At Durkee oil field, a cool anomaly of about 1°C was found to be caused by a reverse drag fold at a depth of about 6,000 ft (1,829 m). Two warm anomalies of about 1°C were found to be the result of two distributary channel sands at 7,000 ft (2,134 m) depth. Another warm anomaly of about 1°C and perpendicular to the channel sands was found to be the result of a fault intersecting the surface.

Where Woodgate fault possessed a scarp, a temperature maximum was found directly on the scarp. Where no scarp was visible, temperature measurements made at 2 m depth were successfully used to trace the fault and some of its associated fractures. The shape of temperature anomalies on and near the fault were found to be related to the pattern of ground-water flow in the area.

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Exploration Applications of Temperatures Recorded on Log Headings: Theory, Data Analysis, and Examples

Using the least accurate of temperature data types, temperature anomalies, "hot spots" believed to be hydrocarbon anomalies have been defined by application of a new analytical technique. To date, the technique has been successful to a significant degree when applied to known fields using only dry hole data and, in some places, only dry hole data for wells drilled prior to field discovery as initial steps toward before-the-fact analysis. Technique testing by the drill remains undone.

The theory accepted herein is that heat flows from the earth's hot interior toward its colder surface in nature's attempt to establish temperature equilibrium. Three facts are accepted: (1) hydrocarbon fluids have very low thermal conductivities (oil about one-fifth that of water and gas about one-fourteenth that of water); (2) equal heat input elevates the temperature of a largely hydrocarbon fluid volume relative to a laterally equivalent volume of largely water-filled porosity; and (3) there are fewer grams of hydrocarbon fluids to warm than water filling an essentially equal porosity volume.

Hydrocarbon fluids insulate more (fact 1) and their temperatures are elevated more easily (facts 2 and 3) than contiguous waters. Hydrocarbon reservoirs whose heat flow effects are not obscured by the anisotropic effects of adjacent water reservoirs, should be potentially definable temperature anomalies.

The technique formulated involves the following steps: (1) calculation of geothermal gradient values; (2) creation of a geothermal gradient field areally; (3) vector analysis or contouring of created data; and (4) anomaly definition. Technique application to ten fields representative of a range of complexities shows promise for this up-the-odds exploration tool. Results for three examples (Black Lake field, Louisiana; Haverhill field, Kansas; and Salt Creek field, Texas) may demonstrate principal use as a grading method for prospects based initially on classical study.

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Stability of Natural Gas at High Temperatures in Deep Subsurface

The components of natural gas are reactive in the deep subsurface and may not survive under all conditions. The stability of natural gas in reservoirs of various lithologies is studied using a combined theoretical and experimental approach.

A computer program uses real gas data to calculate equilibrium in multicomponent (up to 50), multiphase (up to 30) systems simulating subsurface conditions to 12 km. This program predicts the stability of hydrocarbons in sandstone reservoirs by first considering clean sands and then sequentially adding feldspars and clays, carbonate cements, and iron oxides. All equilibrium compositions have been computed for low, average, and high geothermal gradients; hydrostatic and lithostatic pressures; and with and without graphite. Graphite is present when deep gases are generated by the cracking of oil but is absent in reservoirs originally filled with dry gas. Similar calculations have also been made for limestone and dolomite reservoirs with various combinations of clays, iron minerals, anhydrite, and sulfur, again with and without graphite. Natural gas shows considerable stability in sandstone reservoirs under most conditions, but its concentration in deep carbonates is more variable and tends to a hydrogen sulfide-carbon dioxide mixture except when an appreciable concentration of iron is present. Hydrogen is present at the 1 to 2 percent level for most lithologies.

A multicolumn gas chromatograph is used to analyze inorganic and organic gases released by crushing rock samples in a Teflon ball-mill. Samples from deep wells in the Anadarko basin and southern Louisiana have been analyzed and the gas compositions compared with those predicted from the computer program.

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Subsurface Temperatures, Sacramento Valley, California: Guide to F-Zone (Forbes) Gas Accumulations

A complicated hydrodynamic system exists in the Sacramento Valley. Abnormally high fluid potentials are present regionally owing to regional tectonic forces as shown by previous studies. Certain parts of the Colusa basin in the Sacramento Valley have significant near-vertical fractures which permit the rapid ascent of deep waters under channel-flow conditions, and thus with a minimum loss of fluid potentials. The traps for the erratic F-zone (Forbes) gas accumulations are critically dependent, both laterally and vertically, upon the existence of these high fluid potentials as barriers to gas migration.

Advective water transport occurs along these near-vertical fractures under nearly isothermal conditions. The magnitude of the thermal anomalies caused by this transport is so large that the fracture-high potential features can be detected with conventional maximum temperature readings from well logs despite the considerable error in such values. Well log temperature data are much more readily available than accurate subsurface pressure data. Thus, practical exploration for these elusive gas accumulations is facilitated greatly through mapping the subsurface temperature regimes.

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Geotemperatures of North Sea Basins: Implications to Exploration

The petroliferous North Sea basin is classified as an intracontinental failed-rift basin and should as such exhibit "normal to high geothermal gradients," if relating to the world average of 25°C/km.

An updated, regional, present-day geothermal gradient map