proposed. The proximal cycle consists of coarse pebbly biosparites, commonly showing the characteristics of grain flows, passing up into cross-bedded, fine-grained biosparites, which then are overlain by micrite and calcareous shales. Calcareous shales occur interbedded throughout the cycle. This cycle is interpreted as having been deposited in bypass channels on slopes around the Middle Ordovician islands or shoals. The distal cycle consists of poorly washed biosparite passing up into interbedded micrite and calcareous clay, and is interpreted as being deposited near the base of the slope or in the adjacent basin.

Both types of cycles have hardgrounds on their coarser units, indicating long periods of nondeposition and/or erosion after deposition.

A close analogy can be made, both in microfacies and depositional environment, with the Holocene Arabian shelf of the Persian Gulf. Furthermore, both have similar tectonic situations—carbonate shelves on ancient shields undergoing collision with a magmatic arc.

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Facies and Depositional Environments of Energy Shale Member (Carbondale Formation, Pennsylvanian), Southwestern Jefferson County, Illinois

The Energy Shale directly overlies the Herrin (No. 6) Coal Member in southwestern Jefferson County. Five facies of the Energy are recognized in the study area. The depositional environment is interpreted as a large quiet-water bay into which periodic influxes of coarse-grained sediments from the nearby Walshville channel were deposited as crevasse splays. The bay-fill deposits include a nonmarine and a brackish-marine facies; the latter has higher sulfur and boron contents and a sparse marine fauna. Both bay-fill facies are faintly laminated gray shales, and both grade laterally into and underlie deposits of the distal portion of crevasse splays. The distal splay facies is dominantly siltstone with lenticular bedding. The proximal splay facies grade laterally into and are interbedded with the distal splay deposits, and are divided into a channel facies (characteristically a well-sorted sandstone that contains microcross-bedding, clay drapes, contorted bedding, and a shale clast lag-deposit) and an interchannel facies (characterized by massive and flaser-bedded sandstones). Sulfur and boron content of the proximal and distal splay deposits is considerably less than that of the brackish-marine bay deposits, suggesting a non-marine origin. Energy Shale facies have a direct influence on the sulfur content of the underlying Herrin (No. 6) Coal. In areas where thick (> 20 ft, 6 m) nonmarine bay-fill deposits overlie the coal, the sulfur content of the coal is less than 1%. Where the coal is overlain by thick proximal splay deposits, the sulfur content is 2 to 3%. This increase in sulfur content is attributed to downward percolation of sulfate-rich marine waters of a later transgression through the permeable sandstone. Where the coal is overlain by thin brackish-marine Energy or by the Anna Shale, the sulfur content averages 4 to 5%.

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Inorganic Geochemistry of Illinois Basin Coals

Chemical and mineralogical compositions of more than 100 samples of Illinois basin coals have been examined from an existing data base. Multivariate statistical analysis of the data shows that variation of many trace elements is related to mineral impurities in coal, including pyrite, clay minerals, calcite, sphalerite, and quartz. Organic sulfur, germanium, and boron are associated primarily with organic matter. The high sulfur content in most Illinois basin coal results from seawater permeation immediately following peat deposition. Low-sulfur coal (< 2.5% total sulfur) occurs in restricted areas where the coal is overlain by a thick fluvial gray shale (such as the Energy Shale Member that overlies the Herrin Coal Member). The gray shale, which predates marine transgression, acted as an impermeable barrier that effectively reduced infiltration of seawater into the peat. The interpretation is consistent with sulfur-isotopic data indicating that bacterially reduced sulfate is a principal source of sulfur enrichment. High-sulfur coal is significantly enriched in molybdenum, boron, mercury, uranium, iron, and thallium relative to low-sulfur coal. Seawater is a possible source of the high molybdenum, boron, mercury, and uranium contents in high-sulfur coal. Concentrations of iron and thallium in seawater are very low, suggesting that these two elements were

probably derived from a terrigenous source and transported to the swamp by rivers. Positive correlation between sulfur and all these trace elements in Illinois basin coal indicates that their variations are also related to the postdepositional sedimentary environment.

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Geology of Principal Australia Coals and Coal Basins: A Review

Bituminous or subbituminous coals are known from nearly all parts of Australia. Those of greatest economic importance today are found in the Permian and Triassic Bowen and Galilee basins of Queensland and the Sydney-Bowen basin of New South Wales, with some coalfields of lesser significance in the Clarence-Moreton basin in Queensland and New South Wales. The lesser known fields also include the Permian Collie coalfield and Perth (Permian-Cretaceous) and Canning (Permian-Triassic) basins of Western Australia; the Bonaparte basin (Permian), mostly offshore in the Darwin area of Northern Territory and Western Australia; the shallow Permian coals of the large Arckaringa basin, and the smaller Triassic-Jurassic Leigh Creek basin in South Australia; the Early Cretaceous of the Gippsland basin, Victoria; and the Permian and Triassic coals of the Tasmania basin, particularly the Fingal area. Structural, sedimentary, and paleobiologic features of the coal-bearing strata and regional trends of various coal characteristics of some of the principal economic or geologically interesting basins and coals are reviewed and illustrated. These include the Hail Creek syncline, Goonyella, Peak Downs, German Creek, Blackwater, Baralaba, Tolmeis and Moura Mines of the Bowen basin of Queensland and the unique Blair Athol mine at the far western edge of Bowen basin. In New South Wales these include the Hunter Valley area Singleton Coal Measures represented by the Foyebrook-Liddell Seam and Ravensworth mines; the Newcastle area; the Ulan Seam of the Goulburn Valley area; the western shelf area and Sydney-Wollongong region represented by the Illawarra (Permian) Coal Measures which are overlain by the thick Triassic Narrabeen Series, Hawksbury Sandstone, and Wianamatta Group. A paleobiologic analysis of the thick brown coal sequences in the Yallourn, Latrobe Valley, and Bacchus Marsh areas of Victoria, and the significance of tectonics in the development of these great coal swamps will be reviewed.

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Illinois Mined-Out Coal Areas—Map and Data System

The Illinois State Geological Survey has completed a digitized file of outlines and locations of all known abandoned mines in Illinois (more than 5,500) and a computerized file of mining methods, mining conditions, geological conditions, and historical and geographical data for each mine site. The files were compiled in response to increasing requests for such information from public and private agencies involved in urban planning, coal resource evaluations, and mine subsidence investigations.

The mine outlines were digitized from original mine maps and/or microfilm copies of the maps. ILLIMAP, an Illinois State Geological Survey-designed computer-based mapping system, was modified to manipulate the digitized data. Maps generated by this system show mine outlines, portal locations, and index number assigned to each mine.

The end products of this project will be a comprehensive Illinois coal-mine data file and two sets of mined-out-area maps, one set consisting of overlays for the U.S. Geological Survey topographic map series in the coal areas, the other of county base maps. Mine index numbers on the maps will be used to retrieve information from the coal-mine data file. Overlays will be housed at Illinois Abandoned Mined Land Reclamation Council offices.

DROSTE, J. B., Indiana Univ., Bloomington, IN, and J. B. PATTON, Indiana Geol. Survey, Bloomington, IN

Sauk Sedimentation Patterns in Indiana and Adjacent States

The Sauk Sequence in Indiana and adjacent states is composed of two supergroups in mutual facies relationship, the Potsdam below and the Knox above. The Potsdam Supergroup contains, in ascending order, predominantly siliciclastic rocks that include the Mount Simon Sandstone,

Eau Claire Formation, Galesville Sandstone, Ironston Sandstone, and Franconia Formation. The Davis Formation replaces the latter three where they cannot be differentiated. The age of the Potsdam ranges from pre-Dresbachian through Franconian. The Knox Supergroup consists in ascending order of predominantly carbonate rocks of the Potosi Dolomite, Oneota Dolomite, Shakopee Dolomite, and Everton Dolomite. The age of the Knox rocks ranges from Franconian through Whiteckian.

Cambrian sedimentation in pre-Dresbachian time is poorly known and may be restricted to fault-block basins. Terrigenous sand and mud were deposited in peritidal and shallow subtidal, predominantly marine, environments in the early Dresbachian. By the late Dresbachian, carbonate sand and mud, including oolite shoals, accumulated in the south, whereas marine terrigenous sand and mud were deposited in the north. In the Franconian, a bi-lobed delta complex, not yet well understood, dominated by terrigenous sand and mud, formed to the north, and the earlier shallow marine environment of carbonate deposition in the south expanded northward, so that by the end of the Franconian, pervasive carbonate deposition was extremely widespread.

The Oneota and Shakopee rocks were deposited in widespread shallow marine environments, and the record of marine sedimentation of Everton rocks is restricted to the southwestern part of the study area. Extensive post-Knox erosion has greatly reduced the original distribution of the Sauk Sequence, and rocks of the Chazy are unconformably juxtaposed with rocks as old as Franconian. The distribution of rocks at the top of the Sauk and the consideration of the internal stratigraphy of the Sauk should influence future decisions for petroleum exploration, underground gas storage, and deep-injection liquid-waste disposal.

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Thickness and Quality of Springfield Coal Member, Gibson County, Indiana, as a Function of Differential Compaction of Precursor Sediments

The Springfield Coal Member is a time transgressive coal that formed during the Pennsylvanian on a delta platform within the slowly subsiding Illinois basin. In Gibson County, Indiana, the locations of the major Galatia channel and the minor Leslie Cemetery channel were determined by differential compaction of precursor sediments beneath this platform.

The Springfield coal is thick proximal to both channels, but proximal to the Galatia channel it is either a low-sulfur or a high-sulfur coal. It is a low-sulfur coal where it is underlain by a thin to moderately thick platform of shale with some sandstone and overlain by nonmarine shale. It is a high-sulfur coal where it is underlain by a thick platform of fluvial sandstone and overlain by brackish to marine rocks. Distal to both channels the coal is thin and high in sulfur. At distal locations the Springfield is underlain by a platform of either thick bay-fill sandstone or fluvial sandstone and overlain by brackish to marine shale and limestone.

Compaction of pre-Springfield delta sediments allowed for accumulation of thicker peat along the axis of more rapid local subsidence. Compaction of muddy parts of the delta platform proximal to the Galatia channel resulted in rapid subsidence and the deposition of nonmarine shale over the peat. In the areas underlain by bay-fill and fluvial sandstone where compaction was less, the peat became a relatively thin and high-sulfur coal.

Differences in coal thickness and quality in this 500 mi² (1,300 km²) area of Gibson County can be explained largely by differential compaction and deltaic sedimentation.

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U.S. Geological Survey Investigations of Mississippi Embayment Area

Prior to about 1974, most of the work in the Mississippi embayment area by members of the U.S. Geological Survey was motivated by interest in the embayment's paleontologic aspects, stratigraphy, and economic resources, especially ground water. However, an excellent description of the effects of the New Madrid earthquake series was published on the centennial of that 1811-12 seismicity.

During World War II, combined efforts of the U.S. Geological Survey and the U.S. Bureau of Mines produced a wealth of information about the Little Rock pluton and the process of laterizing exposed nepheline syenite to form bauxite. That project, in a search for additional intrusive

bodies at shallow depth, sponsored a reconnaissance aeromagnetic survey along the embayment edge from Little Rock, Arkansas, to Cairo, Illinois. Magnetic anomalies that were identified then are now known to be related to the series of buried plutons aligned along the northwestern margin of the upper Mississippi embayment graben. Later investigations assessed the geochemistry of the more mafic parts of the Little Rock pluton.

In 1974, U.S. Geological Survey effort, along with that of other federal agencies, state agencies, and academic institutions, was directed toward finding the cause of ongoing seismicity in the upper embayment and toward assessing the related potential effects on persons and property. Aeromagnetic, gravity, seismic reflection, seismic refraction, stress-field, surface-geologic, subsurface-geologic, geomorphic, and paleontologic investigations were completed, and many of the results have been published.

The purpose of this poster display is to summarize the more significant findings in this area related to (a) the rock sequence, lower crust to surface; (b) the major structural features, including a rift system; (c) the current state of stress; and (d) the present-day seismicity.

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Petrography and Thickness Variations of Brereton Limestone Member (Carbondale Formation, Middle Pennsylvanian)—An Important Roof-Rock in Part of Illinois Basin

The thickness and lithologic character of the Brereton Limestone Member are important factors in determining roof stability in underground mines in the Herrin (No. 6) Coal. Subsurface data from 216 electric logs or drill cores from two areas in the Illinois basin were used to construct isopach maps and fence diagrams of the Brereton Limestone. The Brereton Limestone is absent locally, and ranges from less than 0.1 to 19.5 ft (3 cm to 6 m) in thickness in most of the study area. Petrographic data from 159 thin sections or acetate peels from 48 drill cores permit recognition of 12 rock types in the Brereton: skeletal, foraminiferal, and algal lime mudstones; skeletal, sponge-spicule, and algal wackestones; skeletal and intraclastic packstones; skeletal and intraclastic grainstones; calcareous shale; and calcareous siltstone. All data are from two areas with a sandstone channel dividing them.

Area I shows a general overall thickening of the Brereton toward the sandstone channel but is characterized by mounds of lime mudstone and wackestone, some of which are capped by grainstones, suggesting shoaling. Area II is characterized by a general thickening of the Brereton away from the sandstone channel and generally an inverse relationship between the thickness of the Brereton and the underlying (Energy? and Anna) shales, but has a few carbonate mounds that were shoaling near the end of Brereton deposition. Lime mudstones and wackestones predominate, and some mound tops contain grainstones.

Thickness variations are depositional. Shallow, offshore marine Brereton facies suggest a "bank" depositional model, with irregular and local facies and thickness changes, rather than a "basin" model, with predictable offshore-onshore facies or thickness changes. Detailed petrologic and paleoecological analysis aimed at paleoenvironmental interpretations will probably be necessary to predict local variations in Brereton lithologic character and thickness in many areas.

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Petrology, Paleocology, and Depositional Environments of a Micritic Limestone in Cave Hill Member of Kinkaid Formation (Mississippian, Chesterian), Southern Illinois

The Cave Hill Member of the Kinkaid Formation (Mississippian, Chesterian) contains a skeletal-lime mud buildup that is a thin lenticular unit which crops out in Johnson County in southern Illinois. The skeletal-lime mud buildup is characterized by a series of biofacies which are laterally correlatable throughout the buildup. These biofacies—the sponge spicule biofacies, the crinoid biofacies, the *Composita-Fenestella* biofacies, and the *Composita* biofacies—represent a series of different communities. In addition, a poorly fossiliferous lime mud facies is present. In the two lower biofacies, the sponge spicule and crinoid biofacies, the skeletal constituents are fragmented and abraded owing to bioturbation. The