

FOOS, ANNABELLE, Univ. Texas at Dallas, Richardson, TX

Geochemistry, Mineralogy, and Petrography of "Hooker" Ironstone Unit, Middle Ordovician Shellmound Formation, Northeast Georgia

The "Hooker" ironstone poses a unique opportunity for the study of the origin of oolitic ironstones in general because both unaltered chamosite facies and altered hematite facies, along with the transitional facies, are preserved in one unit. This unit is composed of the following three facies: (1) a gray chamosite mudstone containing chamosite ooids, (2) a brown chamosite mudstone containing altered chamosite ooids, and (3) a carbonate-cemented hematitic grainstone containing hematite ooids. The vertical association of these facies suggests that the hematitic grainstone is an alteration product of the gray chamosite mudstone and that the brown chamosite mudstone represents the transition zone between the two.

The mineral assemblage in the gray chamosite mudstone (chamosite, pyrite, and ankerite) suggests that the chamosite ooids formed by early diagenesis in the zone of sulfate reduction below the sediment water interface. The gray chamositic mudstone grades upward into the brown chamositic mudstone. The minerals of this facies (chamosite, pyrite, and hematite) represent a disequilibrium assemblage. The altered ooids are composed of fine-grained mixtures of chamosite and hematite. The brown chamosite mudstone resulted from the partial oxidation of the gray chamosite mudstone due to exposure to the aerobic zone of active bioturbation. There is a sharp boundary between the brown chamositic mudstone and the hematite grainstone. The ooids and interclast in the hematitic grainstone were derived from the subaqueous erosion of the brown chamositic mudstone. Exposure of altered chamosite ooids to oxygen-rich marine water would accelerate the oxidation of the ooids producing hematite ooids.

FOSTER, W. R., and H. C. CUSTARD, Mobil Research and Development Corp., Dallas, TX

Role of Clay Composition on Extent of Illite/Smectite Diagenesis

Evidence has been presented from the northern Gulf of Mexico which suggests that, over periods of several million years, the smectite-illite transition is largely controlled by temperature. Although kinetics obviously control rates over shorter intervals of time, the progression from smectite to illite with depth can be viewed largely as a succession of equilibrium states provided source and hence composition have been relatively constant. The abruptness of the transition zone over which this reaction occurs is proportional to the product of reaction enthalpy and geothermal gradient. Arrhenius plots of the log of the equilibrium coefficient versus reciprocal of the absolute temperature yield reaction enthalpies ranging from 26,000 cal/mole along the south Texas coast to as low as 1,800 cal/mole in the Mississippi Delta. It has been found that clays with high reaction enthalpies are typically montmorillonites, derived from volcanic ash, with lattice substitution principally in the octahedral layers. However, low enthalpy smectites found farther east are derived from the Mississippi River provenance and are beidellites with predominant tetrahedral substitution and hence more mica-like in structure.

FOUCH, THOMAS D., U.S. Geol. Survey, Denver, CO

Lacustrine Siliciclastic Rocks and Hydrocarbons

Siliciclastic rocks formed from sediments deposited in lake basins are source and reservoir units for large accumulations of oil and gas in North and South America, Africa, and Asia. Lacustrine strata of China consist primarily of siliciclastic units; those of Brazil, Angola, and Cabinda are principally of siliciclastic rocks with abundant carbonate beds; those of the United States consist of at least 50% carbonate rock.

The sediments were deposited in, or peripheral to, ancient stratified lakes of a variety of ages, which for millions of years maintained a size comparable to that of modern inland seas. In siliciclastic fine-grained beds formed at the depositional center of these large lakes, values of organic carbon commonly average 3% or less. Those sequences of carbonate strata developed in open-lacustrine depositional settings commonly contain greater than 25% organic carbon. However, porosity values are generally very low in reservoir beds associated with the carbonate source rocks (generally cemented with carbonate minerals) relative to those associated with claystone source rocks.

The world's largest lacustrine oil and gas fields are developed in depositional systems with very thick sequences of open-lacustrine clay mudstone that contain relatively low values (generally 3% or less) of organic carbon. In these fields, hydrocarbons migrated from a thick central core of claystone into peripheral and overlying lacustrine and alluvial sandstones at relatively shallow burial depths and prior to significant compaction and cementation of the beds.

Siliciclastic rocks form the principal reservoir units in most of the world's ancient petroliferous lacustrine depositional systems. Lacustrine turbidite, bar, and deltaic sandstones are important reservoir units in Brazil, Africa, China, and the United States. Although nonmarine reservoir rocks are commonly described as being of a lacustrine origin, many were formed from sediment deposited at the edge of the lake or in settings well removed from the lake. A principal reservoir facies in the Uinta basin, Utah, is composed of siliciclastic beds that developed as the basal parts of coalesced fluvial channels at the fluctuating margin of Paleocene and Eocene Lake Uinta. Oil-bearing strata in some Chinese basins are channel-fill sandstones formed from sediment deposited in moderately sinuous streams on an alluvial plain several kilometers from the lacustrine shoreline.

Depositional models of siliciclastic lacustrine rocks constructed to aid in the exploration and exploitation of indigenous hydrocarbon accumulations should be sensitive to type, richness, and thermochemical maturation of organic matter developed and preserved in the lake. Because siliciclastic open-lacustrine beds in many of the large petroliferous lake basins commonly contain relatively small amount of organic matter, thick sequences of such strata may be required to generate large accumulations of oil. Known accumulations are largest where migration has been to porous and permeable beds at relatively shallow burial depths.

FRANKIE, KATHLEEN ADAMS, and JAMES C. HOWER, Univ. Kentucky, Lexington, KY

Comparisons of Pyrite Variability From Selected Western Kentucky and Western Pennsylvania Coals

Pyrite (and marcasite) variation in the lower Kittanning coal of western Pennsylvania has been petrographically characterized using three parameters of size (categories rather than absolute size), morphology (framboidal, euhedral, dendritic, massive, and cleat), and microlithotype (organic) association. The samples analyzed consisted of 12 whole-channel samples from four surface mines. Six channels were collected to represent suspected marine environments of deposition, while the other six represent

freshwater deposition.

The purpose of this study is to evaluate what influence paleoenvironments have on the nature of variation of pyrite in coal. To further the scope of this evaluation, the lower Kittanning samples were also compared to previously studied coals from the predominantly marine environments of western Kentucky.

Comparison of coals has been done using the percentages of pyrite in the microlithotypes vitrite and clarite. In the lower Kittanning coal, framboidal pyrite is generally less abundant and dendritic pyrite was not observed at all. Euhedral pyrite exhibited no clear variation between the two environments. Massive pyrite was more abundant in the set of samples from the mine with the highest average pyritic sulfur but otherwise exhibited no variation. In contrast, a larger percentage of pyrite in the western Kentucky coals examined is framboidal and dendritic. Mines examined in the Moorman syncline of western Kentucky do have a framboidal pyrite percentage comparable to the lower Kittanning samples, but the percentage of dendritic pyrite (particularly in the Western Kentucky No. 9 coal) is significantly higher for the western Kentucky coals.

Bulk petrography of the coals is similar with all having greater than 80% total vitrinite. The association of the pyritic sulfur does, however, change significantly between the various coals studied and particularly between the coals of western Kentucky and among the "marine" lower Kittanning samples and the "fresh water" lower Kittanning samples. Among the pyrite in the "fresh water" coals, massive (perhaps epigenetic) pyrite dominates the associations. In summary, the study of form and association of iron sulfides has the potential to give more information about variations in coal depositional environments than simply the study of bulk petrologic or bulk sulfur variations.

FRANKS, STEPHEN G., ARCO Oil and Gas Co., Dallas, TX

Future Trends in Sandstone Diagenesis

Discovery of highly porous and permeable sandstones at great depths and temperatures has clearly demonstrated that porosity reduction with depth is not monotonic. Recognition that porosity can be created in sandstones at depth has spurred tremendous interest in developing predictive models of porosity evolution and distribution in sedimentary basins. Instead of predicting economic basement, emphasis has shifted to prediction of porosity "windows" in the subsurface.

Historically, diagenesis has been considered a function of sandstone composition and temperature. However, it has become increasingly clear that this view is too simplistic. Factors such as pore fluid composition, flow rate, organic maturation, and time may significantly alter the course of diagenesis. Development of predictive models that provide for these parameters will, when coupled with structural-stratigraphic and hydrocarbon generation models, permit the relative timing of porosity evolution, hydrocarbon generation, and trap formation to be determined.

In order to simulate the diagenetic evolution of basins and predict porosity distribution, the processes that lead to creation and destruction of porosity must be understood. Many of the important porosity-producing processes have been identified through petrologic studies: dissolution of carbonates, feldspars, and rock fragments. Formation of deep porosity in a variety of basins is commonly associated with precipitation of kaolinite and iron-rich carbonate, suggesting that, although the paths of diagenesis may be diverse, common trends exist. Development of predictive diagenetic models will require continued accumulation of petrologic data and case studies more fully using presently available technology (e.g., electron and ion microprobe, stable isotope

geochemistry, age-dating techniques). This will better document the time, temperature, and chemical environment of formation of diagenetic materials.

Areas of research requiring attention are the following. (1) Fluid flow and heat transfer in sedimentary basins. What are the volumes of fluid, rates of flow and flow paths? How do these change as a basin evolves? (2) Geochemistry of subsurface fluids. Reliable analyses are required to identify compositional trends of subsurface fluids. What controls the pH of subsurface fluids? These questions will require further research on shale diagenesis, fluid diagenesis, fluid expulsion, and clay membrane filtration. (3) Diagenesis of organic matter in sediments. Recent studies have shown that by-products of petroleum generation (e.g., CO₂, H₂S, organic acids) may be an important factor in sandstone diagenesis. (4) Computer models simulating the chemical consequences of rock-fluid interaction are restricted by the lack of reliable thermodynamic data for many common diagenetic minerals (e.g., clays, zeolites). We need additional information concerning rates of dissolution and precipitation of common minerals under various conditions. (5) Physical compaction of sandstones. (6) Relationship between depositional environment and subsequent diagenetic events.

Because porosity prediction requires an understanding of many related disciplines, an integrated approach is required. By combining the talents and expertise of petrologists, organic and inorganic geochemists, fluid mechanicians, and structural geologists, not only will we be able to develop powerful models for porosity prediction, but we will also be better able to place porosity development in its proper context as one aspect of basin evolution and hydrocarbon accumulation.

FRANZ, U. A., Mobil Exploration and Producing Services, Inc., Dallas, TX, and A. R. DALY and S. W. BROWN, Brown and Ruth Laboratories, Inc., Houston, TX

Organic Facies of Some Mesozoic Source Rocks on Alaskan North Slope

Geochemical screening (TOC and Rock-Eval pyrolysis) of picked cuttings of Mesozoic age from seven wells located between Prudhoe Bay and the Colville delta distinguished three types of organic facies and one subtype. Identification of the organic facies was based on the organic content of the sediments and their position in a modified van Krevelen diagram. This paper demonstrates relationships between organic facies of the sediments and their inferred depositional environment.

The organic matter type and quantity serve to separate the Mesozoic stratigraphy into five intervals: (a) Shublik Formation; (b) basal Kingak Shale; (c) upper Kingak Shale; (d) Pebble Shale/Hot Zone; and (e) Torok/Seabee Formations. The hydrocarbon-generating potential and predicted hydrocarbon products differ considerably and are controlled by the sedimentary environment of each interval.

The Shublik Formation in the study area was deposited on a carbonate platform with a deep basin lying to the south. High organic-carbon content and relatively high hydrogen content of the Shublik can be explained by preservation of marine organic matter in anoxic lagoons or local depressions.

Deposition of the basal Kingak Shale and of the Pebble Shale/Hot Zone is the result of major transgressions during the Jurassic and the Neocomian, respectively. Both intervals were deposited as bottomsets of prograding sequences (prodelta) and contain high quantities of relatively hydrogen-rich organic matter. Their organic facies are the result of distal sedimentation coupled with high organic productivity and moderate to good preservation. The Fishbone Shale, deposited elsewhere in an environment simi-