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Single or Multiple Sources for Oils in Western Kansas: An Oil-Oil Correlation Study

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Overview

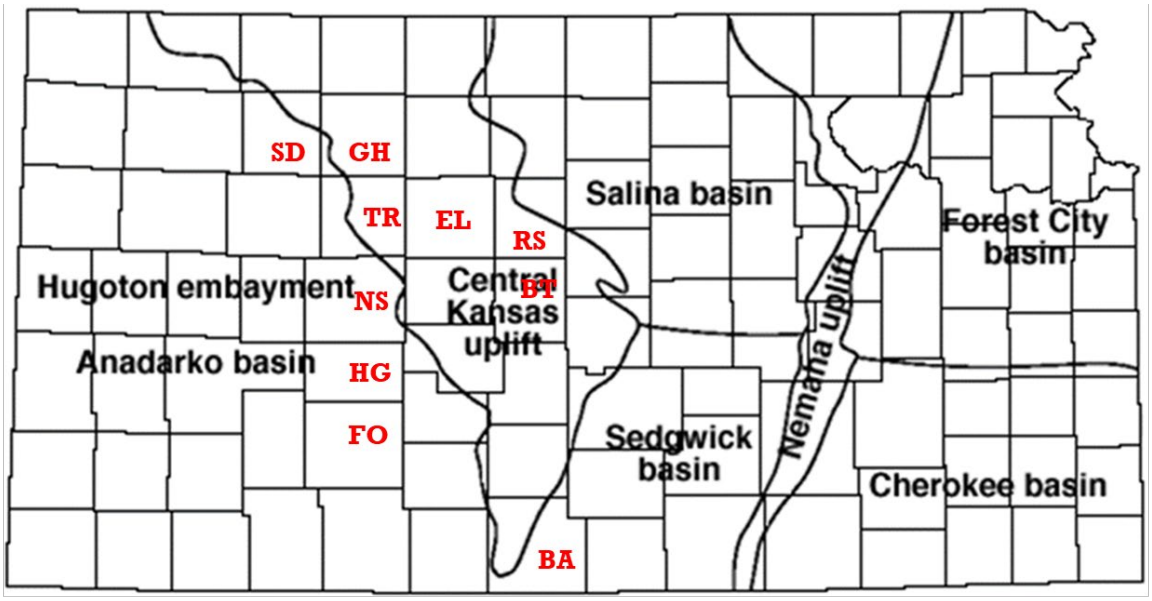
Majority of the oil produced in the State of Kansas come from Western Kansas. However, viable source rocks that could have yielded the oil being produced are absent within the boundaries of the State. It is also not understood if the oil being produced from widely spaced geographically locations in Western Kansas are from a single or multiple source rock. Twelves oil samples produced from five different stratigraphic intervals (Cambrian/Ordovician, Mississippian, and Pennsylvanian) from ten counties in Western Kansas were collected and analyzed using laboratory gas chromatography (GC) and gas chromatography-mass spectrometry (GCMS). API gravity and hydrocarbon fraction distributions in all the samples exhibited similarities and illustrated very low biodegradation. Biomarker compositions, distributions, and ratios indicate marine environment sourced organic matter under reducing conditions for all the oils. It is inferred that oils were all generated from the same source rock.

Introduction

Western Kansas accounts for more than 70 % of the total oil production from the state of Kansas. Oil is produced from limestone and sandstone reservoir rocks that ranged in age from Cambrian to Pennsylvanian. The key elements of the petroleum system producing these oils are still not fully understood. While viable elements such as seal, reservoir and overburden rocks are identified and well characterized, the source rock for the oils has not been conclusively defined. It is also not known if the oils were generated from a single or multiple source-rocks. This work seeks to determine if the oils from different stratigraphic units and Counties in Western Kansa are genetically related.

Methods

Twelve oil samples from 10 Counties and five stratigraphic intervals (Lansing-Kansas City (LK), Marmaton (MT), Mississippian (MS), Cherokee (CH) and Arbuckle (AR)) in Western Kansas were collected and analyzed in this work (Fig. 1). The samples were analyzed using thermal desorption gas chromatography (GC) to determine API gravity, distributions of C1 to C40, and to identify and quantify pristane and phytane. The whole oil samples were fractionated and analyzed using gas chromatography-mass spectrometry (GCMS) to identify and quantify aliphatic and aromatic biomarkers. The trace elements composition of samples were also determined using Wavelength Dispersive X-ray (XRF) technique with a Bruker S8 Tiger Spectrometer. Results were analyzed using biomarkers proxies for source inputs and depositional environments (Peter et al., 2005). Hierarchical cluster analysis (HCA) and principal component analysis (PCA) (Peters, et al., 2013; Wang et al., 2018).



Barber (BA), Barton (BT), Ellis (EL), Ford (FO), Graham (GH), Hodgemen (HG), Ness (NS), Russell (RS), Sheridan (SH), Trego (TR)

Figure 1. Map of the State of Kansas illustrating distribution of sedimentary basins and counties from which samples were analyzed in this study.

Results

The GC results showed the ^{0}API gravity of the samples ranged from 29^{0} API to 35^{0} API indicating all of them to be medium oils. The pristane (Pr) to phytane (Ph) ratio of the samples showed 0.86 + 0.19 which indicated anoxic environment of deposition for the source rock that generated the oils. Cross-plot of Pr/n-C17 and Ph/n-C18 of the samples (Fig. 2) show marine environment sourced organic matter deposited under reducing conditions for all the oils. The analyzed samples showed relative amounts (%) of C_{29}, C_{28} and C_{29} to be 34.85 ± 3.61, 19.34 ± 2. 38 and 45.81 ± 5.72, respectively. A ternary plot of %C_{27}, %C_{28} and %C_{29} regular steranes (Fig. 3) showed mainly marine sourced organic matter for all the samples. The sample from the Mississippian stratigraphic interval in Ford County (FO-MS) however plotted away from all other samples in the ternary plot. A principal component analysis (PCA) plot for six biomarker parameters of Ts/Ts+Tm, Pr/Ph, Gammacerane/C_{30}, %C_{27}, %C_{28} and %C_{29} together with ^{o}API, and the elemental composition of S and P show one principal component to be responsible for all the variance in the dataset. This can be interpreted to suggest that the oils were all generated from the same source rock. A hierarchical cluster analysis (HCA) of the same parameters used for the PCA plot demonstrated two group of oils (Fig. 4). The 11 samples clustering together in the ternary plot belonged to Group 1, while the lone FO-MS sample belonged to Group 2.

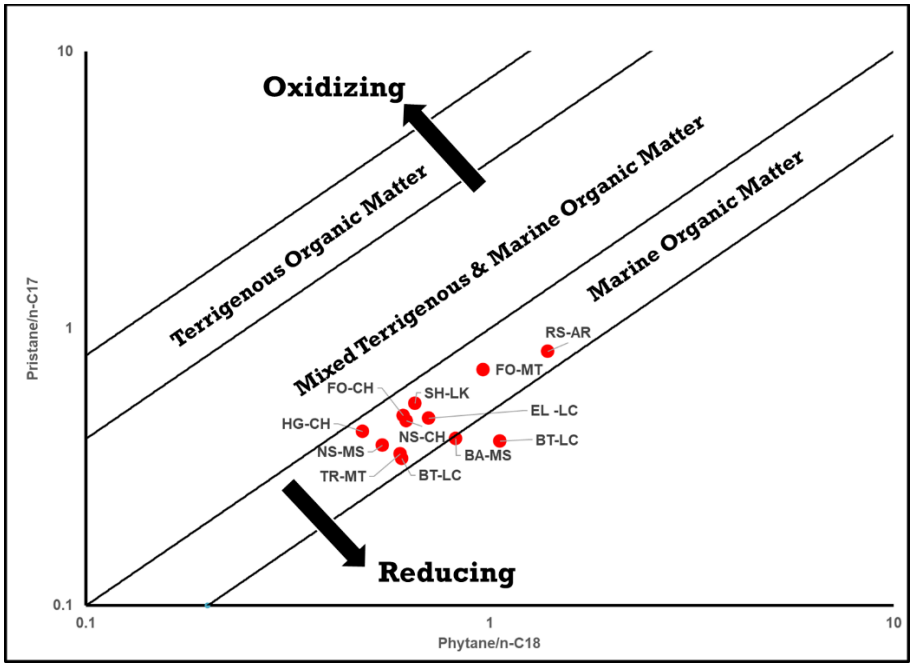


Figure 2: Cross plot of Pristane/n-C_{17} and Phytane/n-C_{18} illustrating organic matter source and redox of conditions.

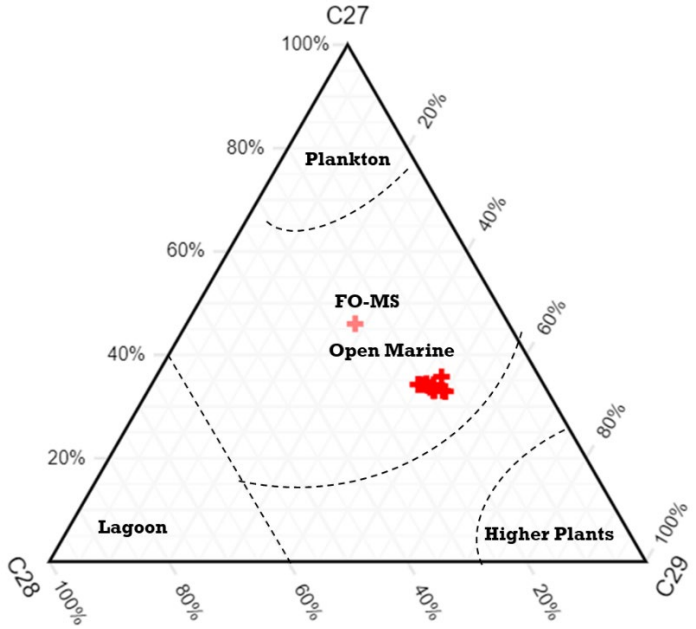


Figure 3: Ternary plot of the relative amount of C_{27}, C_{28}, and C_{29} ααα 20R steranes illustrating 11 samples clustering together indicating a mixed aquatic and terrestrial organic matter with a single sample (FO-MS) from the Mississippian Stratigraphic unit in Ford County (FO-MS) showing a more aquatic organic matter input.

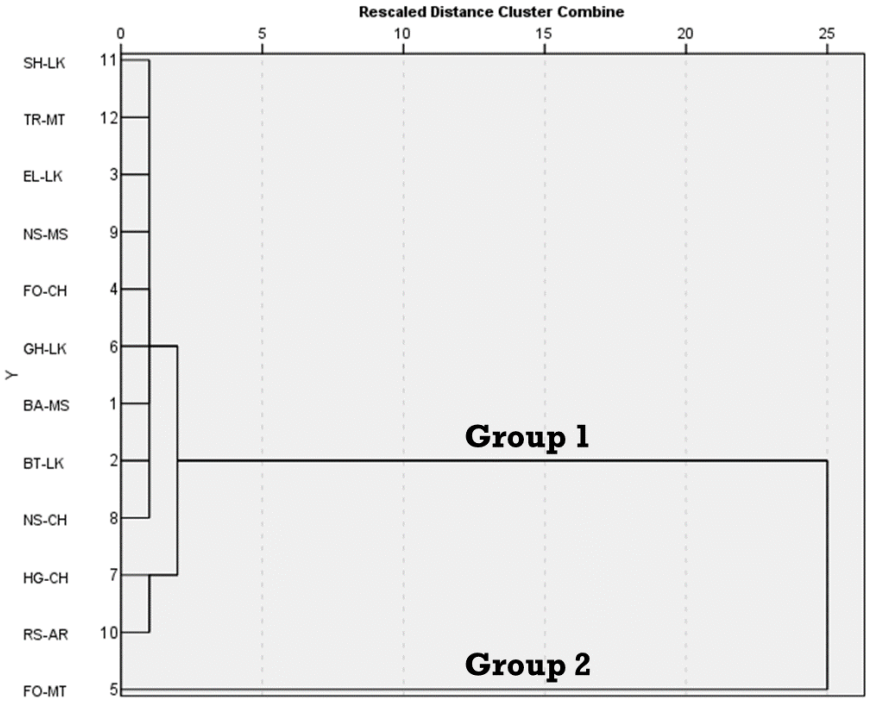


Figure 4: Hierarchical Cluster Analysis dendrogram demonstrating 11 samples belonging to group I with a single sample (FO-MT) belonging to group 2.

Conclusions

Twelve whole oil samples obtained from fiver different stratigraphic intervals and 10 different counties in Western Kansas were analyzed to investigate genetic relationships. Pristine to phytane ratio showed the oils to have been generated by marine sourced organic matter under reducing conditions. Ternary plot of the C_{27}, C_{28} and C_{29} distributions obtained from GCMS analysis also showed the samples to have been sourced from open marine organic matter. PCA of biomarker ratios and elemental distributions of S and P, as well as ^{0}API gravity showed the variances in the dataset of the samples to be due to one principal component. It is therefore concluded that the analyzed oils from Western Kansas were generated from a single source rock.

Acknowledgements

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