Jurassic Sea-Level Changes From Seismic Stratigraphy

Two areas from the northern North Sea, the inner Moray Firth and the north Viking graben, contain sequences defined by seismic stratigraphic techniques which are indicative of Jurassic fluctuations in sea level. The seismic sequences involve Upper Triassic, Jurassic, and Lower Cretaceous strata. Ten sequences have been identified and their geologic ages are: (1) Rhaetian-Hettangian (198-189 Ma); (2) Sinemurian–early Pliensbachian (189-182 Ma); (3) late Pliensbachian-Toarcian (182-174 Ma); (4) Aalenian-Bajocian (174-165 Ma); (5) Bathonian (165-156 Ma); (6) Callovian (156-149 Ma); (7) Oxfordian-Kimmeridgian (149-141 Ma); (8) Tithonian–early Berriasian (141-133 Ma); (9) late Berriasian (133-131 Ma); and (10) Valanginian (131-126 Ma).

High stands of sea level are represented by the Rhaetian-Hettangian, Bathonian, Oxfordian-Kimmeridgian, and Tithonian–lower Berriasian sequences. Distinctive low stands are indicated by the lower Sinemurian, lower Callovian, upper Berriasian, and Valanginian sequences. The remaining sequences are defined by sea-level fluctuations of intermediate magnitude.

The sea-level fluctuations observed in the North Sea have been partly modified by structural activity. Their chronostratigraphic positioning, however, is thought to be caused by sea-level changes on a global scale. Charts of relative changes of sea level generated for the inner Moray Firth and the north Viking graben in the North Sea compare closely with similar charts from northwest Africa, the Gulf of Mexico, and other areas.

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Characterization of Regularly Interstratified Chlorite/Smectite Mixed-Layered Clay Using Combined Scanning Electron Microscopy/X-Ray Diffraction Techniques

Regularly interstratified chlorite/smectite (corrensite) is rarely found in hydrocarbon-bearing reservoir rocks as a dominant constituent of the clay mineral suite. However, several sandstone core samples, when subject to X-ray diffraction (XRD) analysis, were found to contain 46-100% of this mixed-layered clay mineral. The samples containing 100% corrensite permitted characterization of crystal morphology and mode of occurrence by use of scanning electron microscopy (SEM).

Corrensite was identified by XRD analysis because its characteristic basal reflections as the mixed-layered clay mineral responded to glycolation and heating treatment. This mineral consists of a 14A chlorite in a 1:1 relation with a 15A expandable smectite layer, yielding a total thickness of 29A. Glycolation expands the swelling smectite layer to 32.7A (001), 16.0A (002), 7.97A (003), and 5.91A (004).

The identification of corrensite as the dominant clay mineral of this reservoir rock is significant in that it has permitted: (1) characterization of the crystal morphology of this mixed-layered clay mineral by SEM; (2) the definition of a part of the pore-lining clays in a sandstone reservoir rock as water-sensitive due to the expandable smectite layers; (3) identification of chlorite within this mixed-layered clay so that proper completion fluids could be added to chelate the iron released if hydrocloric acid was used to stimulate the formation; and (4) differentiation of this type of corrensite from chlorite-swelling chlorite and chlorite-vermiculite, and other mixed-layered minerals to insure proper reservoir exploitation.

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Evolution and Stress History of Low-Permeability Upper Cretaceous Gas Reservoirs, Rocky Mountains

The physical properties of the Mesaverde gas reservoirs in Wyoming, Utah, Colorado, and New Mexico are the result of stress-induced changes that modified the sediment's original properties. Consideration of the stress history aids in interpretation of well log data and in understanding the reservoir performance that is controlled by natural or artificial fractures.

The poorly sorted and discontinuous reservoir sands were formed in a shifting nearshore environment in a region of nascent tectonic compression. Rapid sedimentation induced compaction and diagenesis, and later Tertiary burial continued compression and promoted some thermal stress. Laramide wrench-faulting could cause early shear fractures; a later uplift-reburial-uplift sequence, together with episodes of extensional tectonics, could promote tensional fracturing and a re-orientation of fractures and other structures in the well-indurated sediments.

Reservoir style is a result of several aspects of basin history, e.g., the depth of Tertiary burial in the Green River versus the San Juan basin. The regions considered are now generally inactive seismically, and there has been very little igenous activity since Cretaceous time, as contrasted to most nearby areas in the Rocky Mountains.

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Applied Petrophysics—Case History

Although the term "petrophysics" was defined by G. E. Archie in 1949, application of petrophysical approaches and techniques to exploration projects has been minimal during the past 30 years. This paper documents the application of varied petrophysical techniques to a field study and illustrates the integration of data to form a detailed interpretation of the reservoir.

Cut Bank field is a giant oil and gas field located on the west flank of the Sweetgrass arch in north-central Montana. Production is from the Lower Cretaceous Cut Bank Sandstone, which was deposited in a braided fluvial system.

Porosity versus permeability cross-plots of core data indicate a wide range of different rock types within the Cut Bank Sandstone interval. Capillary pressure curves, X-ray diffraction analyses, scanning electron micrographs, and thin section evaluation further define the rock types and document pore geometry differences. An Sw versus height-above-sea-level plot indicates field-wide pressure communication with a common water-oil contact. These data explain downdip shows and water production, poor oil production within the field, and gas production updip.

Integration of all information indicates that (1) Cut Bank field is a continuous reservoir which displays the classical updip progression of water to oil to gas, (2) local rock type variation accounts for the varying quality of production within the field; and (3) there is a common oil-water contact on the downdip edge of the field and its position is controlled by rock type differences.

Drilling subsequent to this study has confirmed the interpretation reported here.

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Seelyville Coal—Major Unexploited Seam in Illinois

New mapping has revealed that a major minable coal seam, the Seelyville Coal Member of the Spoon Formation, underlies a large area of eastern Illinois. Although the Seelyville coal has been actively mined in adjacent parts of Indiana for many years, and although its presence in Illinois has been known for some time, its extent in Illinois has not been determined. This study, which principally used geophysical logs from oil test holes, shows that the Seelyville Coal may be 4 to 8 ft (1.2 to 2.4 m) thick under an area of about 1,200 sq mi (3,120 sq km) of Clark, Crawford, Edgar, Lawrence, Cumberland, and Jasper Counties. In-place coal resources are estimated to be more than 7 billion tons. Much of this coalfield borders on the Wabash River, a potential locality for coal-conversion plants. The Seelyville coal has seldom been tested by coal exploration companies, and large blocks of the coalfield are believed to be unleased.

The Seelyville coal lies about 200 ft (61 m) below the Springfield (No. 5) Coal Member of the Carbondale Formation and ranges in depth from 300 to 1,500 ft (91 to 457 m) in the area studied. The Seelyville generally has one or more shale partings that range in thickness from a few inches to more than a foot. The number and thickness of partings are difficult to determine with available geophysical logs, thereby making coal resource estimates somewhat uncertain. The coal commonly has a siltstone or sandstone roof; in some areas cutouts in the coal are numerous. Core data are needed to confirm coal thickness and to evaluate the water content and stability of the sandstone and the quality of the coal. The Seelyville coal has significant resource potential and warrants the attention of coal exploration companies.

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Tabular Uranium Ore in Poison Canyon Area, Morrison Formation, San Juan Basin, and Application of Lacustrine-Humate Model

Surface ore trends in the Poison Canyon sandstone (of economic usage) coincide with a distinct facies in the underlying "K" shale. Uranium mineralization of the sandstone occurs only where the unit is underlain by an offshore-lacustrine, gray, pyritic mudstone facies of the "K" shale. Where the "K" grades laterally into a nearshore-lacustrine red mudstone facies, the overlying Poison Canyon sandstone is unmineralized.

These relations suggest that the lacustrine-humate model may account for the origin of tabular ore in the Grants Mineral Belt. The basic premise of the model is that humate in tabular sandstone ore deposits originated as soluble humic substances in the pore fluids of nearby offshore-lacustrine gray mudstones.

Gray mudstones deposited in reducing, alkaline conditions are considered potentially favorable humate "source rocks" because reducing conditions favor preservation of humic matter in the pore water of lake-bottom sediments and because alkaline conditions favor solubilization of these humic substances so they can be expelled with the pore fluids during compaction. In the "K" shale in the Poison Canyon area early diagenetic reducing conditions are indicated by the presence of pyrite and the dark gray color. Alkaline conditions resulted from alteration of volcanic ash incorporated in the muds; the pore water pH rose sufficiently high to strip the muds of the humic matter and move it, during compaction, into the overlying Poison Canyon sandstone where it was fixed as a humate deposit. Subsequently, uranium delivered by groundwater was fixed by the humate to form the tabular ore deposit.

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Sedimentology of Westwater Canyon Member, Morrison Formation, Southern San Juan Basin

Outcrop measurements taken from trough cross-beds throughout the Westwater Canyon Member indicate that two separate fluvial complexes, each with its own distinct current direction, compose the member along the southern San Juan Basin. Lower Westwater streams flowed east-northeast at all points between Gallup and Laguna, whereas upper Westwater streams flowed consistently southeast over the same area. Measurements in the overlying Poison Canyon sandstone (of economic usage) suggest a return to northeast-flowing streams. Mine maps from the Ambrosia Lake area confirm these current directions in the subsurface.

These data preclude the existence of a single fan emanating from the southwest, as proposed by previous workers. The upper Westwater had a source to the northwest which not only changes the overall picture of Westwater deposition but also raises significant questions about uranium mineralization and basin geometry during Morrison time.

In many surface sections the lower and upper Westwater sandstones merge as a result of scouring by upper Westwater streams. In the subsurface these areas might appear as "sand thicks" on an isopach map. Elsewhere on the surface, the Westwater contains numerous "shale breaks." Regardless of the number of shale breaks or total sandstone thickness, the type of deposition (braided) and the current directions (northeast-lower, southeast-upper) remain the same. This suggests that use of isopachs in the subsurface to determine stream type and current direction is invalid. Areas of greatest sandstone thickness in the mineral belt most likely reflect thicken-