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# Thermal Maturity Data Used by the U.S. Geological Survey for the U.S. Gulf Coast Region Oil and Gas Assessment

By Kristin O. Dennen, Peter D. Warwick, and Elizabeth Chinn McDade

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# Contents



# Tables



# Conversion Factors

| Multiply | By | To obtain |
|---|---|---|
| | Length | |
| foot (ft) | 0.3048 | meter (m) |

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F=(1.8×°C)+32$$

# Thermal Maturity Data Used by the U.S. Geological Survey for the U.S. Gulf Coast Region Oil and Gas Assessment

By Kristin O. Dennen,[1] Peter D. Warwick,[1] and Elizabeth Chinn McDade[2]

## Introduction

The U.S. Geological Survey (USGS) is currently assessing the oil and natural gas resources of the U.S. Gulf of Mexico region using a total petroleum system (TPS) approach (Klett and others, 2000). An essential part of this geologically based method is evaluating the effectiveness of potential source rocks in the petroleum system. The purpose of this report is to make available to the public RockEval and vitrinite reflectance data from more than 1,900 samples of Mesozoic and Tertiary rock core and coal samples in the Gulf of Mexico area in a format that facilitates inclusion into a geographic information system (GIS). These data provide parameters by which the thermal maturity, type, and richness of potential sources of oil and gas in this region can be evaluated.

## Description of Data

The data are divided into spreadsheets—data from oil and gas well cores and cuttings samples (table A–1) with American Petroleum Institute (API) numbers (American Petroleum Institute, 1979) and data from gulf coast coal core, surface, and mine samples (table A–2). Sample analyses are accompanied by geospatial data (latitude, longitude, and sample elevation estimates) and geographical information (county and State). API numbers are supplied with oil and gas well data to facilitate use of gulf coast region online State oil and gas databases to access more information.

Variable headings for the oil and gas well and coal sample tables differ slightly because coal samples do not have API numbers. Tables containing variable headings and explanations appear in tables 1 and 2.

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**Table 1.** Thermal maturity data for core and cuttings samples from oil and gas wells—Descriptions.

[Abbreviations used: API, American Petroleum Institute; $CO_2$, carbon dioxide; ft, foot]

| Variable heading | Description or explanation |
|---|---|
| API no. | A unique number that identifies a well site and cores taken from that well in public well records. It specifies the State, the county or parish, and in some States, a permit number for the well issued by the State in which the well is drilled. |
| Lease/well name | Most wells are named for the person leasing or owning the land where the well is drilled. If multiple holes are drilled on a property, then the name is usually followed by a number. |
| Field name | Name of the oil or gas field in which the well is situated. This is usually specified in public well records. If the well is not associated with a particular field, then the well is usually called a "wildcat." |
| Remarks, longitude and latitude | Arkansas township and range coordinates were converted to latitude and longitude using the University of Montana's conversion program available at http://www.esg.montana.edu/gl/trs-data.html. |
| Longitude | Decimal degrees of longitude. |
| Latitude | Decimal degrees of latitude. |
| Remarks, sample elevation estimates (ft) | If a sample is from an offshore well, this elevation includes the depth of the water above the well location and is indicated by the remark "subsea." |
| Sample elevation estimates (ft) | Subsurface core sample elevations were estimated by subtracting the core depth reported for the sample from the land surface elevation at the latitude and longitude of the core hole. |
| Group or formation | Geologic name of group or formation from which sample was taken. |
| Group or formation age | Geologic name for the age of the group or formation from which sample was taken. |
| State | State where well is located and where there are related public records. |
| County/parish | County or (in the case of Louisiana) parish in which the well is located. If the sample is from an offshore well in Federal waters, then there is no county or parish name associated with it. |
| $T_{max}$ | Temperature from RockEval analysis corresponding to maximum $S_2$ production in °C. |
| $S_1$ | Milligrams of free organic compounds per gram of sample. |
| $S_2$ | Milligrams of hydrocarbons derived from kerogen, resins, and asphaltenes per gram of sample. |
| $S_3$ | Milligrams of $CO_2$ per gram of sample released between 300° and 390°C. |
| PI | Production index = $S_1 / S_1 + S_2$. |
| TOC | Total organic carbon content of sample in weight percent. |
| HI | Hydrogen index = milligrams $S_2$ per gram TOC × 100. |
| OI | Oxygen index = milligrams $S_3$ per gram TOC × 100. |
| Remarks TAI | Range of visual reference scale used for TAI determination. |
| TAI | Thermal alteration index; determined using a visual reference scale. |
| Remarks $\%R_o$ | If the $R_o$ values are calculated, then this is noted. The formula for calculating the value, if known, is provided. |
| $\%R_o$ | Mean value of percent reflectance measurements of vitrinite in oil (American Society for Testing and Materials, 2007), unless otherwise noted. |
| Remarks, source of analyses | In a single published report, different analytical laboratories providing analyses are indicated if given. If data are unpublished, then that and permission to publish the data are indicated. |
| Source of analyses | Published reference from which the analyses were taken or laboratory that provided the analyses. |
| Location source (if different from analytical source) | If the locations for the well core samples were not provided in the publication or by the analytical laboratory, then the locations were retrieved from a publically available online database of well locations. |

**Table 2.** Thermal maturity data for coal core, surface, and mine samples—Descriptions.

[Abbreviations used: $CO_2$, carbon dioxide; ft, foot]

| Variable heading | Description or explanation |
|---|---|
| Sample name | Name of sample provided in report from which the analyses were taken. |
| Sample type | Description of sample type given in publication or by collector of a sample; whether it is from a surface sample (taken from an outcrop) or a well core or cuttings or taken from within a coal mine. The analysis source should be consulted for a complete description. |
| Location name | Name of mine or geographical name of area of outcrop from which coal sample was taken. |
| Longitude | Decimal degrees of longitude. |
| Latitude | Decimal degrees of latitude. |
| Sample elevation estimates (ft) | Subsurface core sample elevations were estimated by subtracting the core depth or coal seam depth reported for the sample from the land surface elevation at the latitude and longitude at the sample site. If a sample was taken at the surface, then this is the height of the outcrop given by the collector or publication. |
| Group or formation | Geologic name of group or formation from which sample was taken. |
| Group or formation age | Geologic name for the age of the group or formation from which sample was taken. |
| State | State where mine or surface sample was obtained. |
| County/parish | County or (in the case of Louisiana) parish where the mine or surface sample was obtained. |
| $T_{max}$ | Temperature from RockEval analysis corresponding to maximum $S_2$ production in °C. |
| $S_1$ | Milligrams of free organic compounds per gram of sample. |
| $S_2$ | Milligrams of hydrocarbons derived from kerogen, resins, and asphaltenes per gram of sample. |
| $S_3$ | Milligrams of $CO_2$ per gram of sample released between 300° and 390°C. |
| PI | Production index = $S_1 / S_1 + S_2$. |
| TOC | Total organic carbon content of sample in weight percent. |
| HI | Hydrogen index = milligrams $S_2$ per gram TOC × 100. |
| OI | Oxygen index = milligrams $S_3$ per gram TOC × 100. |
| $\%R_o$ | Mean value of percent reflectance measurements of vitrinite in oil (American Society for Testing and Materials, 2007), unless otherwise noted. |
| Remarks, source of analyses | If data are unpublished that is indicated. If special permission to publish the data was granted, that is indicated. |
| Source of analyses | Published reference from which the analyses were taken or laboratory that provided the analyses. |
| Location source (if different from analytical source) | If the locations for the core samples were not provided in the publication or by the analytical laboratory, then the locations were retrieved from a publically available online database of well locations. The database source of the location data is indicated. |

# Suggestions for Using and Interpreting the Data

## Geochemical Analyses

Each sample entry in the dataset contains a reference to the source of the data. Because the sample analyses come from a variety of sources, it is important to understand how the analytical values were derived and how they can be compared. The source for each group of data should be consulted to ascertain the analytical methods and reporting conventions used.

Definitions of the geochemical parameters used in source rock evaluation and descriptions of how source rock geochemical analyses are applied to petroleum exploration can be found in Peters and Casa (1994). The American Society for Testing and Materials (ASTM) (2007) methods D2797 and

D2798 respectively contain detailed descriptions of how samples are prepared and analyzed for vitrinite reflectance measurements and how the measurements are reported.

Some of the major source rocks in the Gulf of Mexico, such as the Jurassic Smackover Formation, are marine carbonates. This creates a set of problems for thermal maturity interpretation from vitrinite reflectance data owing to the frequently very low concentrations of nonmarine, plant-based materials from which vitrinite reflectance measurements are made. Two references that address the problems of source rock thermal maturity evaluation in the Gulf of Mexico are Sassen and Moore (1988) and Jarvie and others (2001).

### Latitudes, Longitudes, and Identification Information

Sometimes the sources of the data and of the geospatial information are different. The authors verified and updated the well identification and location information where possible, but there may be recent changes in the API numbers owing to the fact that the API well identification system is being updated to reflect constantly evolving drilling technology (IHS Energy Group, 2008). For the data from Arkansas, only township and range figures were available, so those data were converted using the online calculator at Montana State University's Website (http://www.esg.montana.edu/gl).

Wells drilled before the introduction of digital recordkeeping may not appear in online databases; therefore it may be necessary to contact the appropriate State recordkeeping agency directly for up-to-date information.

### Elevation Estimates

Subsurface core sample elevations were estimated by subtracting the reported core depth from the land surface elevation at the latitude and longitude of the core hole. The accuracy of the estimated elevation estimations depends not only on the reported latitude and longitude but also on the source of data for the digital elevation model (DEM) used for the estimates. Because the land surface elevations in this report have been determined by several DEMs, it is best to consult the sources for each set of data if extremely accurate sample elevations are needed. The USGS National Elevation Dataset (NED) is the basis for many DEMs (U.S. Geological Survey, 2002, 2006).

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# Appendix A.—Thermal Maturity Data