**Geochemistry of Eagle Ford Source Rocks and Oils from the First Shot Field Area, Texas**

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Since the drilling of the STS-241 #1H discovery well by Petrohawk in the fall of 2008 in what would become the Hawkville field in LaSalle County, Texas, there has been considerable interest in the Eagle Ford Shale by the oil and gas industry. Despite this increased interest in the Eagle Ford by the energy industry, few geochemical studies emphasizing subsurface Eagle Ford rock data have been published, and there are even fewer published Eagle Ford oil data. This study not only includes both Eagle Ford oil and subsurface rock data, it also integrates these two types of data to provide information on oil sourcing, generation, and migration. As such, although the study area is limited, this study provides an example of the types of information that can be obtained in shale oil plays when geochemical oil and rock data are combined.

The core and cuttings samples from the First Shot field area, Texas analyzed for this geochemical study are from the lower Eagle Ford. Regionally, the lower Eagle Ford contains marine transgressive and condensed intervals deposited during a second order, Late Cretaceous (Cenomanian to Turonian) transgression and highstand of eustatic sea level. Analyses performed on the Eagle Ford rock samples include total organic carbon (TOC), Rock-Eval pyrolysis, and vitrinite reflectance. Selected Eagle Ford rock samples were also submitted for solvent extraction followed by liquid chromatography separation and analysis of the saturate fractions by C15+ gas chromatography and GCMS/MS (biomarkers). In addition to the source rock samples, 13 Eagle Ford oils from this same area were also analyzed for this study. Analyses performed on the oils were weight percent sulfur, API gravity, liquid chromatography separation, and C15+ gas chromatography and GCMS/MS on the saturate fractions.

The results and interpretation of these geochemical analyses demonstrate the Eagle Ford source rocks have sufficient quantity, quality, and maturity of organic matter to have generated oil. Specifically, the average present-day TOC, S2, hydrogen index (HI), and Tmax values are 1.84 weight percent, 4.53 mg hydrocarbons/g rock, 246 mg hydrocarbons/g TOC, and 444$^{o}$C, respectively. However, the thermal maturity of the Eagle Ford source rock samples varies considerably in the study area from early oil window in the Bell Sample #1 well to peak oil generation in the Estrada et al. #1 well to late oil window in the Robinson-Troell #1 well. These variations in thermal maturity have had a significant impact on the TOC and Rock-Eval pyrolysis parameters. In particular, these source rock parameters have all been reduced by oil generation and expulsion.

A pseudo-van Krevelen diagram of hydrogen index versus oxygen index (HI versus OI) indicates the First Shot Eagle Ford source rocks contain marine Type II oil-prone kerogen. Furthermore, gas chromatography and biomarker parameters for the oils and source rock extracts indicate this kerogen was probably deposited under anoxic depositional conditions (average pristane/phytane of 0.7), and that the source rock lithologies are comprised of both shales (C29/C30 hopane of 0.5) and marls (C29/C30 hopane of 0.8). In addition, % sulfur contents for the oils range up to 2.6%, demonstrating the kerogen generating these oils was enriched in sulfur. As a consequence of the elevated sulfur contents in the First Shot Eagle Ford kerogen, oil generation in the study area probably began earlier in time at lower thermal maturity levels than are characteristic of more typical Type II kerogens. Elemental analysis to determine $S_{org}/C$ is needed to more precisely determine both the source rock kerogen type and the kinetics for hydrocarbon generation modeling.

Comparison and correlation of genetic molecular parameters for both the oils and source rock extracts shows the oils were likely generated from mixtures of oils from both the Eagle Ford shale and marl facies within the study area. Furthermore, beyond having similar genetic parameters, the oils and source rock extracts from equivalent depths in the same wells also exhibit similar molecular maturity parameters. S1/TOC ratios were used to determine that the source rock extracts are indigenous bitumens rather than migrated oils. Based on the similarity of both the molecular genetic and maturity parameters, the oils are interpreted to have been generated locally rather than having undergone long distance migration. Finally, cross plots of gas chromatography (pristane/C17 and phytane/C18) and biomarker (Ts, Tm, C29Ts, and C29Tm) molecular maturity parameters for the oils have linear regression lines with $R^2$ values of 0.8032 and 0.9871, respectively. These positive correlations demonstrate that: 1) the Eagle Ford oils in the study area were sourced from the same or similar source rocks, and 2) the oils represent a thermal maturity series in which the lower maturity oils with lower gravity and higher sulfur values were generated in the early oil window while the higher gravity and lower sulfur oils were generated when these same/similar source facies were in the late oil window. To summarize, thermal maturity has had a pronounced effect not only on the source rock parameters for the First Shot Eagle Ford source rock samples but also on the physical properties of the 13 locally-sourced Eagle Ford oils. The results and interpretations from this study may have important implications for defining and high grading potentially productive Eagle Ford fairways.