

IMPROVED OIL-OIL CORRELATION VIA CHEMOMETRICS: EXAMPLE FROM THE ONSHORE AND OFFSHORE SANTA MARIA BASIN, CALIFORNIA

K. E. Peters^{1,2}, P. G. Lillis³, T. D. Lorenson⁴, and J. E. Zumberge⁵

¹Schlumberger, Mill Valley, California, USA

²Stanford University, Palo Alto, California, USA

³U.S. Geological Survey, Denver, Colorado, USA

⁴U.S. Geological Survey, Santa Cruz, California, USA

⁵GeoMark Research, Houston, Texas USA

Introduction

Geochemical oil-oil and oil-source rock correlations are required to establish petroleum systems. However, many geochemical correlations in the literature are based only on bivariate or ternary plots of source-related biomarker and isotope data. These limited data may be insufficient to reliably infer genetic affinities among samples. This paper demonstrates the value of chemometrics (multivariate statistics) to define oil families and infer source rock organofacies for 52 high-sulfur crude oils from the Santa Maria basin. Stratigraphic data (Sweetkind et al., 2010) support two depocenters in the onshore basin where Miocene Monterey Formation source rock reaches the top of the oil window at ~6700 ft (2040 m) depth (Tennyson and Isaacs, 2001). However, no publications describe genetic differences among oils from these depocenters. Furthermore, offshore production might be expected to be geochemically distinct from the onshore oils because the fields and prospects occur west of the Hosgri fault, although the extent of right-lateral displacement along the fault remains speculative.

Results

Twenty-one source-related biomarker and stable carbon isotope ratios for non- or mildly biodegraded oil samples from the onshore and offshore Santa Maria basin were used to construct a training set that clearly differentiates seven genetic families generated from different organofacies of the Miocene Monterey Formation source rock (Fig. 1). The training set was used to create a chemometric decision tree (e.g., Peters et al., 2007) that can be used to classify newly collected samples of crude oil or source-rock extracts and assign a quantitative level of certainty for each correlation.

The collection localities of onshore families 2, 4, 6, and 7 are related to the subsurface distribution of thermally mature Monterey Formation source rock near two depocenters identified in Fig. 1 at depths greater than ~6700 ft (2040 m). Family 2 consists of 19 oil samples from the Guadalupe, Orcutt, Santa Maria Valley, West Santa Maria Valley, Cat Canyon, Cat Canyon/Gato Ridge, and West Cat Canyon fields. All of these samples were collected on a NW-SE trend updip and immediately to the northeast of the northern depocenter. Family 6 consists of 10 samples from the onshore Barham Ranch, Four Deer, Lompoc, Orcutt, and Careaga Canyon fields collected immediately north or south of the southern depocenter. Families 2 and 6 dominate the onshore portion of Fig. 1. Comparison of the data for these two families indicates that Monterey source rock in the northern depocenter was more carbonate rich, contained ¹³C-enriched organic matter that was more marine in character, and was deposited under more reducing conditions than in the southern depocenter. Family 4 consists of three oil samples from the onshore Zaca and Cat Canyon/Gato Ridge fields in the eastern portion of the map area. Family 7 consists of four oil samples from the Arroyo Grande and Casmalia fields.

The remaining three families occur offshore to the west of the Hosgri fault. Family 1 consists of six oil samples from the Point Pedernales field. These oils show weak affinity to families 2 and 3. Family 3 consists of three oil samples from the offshore Point Sal prospect. Family 5 consists of seven oil samples from several offshore wells in the San Miguel and Point Sal prospects.

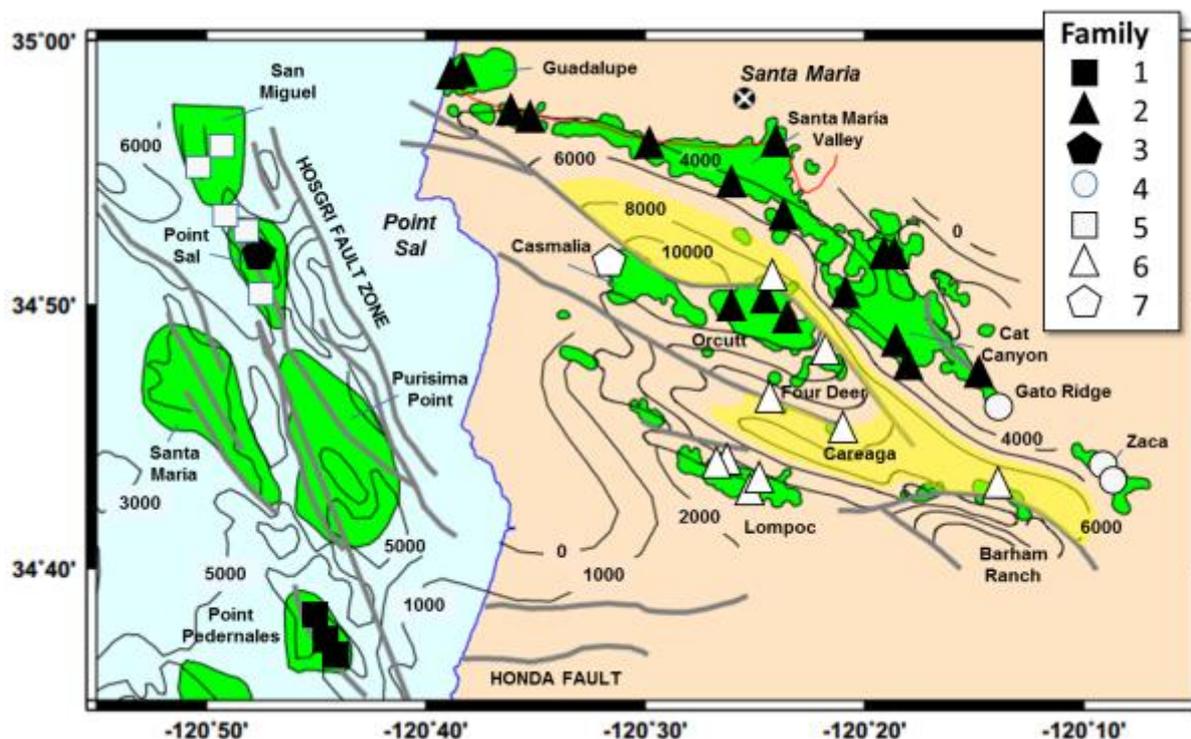


Figure 1. Depth contour map (ft) of the onshore and offshore Santa Maria basin modified from Isaacs (1992) and Tennyson and Isaacs (2001) shows oil families based on chemometric analysis of 21 biomarker and carbon isotope ratios for 52 oil samples. Yellow highlight indicates top Monterey >6700 ft (2040 m). Oil fields and prospects are green. Three family 7 samples in the Arroyo Grande field are ~10 mi (16 km) north of the Guadalupe field.

Conclusions

Chemometric analysis of 21 source-related biomarker and stable carbon isotope ratios for 52 oil samples from the Santa Maria basin identified seven genetic oil families. The detail achieved by this multivariate approach to define oil families is far greater than that allowed by conventional oil-oil correlations based on only a few bivariate or ternary diagrams of source-related data. The seven families show systematic map distributions that reflect local organofacies variations within the Miocene Monterey Formation source rock. Four onshore oil families originated from two pods of thermally mature source rock as defined by depths >6700 ft (2010 m). The offshore oil families are distinct and consist of one family from Point Pedernales and two families from the Point Sal and San Miguel prospects.

References

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