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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.

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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.

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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.

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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