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Brines, Clay Minerals, and Equilibria: Predicting Diagenetic History and Reservoir Quality in Oligocene Frio Formation of Texas

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Effect of Bulk Composition on Clay Mineralogy: Examples from Jurassic Sandstones of North Sea

ABSTRACTS

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Clay Mineral Identification by Remote Sensing

In the past three years there have been major advancements in our ability to identify clay minerals by remote sensing. Two different technologies have been used—imaging broad-band multispectral scanners and non-imaging narrow-band radiometers and spectrometers.

Multispectral scanners, including NASA's Thematic Mapper Simulator (analog for Landsat-D Thematic Mapper) have had several broad-band channels in the wavelength region of 1.0 to 2.5 μm. In particular, the wavelength region 2.0 to 2.5 μm contains diagnostic spectral-absorption features for most layered silicates. Computer processing of image data obtained with these scanners has allowed the identification of the presence of clay minerals, without, however, being able to identify specific mineralogies. Studies of areas with known hydrocarbon deposits and porphyry copper deposits have demonstrated the value of this information for rock-type discrimination and recognition of hydrothermal alteration zones.

Non-imaging, narrow-band radiometers and spectrometers have been used in the field, from aircraft, and from space to identify individual mineralogical constituents. This can be done because of diagnostic spectral absorption features in the 2.0 to 2.5 μm region characteristic of different clay types. The Shuttle Multispectral Infrared Radiometer (SMIRR), flown on the second flight of the space shuttle Columbia in 1981, had 10 narrow-band channels specifically chosen to evaluate the ability to identify directly clay minerals and carbonates. Preliminary analysis of SMIRR data over Egypt showed that kaolinite, carbonate rocks, and possibly montmorillonite, could be identified directly.

Plans are currently under way for development of narrow-band imaging systems which will be capable of producing maps showing the surface distribution of individual clay types. This will represent a major step in remote sensing, by allowing unique identification of minerals rather than the current ability only to discriminate among materials. Applications of this technology will provide geologists with a powerful new tool for resource exploration and general geologic mapping problems.

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K/Ar Dating of Illitic Clay in Sandstone Reservoirs and Timing of Petroleum Migration

Illite and illite/smectite, which occur as authigenic pore-fill in some sandstones, are excellent argon-retentive clocks. Dating their mean time of growth in conjunction with other basin information may add to predictive understanding of illitic cement distribution. Paragenesis and distribution of authigenic clay in the sandstone body with respect to hydrocarbon occurrence may allow the measured age to be related to time of hydrocarbon emplacement. For certain petroleum-source shales, the mean age of illite/smectite burial metamorphism, and thus petroleum maturation, can be measured directly and then compared to the age of clay authigenesis in reservoir sandstones to see if the two phenomena are related.

Three sandstones have been examined: the Cretaceous Muddy on the eastern flank of the Powder River basin; the Jurassic Nugget of the Wyoming Overthrust belt; and the Permian Rotliegendes of northern Europe. For the regressive poorly sorted Muddy, logistic problems arise because of the low abundance of authigenic illite/smectite compared to kaolinite and the common occurrence of old detrital illite. The age of illite/smectite authigenesis thus is asymptotically derived from analyses of a series of progressively finer (and authigenically purer) clay size fractions down to $<0.05\mu$. Over a broad region, this derived age is about 40 m.y., excluding Bell Creek which is anomalous. This age may associate illite/smectite growth in the reservoir with the early Tertiary deep burial of the basin interior. Because similar ages occur in both oil and water zones, illite/smectite growth may either have preceded or accompanied oil emplacement.

Logistic problems are minimized for the abundant, high-K_2O, discrete illite cements of the well-sorted aeolian Nugget and Rotliegendes. For both of these, precise sets of ages have been obtained for individual fields in both water and hydrocarbon zones, implying cementation may have been a relatively short-lived "event." The Nugget samples, all from the Absaroka sheet, give late Mesozoic ages. In the Rotliegendes, complex block faulting has led to unique post-late Jurassic burial and gas generation histories for adjacent fault blocks. However, thus far the three areas of the Rotliegendes examined indicate illite growth largely preceded this history.

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Silica and Metal Release During Clay Mineral Diagenesis and Shale Overpressuring

Mud sidewall cores from the northwest Gulf of Mexico, extending down to the upper portion of the overpressured zone (OPZ), were examined mineralogically (XRD) and chemically. The resultant data is limited, but provides some clues on the 17A→ 10A clay transformation and related shale processes.

Squeezed interstitial water concentrations, corrected for temperature effects and evaporative loss during processing, show little deviation from seawater, other than major K and Mg decrease in the upper 3,300 ft (1,000 m). As the upper OPZ dilution is encountered (water release from 17A→ 10A transformation), K, S, and organic C increase markedly relative to C_1.

Increased Na_2CO_3-leachable Si in the upper OPZ suggests that Si released in the 17A→ 10A transformation may reside in part as weakly absorbed material or, as suggested by a broad 5