Geothermal Gradients in the Deep-Water Gulf of Mexico and their Relationship to Overpressure: Garden Banks, Green Canyon, Keathley Canyon, and Walker Ridge

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Abstract

The continental crust to oceanic crust boundary (COB) runs through the study area consisting of the four Gulf of Mexico protraction areas of Garden Banks, Green Canyon, Keathley Canyon, and Walker Ridge. Early work done by Sclater et al. in 1980 determined there is no detectable difference between the thermal structure of an equilibrium ocean and that of an aged continent. The inference for this study is that there is no measurable difference in the heat flow coming from either side of the boundary; and therefore the computation of geothermal gradients will be the same for all area wells. Bottom-hole temperatures for 147 wells were converted first into geothermal gradients and then to the depths at which the temperature would reach 300ºF (149ºC) in the borehole. A contour map of this depth to 300°F shows a strong correlation to the contour map for sediment thickness between the seafloor and depth to magnetic basement, implying that the heat flux reaching the seafloor is strongly correlated to sediment thickness. The presence of vertical salt underneath the Sigsbee Escarpment also contributes to the relative heat flow. The relative amounts of overpressure contributed by disequilibrium compaction, smectite to illite transformation (shale diagenesis), hydrocarbon generation, and sandstone diagenesis are compared. There is a statistically reliable linear relationship between temperature and pressure within the study area. Direct comparison between temperatures and pressures calculated for 318 data points along the boreholes of 130 wells shows the

regression R2 factor of 0.7807. Low temperatures (≤ 140ºF or 60ºC) and pressures (≤ 17,400 PSI or 120 MPa) in Zone 1 define the realm of mechanical compaction. For the study area, these overpressures are due to disequilibrium compaction. The next level of overpressure (Zone 2) is caused by hydrocarbon generation with a temperature range approximately 140º-212ºF (or 60º-100ºC) and a pressure range 10,000 to 17,400 PSI (or 70-120 MPa). Zone 3 wells exhibit overpressure caused by shale diagenesis and it occurs within the temperature range 212º-302ºF (or 100º-150ºC) and within the pressure range of 11,600-26,000 PSI (or 80-185 MPa). Zone 4 wells are rare in that they evidence the hard overpressure due to sandstone diagenesis that can commence at 248ºF (120ºC) and generate pressures close to 29,000 PSI (200 MPa). The primary factor in determining which types of overpressure dominate is the geothermal gradient.