factors have a direct impact on reservoir performance and mine roof stability. Local structures and stresses typically cannot be defined by normal exploration drill spacing. Underground mine mapping, however, provides a unique opportunity to measure these local features and to determine how they affect petroleum and coal production.

A geologic mapping program was conducted at Old Ben Coal Company's Mine 27, which operates in the Illinois No. 6 Coal in Franklin County, Illinois. The mine is in an area of "pod-type transitional roof," in which isolated Energy Shale pods are overlain by Anna Shale and Brereton Limestone. Each facies has a distinctive structural and deformational assemblage. Mapping shows that an excessive east-west horizontal stress also exists in the area. The stress and the structural and lithologic discontinuities are the primary cause of roof failure in the mine.

The detailed structure and stress data acquired in the Mine 27 investigation can also be used to model oil and gas reservoirs. The measurements of joint density, fracture orientation, etc. can be integrated with petrophysical and mechanical data to evaluate fracture permeability. Because underground stresses control hydraulic fracture propagation, knowledge of the subsurface stress field can be used to evaluate stimulation techniques. The orientation of hydraulically induced fractures can be approximated if the magnitude and direction of the stresses are known.

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#### Structural Geology of Shawneetown Fault Zone, Southeastern Illinois

Vertical movements of crustal blocks along the narrow east-west-trending Shawneetown fault zone in southeastern Illinois occurred between Early Permian and Late Cretaceous. The main blocks moved vertically and returned to roughly their original positions so that strata now show little relative offset across the fault zone. However, individual faults with displacements up to 3,500 ft (1,070 m) bound narrow slices of steeply tilted or overturned strata resulting in a juxtaposition of Kinderhookian (Lower Mississippian) and Upper Devonian strata with Lower Pennsylvanian strata. The bedrock is intensely fractured, commonly brecciated, and cemented with either silica or calcite. Slickensides and mullion display various orientations within the zone and on individual outcrops. The dominant movement, however, appears to be vertical with no evidence for significant strike-slip movements. Pleistocene deposits do not exhibit offsets across the fault zone, indicating that no tectonic activity has occurred since the beginning of that epoch.

The trend of the fault zone changes abruptly from east-west in south-

ern Gallatin and easternmost Saline Counties to south-southwest in southern Saline and northeastern Pope Counties, where it joins the Fluorspar area fault complex. Here the zone widens and develops a braided pattern as the amount of displacement along individual faults decreases. The Shawneetown fault zone and Fluorspar area fault complex in part are younger than the Cottage Grove fault system to the northwest and the Wabash Valley fault system to the north. The hope of finding structural traps near the junctions of the fault systems has spurred recent oil exploration in the area.

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#### Geology and Petrology of Tertiary Lignites Adjacent to Beartooth Mountain Front, Montana-Wyoming

Along the eastern margin of the Beartooth front a sequence of Laramide conglomerates, sandstones, siltstones, shales, and minor coals are exposed. These minor Paleocene-Eocene coals, ranging from lignite to subbituminous in rank, are the focus of this study.

Four coal exposures were sampled along a north-south strip (17 mi, 27 km), proximal to the Beartooth front. These coals range in thickness from less than a 1-in. (2.5 cm) lens to about 10 ft (3 m) and contain partings of carbonaceous shale, shale, siltstone and sandstone. Two of the seams, designated as Meeteetse Trail and Burgess Lignite occur in typical Fort Union sediments. The Meeteetse Trail locality is less than 0.25 mi (0.4 m) from vertical Madison Limestone with a westerly dip "under" the Madison. The other, the Burgess Lignite locality, is composed of alternating papery fusinitic lignite, siltstones, thin lenses of channel sandstones, carbonaceous shales, and carbonaceous mudstones. The coals here are high in organic matter, fossil stems, leaves, megascopic resins, randomly oriented petrified tree stumps, and gypsiferous deposits.

Two other localities, Gold Creek and Clarks Fork Canyon, are in Paleocene alluvial fan deposits. The Clarks Fork coals are found at the distal end of an alluvial fan system and dip rather gently basinward. The Gold Creek coals are found at the base of a fan interbedded with massive sandstones and conglomerates containing andesitic porphyry clasts up to 1.5 ft (0.4 m) in maximum dimension.

The Fort Union Formation in this area includes lacustrine, paludal, fluvial, and conglomeratic members. There is a wide diversity of megafloora in different sedimentary facies. Petrographic examination reveals well preserved cell structure, especially in the fusinoid macerals. Although the coals have undergone severe alteration and weathering, they still exhibit excellent fluorescence properties.

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#### Petroleum Geology of Macoupin County, Illinois

The Carlinville oil field is located along the upper flexure of a monocline and is not associated with an anticline or domes as previously described. West of the monocline, minor accumulations of petroleum occur in stratigraphic traps in Pennsylvanian sandstones that are organic matter-enriched. The oil is "heavy," may be relatively immature, and may have formed in the sediments in which it occurs. Significant oil shows also occur in oolites of the Ste. Genevieve Formation.

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#### Analysis of Effects of Foam Stimulation Treatment on Upper Freeport Coal Seam in Indiana County, Pennsylvania

A detailed underground mapping survey to determine the impact of foam stimulation treatments on the mining environment was conducted at an underground mine in Indiana County, Pennsylvania. Three vertical boreholes intercepted unmined coal south of active workings. The boreholes were geophysically logged, and cased to the top of the Upper Freeport Seam. Nitrogen-generated foam was injected to fracture the seam, and 20/40 mesh sand was used to prop open the fractures. The