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Chapter 1—Analyses of Oil Shale Samples from Core Holes and Rotary-Drilled Wells from the Green River Formation, Southwestern Wyoming

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Chapter 1—Analyses of Oil-Shale Samples from Core Holes and Rotary-Drilled Wells from the Green River Formation, Southwestern Wyoming

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Abstract

This CD-ROM chapter is a database of digitized Fischer (shale-oil) assays of cores and cuttings from boreholes drilled in the Eocene Green River oil shale deposits in southwestern Wyoming. Assays of samples from some surface sections are also included. Most of the Fischer assay analyses were made by the former U.S. Bureau of Mines (USBM) at its laboratory in Laramie, Wyoming. Other assays, made by institutional or private laboratories, were donated to the U.S. Geological Survey (USGS) and are included in this database as well as Adobe PDF-scanned images of some of the original laboratory assay reports and lithologic logs prepared by USBM geologists. The size of this database is 75.2 megabytes and includes information on 971 core holes and rotary-drilled boreholes and numerous surface sections. Most of these data were released previously by the USBM and the USGS through the National Technical Information Service but are no longer available from that agency. Fischer assays for boreholes in northeastern Utah and northwestern Colorado have been published by the USGS.

Additional data include geophysical logs, ground-water data, chemical and X-ray diffraction analyses, and other data. These materials are available for inspection in the office of the USGS Central Energy Resources Team in Lakewood, Colorado.

The digitized assays were checked with the original laboratory reports, but some errors likely remain. Other information, such as locations and elevations of core holes and oil and gas tests, were not thoroughly checked. However, owing to the current interest in oil-shale development, it was considered in the public interest to make this preliminary database available at this time.

Introduction

For many years, the U.S. Geological Survey (USGS) has been collecting drill-hole samples of the Eocene Green River oil-shale deposits in the three-State area of Colorado, Wyoming, and Utah (fig. 1). Some data and samples of drill cores were also collected from the Devonian oil-shale deposits in Eastern United States as well as from a few foreign deposits. The purpose of collecting the oil-shale drill cores and data was to preserve them for study by researchers, energy companies, and other government agencies, as such deposits may move toward possible commercial development.

From the late 1940s to the early 1980s, the former U.S. Bureau of Mines (USBM) analyzed many cores and cuttings from holes drilled in the Green River oil-shale deposits in the three-State area. Only a few exploratory holes have been drilled for oil-shale evaluation after oil prices collapsed in the 1980s and interest in oil shale waned. Energy companies holding private or leased public oil-shale lands in the region generously

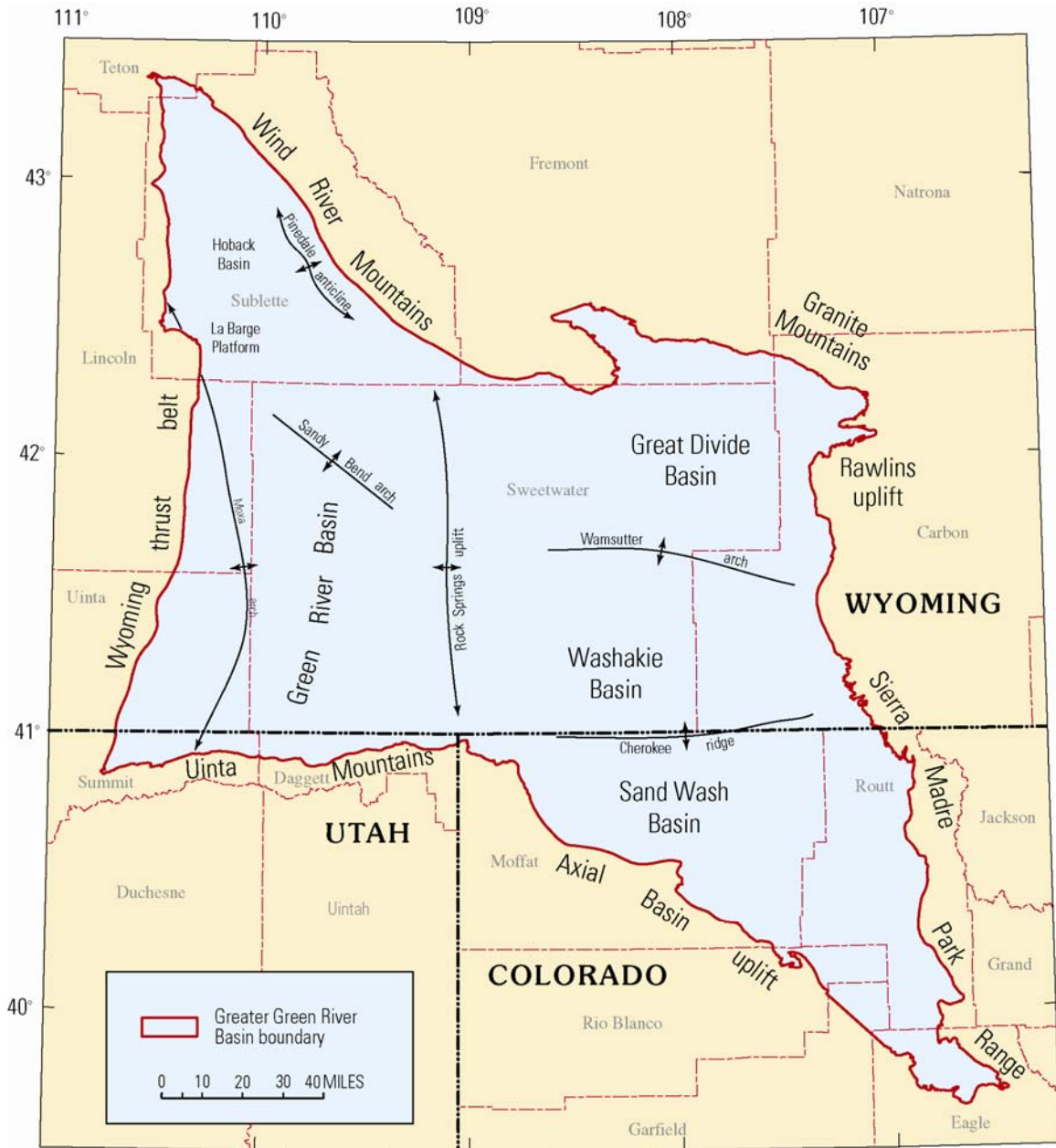


Figure 1. Map showing boundary of Greater Green River Basin and areas of Green River, Great Divide, Washakie, and Sand Wash Basins, county lines, and major geologic structures and uplifts in southwestern Wyoming, northwestern Colorado, and northeastern Utah. Modified from Finn and others (2005).

donated much analytical data, as well as drill cores, that are now being preserved by the USGS. Fischer assays for boreholes in northeastern Utah and northwestern Colorado have been published by the USGS (Dyini, 1998; Dyini and others, 2006).

During the 1970s and 1980s, the USBM and USGS each prepared digital databases of the Fischer assays of the Green River oil-shale deposits. The USBM database included all of the assays made at its Laramie, Wyoming, laboratory from the 1940s to the early 1980s, plus some analyses of cores furnished by several energy companies. These data were made available to the public through the National Technical Information Service (NTIS) (Laramie Energy Technology Center, 1984). The USGS prepared a digital database of the USBM assays but also included analyses from numerous core holes drilled by private companies that were not published by the USBM. These analyses were also made available to the public on magnetic tapes through the NTIS (Pitman, 1982; Pitman and Van Trump, 1974, 1975). However, these tapes have degraded in storage and can no longer be read.

In the early 1990s the U.S. Department of Energy (DOE) and the USGS initiated a cooperative project to create a digital National Oil Shale Database (NOSDB) that would combine all available Fischer assay information in the possession of the USBM and the USGS and prepare it for publication. The DOE provided 2 years of funding for clerical help to digitize the Fischer assay analyses. Most of this work was accomplished at the local office of the DOE in Laramie, Wyoming, under the direction of the senior author. The original assay data sheets were scanned and saved as Adobe PDF files for this disc.

CD-ROM

This CD-ROM chapter reports on data found in four folders: Assays, Images, Spatial, and Spreadsheets. The Assays folder contains column-delimited and text files for 426 drill holes with Fischer assay data. The Images folder contains 258 files of the original laboratory Fischer assay reports and lithologic drill-core descriptions in Adobe PDF format. Each file is identified by a USGS numbering system that includes a prefix "W" for Wyoming, followed by a four-digit number, and a suffix of "R" for rotary holes, "F" for Fischer assay, or "L" for lithologic log (example, W0346R_F.pdf). The Spatial folder contains an ArcGIS point shapefile that includes the locations of 906 oil-shale exploration holes in Wyoming and its metadata file (wy_oilshale_pts_dd.shp.xml). The approximate locations of these drill holes are shown in figure 2. ASCII and Google Earth KML file formats of the locations of the drill holes are also included in the Spatial folder. The majority of the locations were digitized in ArcGIS v. 9.1, based on footage measurements east and west of Public Land Survey System (PLSS) section corners contained in the original database. A custom tool that combined the distance and sketch tools in ArcEditor was used to measure and plot points. Public Land Survey System files used for plotting locations were obtained from Wyoming Bureau of Land Management and projected to North American Datum 27 (NAD27). Where footage measurements were not available, a given well was digitized as being in the center of the quarter-quarter section, in the quarter section or in the center of the section—that is, the best location data available in the original database were used. In a minimal number of cases where location data in the original database were questionable, locations were verified using the State of Wyoming Oil and Gas Conservation Commission's online database.

The Spreadsheets folder includes two EXCEL spreadsheets (WY_Borehole_Info.xls, WY_Oil_Shale_Assays.xls) and one Access database (WY_Oil_Shale_Assays.mdb). The assays spreadsheet includes 47,003 assays that were digitized from the original laboratory assay reports, such as those shown as images in the Images folder. The WY-Borehole_Info.xls spreadsheet contains information for 971 core holes and rotary-drilled wells, and oil and gas tests, as well as a few surface sections of oil shale. The borehole information file includes well location, operator and well name, surface elevation, core-hole location when known, depths of lithologic units, geophysical logs, and other data.

Table 1 near here

The Chapter 1 root directory contains this chapter and the Images subdirectory containing 258 files of the original laboratory Fischer assay reports and lithologic drill-core descriptions in Adobe PDF format. Each file is identified by a USGS numbering system that includes a prefix "W" for Wyoming, followed by a four-digit number, and a suffix of "R" for rotary holes, "F" for Fischer assay, or "L" for lithologic log (example, W0346R_F.pdf).

Fischer Assays

Fischer assays were conducted on samples from core holes drilled for oil shale and trona ($\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$) and on rotary cuttings from wells drilled for oil and gas. A few assays of outcrop samples were not included in the spreadsheet but are included with the imaged laboratory data sheets. The assays are grouped into 426 sets of data representing 186 core holes and 240 rotary-drilled wells.

The Fischer assay is the accepted standard for measuring oil yields from oil shale; however, the assay does not give a complete picture of the energy available in the organic fraction of the oil shale. For example, the method does not measure the composition of the gases released, but merely subtracts the sum of the weights of oil, water, and spent shale from 100 percent and reports this amount as “gas plus loss.” Thus, “gas plus loss” accounts for all noncondensable gases released in the Fischer assay, including light hydrocarbons and carbon dioxide, plus analytical errors. Despite such shortcomings, the Fischer assay remains a useful tool for evaluating an oil-shale resource.

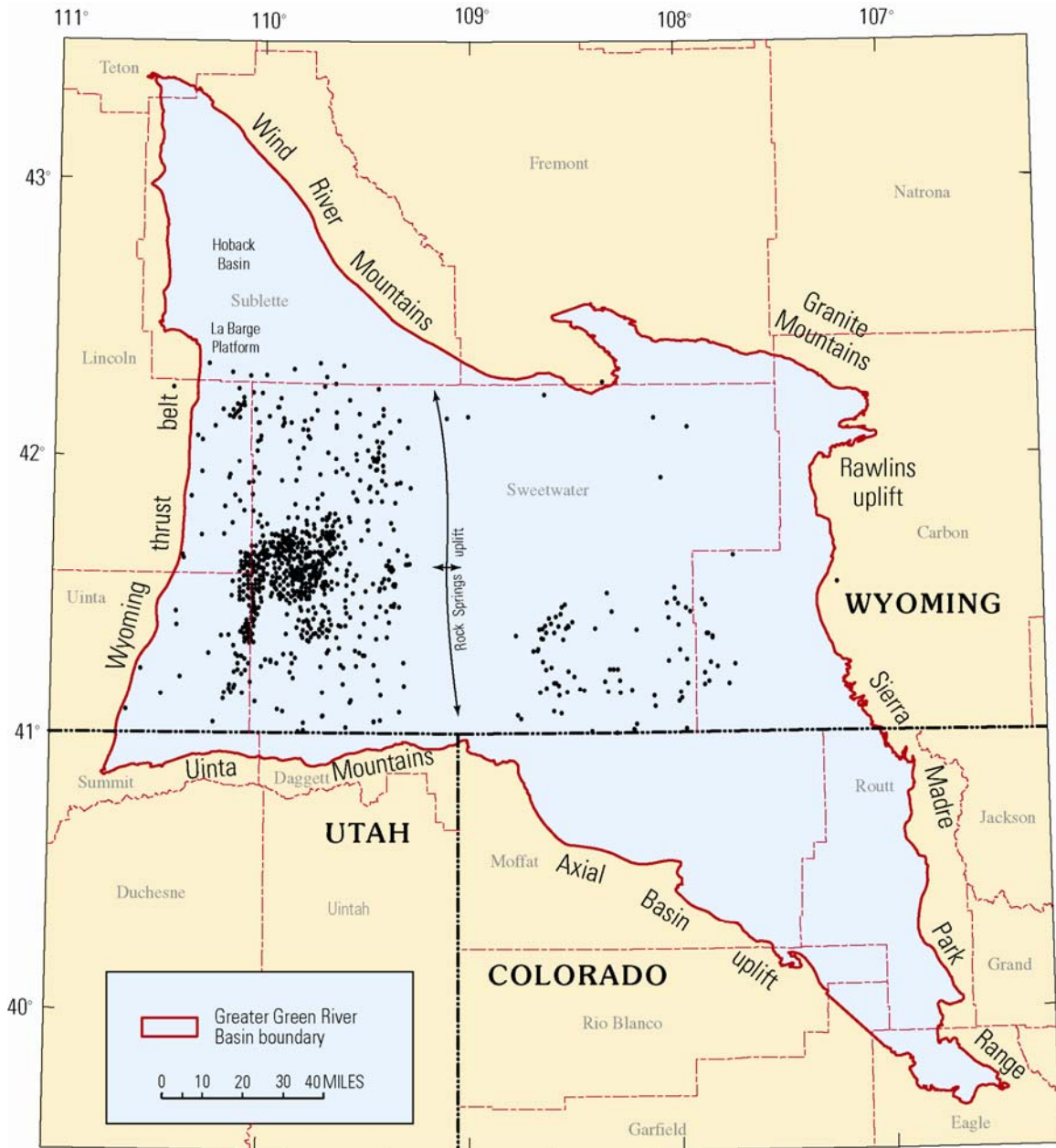


Figure 2. Map showing the approximate locations of 906 drill holes included in the Wyoming oil-shale assay database (WY_oil_Shale_Assays.xls), southwestern Wyoming. See figure 1 for locations of subbasins in the Greater Green River Basin.

Table 1. Names and definitions for the column headers for the Wyoming oil-shale borehole information spreadsheet (WY_Borehole_Info.xls).

Column name	Column definition
USGSID	Unique ID assigned by staff geologist
EW_FT	Distance in feet measured east or west from section line
NS_FT	Distance in feet measured north or south from section line
QQSEC	Quarter-quarter section
SEC	Section
TWP	Township
RNG	Range
LATITUDE	Latitude in decimal degrees, North American Datum 1927, software-calculated
LONGITUDE	Longitude in decimal degrees, North American Datum 1927, software-calculated
XUTM12	Easting value in meters, Universal Transverse Mercator, zone 12, North American Datum 1927, software-calculated
YUTM12	Northing value in meters, Universal Transverse Mercator, zone 12, North American Datum 1927, software-calculated
XUTM13	Easting value in meters, Universal Transverse Mercator, zone 13, North American Datum 1927, software-calculated
YUTM13	Northing value in meters, Universal Transverse Mercator, zone 13, North American Datum 1927, software-calculated
OPERATOR	Name of the company or agency that drilled the borehole
WELLNAME	Name of the borehole assigned by the company or agency that drilled it
COUNTY	Name of county in Wyoming
LOCSOURCE	Source of the borehole location, usually from the Fischer assay file, geophysical log, lithologic log, or survey
REFELEVFT	Borehole reference elevation, such as ground surface, rotary bushing (Kelly), or rotary table, from which downhole depths were measured
TD_FT	Total depth of the borehole, in feet
ELEVSRC	Source of elevation, usually from the Fischer assay file, geophysical log, lithologic log, or survey
COREDEP_FT	Depths, in feet, of the sequence that was cored in the borehole
REFDATUM	Elevation, in feet, for various reference surfaces including Kelly bushing, ground level, topographic map, and rotary table
KB	Kelly bushing elevation on drill rig, in feet
GL	Ground-level elevation, in feet
TOPO	Surveyed ground elevation, in feet, shown on topographic map adjacent to borehole

Table 1. Names and definitions for the column headers for the Wyoming oil-shale borehole information spreadsheet (WY_Borehole_Info.xls).—Continued.

EST_TOPO	Estimated ground elevation, in feet, of borehole plotted on topographic map
RT	Elevation, in feet, of the drilling rig rotary table
7_5_QUAD	Name of 7.5-minute USGS topographic map; borehole may or may not be shown on map
SHOWN_MAP	Indicates whether the actual borehole location is shown on the topographic map
YEARDRILL	Year that the borehole was drilled
CORE2	Physical location of the core from core hole; for example, USGS Core Research Center
LITHLOG_FT	Top and bottom borehole depths, in feet, of sequence of core or rotary cuttings for which a lithologic log was prepared
PHOTOLOG_FT	Top and bottom borehole depths, in feet, of photographic record of drill core
RQD	Top and bottom borehole depths, in feet, of rock quality data log
SONICLOG_FT	Top and bottom depths, in feet, of sonic log of borehole
ELECLOG_FT	Top and bottom depths, in feet, of electric log of borehole
TEMPLOG_FT	Top and bottom depths, in feet, of temperature log of borehole
GAMMALOG_FT	Top and bottom depths, in feet, of gamma-ray log of borehole
DENSLOG_FT	Top and bottom depths, in feet, of density log of borehole
NEUTLOG_FT	Top and bottom depths, in feet, of neutron log of borehole
CALIPLOG_FT	Top and bottom depths, in feet, of caliper log of borehole
FISCHASSAY_FT	Top and bottom depths, in feet, of sequence analyzed by Fischer assays
ASSAYLAB	Name of laboratory where Fischer assays were performed
NO_ASSAYS	Number of Fischer assays that were made
USBMNO	Lab number assigned to the report of Fischer assays made by the former U.S. Bureau of Mines, Laramie, Wyoming
XRD	Number of X-ray diffraction analyses made on samples from the borehole
LOCATNOTE	Additional information, commonly used where there is a problem with the location
ELEVNOTE	Additional information, commonly used where there is a problem with the elevation
MISCNOTE	Miscellaneous information, such as publications related to the borehole, and other data

Fischer assays made by different laboratories may not be strictly comparable because of differences in equipment and modifications of the analytical methods. Although most laboratories followed the ASTM-modified Fischer assay method (American Society for Testing and Materials, 1980), some differences were detected (Keighin, 1980). One laboratory, for example, was noted to yield consistently higher results, owing in part to their using a more finely ground sample, whereas another laboratory gave consistently higher than expected results, but the reason is unclear. However, because most Fischer assays were made by the USBM, the assays should give consistent results from one borehole to the next.

Fischer assays of cuttings from rotary holes should be used with caution because they tend to mix and blend upon recovery from the borehole. They are not recommended for resource evaluations but can be useful in identifying stratigraphic intervals that contain measurable oil.

In southwestern Wyoming, the carbonate minerals—trona ($\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$) and shortite ($\text{Na}_2\text{CO}_3 \cdot \text{CaCO}_3$)—are abundant in the Wilkins Peak Member of the Green River Formation. The sodium carbonate/bicarbonate in these minerals decomposes at retorting temperatures and yields anomalously high amounts of “gas plus loss” (that is, CO_2) and water in samples of oil shale containing these minerals. Thus, Fischer assays may aid in identifying zones of sodium carbonate minerals.

The assays spreadsheet (WY_Oil_Shale_Assays.xls) consists of 12 fields (table 2). The data are organized in the same way as they appear on the original laboratory assay reports as shown in the Image folder. Each core hole listed in column USGSID is

identified by a unique number beginning with "W" for Wyoming followed by four digits.

The suffix "R" is added to identify rotary-drilled oil and gas test wells.

Table 2. Names and definitions for the column headers for the Fischer assay data spreadsheet. USGS, U.S. Geological Survey; Wyo., Wyoming.

Column name	Column definition
USGSID	Unique drill-hole number assigned by the USGS
LABNO	U.S. Bureau of Mines, Laramie, Wyo., laboratory number
TOPFT	Depth, in feet, measured from surface datum to top of sampled interval
BOTFT	Depth, in feet, measured from surface datum to base of sampled interval
SHLOILPT	Amount of shale oil in weight percent
WATERPT	Amount of water in weight percent
SHLRSDPT	Amount of shale residue in weight percent
GASPLSLSPT	Amount of "gas plus loss" in weight percent
OILGLTON	Shale oil in U.S. gallons per short ton of rock
WTRGLTON	Water in U.S. gallons per short ton of rock
SPCFGRAV	Specific gravity of shale oil
CIJETEBD	Tendency for spent shale to coke

No Fischer assays are given for boreholes between W0563R and W0946 (WY_Borehole_Info.xls). More than half of these missing wells are core holes drilled for trona only, and geologic data for them are not included in this database. About 40 percent of the boreholes in this interval were drilled for oil and gas, but assay data for them have not yet been located. A few wells drilled for water or other purposes are also excluded.

Column LABNO (table 2) lists a USBM Laramie laboratory number consisting of six digits, the first two digits of which indicate the year in which the analysis was made; the remaining four digits indicate the order in which the analysis was made in that year. The USBM laboratory number is included because it is keyed to a large collection of crushed raw sample splits from which the assayed sample was taken. These raw samples are stored at the USGS Core Research Center in Lakewood, Colorado.

The assayed sample depths, in feet, are listed in columns TOPFT and BOTFT. The remaining columns include the results of the Fischer assay, including weight percents of shale oil and water, spent shale (mineral residue), "gas plus loss" in weight percent, gallons per short ton (GPT) of shale oil and water in raw oil shale, specific gravity of the shale oil, and the "tendency to coke" value. All Fischer assay are numeric fields. For missing intervals, the column for the USBM laboratory number is blank, and a 0 is entered in each assay field. Most of the Fischer assays reported here were determined by the modified Fischer assay method, which is described in detail by Stanfield and Frost (1949) and by the American Society for Testing and Materials (1980).

Some surface samples with minimal amounts of oil, in the range of 0 to 3 GPT, were analyzed by USBM's "rapid test tube method." This method provides only the estimated amount of oil in GPT as "no oil," "trace," "b" for less than 1 GPT, and "c" for 1 to 3 GPT. These estimates made by the test tube method are recast numerically in this database as 0 for "no oil" and "trace," 0.5 GPT for "b," and 2 GPT for "c"; 0.0B is assigned to the remaining undetermined field in the assay database.

The Assays folder contains all of the Wyoming Fischer assays in ASCII format, but in separate files for each drill hole. The data are presented in column-delimited fields with a one-row header, as described below. The first two records in each ASCII file contain information about the drill holes as follows:

Row/Record 1

Columns 1 to 46: name of the operator and the drill-hole name;

Columns 47 to 64: well location by section, township, and range.

Row/Record 2

The assay data begin with record 2, ordered by the following columns:

Columns 1–11: Six-digit USBM Laramie laboratory number, left justified. These laboratory numbers are included in the database because the unused portions of the samples analyzed by the USBM are preserved by the USGS and are identified by these numbers. Laboratory numbers of samples analyzed by private laboratories are not included because the USGS does not have splits of these samples.

Columns 12–21: Depth, in feet, measured from the surface datum to the top of the sampled interval.

Columns 22–29: Depth, in feet, measured from the surface datum to the base of the sampled interval.

Columns 30–35: Shale oil, weight percent.

Columns 36–41: Water, weight percent.

Columns 42–47: Shale residue (spent shale), weight percent.

Columns 48–54: “Gas plus loss,” weight percent.

Columns 55–60: Shale oil, U.S. gallons per short ton of rock.

Columns 61–66: Water, U.S. gallons per short ton of rock.

Columns 67–72: Specific gravity of the shale oil.

Columns 73–76: Tendency for spent shale to coke.

In the text data files, samples not analyzed are represented by “0.000B” in all of the Fischer assay data fields. Missing sample intervals can be located in text files by the lack of a USBM laboratory number followed by “0.0B” in all of the Fischer assay data fields.

If errors or omissions of data are found in this disc, users are encouraged to contact John Dyni at jdyni@usgs.gov or Ronald C. Johnson at rcjohnson@usgs.gov.

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