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Tracing the Origins of Crude Oil in the San Joaquin Basin and Coastal California

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If you find a tar ball on the beach or crude oil from a seep or exploration well, how do you determine its origin? Biomarkers are molecular fossils from once-living organisms in crude oil and extracts of petroleum source rock (Peters et al., 2005). Biomarkers, isotopes, and other geochemical tools can be used to trace the origin of petroleum and establish the genetic links between crude oils and their source rocks.

Geochemical analysis of crude provides hundreds of parameters. Which parameters are important to identify the origin of crude oil? Decision-tree chemometrics (Peters et al., 2007) is a powerful tool for oil-oil and oil-source rock correlation. Chemometrics uses statistics to extract information from multivariate data. A purely statistical approach is unreliable for oil-oil or oil-source rock correlation because crude oil is a quasi-stable mixture that changes composition due to secondary processes, such as biodegradation. However, geochemical expertise can be used to improve the utility of chemometrics.

For example, rather than using all compositional data, 17 source-related biomarker and isotope ratios for 171 samples of crude oil from the San Joaquin Basin were used to create a ‘training set’ based on principal component analysis. A chemometric decision tree based on the training set can be used to classify newly collected samples from the basin (Figure 1). Each tier in the decision tree consists of a layer of unique models. The decision tree assigns confidence limits to each classification. The results for about 200 samples identify three tribes and a total of 14 families of oils, which retain the geochemical imprint of the vertical and lateral organofacies variations in their source rocks (Figure 2):

1.) *Eocene* Tumey and Kreyenhagen formations (4 families)
2.) *Miocene* Monterey Formation (North depocenter, 8 families)
3.) *Miocene* Monterey Formation (South depocenter, 2 families)

The *Eocene* oil families originated in one depocenter from basal Kreyenhagen and overlying Tumey source-rock organofacies. The *Miocene* families originated from Upper and Lower Monterey source-rock organofacies in two depocenters. Both the *Eocene* and *Miocene* families show little cross-stratigraphic migration due to internal seals within the source rocks as evidenced in outcrops at Chico Martinez Creek and elsewhere in the basin.

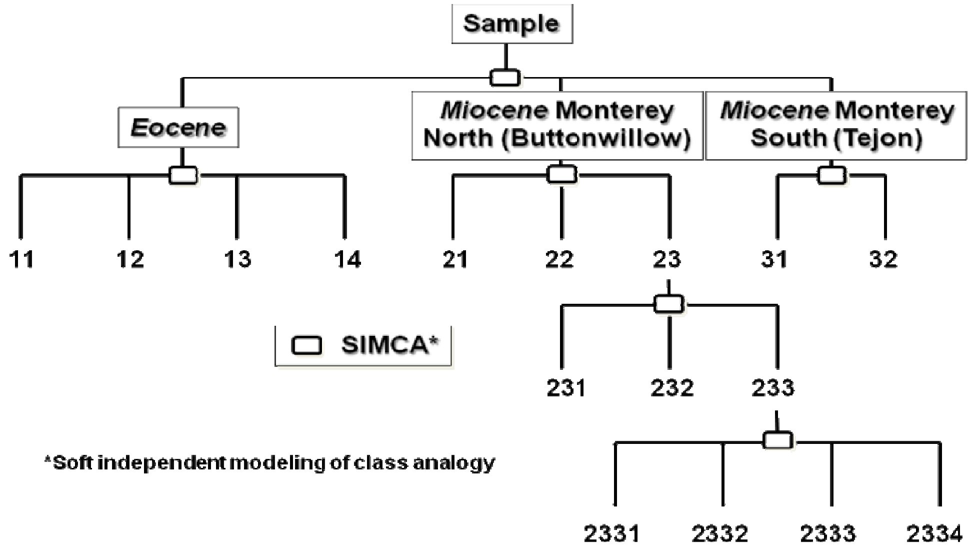

Figure 1. Chemometric decision tree constructed using geochemical data for 171 training set oil samples identifies three tribes and 14 genetic families in the San Joaquin Basin (Peters et al., 2010).

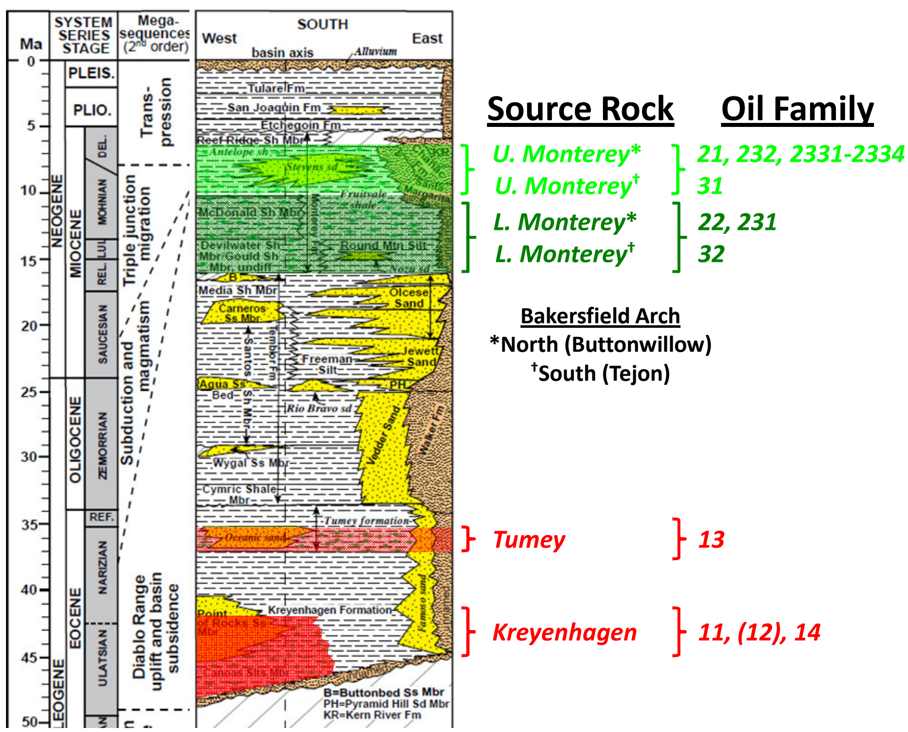

Figure 2. San Joaquin Basin oil families retain the geochemical imprint of their source rock organofacies without major cross-stratigraphic migration (Peters et al., 2010).

A similar training set of 388 crude oil, seep, and tarball samples was used to identify genetic relationships among an additional 288 petroleum samples from coastal

California (Peters et al., 2008). For example, in a test of the decision tree 10 tarball samples collected from beaches in Monterey and San Mateo counties were found to originate from natural seeps representing different organofacies of Miocene Monterey Formation source rock instead of anthropogenic pollution. The seeps apparently become more active during periods of increased storm activity.

References

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