UTAH OIL SHALE DATABASE

Open-File Report 469
Utah Geological Survey

a division of

Utah Department of Natural Resources

compiled by
Michael D. Vanden Berg, John R. Dyni, and David E. Tabet

2006

UTAH DNR GEOLOGICAL SURVEY

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Abstract

The Utah oil shale database contains a large assortment of information on boreholes that were drilled in the Eocene Green River Formation oil shale deposits in the Uinta Basin of eastern Utah. Available files include: Fischer assays made from drill cores and cuttings, scanned geophysical logs, detailed location information, lithologic descriptions, formation top information, and overview resource map. This database was constructed to preserve historical oil shale data and present it in a useable electronic fashion for the business and scientific communities. Fischer assay data for 581 unique boreholes are available in separate and combined MS Excel™ and Text file spreadsheets for easy reference and data manipulation. Scanned geophysical logs are included for 173 different boreholes, along with an inventory of paper logs for an additional 290 wells available in the Utah Geological Survey's library. Spotty to complete formation top information for key beds in the Green River Formation is included for over 1000 different wells, while detailed lithologic descriptions are available for 168 wells. Also included with this database is an extensive oil shale bibliography for resources in the state of Utah, as well as information on who retains oil shale core and cutting samples.

Introduction

In 1967, the U.S. Department of Interior started an aggressive program to investigate the commercialization of Green River Formation oil shale deposits. The dramatic increase in petroleum prices resulting from the Organization of the Petroleum Exporting Countries (OPEC) oil embargo of 1973 triggered a second resurgence of oil shale research during the 1970s and early 1980s. When oil prices plummeted in the mid-1980s, so did research associated with oil shale. With crude oil prices again rising to new heights, and as conventional crude oil supplies continue to diminish, there has once again been renewed interest in unconventional fuel sources such as oil shale.

This information database was put together to archive and preserve data from exploration and research conducted within the state of Utah. Since personal computers were not widely available until the mid-1980s, older data was mainly archived on paper or mainframe computer tapes. With the cooperation of the U.S. Geological Survey (USGS) and the U.S. Bureau of Land Management (BLM), the Utah Geological Survey (UGS) has gathered and organized hundreds of important oil shale-related documents, reports, and logs, which should be an invaluable and useful resource as new oil shale research projects are developed.

Geologic Setting and Resource Overview

The largest known oil shale deposits in the world are in the Eocene Green River Formation, which covers portions of Utah, Colorado, and Wyoming (figure 1). Lacustrine sediments of the Green River Formation were deposited in two large lakes that occupied 25,000 square miles in several sedimentary basins including the Piceance, Uinta, Green River, and Washakie. Fluctuations in the amount of stream inflow caused large expansions and contractions of the lakes, as evidenced by widespread intertonguing of marly lacustrine strata with beds of land-derived sandstone and siltstone. During arid times, the lakes contracted in size and the lake waters became increasingly saline and alkaline (Dyni, 2003). The warm alkaline waters provided excellent conditions for the abundant growth of cyanobacteria (blue-green algae), which is thought to be the major precursor of the organic matter in the oil shale (Dyni, 2003). The organic matter preserved in the shale is called kerogen, which when heated can produce crude oil and natural gas. Figure 2 shows a generalized stratigraphic section of the Parachute Creek Member of the Upper Green River Formation in the Uinta Basin, Utah. The section with the richest oil shale is the Mahogany Zone, which can exceed 40 gallons of oil per ton of shale and is often over 100 feet thick. Other oil shale rich zones include the Big Three, the Stillwater, the Four Senators, the R-6, R-5, R-4, R-3, and the R-2.

Estimates of the in-ground oil resource within the Green River Formation range from 1.5 trillion (Smith, 1980; Dyni, 2003) to 1.8 trillion barrels (Culburtson and Pitman, 1973; Federal Energy Administration, 1974). The Utah portion of this resource varies from 165 billion (Smith, 1980) to 321 billion barrels (Cashion, 1964). Colorado and Wyoming are thought to contain 1.0 trillion and 300 billion barrels, respectively (Smith, 1980; Pitman and others, 1989; Culbertson and others, 1980; Trudell and others, 1973). These in-place resource estimates are based on oil shale present at a grade of greater than 15 gallons per ton. As a comparison, the total U.S. conventional crude oil proved reserves are estimated at 21.4 billion barrels, Saudi Arabia's reserves at 266.8 billion barrels, and the world's proved reserves at 1.3 trillion barrels (Energy Information Administration, 2006). Estimated recoverable reserves of crude oil from oil shale deposits in Utah are presumably much less, but specific numbers are unknown as proven commercial shale oil recovery technology is currently not available.

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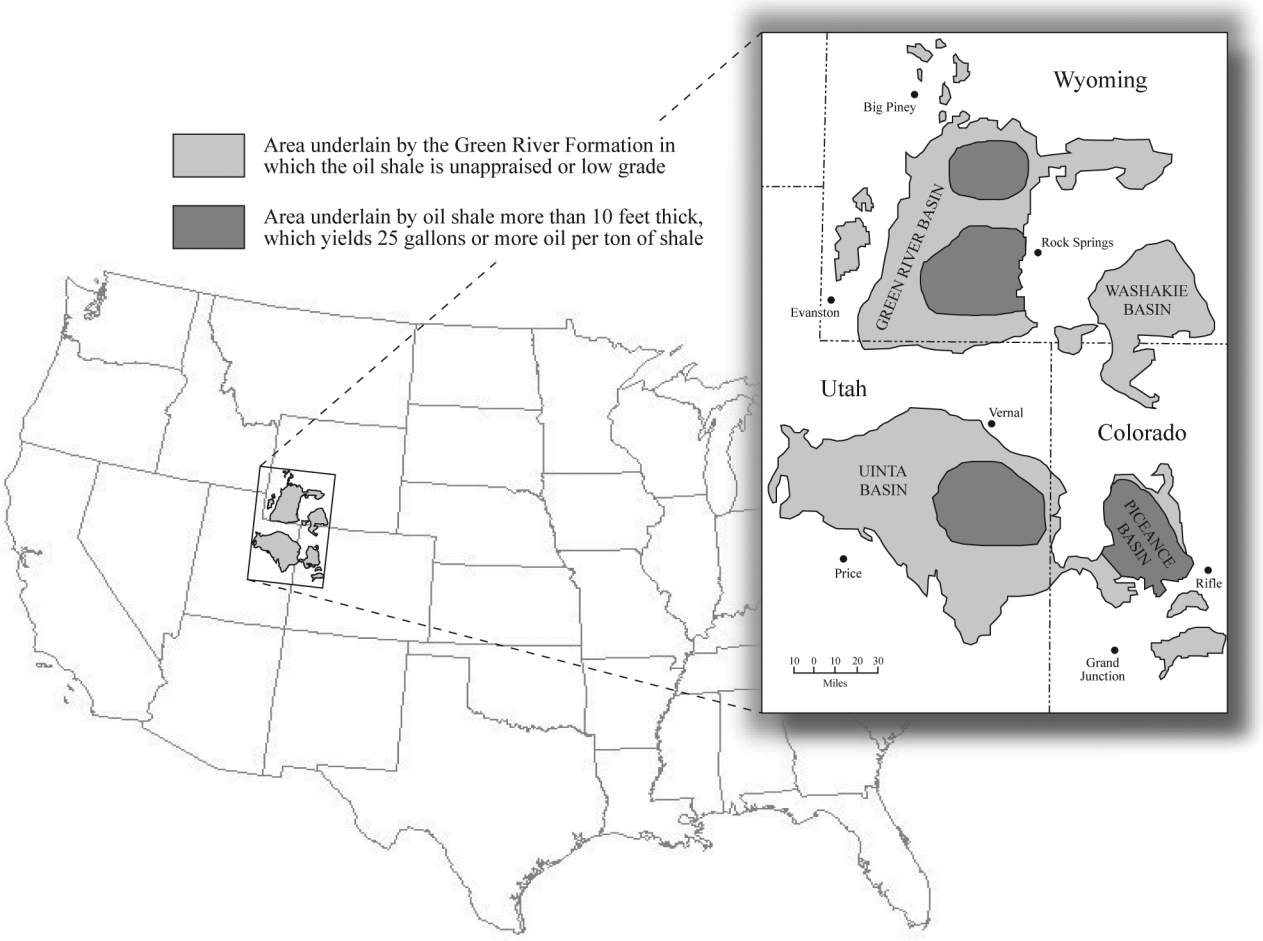

Figure 1. *Oil shale resource areas of Utah, Colorado, and Wyoming. Adapted from Bartis and others, 2005 and Bunger and others, 2004.*

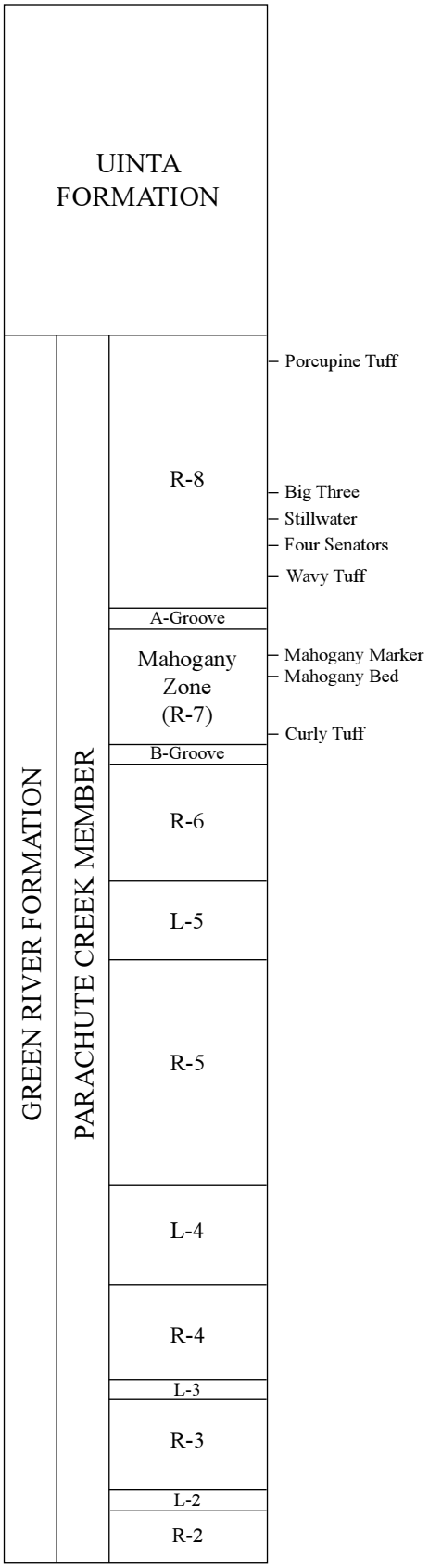

***Figure 2**. Generalized stratigraphic section of the Parachute Creek Member of the Upper Green River Formation in the Uinta Basin, Utah. Thickness of the different beds varies across the basin. "R" - Rich-oil shale zone, "L" - Lean oil shale zone. Adapted from Young, 1995.*

Folders and Files Included with Report

• Utah Oil Shale Well Information

This file lists 691 different boreholes that are associated with oil shale deposits in Utah. Each borehole is designated with a 3-digit number preceded by "U" for Utah; this numbering scheme was developed by the USGS in earlier work on oil shale and is carried forward in this database. This file contains detailed well location information, year well was drilled, total depth of well, surface elevation, interval and location of available cores and cuttings, available Fischer assays, interval of available lithologic logs, and interval and type of available geophysical logs. Text in red indicates unverified data.

This file is organized as follows:

Column A - USGS # - unique 3-digit number preceded by "U"
Column B - USGS # Note - the letter "A" or "B" indicates two sets of assays from the same borehole, the letter "R" indicates a rotary-drilled hole, and the letter "S" indicates a surface sample
Column C - Operator
Column D - Well Name
Column E - API - American Petroleum Institute number assigned to oil and gas wells
Column F - Alternate API - in some instances, two different API numbers are assigned to the same well
Column G - County
Column H - Township
Column I - Range
Column J - Section
Column K - 1/4-1/4 - fractional location within the section
Column L - Meridian - "SL" - Salt Lake base meridian; "UN" - Uintah special meridian
Column M - UTM E - Universal Transverse Mercator Easting - NAD83
Column N - UTM N - Universal Transverse Mercator Northing - NAD83
Column O - Latitude - decimal degrees
Column P - Longitude - decimal degrees
Column Q - E-W - well location measured in feet from the east or west boundaries of the section (e.g., FWL - From West Line)
Column R - N-S - well location measured in feet from the north or south boundaries of the section (e.g., FNL - From North Line)
Column S - Year Drilled
Column T - Total Depth - measured in feet
Column U - Ground Level Elevation - measured in feet above mean sea level
Column V - Elevation at Kelly Bushing - measured in feet above mean sea level

Column W - Elevation at Drill Frame - measured in feet above mean sea level

Column X - Depth in feet to the top of available core

Column Y - Depth in feet to the bottom of available core

Column Z - Repository holding the core - "CRC" - Core Research Center

Column AA - Depth in feet to the top of available cuttings or core chips

Column AB - Depth in feet to the bottom of available cuttings or core chips

Column AC - Repository holding cuttings or core chips

Column AD - Depth in feet to top of assayed interval

Column AE - Depth in feet to bottom of assayed interval

Column AF - Number of assayed intervals

Column AG - Number of assays greater than or equal to (≥) 25 gallons of oil per ton of shale (gpt)

Column AH - Laboratory where assay analyses were preformed and in what year, "Laramie" - Laramie Energy Research Center, "CSMRI" - Colorado School of Mines Research Institute, "CSMRF" - Colorado School of Mines Research Foundation, "Core Labs" - Core Laboratories, Inc., "Dickinson Labs" - Dickinson Laboratories, Inc., "Tosco" - Rocky Flats Research Center, "Hazen Research" - Hazen Research, Inc.

Column AI - Depth in feet to top of lithologic log

Column AJ - Depth in feet to bottom of lithologic log

Column AK - Location of log, "UGS Oil Shale Database" - scanned copy included as a PDF or TIFF file with this database, "USGS" - original paper copy located at the USGS, "UGS Library" - original paper copy located in the UGS library, "DOGM" - scanned copy available as a TIFF file on the Utah Division of Oil, Gas and Mining Web site

Columns AL to BK - Available geophysical logs with depths in feet to the top and bottom of the logged interval; available logs may include density, neutron (porosity), sonic, electric, gamma ray, caliper, temperature, cement bond, 3-D velocity, elastic properties, com-pro (kerogen analysis), spinner survey, and radioactive tracer

Column BL - Location of log, "UGS Oil Shale Database" - scanned copy included as a TIFF file with this database, "USGS" - original paper copy located at the USGS, "UGS Library" - original paper copy located in the UGS library, "DOGM" - scanned copy available as a TIFF file on the Utah Division of Oil, Gas and Mining Web site

• Oil Shale Map of Utah

The Oil Shale Map of Utah (Plate 1), available as a PDF file, provides an overview of the oil-shale rich areas within Utah and includes the location of wells compiled in this database. Also included are isopachs for the Mahogany Oil Shale Zone (Figure 2) containing 25 or more gallons of shale oil per ton of rock (currently being revised) (Utah Geological and Mineral Survey, 1983), and the known outcrop extent of the Mahogany Zone (Cashion, 1967, 1974, 1977, 1978, 1984, 1994; Gualtieri, 1988; Keighin, 1977a, 1977b, 1977c; Pantea, 1987; Pantea and Scott, 1986; Pipiringos, 1978, 1979; Scott and Pantea, 1985, 1986; Weiss and others, 1990; Witking, 1988). In addition, the newly designated BLM Uinta Basin oil shale withdrawal is included, as well as an inset displaying the 1974 U-a and U-b prototype federal lease tracts.

• Fischer Assays

A total of 586 sets of Fischer assays are provided in both MS Excel™ and standard tab delimited Text formats for 581 different boreholes drilled in the Eocene Green River oil shale deposits, mostly within the Uinta Basin of eastern Utah. Each file represents analyses from one borehole and is designated with the U-number. In a few instances, two sets of assays from the same borehole are indicated by an "A" or "B" following the borehole number. An additional folder contains PDF scans of the original Fischer assay report for 265 of the above-mentioned wells, with some boreholes having more than one report. These original files offer a way to double check the accuracy of the digitized data and often supply useful handwritten notes and other information.

Each Excel and Text file is organized as follows:

Column A - USGS # - a unique 3-digit number preceded by "U"

Column B - Operator

Column C - Well Name

Column D - Township

Column E - Range

Column F - Section

Column G - USBM # - the first two digits of this United States Bureau of Mines (USBM) Laramie laboratory number indicate the year the analysis was made and the remaining digits indicate the order in which the analysis was made in that year; laboratory numbers analyzed by private laboratories are not included

Column H - Depth, in feet, measured from the surface datum to the top of the sampled interval

Column I - Depth, in feet, measured from the surface datum to the base of the sampled interval

Column J - Amount of oil shale in weight percent

Column K - Amount of water in weight percent

Column L - Amount of shale residue in weight percent

Column M - Amount of "gas plus loss" in weight percent

Column N - Shale oil in gallons per short ton if rock

Column O - Water in gallons per short ton of rock
Column P - Specific gravity of the oil shale
Column Q - Tendency for spent shale to coke

Intervals that were not assayed owing to missing samples are included in the files and are identified by depth and "9999999999" in the USBM_# column.

Also included are two files that contain all the assay data combined together (there are two files due to the enormous amount of data and the ~65,000 row limit in MS Excel™). These files can be imported into MS Access™ for easy querying of the data (e.g., querying by township and range).

Most of the assays were made by the modified Fischer assay method as described by Stanfield and Frost (1949) and later adopted by the American Society for Testing and Materials (1980). This method was developed primarily for evaluating the Green River oil shale resources. Generally, the assays of drill cores were made on crushed samples prepared from one- or two- foot lengths of quartered core. Assays from rotary oil and gas tests were usually made on cuttings that represent 10-foot increments of depth.

Although useful for resource evaluation and stratigraphic studies of oil shale deposits, the Fischer assay does not give a complete picture of the energy available in the organic fraction of the oil shale. According to J.R. Dyni (1998), 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". Gas plus loss includes all noncondensable gases released in the Fischer assay including light hydrocarbons and carbon dioxide, plus analytical errors.

The Fischer assays of rotary cuttings should be used with caution because of the contamination by mixing of cuttings, contamination from borehole cave-ins, and whether the samples were accurately lagged for travel time up the borehole. Because of their inaccuracy, caution should be employed when using assays of rotary cuttings during shale oil resource evaluations.

• Geophysical Logs

These two folders contain 826 scanned geophysical logs for 173 different wells within the Uinta Basin. The folders are organized by U-number and well name, and all logs are in TIFF format. The most useful logs for determining stratigraphy and assessing shale oil resources are the sonic and density logs. Other types of available logs may include electric, gamma ray, caliper, temperature, cement bond, 3-D velocity, elastic properties, spinner survey, and radioactive tracer. The UGS library is currently in the process of scanning their vast holdings of old paper logs, so more digital files will be available in the future.

• Lithologic Logs

This folder contains PDF scans or TIFF images of lithologic logs for 168 different boreholes. The files are organized by U-number and well name.

• Miscellaneous PDF Files

This folder contains scanned copies of oil shale-related papers archived by the USGS or the BLM. The reports are organized by U-number and type, and all papers are in PDF format. Reports found in this folder include: oil yield graphs, drilling reports, elastic properties tables, location maps, and water analyses. Also included are very detailed corehole reports for U092, U102, U112, and U113.

• Tops Picked by USGS

This file contains depths in feet to the top of stratigraphic units in the upper part of the Eocene Green River Formation in the Uinta Basin, Utah for 221 different boreholes. All tops were picked by J.R. Donnell, USGS (Dyni and others, 2006), L.G. Trudell, Laramie Energy Technology Center (Trudell and others, 1983), or other unknown persons. Less certain tops data are indicated by red font.

This file is organized as follows:

Column A - USGS # - unique 3-digit number preceded by "U"
Column B - Operator
Column C - Well Name
Column D - API - American Petroleum Institute number assigned to oil and gas wells
Column E - County
Column F - Township
Column G - Range
Column H - Section
Column I - 1/4-1/4 - fractional location within the section
Column I - Meridian - "SL" - Salt Lake meridian; "UN" - Uintah special meridian
Column K - UTM E - Universal Transverse Mercator Easting - NAD83
Column L - UTM N - Universal Transverse Mercator Northing - NAD83
Column M - Ground Level Elevation - measured in feet above mean sea level
Column N - Total Depth - measured in feet
Columns O to CS - Depths in feet to the top (and sometimes base) of select beds within the upper part of the Eocene Green River Formation. Several beds above the Mahogany Zone are only recognized by number. Beds below the Mahogany Zone are labeled as "R" for rich oil shale zones and "L" for lean oil shale zones.

• Quintana - Tops and Shale Oil Yields

This file was synthesized from several unpub-

lished Quintana Mineral Corporation reports that contain depths in feet to the top and bottom of certain stratigraphic units in the upper part of the Eocene Green River Formation in the Uinta Basin, Uintah County, Utah for 234 different boreholes. This file also contains average oil yields, as well as tops and thicknesses of oil shale zones with 40, 35, 30, and 25 gallons of oil per ton of rock. These oil yields were estimated using Fischer assays, digitized sonic logs, or digitized density logs.

This file is organized as follows:

Column A - USGS # - unique 3-digit number preceded by "U"
Column B - Quintana # - unique number given to each borehole by Quintana Mineral Corporation
Column B - Operator
Column D - Well Name
Column E - API - American Petroleum Institute number assigned to oil and gas wells
Column F - County
Column G - Township
Column H - Range
Column I - Section
Column J - 1/4-1/4 - fractional location within the section
Column K - UTM E - Universal Transverse Mercator Easting - NAD83
Column L - UTM N - Universal Transverse Mercator Northing - NAD83
Column M - Ground Level Elevation - measured in feet above mean sea level
Column N - Log data used to calculate shale oil yields
Columns O to FJ - Depths in feet to the top and base of select beds within the Eocene Green River Formation. Also included are average shale oil yields for each stratigraphic layer and tops and thicknesses of beds with 40, 35, 30 and 25 gallons of oil per ton of rock. Beds below the B Groove are labeled as "R" for rich oil shale zone and "L" for lean oil shale zone.
Columns FK to FN - Depths in feet to the top of the Big Three layer and the base of the R-4 layer. An average shale oil yield for the entire section is also included.

• Depths Picked by Johnson and Roberts (2003)

This file contains depths in feet for selected stratigraphic horizons in the Upper Cretaceous and Lower Tertiary of 745 oil and gas wells located in the Uinta Basin, Utah. All formation depths were picked by R.C. Johnson and L.N.R. Roberts of the USGS (Johnson and Roberts, 2003).

This file is organized as follows:

Column A - USGS # - a unique 3-digit number preceded by "U"
Column B - Quintana # - a unique number given to each borehole by Quintana Mineral Corporation
Column B - Operator
Column D - Well Name
Column E - API - American Petroleum Institute number assigned to oil and gas wells
Column F - County
Column G - Township
Column H - Range
Column I - Section
Column J - 1/4-1/4 - fractional location within the section
Column K - Meridian - "SL" - Salt Lake meridian; "UN" - Uintah special meridian
Column L - UTM E - Universal Transverse Mercator Easting - NAD83
Column M - UTM N - Universal Transverse Mercator Northing - NAD83
Column N - Elevation at Ground - measured in feet above mean sea level
Column O - Elevation at Kelly Bushing - measured in feet above mean sea level
Column P - Total Depth - measured in feet
Columns Q to Y - Depths to selected stratigraphic horizons - measured in feet

• Utah Oil Shale Bibliography

The Utah oil shale bibliography contains 981 references on Utah's oil shale resources, as well as general oil shale research and mining potential. This bibliography was adapted from an extensive reference list on the Green River Formation compiled by Marjorie C. Smith, USGS (Smith, 1990). Several references were also added from the unpublished "Selected References for the Uinta Basin, Utah" by Craig Morgan, UGS (available on the UGS Web site).

Acknowledgements

The U.S. Bureau of Land Management supplied data and provided funding for this project. Significant contributions in data acquisition and organization were made by J.R. Donnell, U.S. Geological Survey, and Eric Sahm and Tom Dempster, Utah Geological Survey. Contributions to the bibliography were made by Mike Kirschbaum and Cheryl Gustin, Utah Geological Survey.

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