A thorough understanding of the interrelationship of the geologic history, thermal maturation, and petrographic characteristics of a coal bed is necessary to interpret its present methane content. Coalification of organic matter occurs contemporaneously with burial through the interaction of temperature and pressure during geologic time. In initial stages of coalification, pressure is an important factor in volume, pore, and moisture reduction. In later stages of coalification, temperature and duration of heating are more significant. During this period, methane and other gases are generated as coalification by-products. The degree of coalification, referred to as rank or thermal maturity, is commonly measured by vitrinite reflectance. This value has been used by the Bureau of Mines to determine the rank of Permian and Pennsylvanian coal beds from several boreholes in southwestern Pennsylvania. From these values, estimates of former depths of burial and coalification temperatures may be made. Owing to the discontinuous nature of the Permian coal beds, detailed lithologic correlation of noncoal marker units was necessary to ensure that the coal bed reflectance values were placed in proper stratigraphic sequence. The thermal maturity, as indicated by vitrinite reflectance, was found to relate directly to by-product gas content.

The average vitrinite reflectance gradient of all the bore holes is 0.10%/100 m (320 ft), which corresponds to gradients measured for the Rocky Mountain Foothills of Canada. An estimate of the paleogeothermal gradient for the study area, using the Karweil nomogram to appraise the paleotemperatures of the coal beds, indicates a significantly higher gradient than that proposed earlier. The former maximum depth of burial for these coal beds, based on the estimated paleogeothermal gradient, would be 1.2-1.5 km (0.7-0.9 mi).

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Stratigraphy and Structure of Clinton Section in Wayne County, Ohio

The Clinton section in Wayne County represents a clastic wedge of the Lower Silurian Albian Group. It was deposited on the distal flank of the Appalachian basin as a result of the Taconic orogeny. The section extends vertically from the Queenston unconformity to the base of the Packer shell (Brassfield Limestone). It is primarily composed of sandstone, shale, limestone, and dolostone. Within this stratigraphic section, the sandstone facies is an important hydrocarbon reservoir rock. The sandstone facies pinches out laterally along a north-south depositional limit that is roughly located along the western boundary of Wayne County.

The study relied primarily on geophysical log data. However, drill cuttings were used to correlate lithologies to specific curve assemblages on the geophysical logs. This helped define lithologies to logs in areas where drill cuttings were lacking. Eight cross sections—four north-south and four east-west—show the complexity of the intertonguing clastic and carbonate deposits resulting from the progradation and shifting of deltaic and nearshore marine environments. The cross sections also show that the driller's terms of stray, red (1st), and white (2nd) Clinton sandstone are arbitrary units and are not temporally equivalent or correlative from well to well over great distances.

Stratigraphic interpretations indicate that the deposition of the Clinton section began with a marine transgression from the northwest across a subaerially exposed coastal plain that was deposited as the distal end of the Ordovician Queenston delta. This transgression reworked the upper Queenston sediments and redeposited them as calcareous silts and sands. Renewed uplift of the Taconic highlands caused a clastic influx into the areas and a relative regression of the sea. These sediments were deposited in prodeltaic and lower delta-plain environments. Some of the sediments were reworked offshore by ocean currents and wave action and redeposited as offshore bars. As the influx of Taconic sediment ended, muds were deposited, which were eventually transgressed by a carbonate-rich sea. A limestone unit, the Packer Shell, was then deposited ending the Alexandrian Epoch.

The structural setting is one of homoclinal dip to the southeast, with localized basement-controlled, minor folds normal to the basinal axis. Small-scale faulting can also be seen on structure maps of the base of the Packer Shell and the top of the Queenston. Local structural highs and faults affect oil and gas production in this mainly stratigraphic trap. Local structure commonly segregates the oil and gas in the same reservoir body.

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High Fluid-Inclusion Homogenization Temperatures in Carbonates of Lower Ordovician Beekmantown Group in Northern Appalachian Basin

Data from analysis of fluid inclusions in carbonates of the northern Appalachian basin indicate higher paleotemperatures and greater depths of burial than have been inferred for the rocks of this region.

Preliminary research has revealed fluid homogenization temperatures averaging 96°C (205°F) for the formation of saddle dolomite, 114°C-170°C (237°F-338°F) for calcite vein fillings, and 290°C (554°F) for calcite cements in samples from the Mohawk and Champlain valleys of New York state.

The calcite-filled veins sampled in the Champlain valley of eastern New York display higher average homogenization temperatures than similar veins from the Mohawk valley of central New York. This difference may reflect a higher post-Early Ordovician paleogeothermal gradient operative in eastern New York.

Drusy calcite cements in samples from central New York are interpreted as precipitates from saline brines having temperatures between 267°C (512°F) and 302°C (576°F). These temperatures support conodont alteration data obtained by others for the rocks of this area.

Using a geothermal gradient of 25°C/km (72°F/mi), a former depth of burial in excess of 9 km (5.6 mi) is implied. Seismic and gravity data do not show evidence of the presence of post-Early Ordovician shallow plutons. Therefore, it appears unlikely that precipitation at the high temperatures measured resulted from magma-derived hot meteoric fluids.

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Oriskany Sandstone Lithofacies, Paleoenvironment, and Fracture Porosity in Somerset County, Pennsylvania

The Lower Devonian Oriskany (Ridgeley) Sandstone is an important deep exploration target in the Appalachian basin. In outcrop, the Oriskany is typically a calcareous quartzarenite with few discernible lithologic variations. Petrographic examination of two drill cores of the Oriskany–Needmore Shale interval from south-central Somerset County indicates that identifiable lithofacies of the upper Oriskany Sandstone exist in the subsurface. Oriskany lithofacies are defined as silica-cemented quartzarenite, sandy biosparite, calcareous-cemented quartz wacke, and coquinoid calcareous-cemented quartzarenite. These lithofacies are interpreted as depositional features of a shallow marine sand-bar complex, corresponding to central-bar, bar-margin, interbar, and storm-generated sheet-sand (tempestite) depositional units. Paleoenvironmental interpretations are supported by diagnostic trace-fossil assemblages and coarsening-upward grain size trends indicative of vertically stacked marine bars. Correlation of gamma-ray logs from Oriskany wells across Somerset County suggests that these marine bars are laterally discontinuous and may change abruptly in thickness over relatively short distances. The basinal Needmore Shale overlies the Oriskany in this area, indicating a deepening of the depositional setting after Oriskany deposition.

Although vertically oriented fractures were observed in all the Oriskany lithofacies and Needmore Shale, most of the fractures are healed by secondary calcite. Fracture porosity occurs primarily in the silica-cemented quartzarenite lithofacies, or central-bar paleoenvironmental unit. The quartzarenite lithofacies is recognizable on gamma-ray logs by its blocky, low API unit signature at the top of sequences that exhibit a downward increase in shale content. As the presence of fracture porosity is important in Oriskany natural gas production in this region, central-bar units are primary targets for exploration.

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Geology of Trenton Limestone (Middle Ordovician) of Northwestern Ohio

The Middle Ordovician Trenton Limestone has produced over 350 million bbl of oil and an unestimable amount of gas from reservoirs in northwestern Ohio since the 1880s. Owing to unchecked production methods and inadequate plugging procedures by the early drillers, sufficient reservoir pressures no longer exist in the once prolific Lima-Indiana fields.

In northwestern Ohio, the Trenton was deposited as primary limestone, ranging from mudstone to grainstone. However, most early production came from dolomitized zones within the upper part of the formation. Many past workers have attributed this dolomitization to an unconformity at the top of the Trenton. Current work indicates the dolomitization to be secondary, possibly caused by solution and precipitation by mobile, concentrated brines. Dolomitization is not restricted to the upper portion of the formation. In many wells, a thick limestone section caps porous dolomitized hydrocarbon zones. Along or near fractures or faults, it is not uncommon for the entire Trenton-Black River sequence to consist of dolomite. Much of the current exploration within the Trenton is being focused on locating such fractures.

In the northwest corner of the state, the Trenton is overlain by the gray Utica Shale. To the south and east, the Trenton is overlain by brown to black, highly calcareous shales commonly referred to as the Cynthiana formation. These two shales provide the seal for most Trenton reservoirs and are the probable source rock for the hydrocarbons.

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Subsurface Stratigraphy and Depositional Environment of Ravencliff Sandstone (Upper Mississippian) in Southern West Virginia

This study, a stratigraphic subsurface analysis of the Ravencliff sandstone, attempted to determine the depositional environments, depositional history, and paleogeography of the interval. Gas production was compared to thickness, position on sand trends, shale content, porosity, and structural position to determine the effect that these have on the Ravencliff gas production.

The study area includes 1,037 mi^2 (2,686 km^2) from the subsurface of southern West Virginia counties of McDowell, Wyoming, and Mercer.

The interval studied is a member of the Hinton Formation of the Mauch Chunk Group. This Ravencliff interval is bounded below by the Avis Limestone, a marine unit, and bounded above by a black, carbonaceous shale. Thickness of the interval ranges from 150 ft (45 m) in northwestern Wyoming County to 450 ft (137 m) in southeastern Mercer County.

Petrographically, the Ravencliff sandstone is a clean white sandstone showing well-rounded grains and pebbles and commonly containing more than 90% quartz. Examination of three cores from the area reveals an orthoquartzitic sandstone with conglomeratic and pebbly zones throughout. Unidirectional, high-angle cross-bedding was prevalent throughout all of the cores.

Twenty-three cross sections were constructed and show multiple stacked sandstones up to 150 ft (45 m) thick. Lithofacies, isopach, and isolith maps of the interval and individual sandstones reveal a series of northeast-southwest sandstone trends.

The Ravencliff interval is interpreted to represent a regressive phase of deposition from the marine Avis Limestone to the fluvial-deltaic environment of the Ravencliff sandstones. Source areas for the Ravencliff system are believed to be northeast of the study area.

The first phase of the Ravencliff fluvial-deltaic system was the erosion and subsequent filling of a major northeast-trending valley. Tributary systems perpendicular to this valley became incised in the underlying Avis Limestone and provided feeder systems into this major upper deltaic-plain valley.

Subsequent to the filling of the major valley, the Ravencliff system went through periodic avulsions in an aggradational lower deltaic-plain environment. These fluvial-deltaic systems, in some areas, accumulated over 120 ft (37 m) of recognizable channel sandstone.

Gas production appears to be controlled by a variety of factors, including sandstone thickness, shale content, and diagenetic loss of primary porosity.

ERRATA

AAPG Bulletin (September 1984), v. 68, no. 9, p. 1221, first column. Abstract, "Metallic Sulfide Deposits in Winnfield Salt Dome Louisiana . . . ," by Mark R. Ulrich, should include the additional authors, J. Richard Kyle and Peter E. Price.

AAPG Bulletin (June 1984), v. 68, no. 6, p. 704-712, "Flexure of Lithosphere Beneath Apennine and Carpathian Foredeep Basins: Evidence for an Insufficient Topographic Load," by L. Royden and G. D. Karner. From the authors:

The vertical force (F) given in Figures 4B, 5B, and 6B should be increased by a factor of two to 2.6×10^{15}, 4.0×10^{15}, and 3.0×10^{15} dyne/cm, respectively. The curves shown in Figures 4, 5, and 6 remain unchanged. The numbers given in the discussion (p. 711) should be changed accordingly, so that the force applied at the plate ends is equivalent to the negative buoyancy force generated by a slab with cross-section area of 4,000 km^2 (1,540 mi^2), 2,600 km^2 (1,000 mi^2), and 3,000 km^2 (1,160 mi^2) (second paragraph of discussion). This implies that the vertical force applied at the slab end is about 100 to 400% of the topographic load, and about 10% of the total load. Otherwise, the results and discussion remain unchanged. This does not change any of the basic results of this paper, and, if anything, strengthens the arguments made that a subsurface load plays a major role in the formation and maintenance of the Apennine and Carpathian foreland basins.