GEOCHEMICAL ANALYSIS OF THE SULFUR-RICH LOWER EAGLE FORD ACROSS A NATURAL THERMAL MATURITY TRANSECT

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Thermal maturity and organic matter type are critical properties that determine the relative abundance of gas versus liquid hydrocarbons that a given source rock will generate. In addition to its economic importance, thermal maturity is a critical parameter in evaluating biomarker results for paleoenvironmental and geobiology studies. Biomarkers may be present or absent due to thermal maturation effects rather than primary depositional environmental factors. Likewise, thermal maturity is also a valuable guide for determining whether an observed biomarker or suite of biomarkers should be present in a sample or may owe its occurrence to migration or contamination. Many thermal maturity indices were developed for marine source rocks with type-II kerogen, so their behavior in sulfur-rich source rocks with type-IIS kerogen (atomic S_{org}/C > 0.04) requires further investigation.

Here, we present geochemical analyses across a natural thermal maturity transect of the Cenomanian strata of the Eagle Ford Group (lower Eagle Ford) to evaluate thermal maturity parameters of sulfur-rich source rocks. This comprehensive evaluation includes 1) total organic carbon, programmed pyrolysis, X-ray diffraction, infrared spectroscopy, major/trace elemental analysis, and vitrinite reflectance on whole and extracted rock samples; 2) elemental analysis, infrared spectroscopy, and δ^{13}C of isolated kerogens; and 3) gas chromatography triple quadrupole mass spectrometry biomarker analysis of extracted organic matter. The focus of this presentation will be on the biomarker results and their integration with the other data types.

Despite the geographic sample spread (~100 miles), inorganic data show that the samples contain similar mineralogy and trace element composition, thereby minimizing potential lithology effects on thermal maturity parameters. The atomic H/C ratios and programmed pyrolysis results, including hydrogen index and T_{max}, show that the samples range from pre-oil through the dry-gas generation windows. The kerogen S_{org}/C ratio ranges from 0.00 to 0.04. However, the biomarker thermal maturity parameters, programmed pyrolysis data, and atomic H/C ratios together with the kerogen S_{org}/C ratios show that the immature samples host both type-IIS and sulfur-rich type-II kerogen (atomic S_{org}/C: 0.032 to 0.045) while the samples with lower S_{org}/C ratios (atomic S_{org}/C < 0.03) are more mature. Based
on the crossplot relationships between thermal maturity parameters (biomarkers, programmed pyrolysis, and atomic H/C), dibenzothiophene/(dibenzothiophene+phenanthrene) ratios, and $S_{org}/C$ ratios, the more mature samples host matured type-IIS or sulfur-rich type II kerogens that had higher initial organic sulfur contents prior to maturation. Some previously established thermal maturity biomarker ratios track the sample range of thermal maturity remarkably well (e.g., $C_{21+22}$ monoaromatic steroids/total monoaromatic steroids), while other biomarker thermal maturity parameters display weaker relationships with thermal maturity ($C_{31}$ $17\alpha$, $21\beta$ $22S/(22S+R)$). Potential new biomarker relationships with thermal maturity are also evaluated.