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

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2004

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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.

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Slides:

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Slide 2. Acknowledgments.

Slide 3. Talk outline.

Slide 4. Index map. Map of San Joaquin Basin (gray shading) showing location of cities, counties, and oil (green) and gas (red) fields.

Slide 5. Generalized stratigraphic chart. San Joaquin Basin stratigraphy showing the Cretaceous through Eocene. Potential source rocks are identified with green stars.

Slide 6. Generalized stratigraphic chart. San Joaquin Basin stratigraphy showing the Oligocene through Pliocene. Potential source rocks are identified with green stars.

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Slide 11. Plot of San Joaquin API gravity vs. sulfur (USGS data). Data from new USGS analyses, as well as from Kaplan and others (1988) and Peters and others (1994). Most San Joaquin oil has low to moderate sulfur content, although some Miocene Monterey oil is derived from Type II-S kerogen as defined by Orr (2001).

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Slide 22. Hierarchical cluster analysis diagram. Enlarged portion of the same dendrogram in the previous slide (Slide 21).

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Slide 27. Plot of $\delta^{13}C$ aromatic hydrocarbons vs. pristane/phytane of San Joaquin oils. Repeat of Slide 20.

Slide 28. Plot of $\delta^{13}C$ aromatic hydrocarbons vs. pristane/phytane of San Joaquin source rocks. Source rock data are plotted with the boundary boxes of the three main oil types from Slide 27. Eocene Tumey source rock bitumen is similar in composition to the Tumey-Temblor oil type (red box). Data from Kaplan and others (1988) and Curiale and others (1985).

Slide 29. List of petroleum system maps.

Slide 30. Index map of San Joaquin Basin. Map of San Joaquin Basin (gray shading) showing location of cities, counties, oil localities, and oil (green) and gas (red) fields.

Slide 31. Map of all oil data localities in San Joaquin Basin. Data from new USGS analyses and from Kaplan and others (1988), Curiale and others (1985) and Peters and others (1994). Letter designation after oil type refers to reservoir age (j = Jurassic, e = Eocene, o = Oligocene, l = lower Miocene, m = Miocene).

Slide 32. Map of Cretaceous Moreno oil localities. The Moreno oil type has only been found in the Coalinga area, southwestern Fresno County, and the Griswold Canyon area of Vallecitos field, San Benito County (McGuire, 1988).

Slide 33. Map of Eocene Kreyenhagen oil localities. The Kreyenhagen oil type is widely distributed along the western half of the basin.

Slide 34. Map of Eocene Kreyenhagen oil localities. Also shown is the Kreyenhagen petroleum system boundary.

Slide 35. Map of Eocene Tumey oil localities. The Tumey oil type is predominantly present along the west side, but a few occurrences are found on the east side.

Slide 36. Map of Eocene Tumey oil localities. Also shown is the Tumey petroleum system boundary.

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).

Slide 38. Map of Miocene Monterey oil localities. Also shown is the Monterey petroleum system boundary. Letter designation after oil type refers to reservoir age if older than middle Miocene (j = Jurassic, e = Eocene, o = Oligocene, l = lower Miocene).

Slide 39. Map of Miocene Monterey oil localities. Also shown are the locations of Monterey oil type in Oligocene (o), Eocene (e) and Jurassic (j) age reservoirs along the margins of the basin.

Slide 40. Map of outlier oil localities. Outliers are oils with compositions that differ from the main oil types and the confidence in the correlation is low.

Slide 41. Map of all oil localities and petroleum systems.

Slide 42. Summary listing of San Joaquin petroleum systems.

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

Paul Lillis and Les Magoon

U.S.Geological Survey

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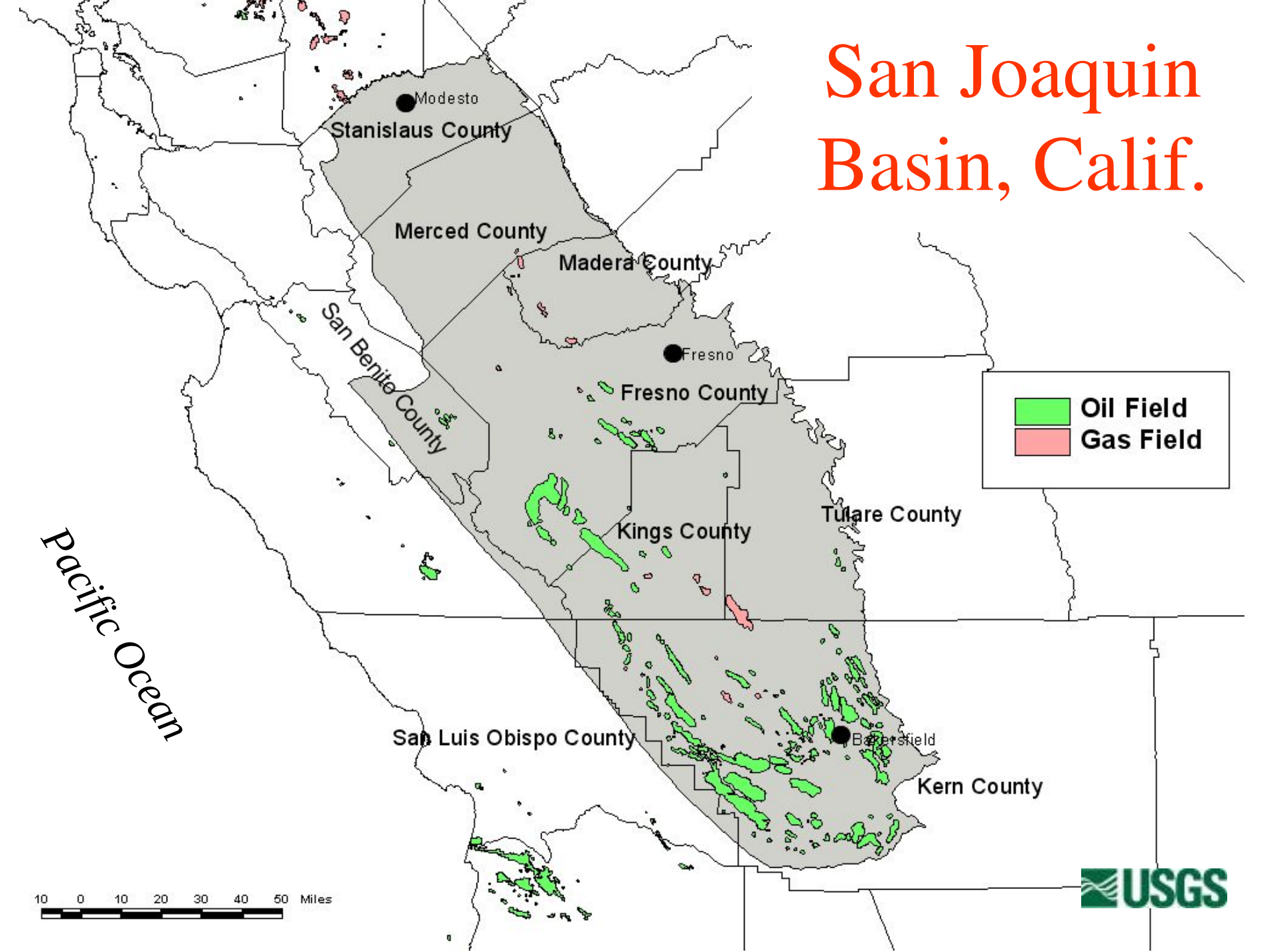
- Analytical work was performed by Dave King, Augusta Warden, and Mike Pribil at the USGS Organic Geochemistry Lab, Denver, CO.
- Numerous operators, too many to list here, kindly allowed access for sampling by Les Magoon, George Claypool, Paul Lillis, Tom Lorenson, Elizabeth Rowan, Keith Kvenvolden and Zenon Valin.
- Several samples were provided by Ken Peters, Joe Curiale, and Ian Kaplan

USGS

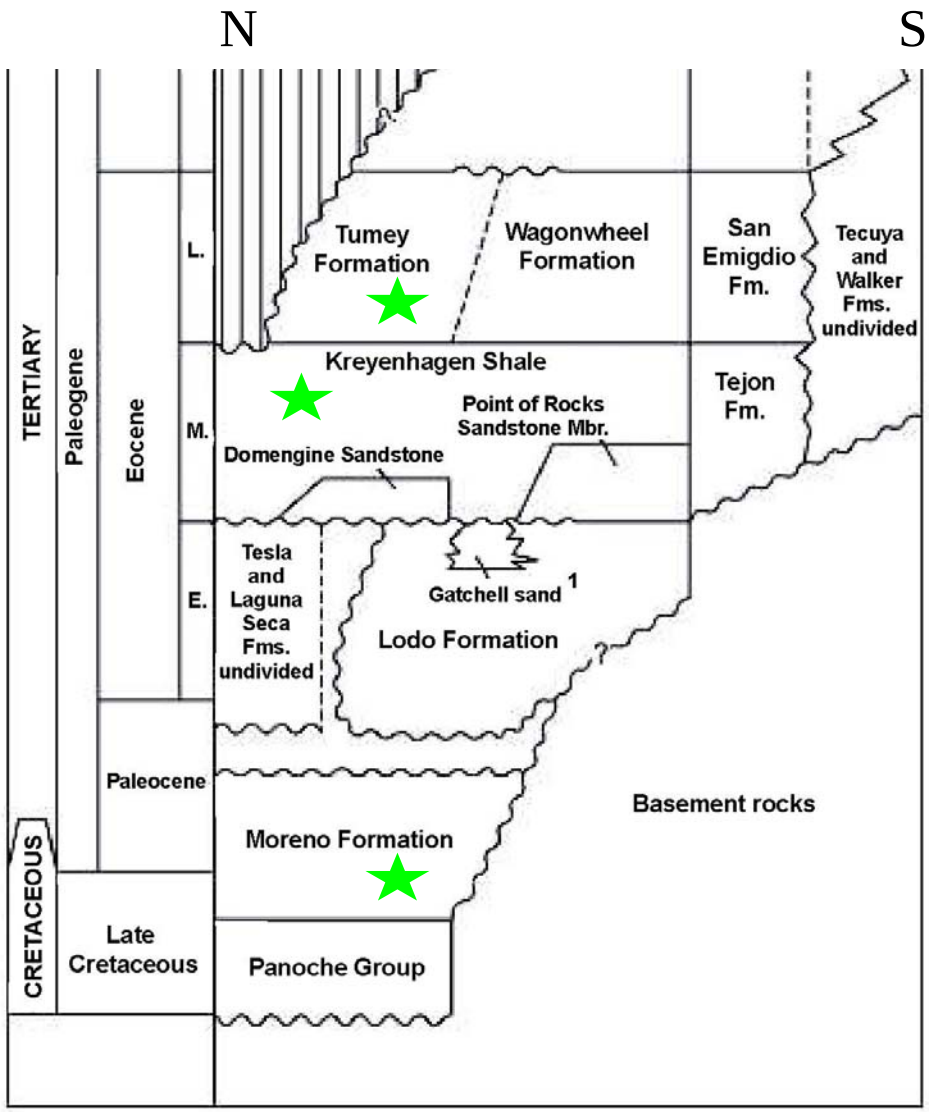
Outline

- Previous studies
- Methods
- Results

USGS


San Joaquin Basin, Calif.
Modesto
Stanislaus County
Merced County
Madera County
Fresno
Fresno County
San Benito County
Kings County
Tulare County
Bakersfield
Kern County
San Luis Obispo County
Pacific Ocean
Oil Field
Gas Field
10 0 10 20 30 40 50 Miles
USGS

Stratigraphy ½



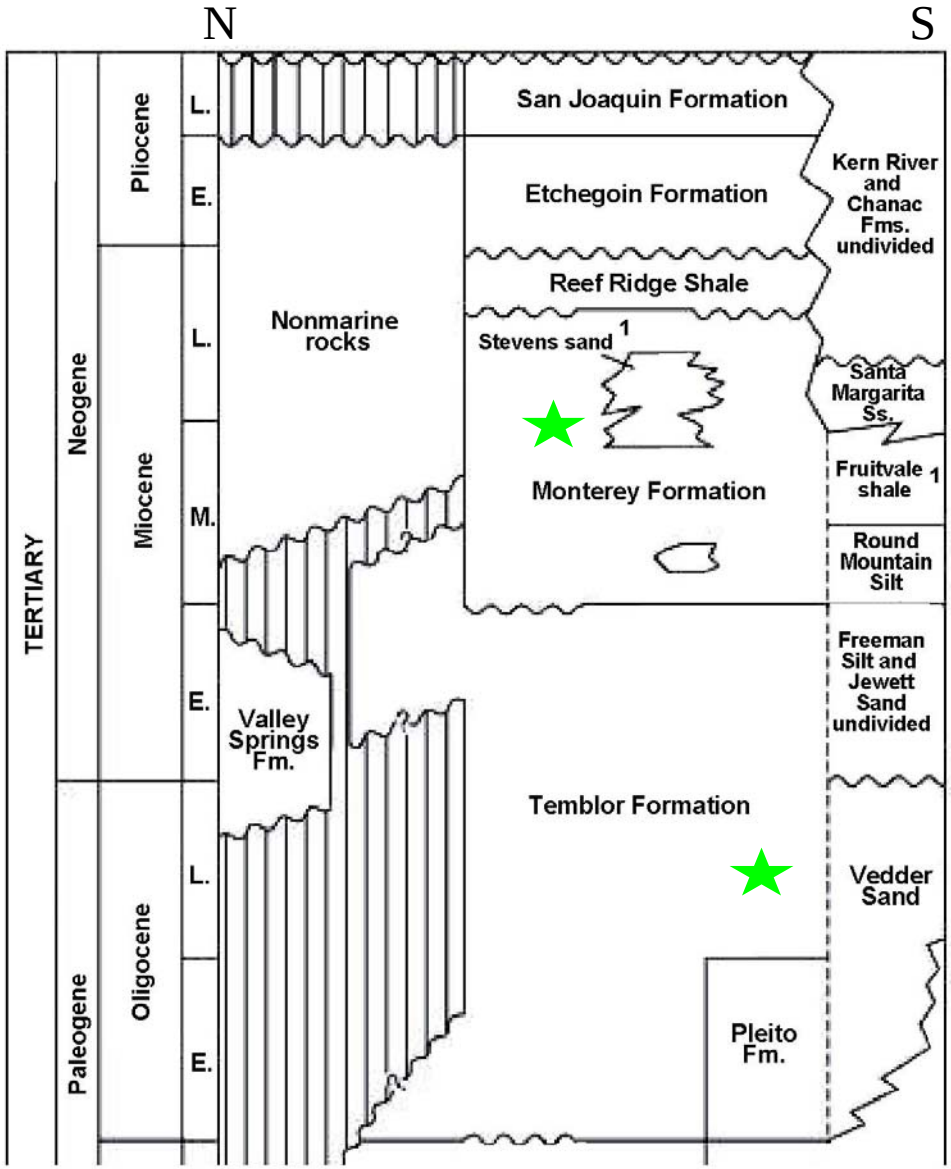
★ Source rocks

[1] An informal unit

Modified from Beyer (1995)

USGS

Stratigraphy 2/2



★ Source rocks

1 An informal unit

Modified from Beyer (1995)

Previous Geochemical Studies

- ***Seifert and Moldowan, 1978,*** Applications of steranes, terpanes and monoaromatics to the maturation, migration and souce of crude oils: Geochim. Cosmochim. Acta, v. 42, p. 77-95.
- ***Curiale and others, 1985*** Biological marker distribution and significance in oils and rocks of the Monterey Formation, California: Geochimica et Cosmochimica Acta, v. 49, p. 271-288.
- ***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
- ***Lillis and others, 2001***, Characterization of Northern California Petroleum by stable carbon isotopes, Open-File Report 99-164

USGS

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)

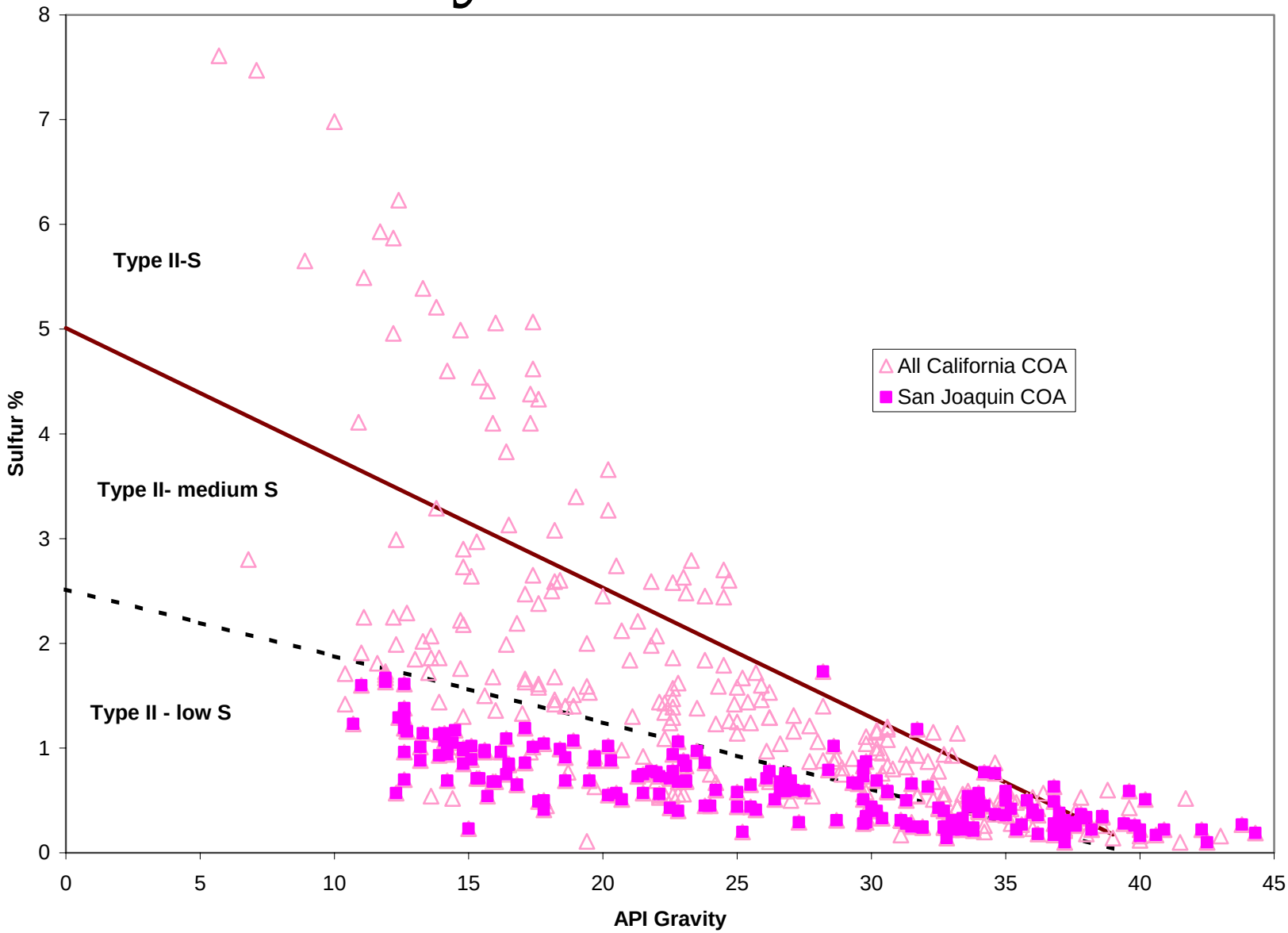
USGS

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

USGS

Gravity vs Sulfur (COA data)



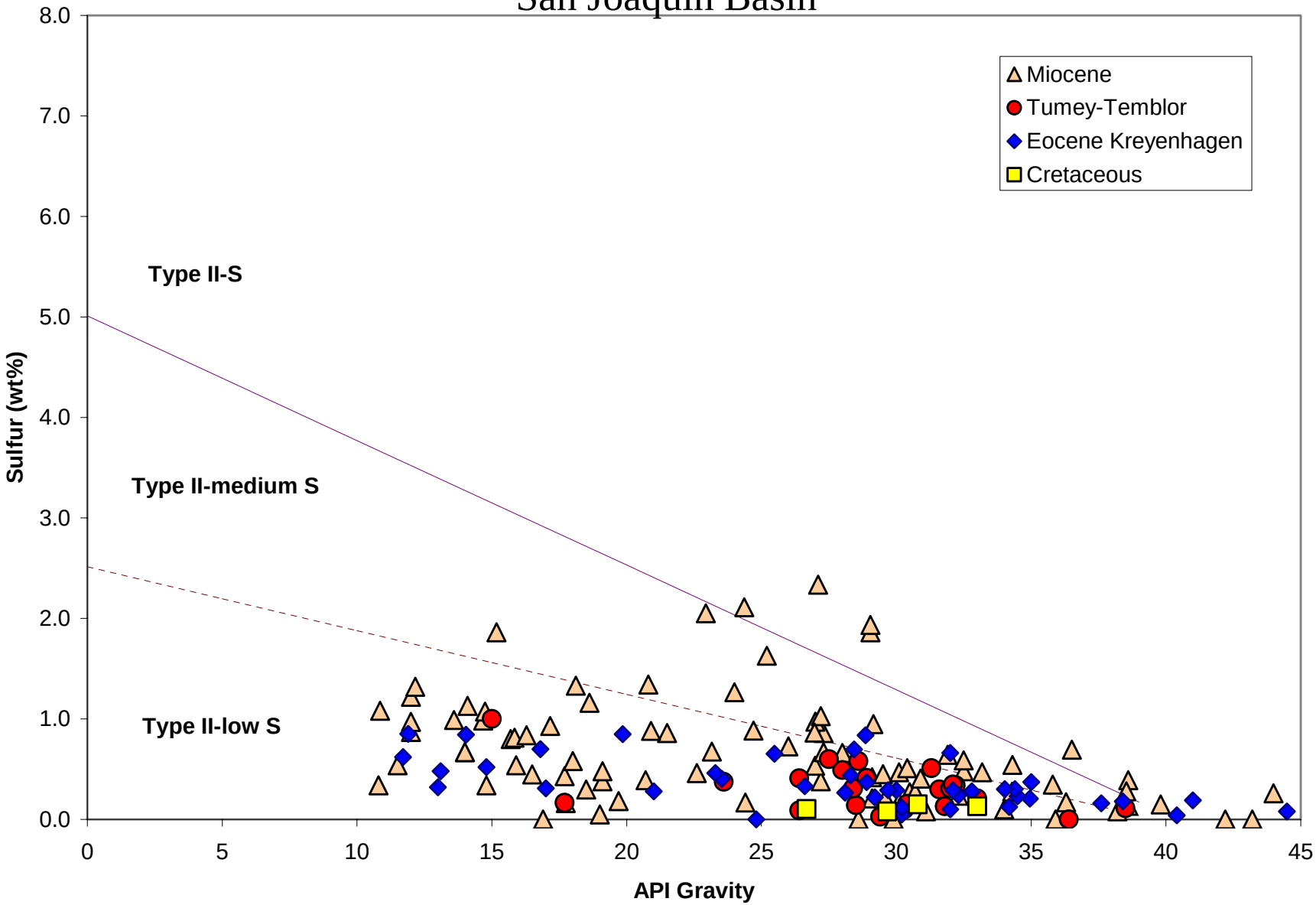
COA data from Sellers and others (1996)

Boundary lines from Orr (2001)

USGS

Gravity vs Sulfur (USGS)

San Joaquin Basin



USGS

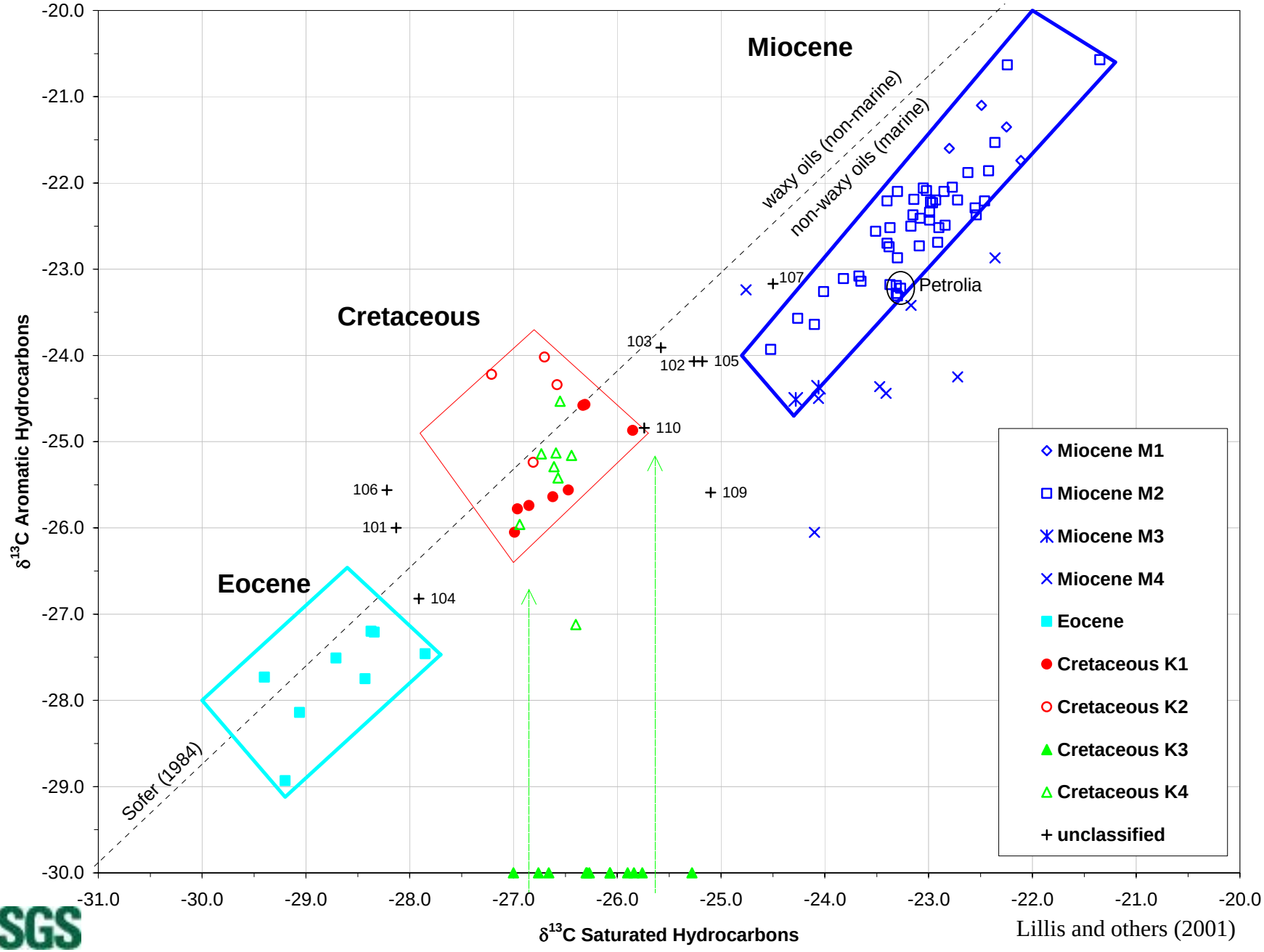
Data from USGS, Kaplan and others (1988), and Peters and others (1994)

Stable Carbon Isotopes

- C_{15+} saturated and aromatic hydrocarbons
- Powerful tool for oil typing
- Previous studies separate Eocene, Cretaceous, and Miocene oils

USGS

Stable Carbon Isotopes of oils -Northern California



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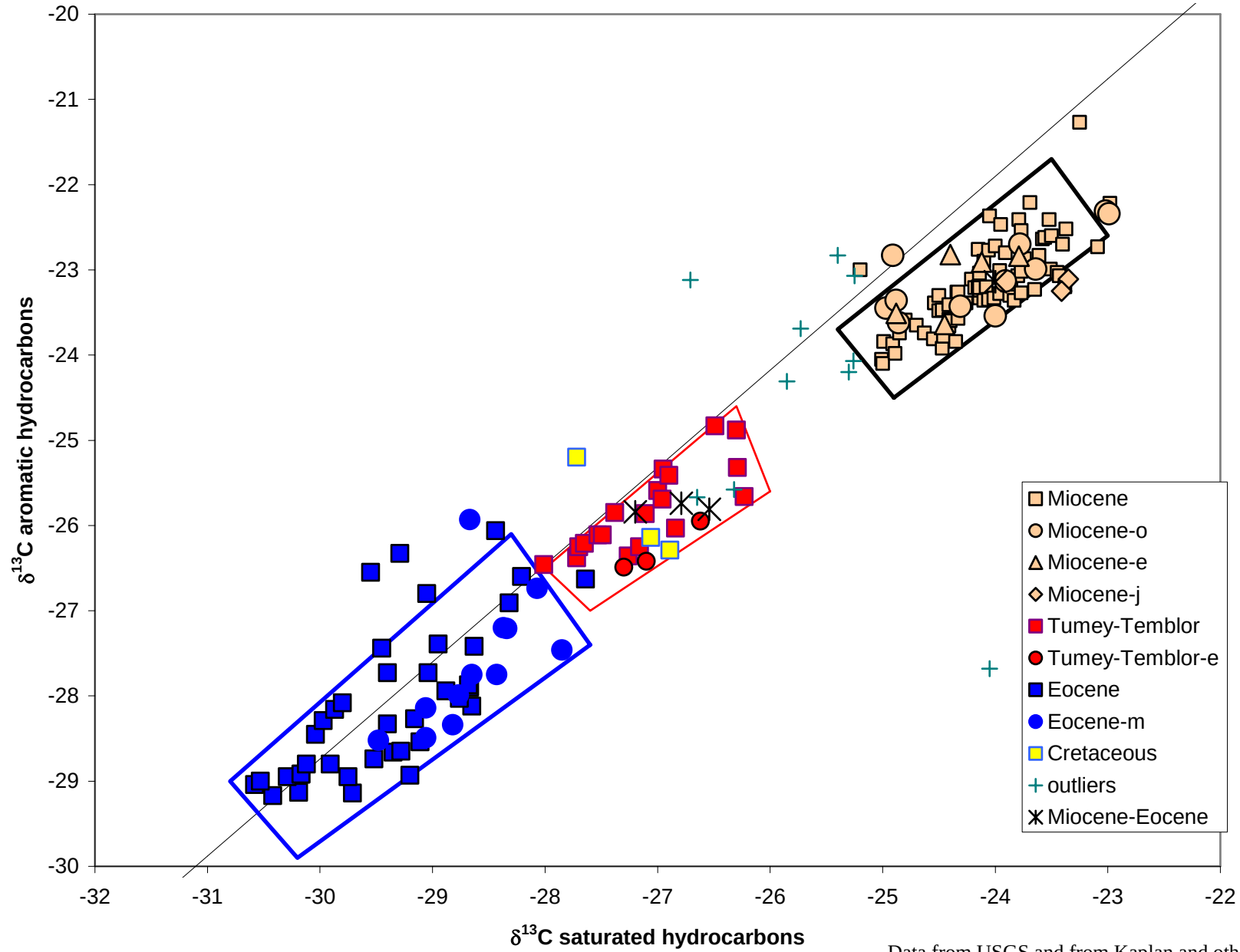
Lillis and others (2001)

Stable Carbon Isotopes of oils - San Joaquin Basin



USGS

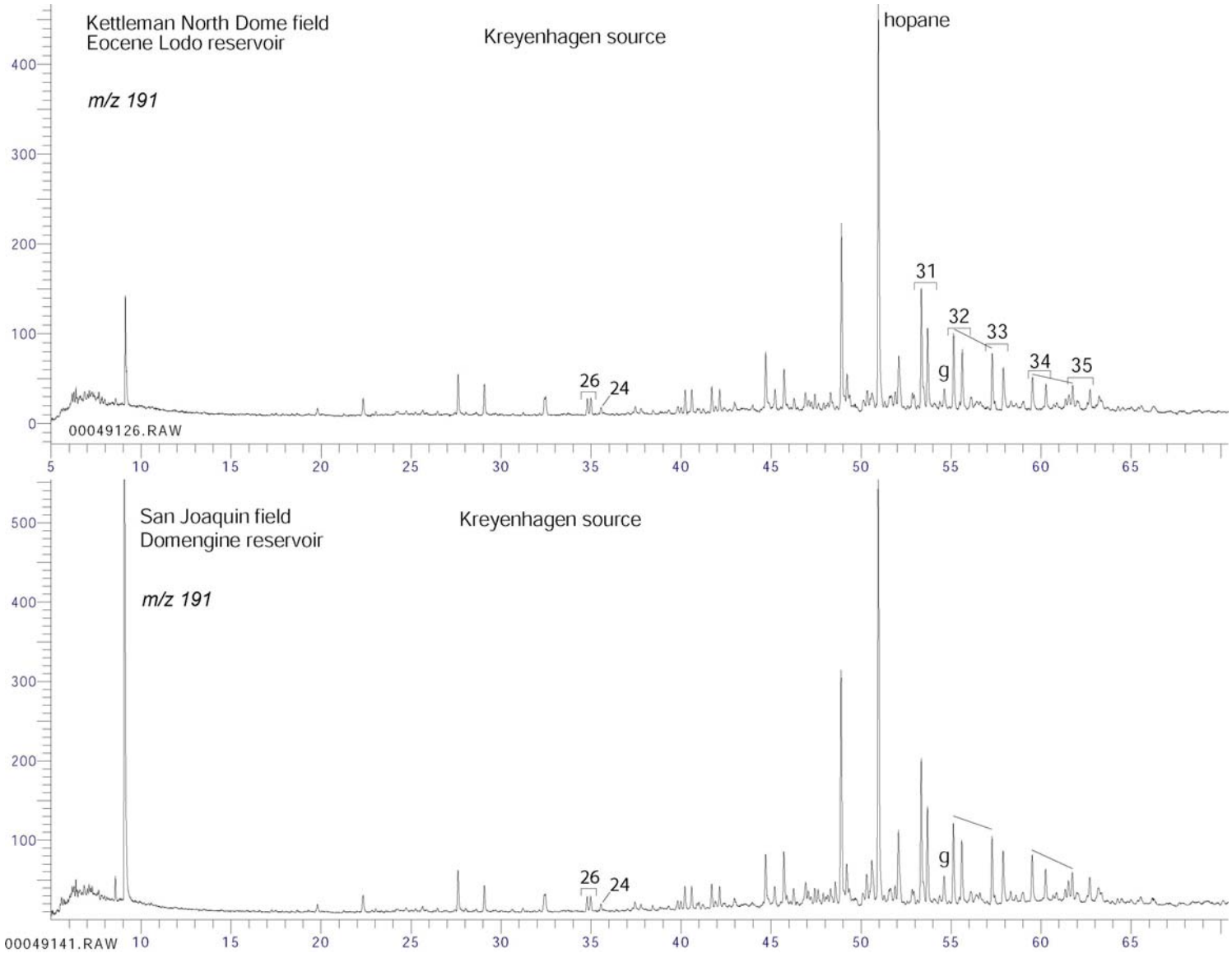
Data from USGS and from Kaplan and others (1988), Curiale and others(1985) and Peters and others (1994).

Biomarkers

- Pristane/phytane
- Steranes (m/z 217)
- Terpanes (m/z 191)

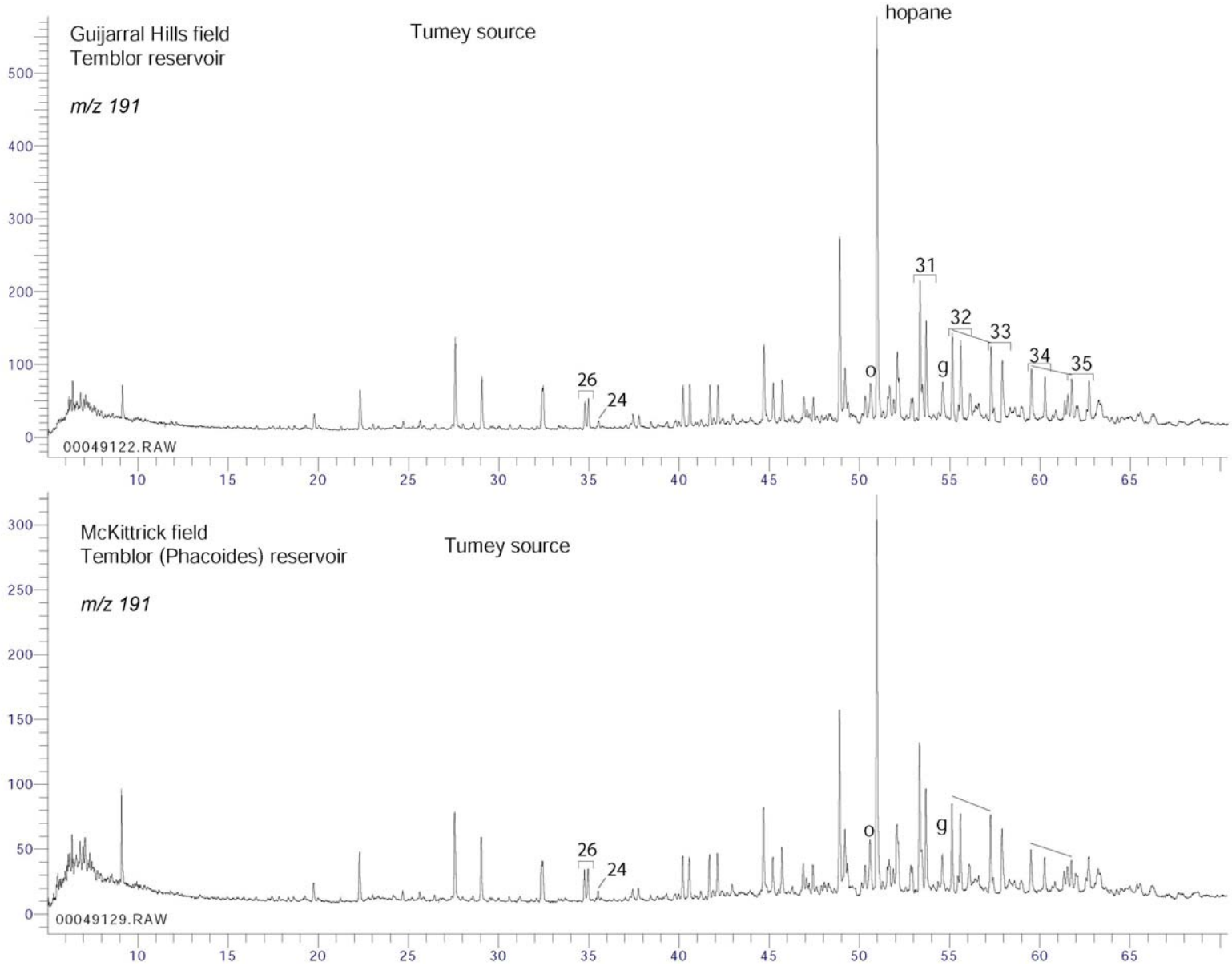
USGS

Mass Chromatograms of Terpanes - Kreyenhagen



g = gammacerane

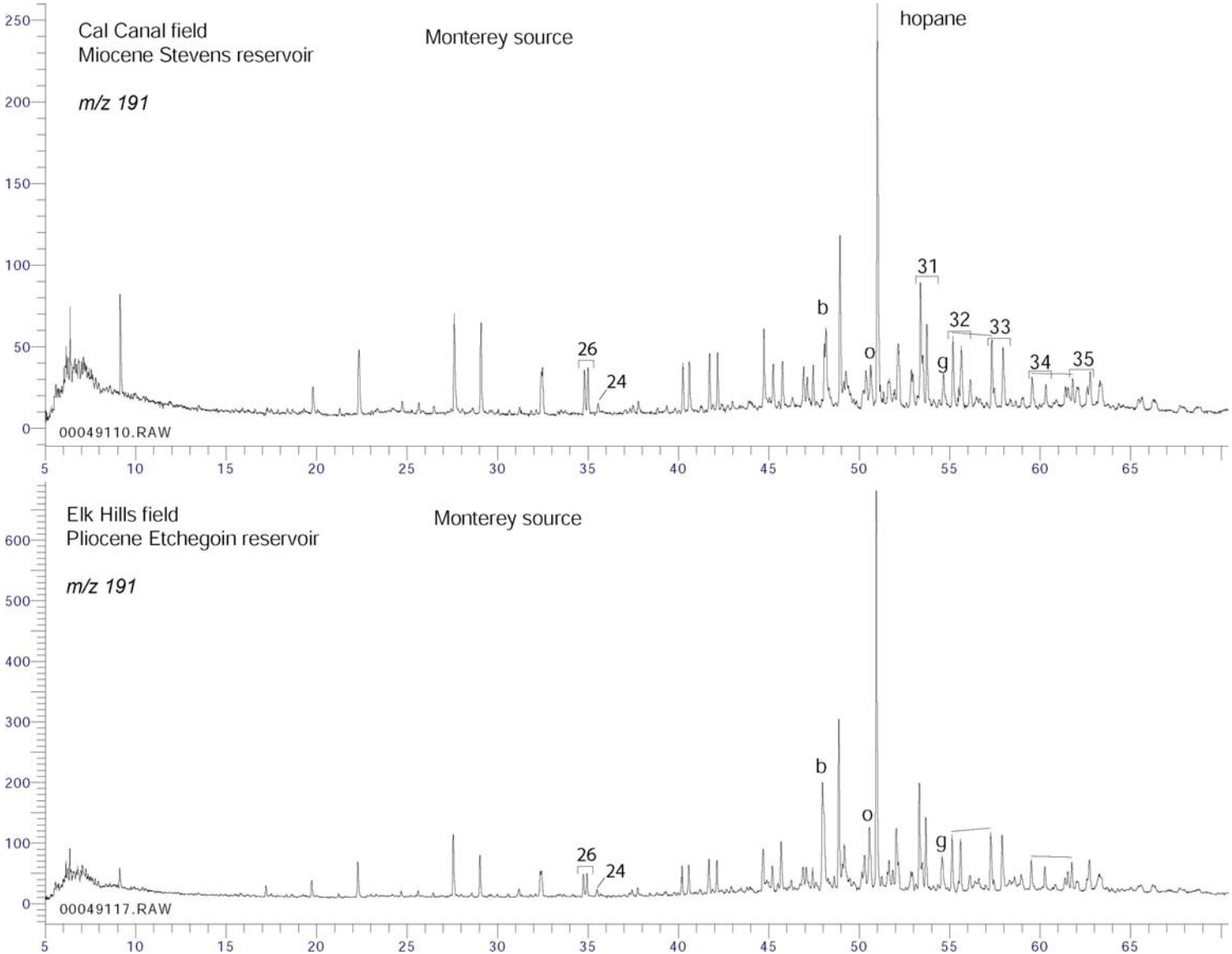
Mass Chromatograms of Terpanes - Tumey



o = oleanane

g = gammacerane

Mass Chromatograms of Terpanes - Monterey

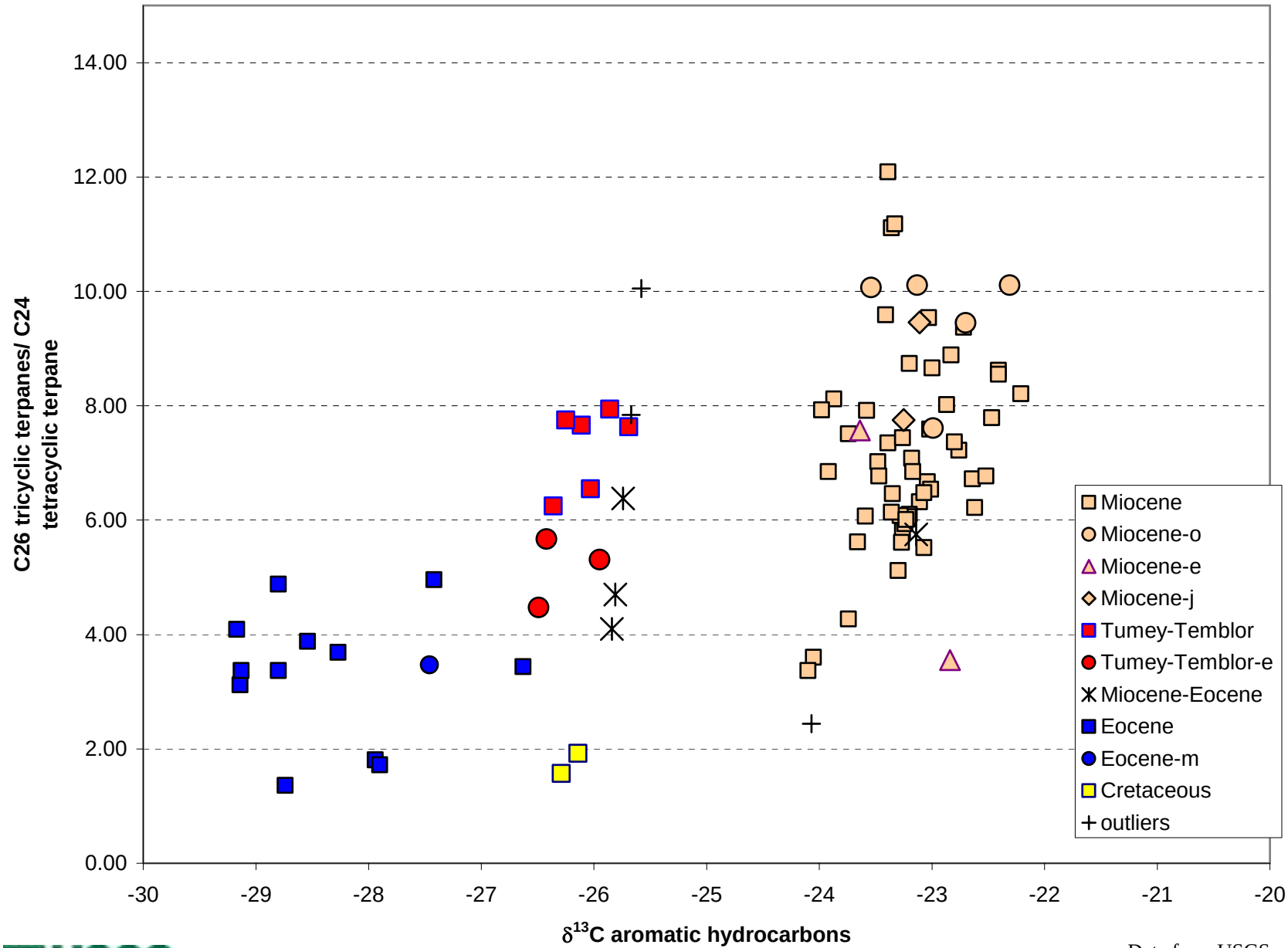


b = bisnorhopane

o = oleanane

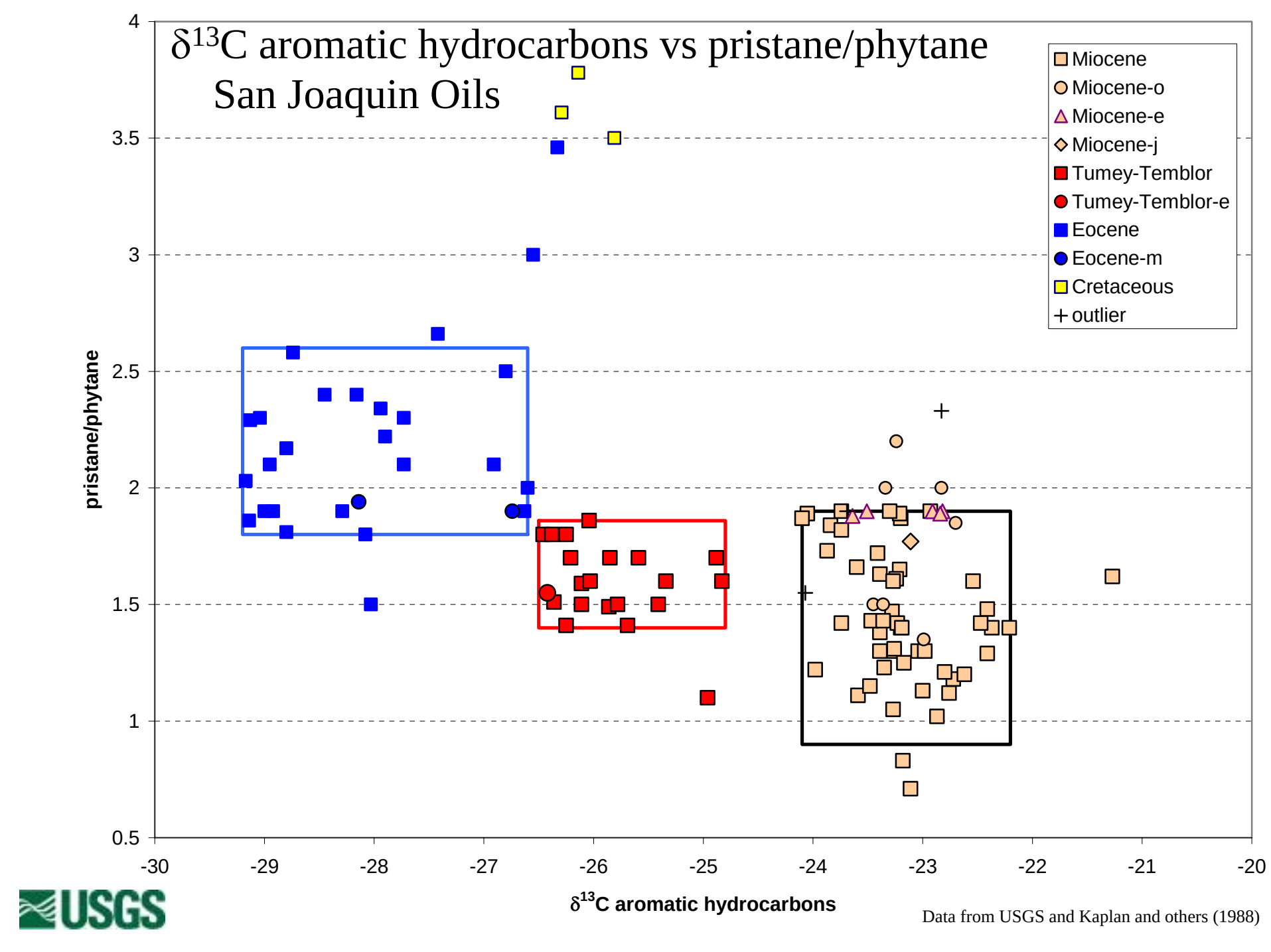
g = gammacerane

Terpane Ratio vs $\delta^{13}C$ aromatic hydrocarbons



USGS

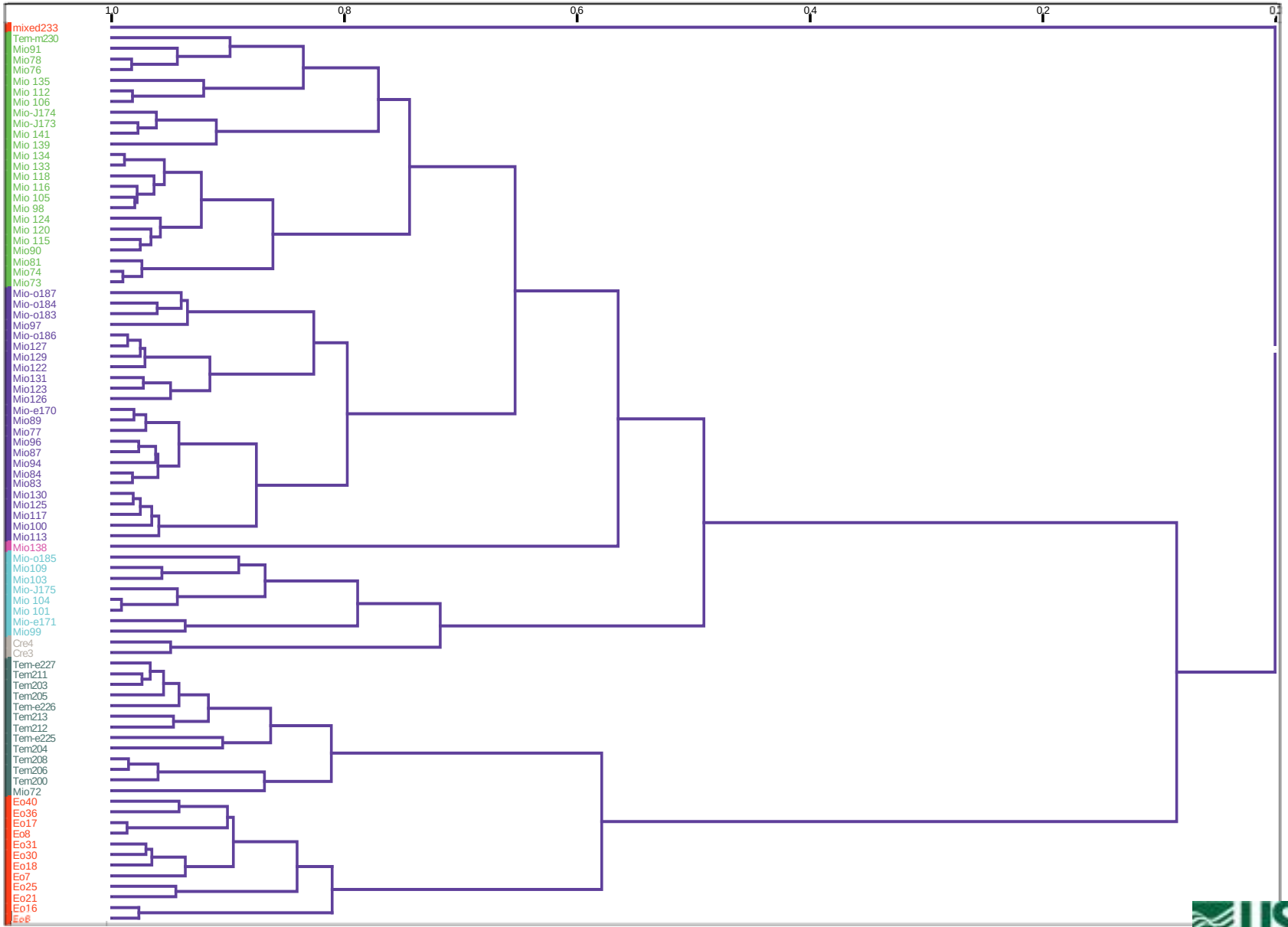
Data from USGS



USGS

Data from USGS and Kaplan and others (1988)

Hierarchical Cluster Analysis



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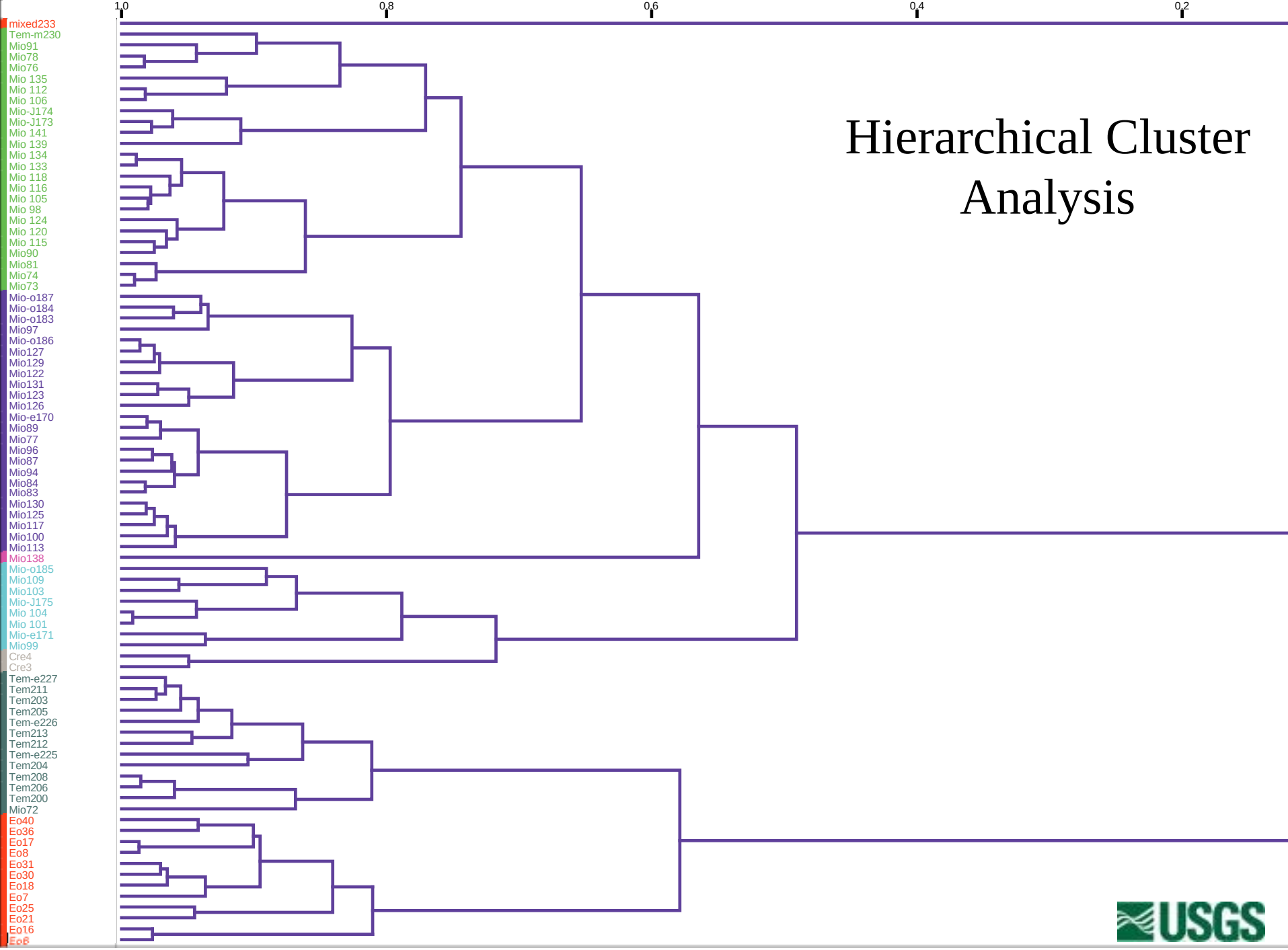


Hierarchical Cluster Analysis

USGS

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

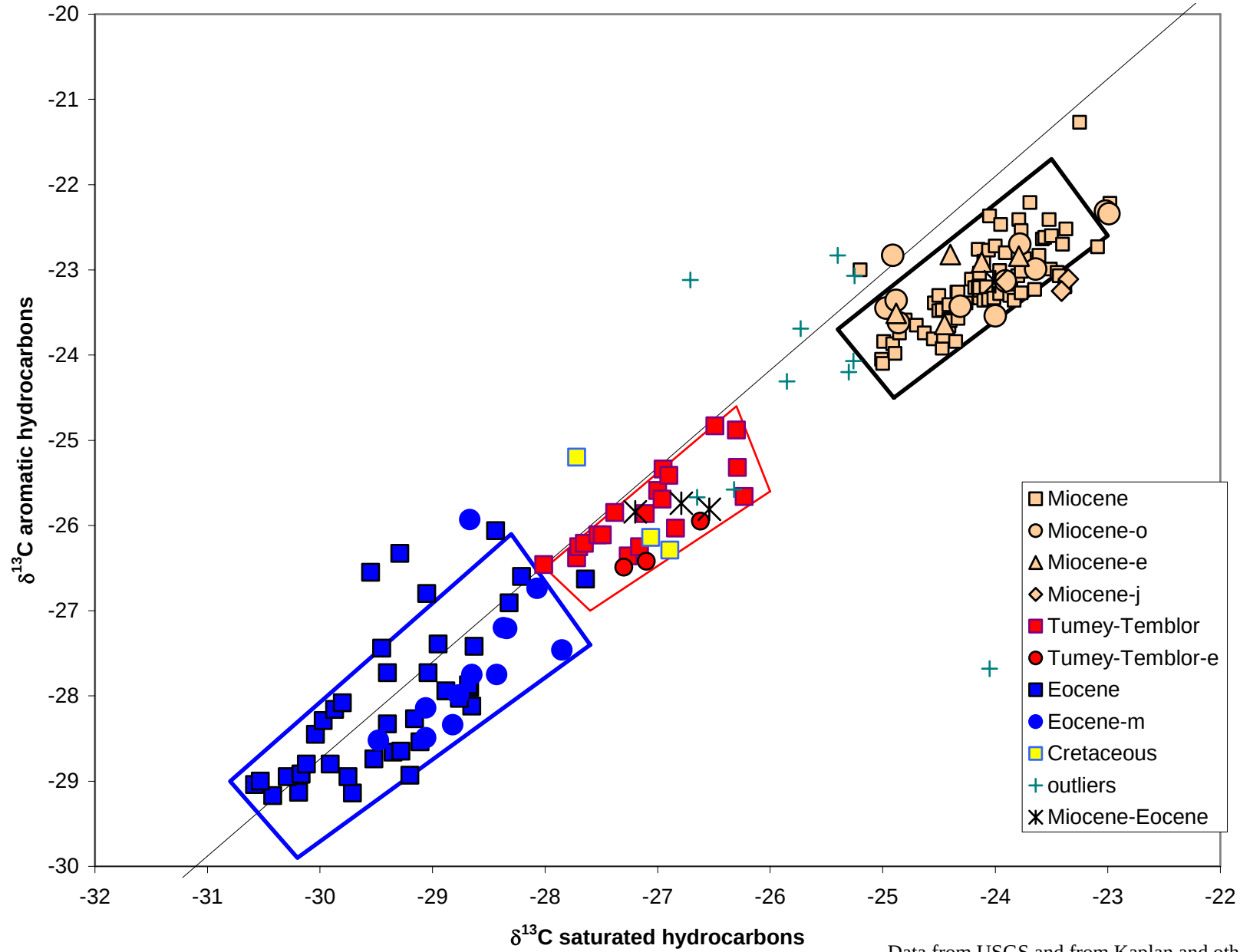
USGS

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?

USGS

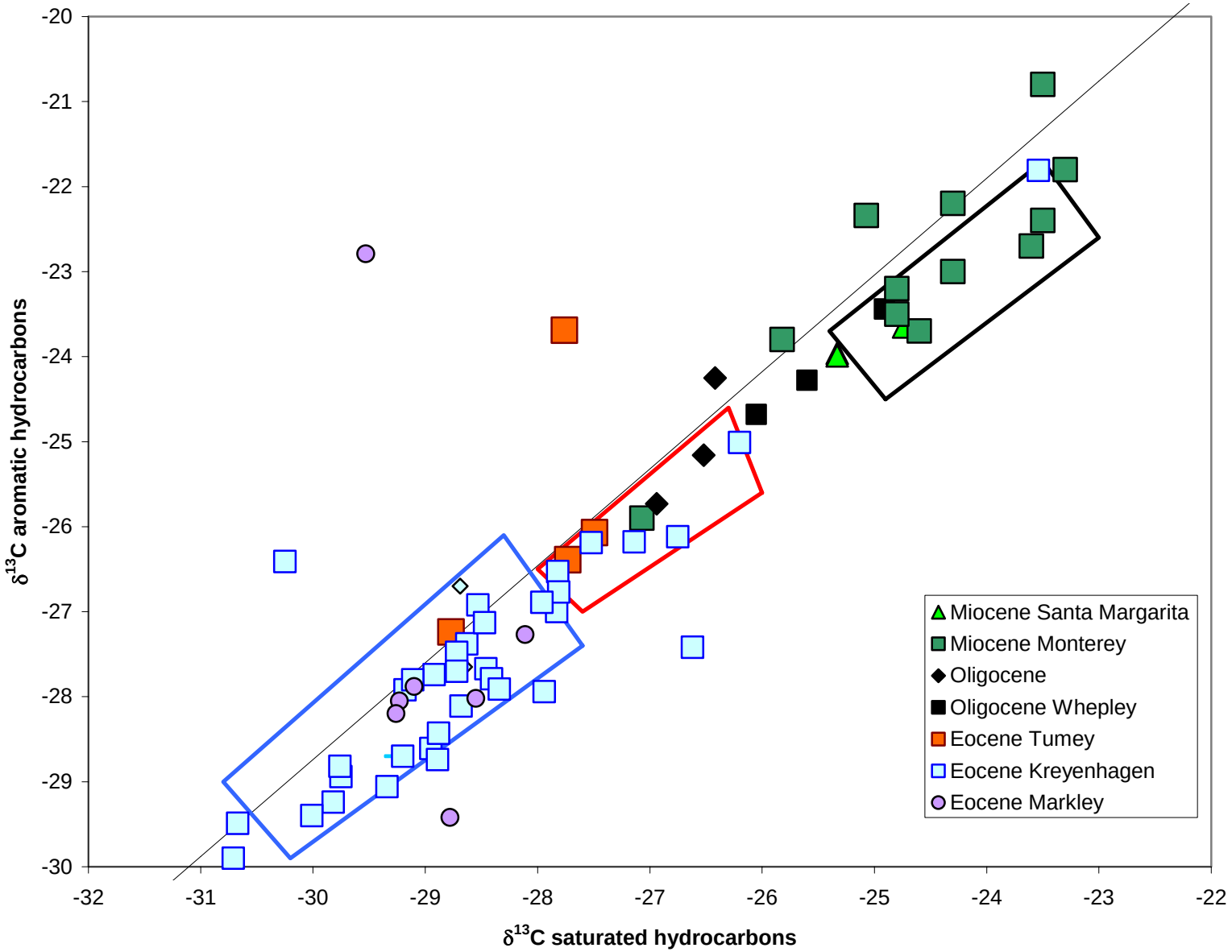
Stable Carbon Isotopes of oils - San Joaquin Basin



USGS

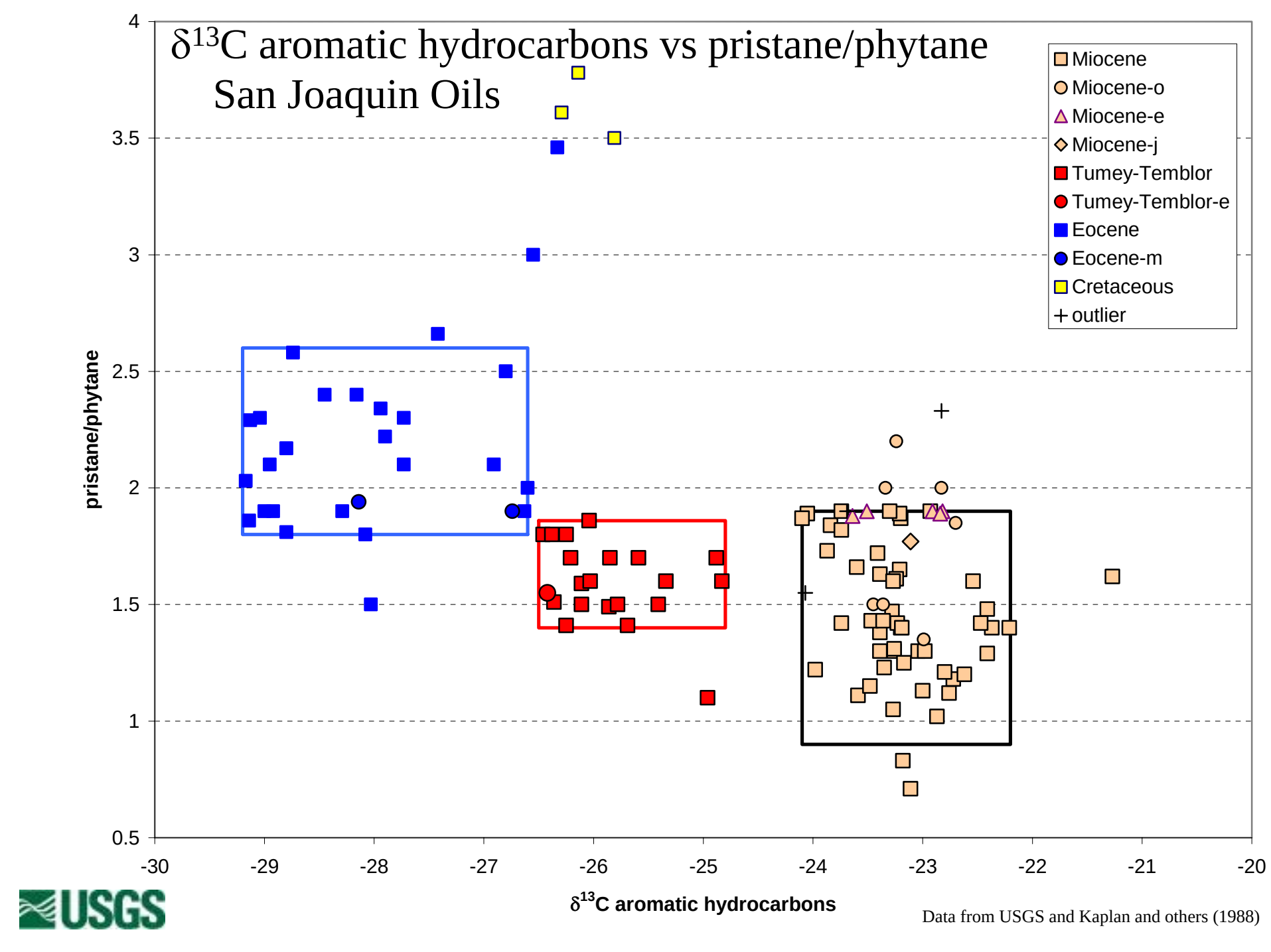
Data from USGS and from Kaplan and others (1988), Curiale and others(1985) and Peters and others (1994).

Stable Carbon Isotopes of San Joaquin Source Rocks



Data from Kaplan and others (1988) and Curiale and others (1985)

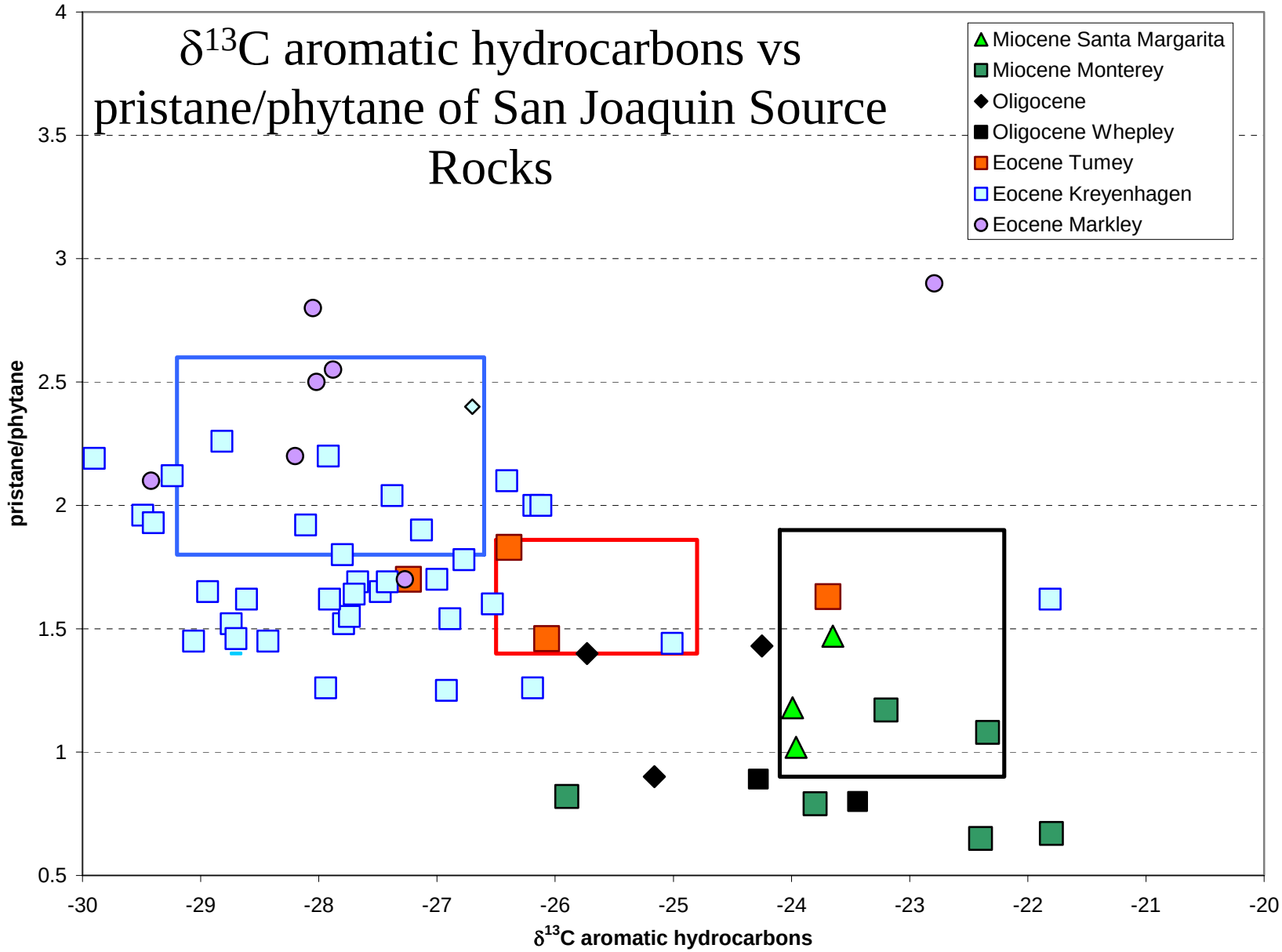
USGS



USGS

Data from USGS and Kaplan and others (1988)

$\delta^{13}C$ aromatic hydrocarbons vs pristane/phytane of San Joaquin Source Rocks



USGS

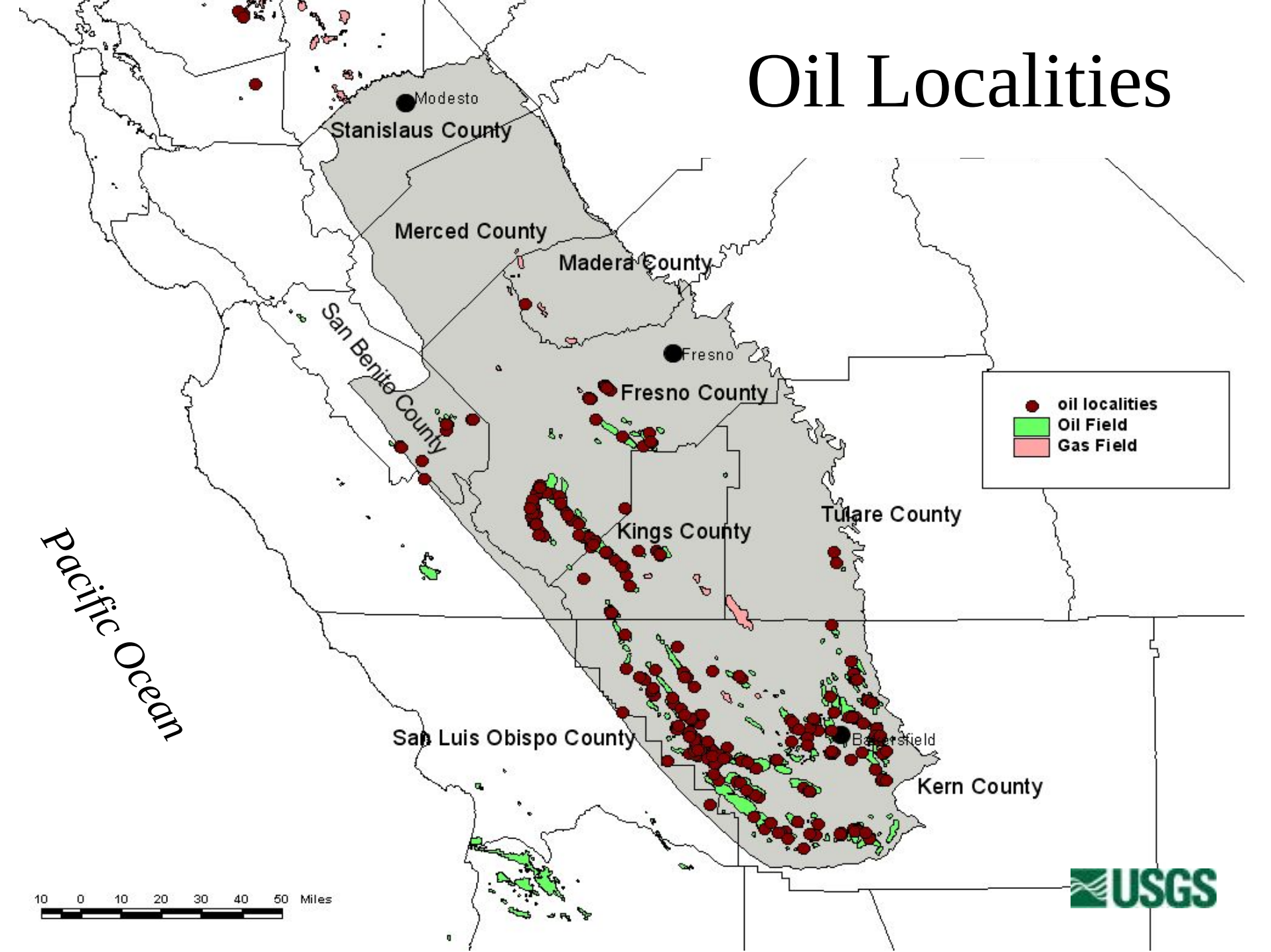
Data from Kaplan and others (1988) and Curiale and others (1985)

Petroleum System Maps

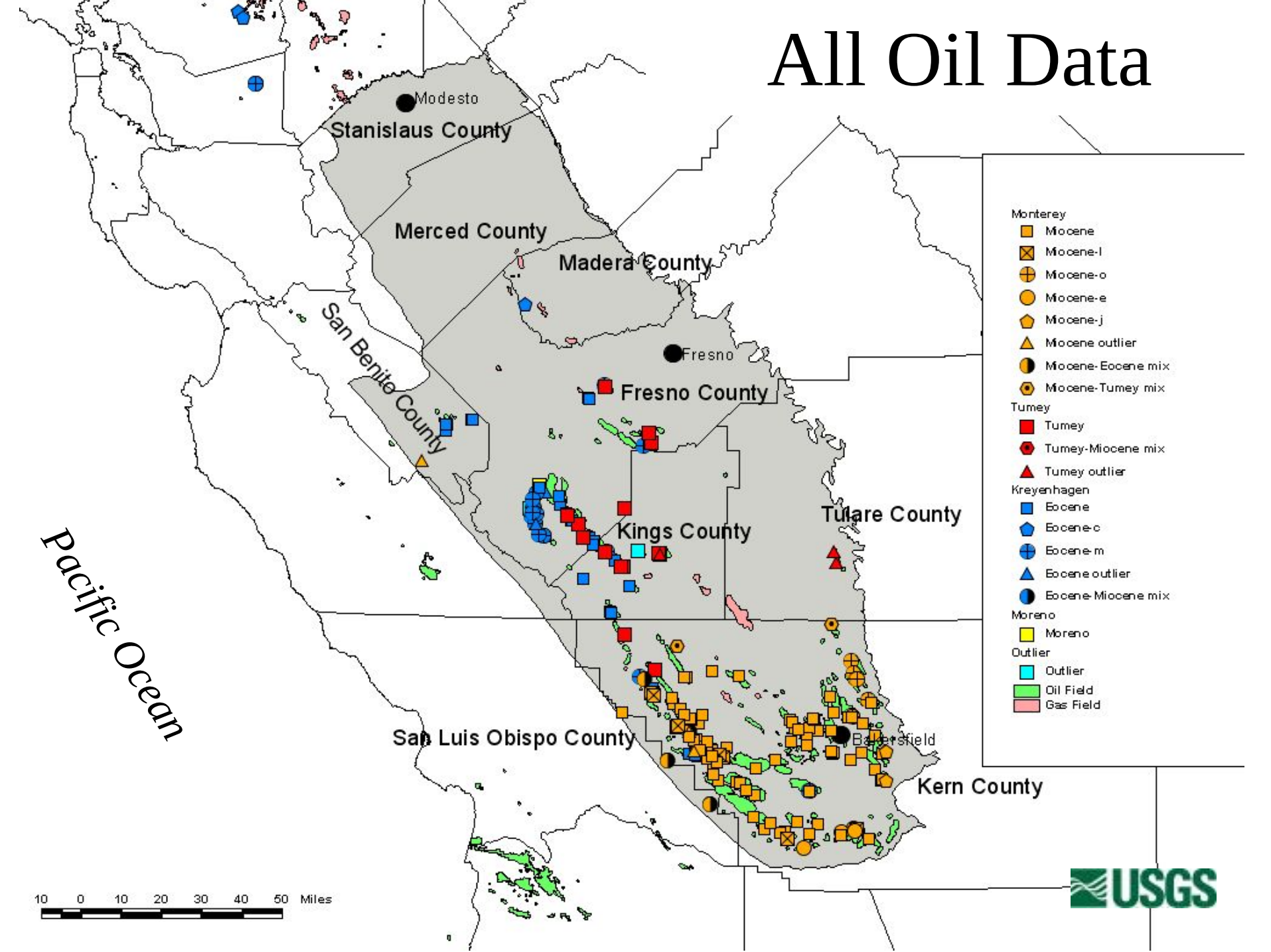
- Moreno
- Kreyenhagen
- Tumey
- Monterey

USGS

Oil Localities



All Oil Data


Modesto
Stanislaus County
Merced County
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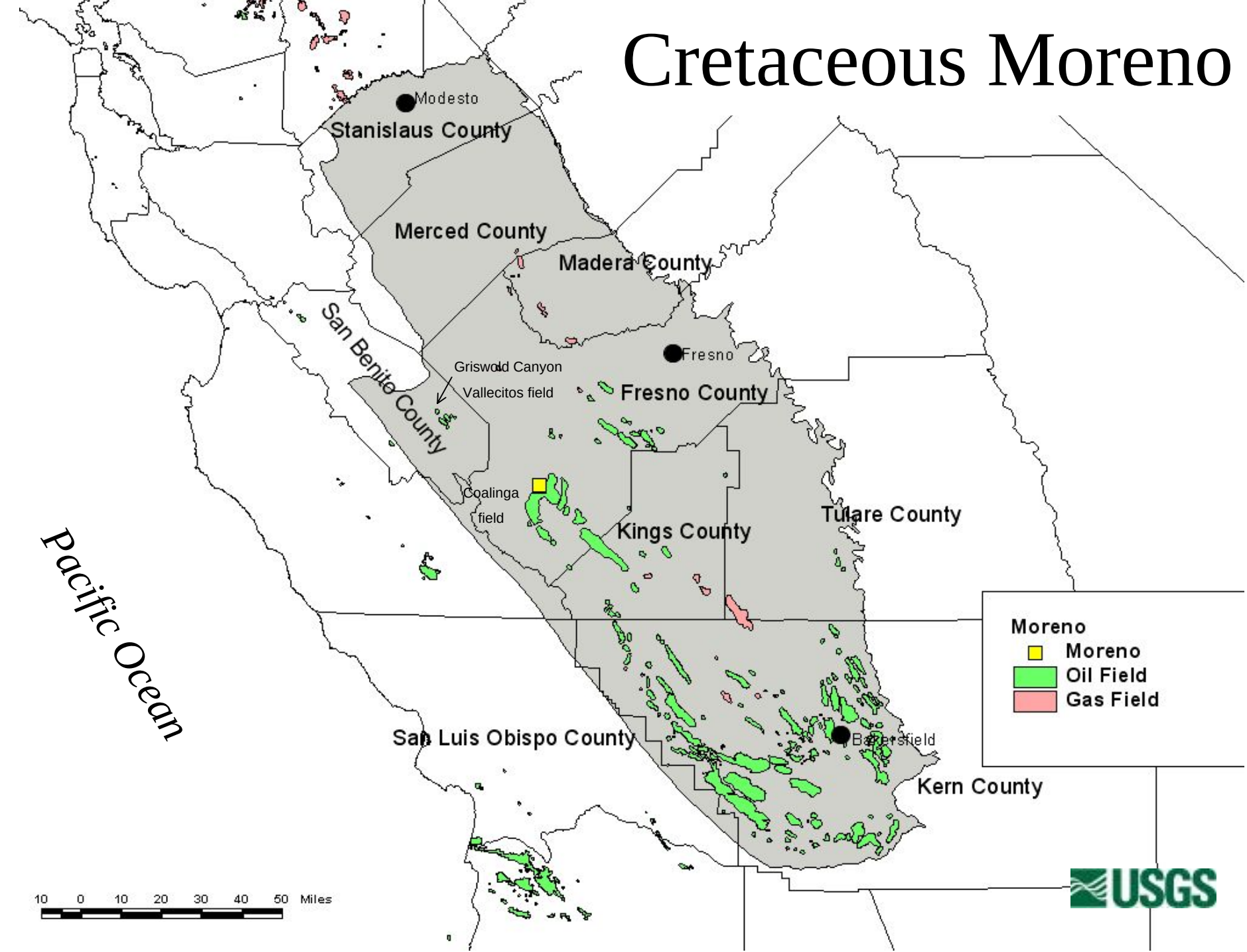
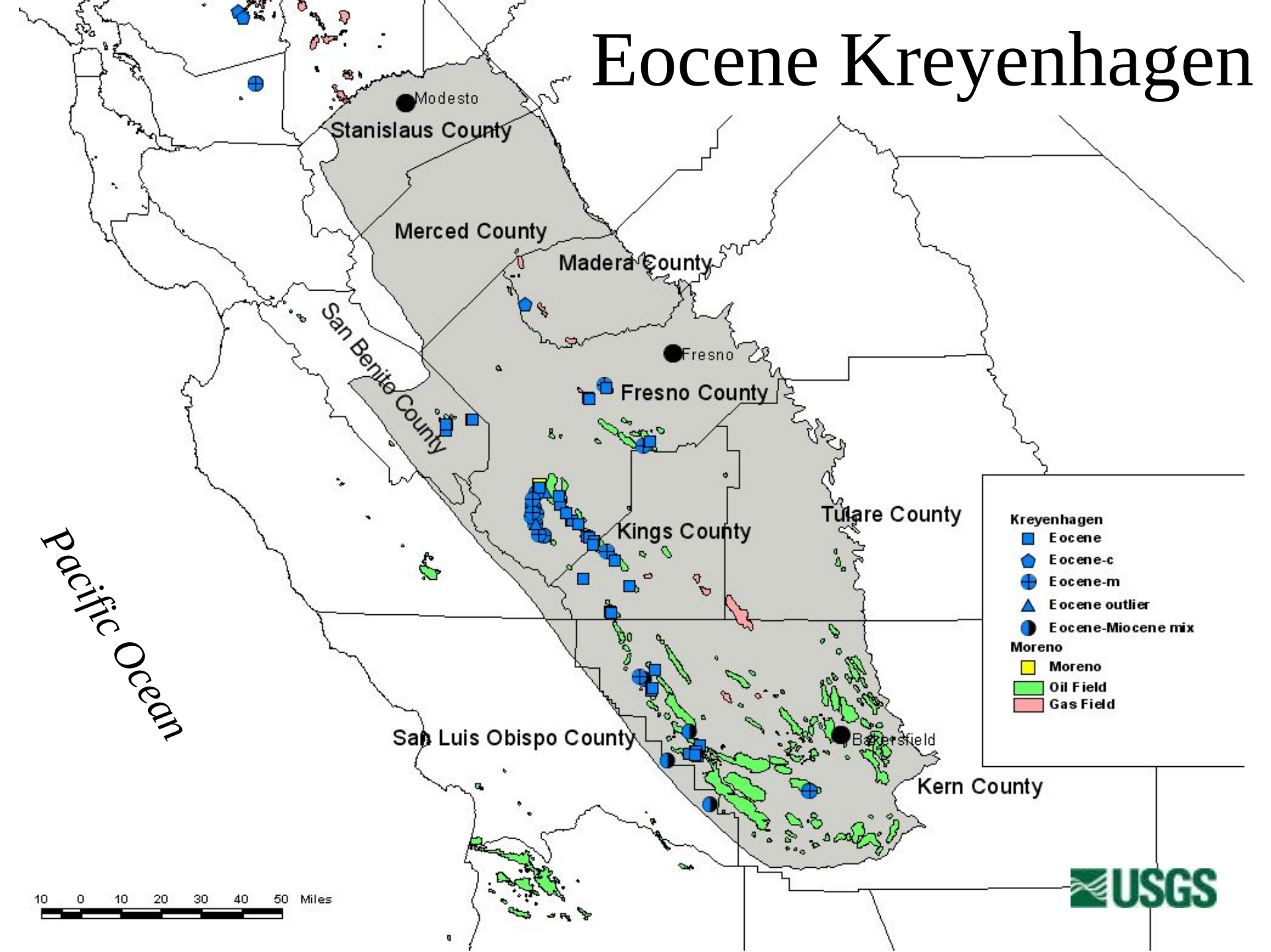
Fresno
Fresno County
San Benito County
Kings County
Tulare County
Pacific Ocean
San Luis Obispo County
Bakersfield
Kern County
Monterey
Miocene
Miocene-l
Miocene-o
Miocene-e
Miocene-j
Miocene outlier
Miocene-Eocene mix
Miocene-Tumey mix
Tumey
Tumey
Tumey-Miocene mix
Tumey outlier
Kreyenhagen
Eocene
Eocene-c
Eocene-m
Eocene outlier
Eocene-Miocene mix
Moreno
Moreno
Outlier
Outlier
Oil Field
Gas Field
10 0 10 20 30 40 50 Miles
USGS

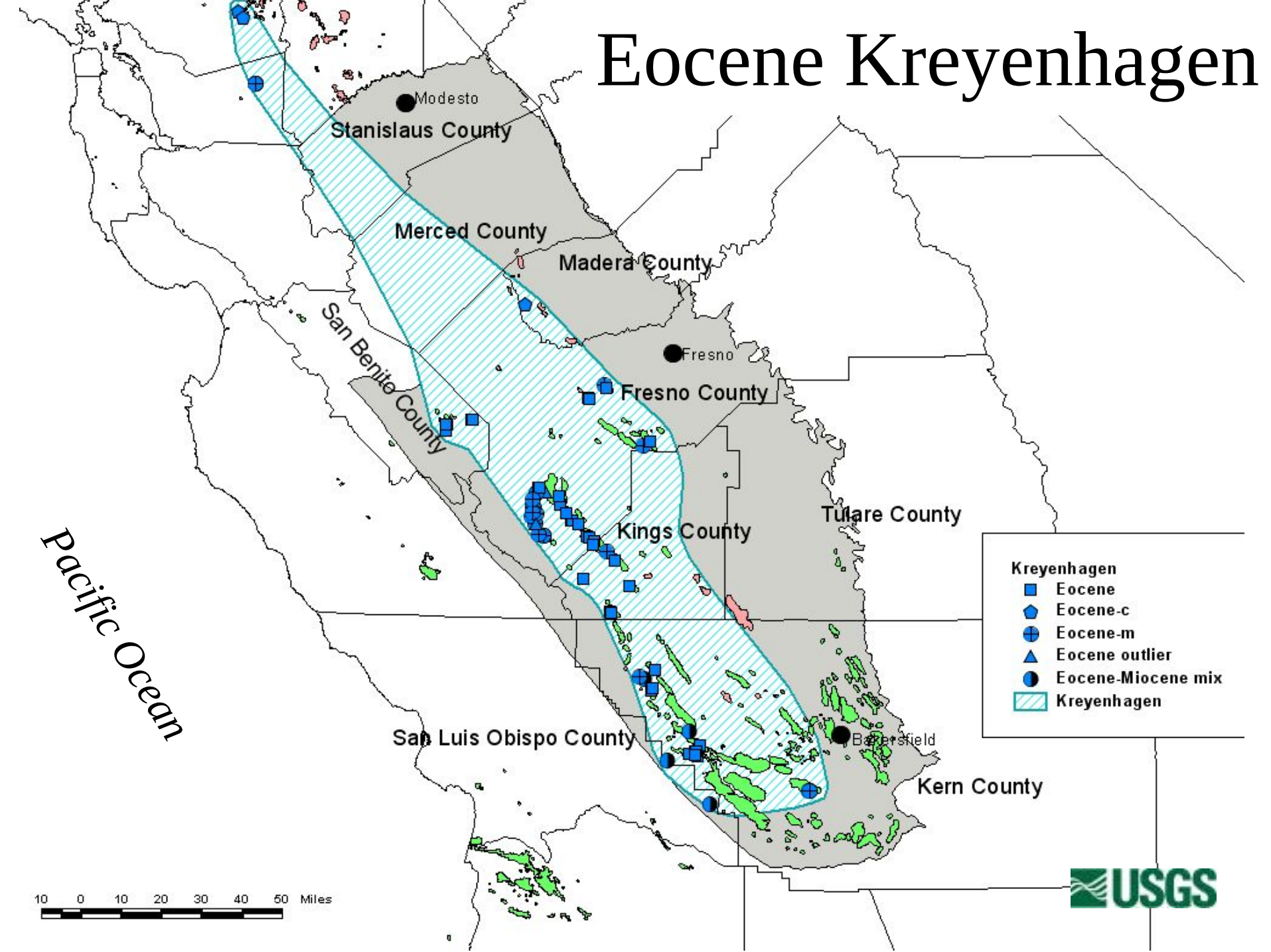
Cretaceous Moreno

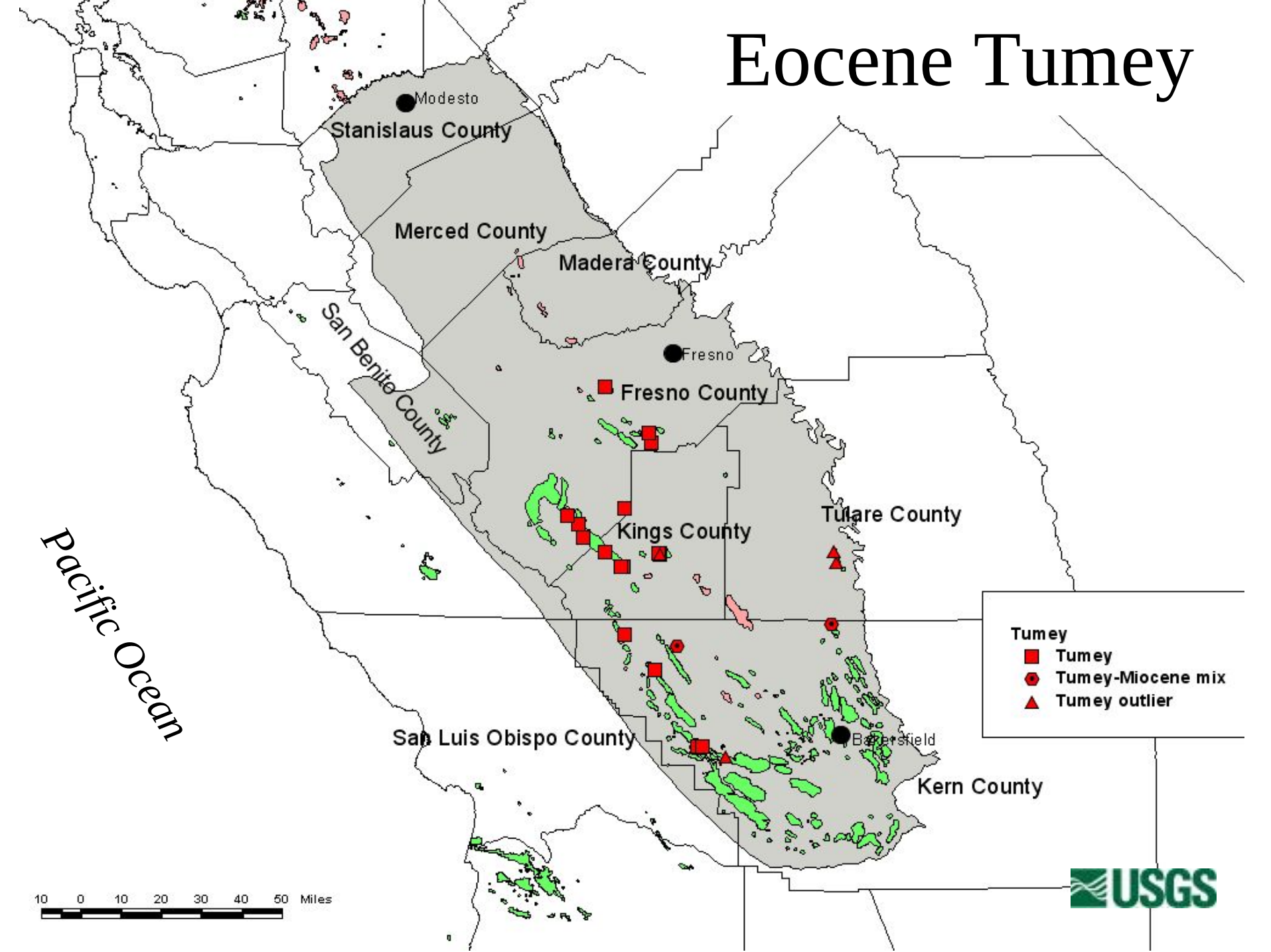


Eocene Kreyenhagen

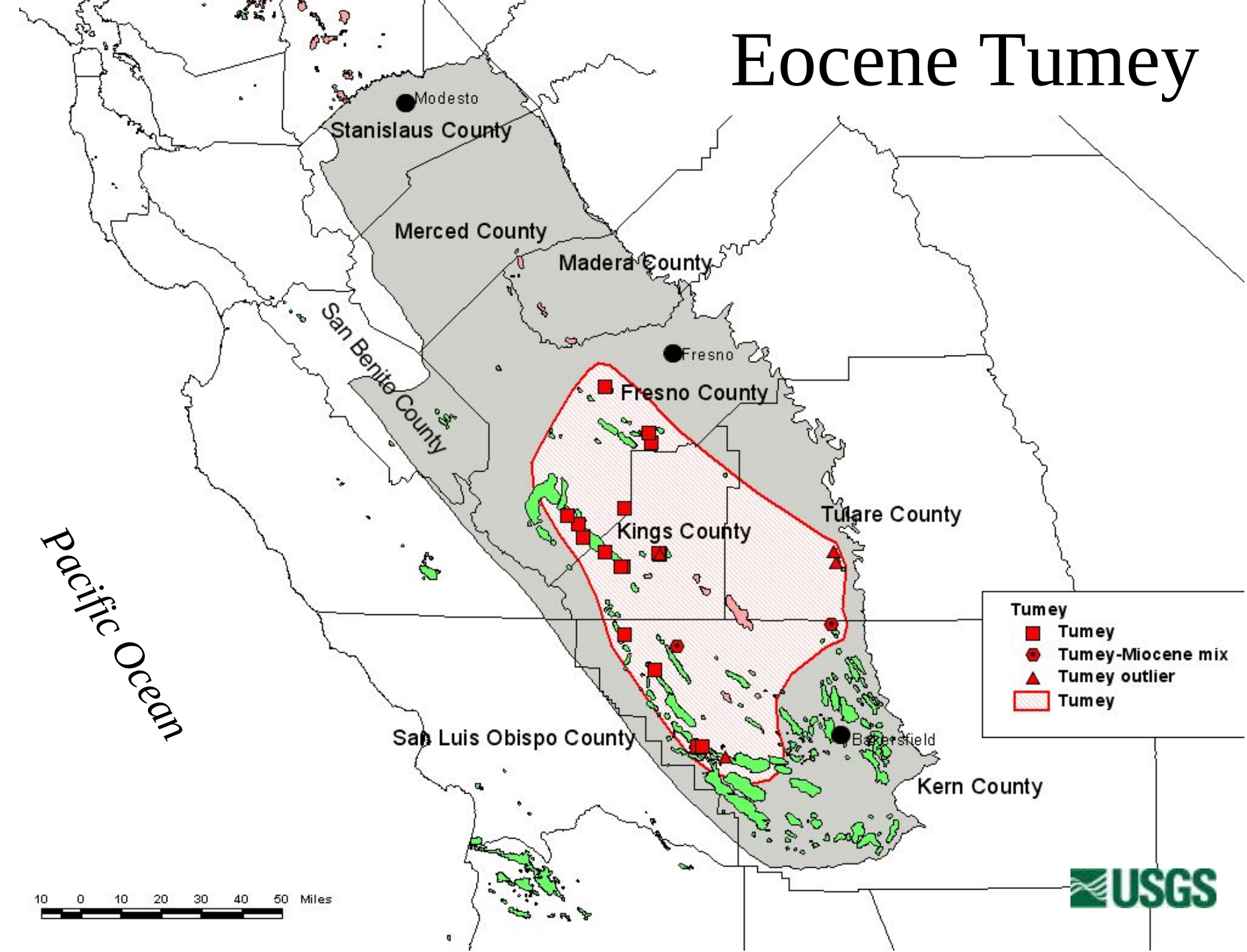


Eocene Kreyenhagen

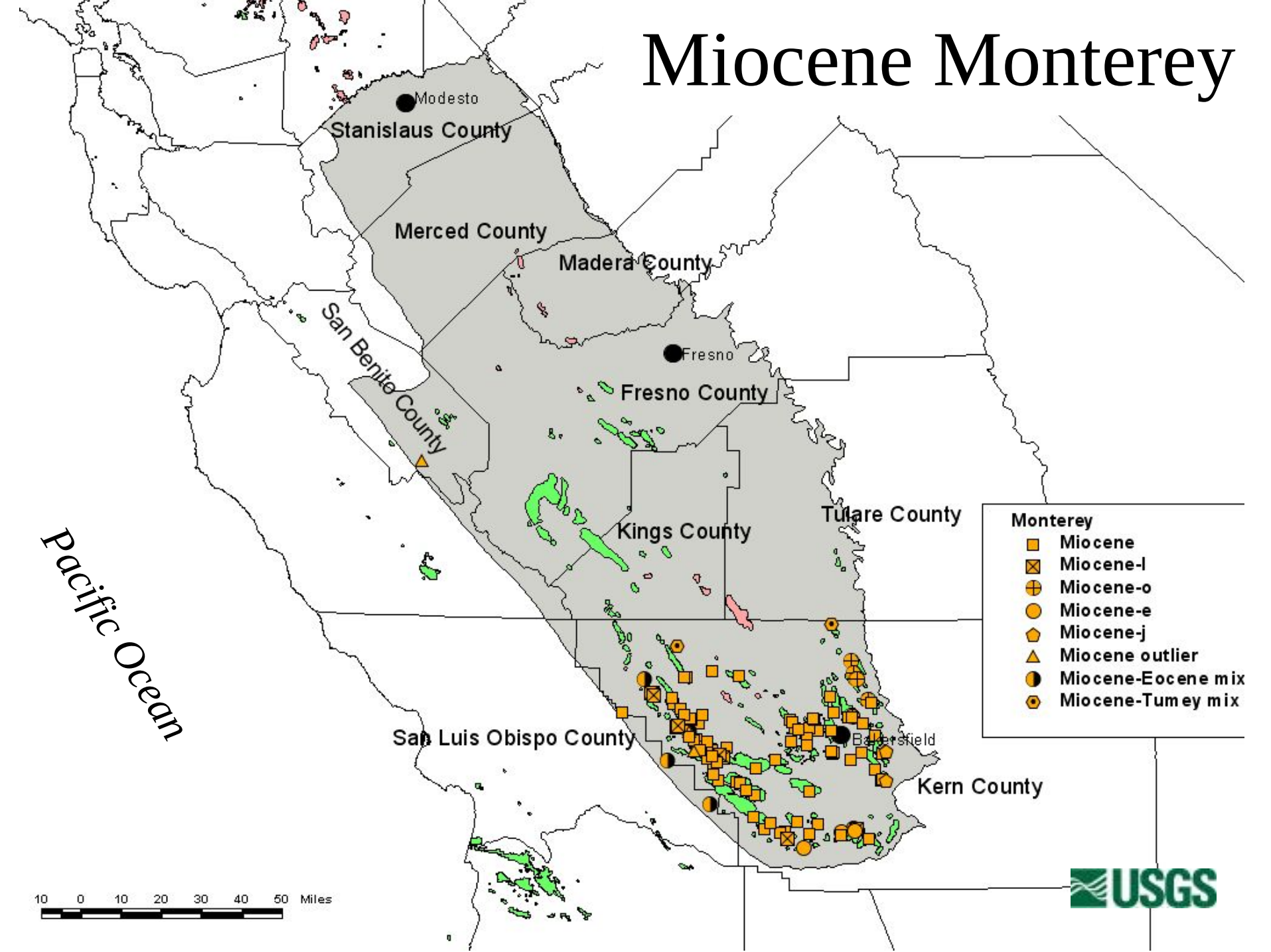



Eocene Tumey
Modesto
Stanislaus County
Merced County
Madera County
Fresno
Fresno County
San Benito County
Kings County
Tulare County
Pacific Ocean
San Luis Obispo County
Bakersfield
Kern County
Tumey
Tumey
Tumey-Miocene mix
Tumey outlier
10 0 10 20 30 40 50 Miles
USGS

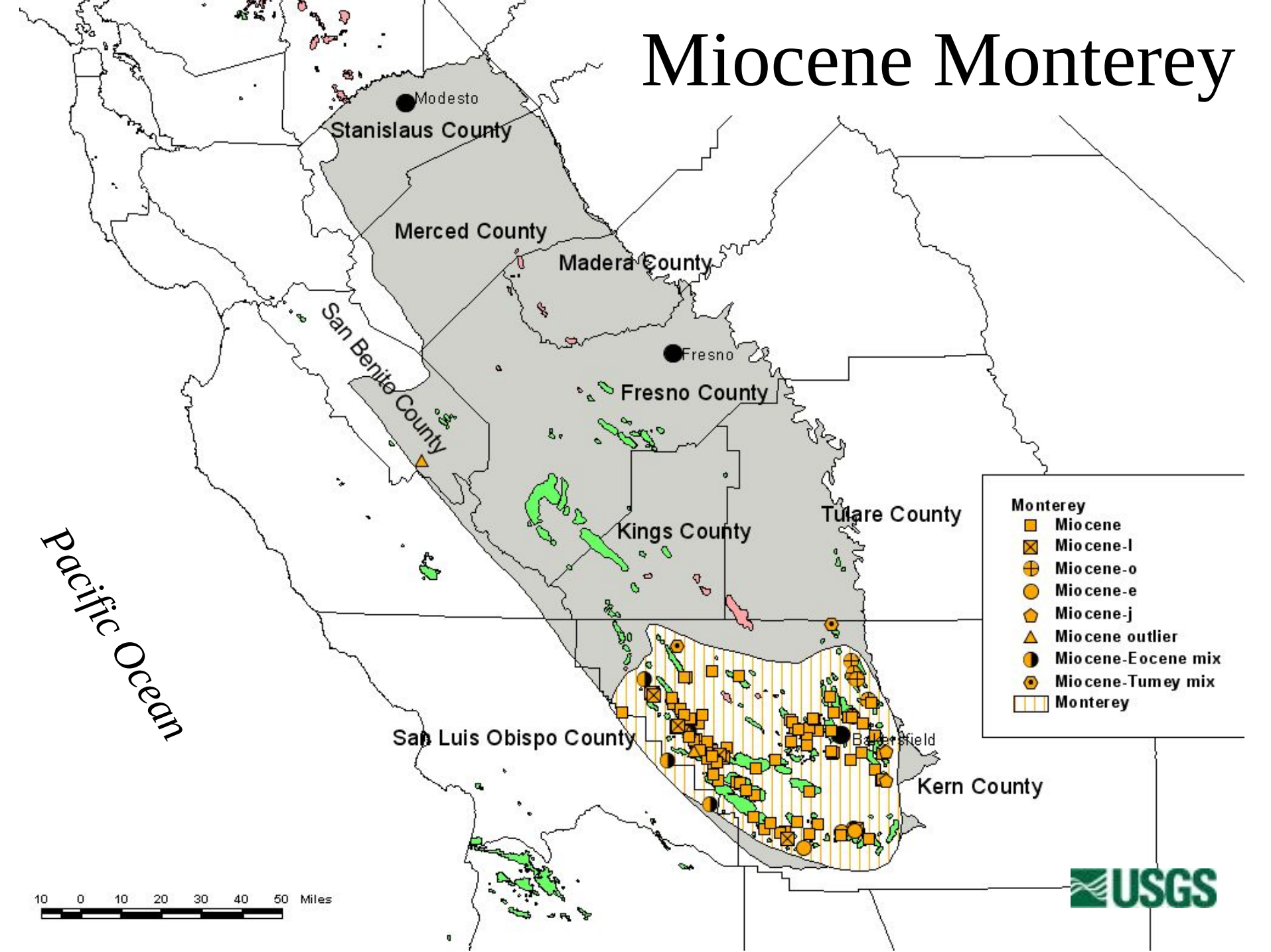
Eocene Tumey



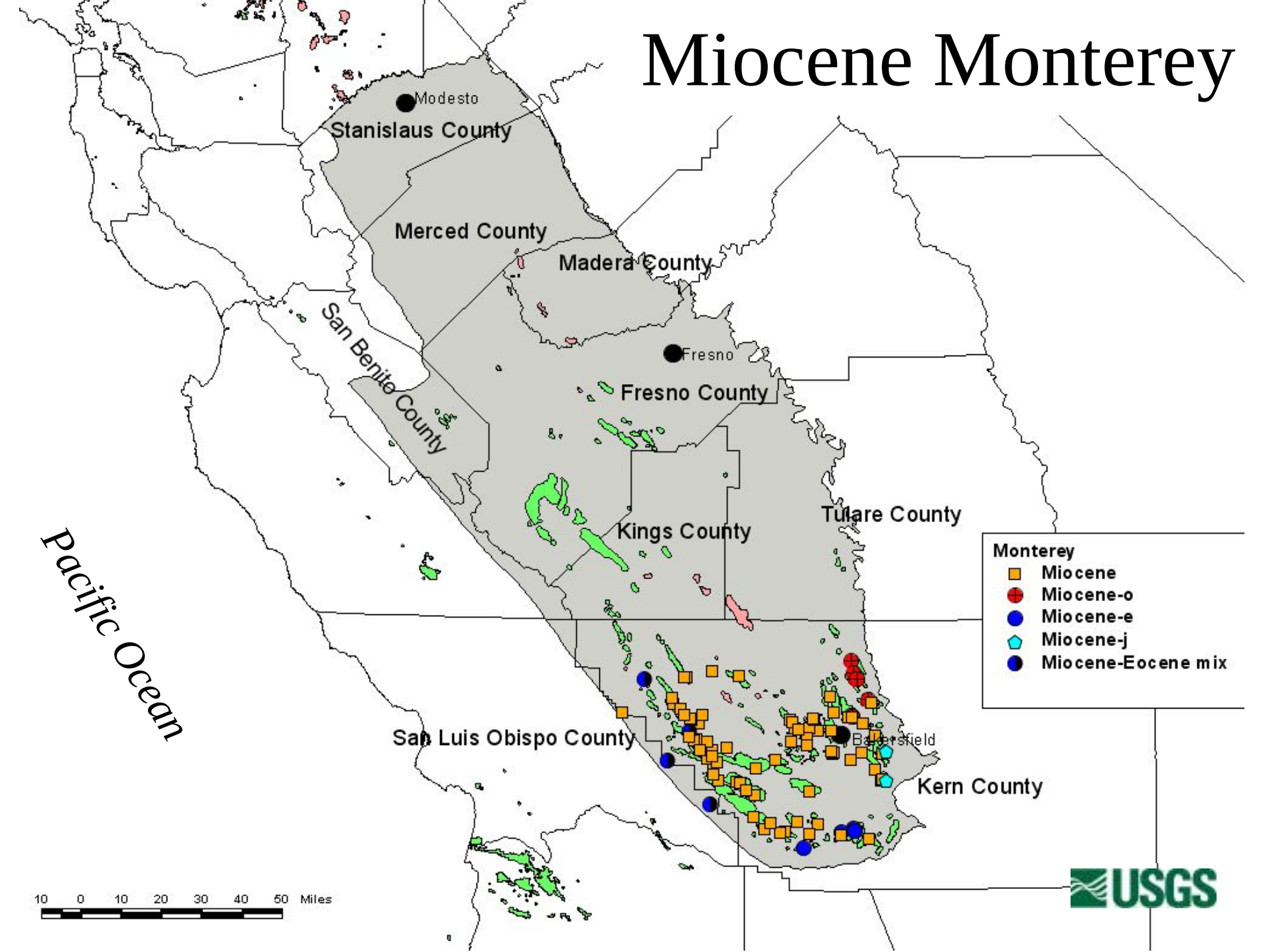
Miocene Monterey



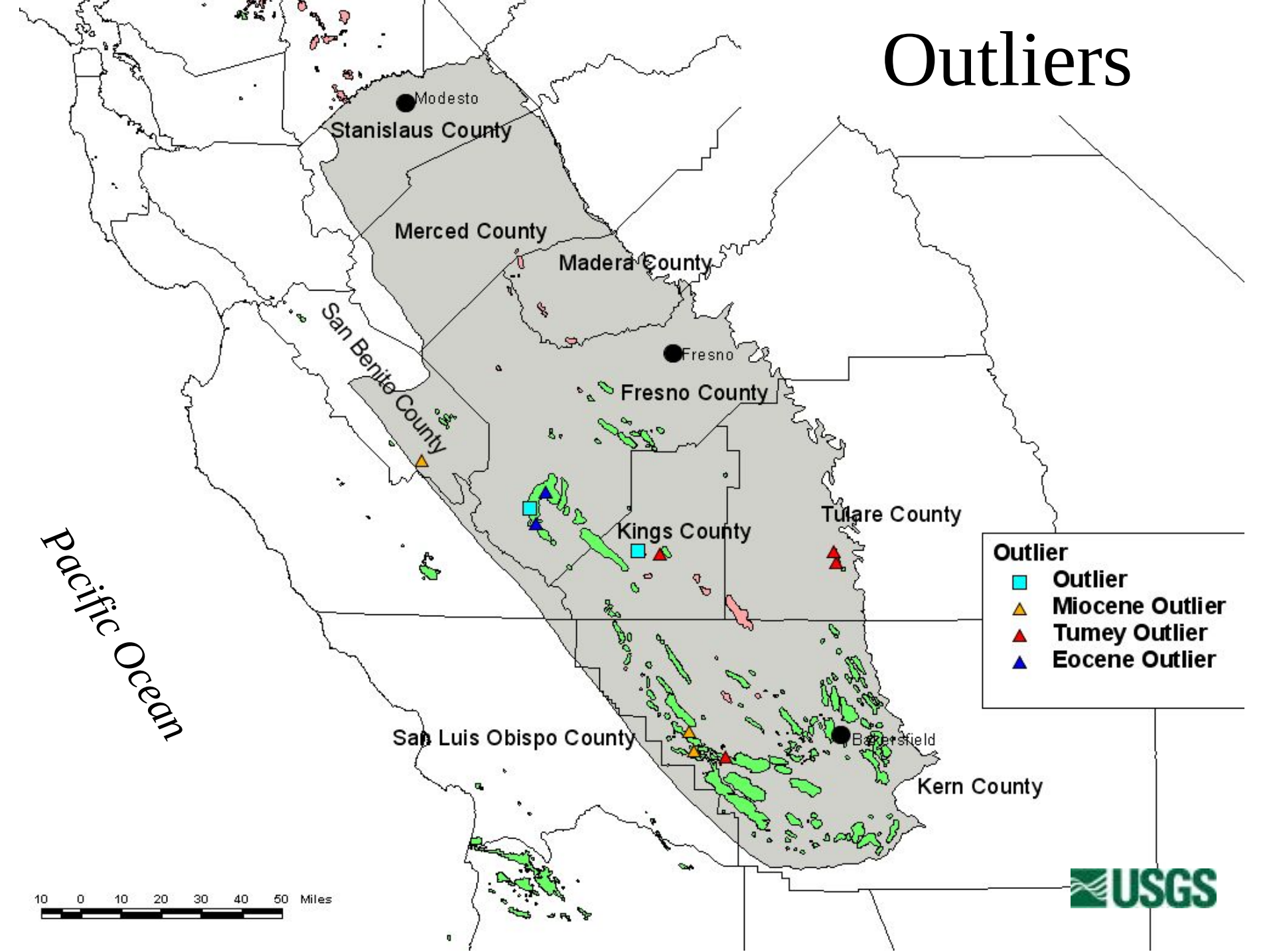
Miocene Monterey



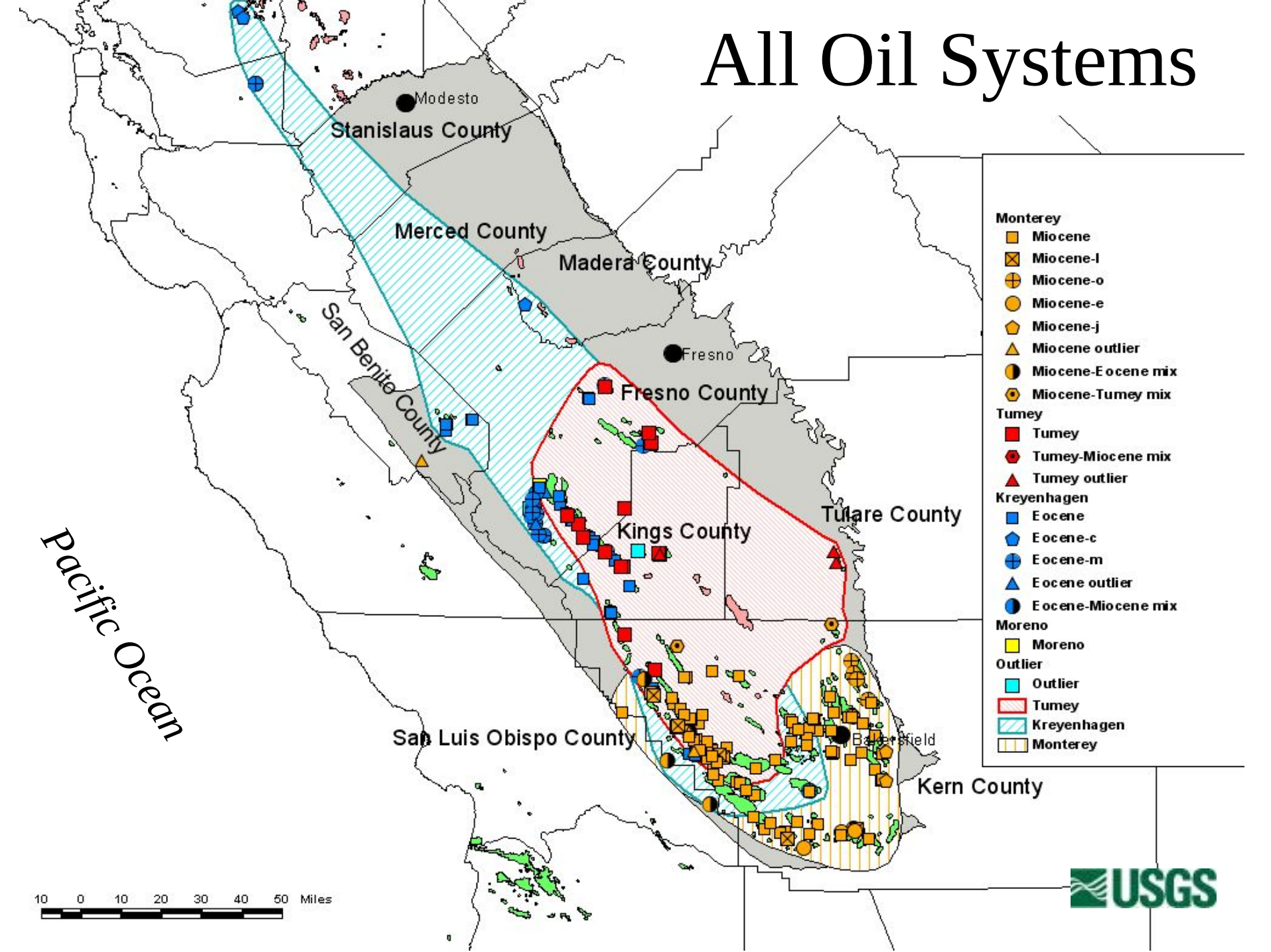
Miocene Monterey



Outliers


Modesto
Stanislaus County
Merced County
Madera County
Fresno
Fresno County
San Benito County
Kings County
Tulare County
Outlier
Outlier
Miocene Outlier
Tumey Outlier
Eocene Outlier
San Luis Obispo County
Bakersfield
Kern County
Pacific Ocean
10 0 10 20 30 40 50 Miles
USGS

All Oil Systems



Petroleum Systems Summary

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

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