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Lineament Analysis for Oil and Gas Exploration and Production in Wyoming

Lineament analysis from satellite and aerial photos is being used successfully in exploration for anticlinal oil and gas traps and to select drilling locations for maximum porosity in tight formations. Meticulous mapping of lineaments on a series of overlays by a specially trained team of interpreters commonly reveals complex, conjugate nets of lineaments. Many of the lineaments are interpreted as strike-slip faults and shears on which relative movement can usually be ascertained by the direction in which cross faults are dragged. A lineament pattern resulting from drag is the Nu pattern which resembles the lower case Greek letter ν. Overlapping Nu patterns are characteristic of anticlines. As a refinement to models relating anticlines to intersections of synthetic and antithetic wrench faults, a model containing the Nu pattern indicates the trend and location of the anticline better than existing models. Correlation of Nu patterns with faults in known oil fields indicates that cross-lineaments at tips of Nu patterns tend to be normal faults. Lineament analysis was used to delineate the Overland Dome oil and gas field, Carbon County, Wyoming, and to select each well site. To date, each of the 10 wells drilled into the Niobrara Formation (drilled 1 to 2 mi or 1.6 to 3.2 km apart to outline the 7 mi or 11.3 km long field) has tested at 150 to over 600 bbl of oil per day in contrast to numerous dry holes within the field which were not located by lineament analysis.

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Petroleum Occurrences in Nonmarine Rocks

For many years petroleum was assumed to be largely of marine origin. However, it is now clear that significant amounts of petroleum of nonmarine origin are present in the Rocky Mountains, Europe, Africa, China, and elsewhere.

Petroleum in the Green River Formation (Eocene) is indigenous to continental beds, whose lacustrine facies were largely responsible for their formation. Green River source rocks were deposited in fresh to brackish water environments in stratified lakes. Large amounts of organic material accumulated over widespread areas in stable, reducing, low-energy settings. Migration distances from source beds to reservoir beds were small. Similar types of nonmarine marginal basins occur in west Africa.

In the southern San Juan basin, oil is trapped in eolian beds of the Entrada Sandstone (Jurassic). Overlying lacustrine limestone and anhydrite of the Jurassic Todilto Formation provide a seal. Oil was formed within the Todilto and migrated into the Entrada.

Eolian sandstone beds commonly are good reservoir beds in other situations. In the Overthrust belt of the Rockies, eolian parts of the Nugget Sandstone (Jurassic) contain large amounts of petroleum that migrated into the sandstone from marine Cretaceous sources. The best reservoirs in the Permian Rotliegendes of the southern North Sea consist of eolian dune sandstone. Exceptional porosities of 30% are found in some intervals that produce gas.

Gas has formed in several early Tertiary fluvial beds of the Rocky Mountain area and migrated short distances into fluvial sandstone reservoirs. Fluvial sandstone sequences also contain oil generated in nonmarine source beds.

The examples of petroleum occurrences in nonmarine rocks given in this program may serve to reawaken the interest of petroleum geologists. Certainly, the petroleum potential of nonmarine beds is large.

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Seismic Modeling of Pennsylvanian Carbonate Mounds in Paradox Basin, Utah

The Aneth oil field in southeastern Utah produces from a Pennsylvanian carbonate mound which forms one of the largest stratigraphic oil traps in the United States. Efforts in the past 20 years to locate this and other carbonate mounds using reflection seismology have been spectacularly unsuccessful in this area.

From very detailed isopach and structural maps made from well control, it was found that these carbonate mounds are characterized by an extremely abrupt thickening of the producing zone and a thinning of the overlying shale. Also, contrary to normal stratigraphic traps, the productive zone is actually less porous than off-mound non-productive carbonate rocks. To determine if these thickness changes would be detectable seismically, one- or two-dimensional seismic models were generated using wavelets of varying frequency content and phase. It was determined from these models that thickness changes which characterize carbonate mounds would be detectable by a decrease in amplitude of reflections from overlying shale owing to the tuning effect. However, this decrease in reflection amplitude was only found for zero-phase wavelets having a bandwidth of 10 to 70 Hz or more.

The significance of these results is that by using seismic amplitudes, we are able to determine the thickness of the shale bed even if the bed is less than 10 ft thick and surrounded immediately above and below by other thin shale beds. Since many, if not most, stratigraphic traps involve changes in bed thickness, these results suggest that with seismic modeling, zero-phase processing, and high resolution techniques many stratigraphic traps could be located with a higher degree of accuracy.

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Phanerozoic Carbonate Diagenesis—A New Model

Observations from petrography, paleontology, and geochemistry indicate the varied carbonate mineralogy of Holocene sediments may not be representative of pre-Carboniferous rocks.

Petrographic examination of Phanerozoic oolites reveals that ooids with calcitic relict textures are characteristic of pre-Carboniferous carbonate rocks, whereas ooids with aragonitic relict textures are dominant in younger rocks. Marine invertebrates that secreted magnesian calcite or aragonite hard parts characterize