Oil-oil correlations to establish a basis for mapping petroleum systems, San Joaquin Basin, California

Compiled PowerPoint Slides

by Lillis, P.G., and Magoon, L.B.

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Oil-oil correlations to establish a basis for mapping petroleum systems, San Joaquin Basin, California

by Lillis, Paul G.¹ and Magoon, Leslie B.²

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U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

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Preface

The PowerPoint presentation in this report was given at a public forum presented by the U.S. Geological Survey entitled “Petroleum Assessment of San Joaquin Basin—Project Details and Workshop,” which was hosted by the San Joaquin Geological Society in Bakersfield, California, April 2, 2003. It presents new results of a petroleum geochemical study of the San Joaquin basin based on recently analyzed data combined with published data in order to characterize oil types and establish a basis for mapping petroleum systems in the basin. Some diagrams that appeared in the original presentation have been updated in this report.

The approach for this study was to first correlate the crude oils into genetic types or families by evaluating the similarities of various bulk and molecular geochemical parameters using x-y plots and hierarchical cluster analysis, then map the distribution of the oil types in the basin. Chemical parameters most useful for oil correlation are stable carbon isotope ratios and biomarker composition including pristane/phytane, sterane, and terpane ratios.

In previous studies, the middle and upper Miocene Monterey and the middle Eocene Kreyenhagen formations were recognized as the main sources of petroleum in the basin, while the Upper Cretaceous portion of the Moreno Formation was considered a minor source. The results of the current study show that there are three main oil types: the Kreyenhagen, upper Eocene Tumey Formation, and the Monterey Formation and equivalents. The Moreno Formation is again recognized as only a minor oil type.

Mapping the distribution of the oil types shows that the Miocene Monterey is largely restricted to Kern County at the southern end of the basin, while the Eocene
Kreyenhagen is widely distributed along the western half of the basin. Tumey oil is also predominantly present along the west side, but a few occurrences are found on the east side. The Cretaceous Moreno oil has been found only in the Coalinga area, southwestern Fresno County, and the Griswold Canyon area of Vallecitos field, San Benito County (McGuire, 1988). These maps provide the basis for petroleum system maps that incorporate source rock distribution and burial history, migration pathways, and geologic framework. Petroleum system maps are, in turn, used for USGS resource assessments of the basin.

References


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Slide 37. Map of Miocene Monterey oil localities. Miocene Monterey is largely restricted to Kern County at the southern end of the basin. Letter designation after oil type refers to reservoir age if older than middle Miocene (j = Jurassic, e = Eocene, o = Oligocene, l = lower Miocene).

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Oil-oil correlations to establish a basis for mapping petroleum systems - San Joaquin Basin

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U.S. Geological Survey
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• Several samples were provided by Ken Peters, Joe Curiale, and Ian Kaplan
Outline

• Previous studies
• Methods
• Results
San Joaquin Basin, Calif.
Stratigraphy ½

Source rocks

Modified from Beyer (1995)
Stratigraphy

Source rocks

Modified from Beyer (1995)
Previous Geochemical Studies


- **Kaplan and others 1988**, The petroleum geochemistry of crude oils and potential source rocks from the Paleogene of the San Joaquin and Ventura/Santa Barbara Basins, Pacific Section AAPG CD ROM Series 1, 2000

- **Peters and others, 1994**, Identification of petroleum systems adjacent to the San Andreas Fault, California, AAPG Memoir 60

Conclusions of Previous Studies

• Two main oil types
  – Miocene Monterey and equivalents
  – Eocene Kreyenhagen

• Other oil types recognized
  – Cretaceous Moreno
  – oil in Wygal Ss. Mbr. (Phacoides zone) of the Temblor Formation
  – Lower Miocene Soda Lake or Lambert (west of the San Andreas Fault)
Methods and Approach

• Analysis of 123 crude oils
  – Stable carbon isotopes
  – API gravity
  – Sulfur content
  – Biomarkers
  – Ni/V
• Integration with other data
• Statistical Analysis
• GIS mapping of oil types for each petroleum system
Gravity vs Sulfur (COA data)

COA data from Sellers and others (1996)

Boundary lines from Orr (2001)
Gravity vs Sulfur (USGS)

San Joaquin Basin

Data from USGS, Kaplan and others (1988), and Peters and others (1994)
Stable Carbon Isotopes

- $C_{15+}$ saturated and aromatic hydrocarbons
- Powerful tool for oil typing
- Previous studies separate Eocene, Cretaceous, and Miocene oils
Figure 2. Isotopic composition of oils, oil seeps, and oil stains, northern California. See table 2 for oil boundary.

### Table 2: Stable Carbon Isotopes of Oils - Northern California

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**Stable Carbon Isotopes of Oils**

- δ¹³C Saturated Hydrocarbons
- δ¹³C Aromatic Hydrocarbons

**Geologic Units**

- Miocene
- Cretaceous
- Eocene

**Locations**

- Miocene: M1, M2, M3, M4
- Cretaceous: K1, K2, K3, K4
- Eocene: unclassified

**References**

- Lillis and others (2001)
- Söder (1994)
Stable Carbon Isotopes of oils - San Joaquin Basin

Data from USGS and from Kaplan and others (1988), Curiale and others (1985) and Peters and others (1994).
Biomarkers

- Pristane/phytane
- Steranes (m/z 217)
- Terpanes (m/z 191)
Mass Chromatograms of Terpanes - Kreyenhagen

g = gammacerane
Mass Chromatograms of Terpanes - Tumey

Guijarral Hills field
Temblor reservoir

McKittrick field
Temblor (Phacoides) reservoir

m/z 191

o = oleanane
g = gammacerane
Mass Chromatograms of Terpanes - Monterey

Cal Canal field
Miocene Stevens reservoir

Elk Hills field
Pliocene Etchegoin reservoir

b = bisnorhopane
o = oleanane
g = gammacerane
Terpane Ratio vs δ¹³C aromatic hydrocarbons

Data from USGS
δ^{13}C aromatic hydrocarbons vs pristane/phytane
San Joaquin Oils

Data from USGS and Kaplan and others (1988)
Hierarchical Cluster Analysis
Main Oil Types

- **Kreyenhagen**
  - Middle Eocene

- **Tumey – Temblor (?)**
  - Upper Eocene - Oligocene (?)

- **Monterey and equivalents (3 sub-types)**
  - Middle and upper Miocene

Cretaceous Moreno is a minor oil type

Lower Miocene oil not recognized east of San Andreas Fault
Oil-Source Rock Correlation

- Published source rock data
  - Kaplan and others (1988)
  - Curiale and others (1985)
- Moreno, Monterey and Kreyenhagen correlations already established in the literature
- What is the origin of Temblor reservoir oil?
Stable Carbon Isotopes of oils - San Joaquin Basin

Data from USGS and from Kaplan and others (1988), Curiale and others (1985) and Peters and others (1994).
Stable Carbon Isotopes of San Joaquin Source Rocks

Data from Kaplan and others (1988) and Curiale and others (1985)
$\delta^{13}C$ aromatic hydrocarbons vs pristane/phytane
San Joaquin Oils

Data from USGS and Kaplan and others (1988)
Data from Kaplan and others (1988) and Curiale and others (1985)
Petroleum System Maps

- Moreno
- Kreyenhagen
- Tumey
- Monterey
Petroleum Systems Summary

- Cretaceous Moreno – limited extent
- Middle Eocene Kreyenhagen
- Upper Eocene Tumey
- Middle and Upper Miocene Monterey and equivalents