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Radon and Hydrocarbons in Soil Gases of Northeast Ohio

Radon survey techniques are being used to determine whether significant variations of Rn^{222} content occur in soil gases of northeastern Ohio and, if so, whether they have hydrocarbon prospecting potential. Radon activities are determined by using electronic detectors for short-term variations and film cups for long-term variations.

Preliminary traverses covered more than 300 sites. Three localities were found in which the radon activities are reproducibly higher than regional "background" by a factor of 5 to 10. One case correlates with proximity to the outcrop belt of the uranium-rich Huron Member of Ohio Shale. The others consist of localized anomalies not directly associated with uranium-rich shales. Laboratory experiments of soil samples showed radon in anomalous regions is not produced in situ within the upper 1 to 2 ft (0.3 to 0.6 m) of soil, suggesting a deeper origin for migration of radon to near-surface soil gas.

Occasional localized seeps of natural gas occur in northeastern Ohio. Light hydrocarbons C_1 to C_3 are usually associated with reducing environments causing precipitation of uranium and its products at shallow depths which could conceivably enhance radon activity at the surface. Also, hydrocarbons migrating upward from deeper sources would carry radon to the surface along more permeable and fractured rocks and create a radon anomaly. Light hydrocarbon analyses of shallow soil gases showed greater total hydrocarbon contents and greater C_2/C_1 and C_2/C_3 ratios in areas of higher radon activities. Measurements of hydrocarbons at greater soil depth, coupled with additional radon measurements, are in progress to interpret further the significance of radon-survey data.

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Austin Chalk Exploration

"Do you have such an objective in your own backyard?"

Since the "energy crunch" of the past few years, the incentive for domestic oil has led to exploitation of the Austin Chalk reserves. These areas have long been known, poorly understood, and sporadically utilized.

Exploration, completion, logging, and production techniques for these type reservoirs have been neglected, ignored, and "bad-mouthed" by the oil fraternity in general. Preference has been given to the mechanical log porosity types found high on structure in closure areas. While recognition of the fact that some of the earliest long-lived production (since 1870) has been from synclinal regional structure, the presence of shale or brittle limestone as reservoir rock types has been ignored.

Many young geologists and engineers are not cognizant of the possibility that commercial oil may exist in such traps or that they are worth exploring for. The rocks themselves must be examined for clues to their existence and this is considered old-fashioned and out of date by many.

Three major geologic controls and many man-induced techniques influence successful exploration for Austin Chalk and similar type oil accumulations. These geologic controls include (1) stratigraphic interplay of diverse facies types, (2) source-bed existence and maturation, and (3) tectonism for both maturation and fracture permeability development in potential reservoir rocks. All three of these geologic factors are interrelated and at times almost inseparable in importance.

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Paleomagnetic Methods for Orientation of Borehole Cores, Horizon Cleveland Field, Ochiltree County, Texas

Paleomagnetism provides a powerful tool for initially determining or verifying the compass orientation and top direction of conventional borehole cores from the Mid-Continent region. This is demonstrated by a study of four fully oriented diamond cores of Pennsylvanian fine-grained sandstone and siltstone taken to determine the orientation of a system of vertical fractures thought to control production in the Horizon Cleveland field, Ochiltree County, Texas. Although fractures in one of the cores were aligned 50 to 60° counterclockwise from the fractures in the other cores, suggesting the presence of two fracture directions in the field, paleomagnetic data show clearly that the core with anomalous fracture directions was improperly oriented and only one major system of vertical fractures exists. After "cleaning" by partial alternating field demagnetization, the mean directions of remanent magnetization for cores having consistent fracture orientations agree within $\pm 6°$ with the expected direction of orientation, based on the known average Pennsylvanian pole position for the North American craton, which confirms the correct orientation of these cores. The mean direction of remanent magnetization for the anomalous core, however, deviates about 60° counterclockwise from the expected direction proving that the core is misoriented.

Progressive partial alternating field and thermal demagnetization studies isolate and remove from nearly all the samples a strong magnetic component oriented vertically downward that partially overprints the original remanent magnetization direction. This overprint, resulting from a vertical magnetic field produced by the drill pipe and core barrel, was used to determine that several samples had been inadvertently placed in the core box upside down.

Paleomagnetic core orientation techniques should be generally applicable in the Mid-Continent and other regions with relatively uncomplicated geologic structure located on crustal plates for which paleomagnetic polar wandering curves are well established.

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Depositional Environment and Reservoir Morphology of Canyon Sandstones, Central Midland Basin, Texas

Canyon sandstones in the Midland basin were originally thought to be part of the Canyon Group, but are actually downdip equivalents of fluvial and deltaic sandstones in the Cisco and Wolfcamp Groups. The repetitive, ordered sequence of sedimentary structures and the texture and composition of these basinal sandstones indicate that they are deposited by turbidity currents.

Canyon sandstones were deposited as constructive turbidite channels. Bedset associations and reservoir morphology of constructive turbidite channels exhibit changes from upper-fan channels at Jameson field to middle-fan channels at Rock Pen field and to distal-fan channels and interchannel areas at Burnt Rock field. The upper-fan channels at Jameson field are commonly more than 50 ft (15 m) thick and consist of incomplete "AE" bedsets up to 6 ft (2 m) thick. The middle-fan channel at Rock Pen field averages 30 ft (9 m) thick, but displays similar incomplete "AE" sequences up to 3 ft (1 m) thick. Distal channels are thinner, have limited lateral extent compared to upper- and middle-fan channels, and consist of better developed Bouma sequences. Few sequences exceed thicknesses of 1 ft (0.3 m) in distal channels.

Canyon sandstones are low-permeability reservoirs, with mean porosity and permeability of 10% and 0.2 md, respectively. Isoporosity and isopermeability maps indicate that porosity and permeability are greatest in turbidite channels and decrease laterally. Interchannel sandstones have limited lateral extent and make poor reservoirs.

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Prediction of Oil or Gas Potential by Near-Surface Geochemistry

Recent development in surface geochemical prospecting have enabled this age-old seep-detection technology to be used to determine the gas versus oil character of a potential fairway. Extensive field work has demonstrated that the chemical compositions exhibited by near-surface hydrocarbon soil gases are strongly coupled to the chemical compositions known to exist in the nearby underlying reservoirs. By using the compositions and ratios of the light hydrocarbons (methane, ethane, propane, and butane), it is possible to predict whether oil or gas is more likely to be discovered in the prospect area. Histograms which represent average soil gas compositions are observed to be strongly correlative with reservoir gas analysis histograms and with compositions from gas shows recorded in downhole mud logging. This correspondence with the actual formation gases suggests that the upward migration of reservoired light hydrocarbons into near-surface soils represents a viable mechanism, allowing surface geochemical exploration techniques to be utilized for regional hydrocarbon evaluations.

Geochemical investigations indicate that seep magnitudes depend on tectonic activity to aid migration along the fault and fracture avenues which appear to provide the major migration pathways. This fault association suggests the diffusion process to be of secondary importance. Geochemical prospecting must be used with caution, and only in conjunction with geologic and geophysical tools, because the location and shape of geochemical anomalies are commonly governed more by the local tectonic structure of the region rather than by the actual physical shape of the deposit. Thus geochemical prospecting, when used alone, cannot predict whether or not a particular soil gas anomaly is associated with a commercial deposit. It can only be used to verify the existence of petroleum hydrocarbons and to predict whether a potential structure is likely to contain gas or oil. Geochemical prospecting yields excellent regional evaluations of hydrocarbon potential.

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Geologic Interpretation Based on Dipmeter Data—Field Study

The Lambert Granite Wash field was discovered in Oldham County, Texas, in 1979. With the exception of the discovery well, every well in the field was logged with a 4-arm high-resolution dipmeter, and the log data were processed by computer. The data interpretation identified the paleoenvironment of the field and determined the source of the granite wash and how it was transported.

Log data indicated that a subsea distributary-channel system transported the detrital granite, and that the deposition was influenced by the remnants of a small Precambrian ridge. The channels were diverted around the ridge until it was eventually buried. The deposition continued, from the west, until the source of granite was depleted.

Through analysis of the dipmeter data, the Bravo dome was identified as the source of the granite, and it was determined that the channel system was located on the north side of the dome in Oldham County.

During Late Pennsylvanian time, a horst formed in the area as a result of basin subsidence. Log data indicate this horst is a suitable structure for the accumulation of hydrocarbons and has overlying shale which forms a stratigraphic trap.

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Carbonate Cementation of Gulf Coast Barrier-Island Sands and Formation of a Stratigraphic Trap

Field investigations in the area of Grand Isle, Louisiana, indicate the presence of active carbonate precipitation. Modern shoreline facies are being cemented by high-magnesium calcite, ranging from 10 to 50 mole % magnesium carbonate. Cementation occurs between the beach and marsh environments as surface crusts or laminae. The environment is characterized by seasonal high temperature (up to 50°C), high salinity (40 to 90° /₀₀), supratidal stromatolites and organic decomposition.

After burial, lithified crusts undergo chemical alteration, as indicated by a decrease in magnesium carbonate content (20 to 35 mole %). The cement eventually undergoes dissolution and reprecipitation, forming a well-cemented sandstone. Rip-up clasts of these sandstones are found along Gulf Coast beaches where a transgressive sequence occurs. These clasts are typically cemented by high-magnesium calcite with 10 to 15 mole % magnesium carbonate. Carbon isotope analyses of rip-up clasts indicate that dissolution and reprecipitation processes are methane-derived due to organic decomposition.

Buried crusts may be preserved in the subsurface and form an effective barrier to fluid migration. Where cementation is extensive, porosity is occluded on the marsh-side of the barrier-island sequence. Cement distribution is, therefore, a primary controlling agent of hydrocarbon migration and subsequent entrapment. Migration of hydrocarbons from organic-rich marsh sediments would be prevented by the early formation of the permeability barrier. Cementation, then, would account for accumulation of hydrocarbons on the marsh side of the barrier-island sequence and the formation of a stratigraphic (or "diagenetic") trap.

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Principles of Dipmeter Interpretation in Fluvial Systems

Identification of fluvial reservoirs has become increasingly more important in exploration. Stratigraphic information provided by dipmeter data is useful in defining the fluvial facies and reservoir morphology.

Field studies utilizing dipmeter data indicate that the middle Bartlesville sandstones in southeast Kansas and northeast Oklahoma are fluvial in origin and are composed of point-bar and longitudinal-bar facies. Dipmeter patterns within composite bedsets of each facies display a decrease in dip upward. This pattern indicates an upward decrease in the scale of sedimentary structures from cross-laminated to ripple-