Digital Cartography

By Michael A. Domaratz and Jo Anne Stapleton

PETROLEUM POTENTIAL OF WILDERNESS LANDS IN THE WESTERN UNITED STATES

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ABSTRACT

The petroleum resource assessment program for the Wilderness Lands in the Western United States involved the analysis of a large volume of spatial data. A method was needed to expedite the gathering, managing, and manipulating of this spatial data in a precise and versatile manner and to provide results quickly. Digital techniques were used to process large volumes of data, such as boundaries of Wilderness Lands, USGS petroleum provinces, geologic and tectonic boundaries, and locations of wells drilled within or near Wilderness Lands. These techniques were used to provide area calculations, tabulations of types of Wilderness Lands and identification of controlling agencies. Digital techniques were also successful as a means of generating statistical reports and graphic products rapidly.

Computer-generated maps were plotted showing the geologists' qualitative petroleum potentials for each of the Wilderness Lands. A series of printed maps for each State accompanies this circular showing the location and qualitative petroleum potential of the Wilderness Lands studied, the USGS petroleum provinces and other base information about the State (Miscellaneous Investigations Series Maps I–1537 through I–1547, in press).

INTRODUCTION

The petroleum resource assessment program for the Wilderness Lands in the Western United States involved the analysis of a large volume of spatial data. A method was needed to gather, to manage, and to manipulate this spatial data in a consistent manner. This method had to be able to generate various map products, report the interrelationships between different themes of data, and generate other statistical reports (such as area calculations). This method had to be precise and versatile and had to provide results quickly.

After discussing their requirements with members of the National Mapping Division and seeing the techniques used in digital (computer) applications in cartography, the geologists agreed that digital techniques would meet their needs. These techniques offered several advantages over manual methods of performing the required analyses. Digital techniques can be used to process large volumes of data efficiently and in a consistent manner and to generate a great variety of graphic products quickly and precisely. They can be used to generate statistical reports such as area calculations, to compare the occurrences of themes in a given area, and to cross-tabulate the different combinations of themes that exist. Finally, the data produced with these methods can be used with other systems and data files for additional analysis. After further consultations, the National Mapping Division agreed to supply digital cartographic support for the project.

DATA ENCODING

These digital cartographic techniques require that the data to be analyzed exist in digital (computer-compatible) form. All of the data sources available for the themes required, however, existed as maps. The first step to be performed, therefore, was the digital encoding, or digitizing, of the map data for these themes.

The purpose of the digitizing process is to digitally encode the information for a theme shown on a map. This information includes such concepts as the location of points, lines, and areas; the connectivity between different lines; and the adjacency of different areas. To encode these concepts into the computer, a special data organization, a topological data structure, is employed. The topological data structure permits simple applications such as drawing all of the lines found on a map, as well as more advanced applications such as assigning colors to different shapes and calculating the areas of shapes. This data structure was used in digitizing the themes required for the petroleum resource assessment program.

Most of the digitizing was done by using stable-base film materials. All of the digitizing was done at 1:1,000,000 scale, on a State basis, by using manual line-following techniques.

THEMES DIGITIZED

The geologists identified three themes of data required for the study: the Wilderness Lands themselves, the USGS petroleum province units (Dolton and others, 1981), and the predominate geologic regions of the study areas.

WILDERNESS LANDS

Since the Wilderness Lands were the primary focus of the study, accurate and recent compilation of these tracts was required. The data were digitized from the Bureau of Land Management (BLM) Wilderness Status Maps 1981 series (1981a–j) for the States of Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, and Wyoming, and the American Petroleum Institute map of Wilderness Lands (1981) for the State of Washington. Lands administered by BLM, the U.S. Forest Service (USFS), the National Park Service (NPS), and the Fish and Wildlife Service (FWS) were digitized.

The categories of Wilderness Lands digitized include Designated Wilderness Lands, Lands Administratively Endorsed as Suitable (prior to 1981), Further Planning or Study Areas (Wilderness Study Areas (WSA's)), BLM Wilderness Inventory Not Completed, BLM Lands Under Appeal (WSA's), and USFS RARE II lands under litigation (California only). Each digitized tract, or polygon, was assigned (1) a numeric code identifying that polygon by State, wilderness category, and administering agency, and (2) a unique number identifying the polygon as a particular Wilderness Land.

USGS PETROLEUM PROVINCES

For the geologists to use the results of other petroleum assessment activities of the USGS, the spatial statistical units used in these previous studies were digitized. These units are assigned a numeric code identifying a unit by State, petroleum province number (as published in USGS Open-File Report 82–666–A, by Varnes and others, 1982), and a unique number identifying the individual polygons.

GEOLOGIC REGIONS

To assist the geologists in their initial estimates of the potential for petroleum in a particular Wilderness Land, the boundaries of geologic regions were digitized. The regions were interpreted by geologists for each State. These regions are identified by a numeric code indicating the rock type (for example, volcanics or crystalline) or tectonic type (for example, arch, dome, or basin) and a unique number identifying the polygon as a particular geologic feature (for example, Yellowstone volcanics or Wind River Basin).

INTERMEDIATE PRODUCTS

Once the digitizing was completed, several different intermediate products were generated. These working documents illustrated different aspects of the three data themes as well as the interrelationships between the themes. The two major groups of products generated include maps and tabular reports. Since all of these items were generated from one digitized data set, the products are consistent with each other.

MAPS

A variety of computer-generated maps was plotted. These maps illustrate the position, areal extent, and class of the features in each theme. When overlaid, the maps show the interrelationships between the different themes. For example, when the map of Wilderness Lands in a State is superimposed on the map of geologic regions for that State, all of the Wilderness Lands lying within any particular geologic region can be readily determined. This technique was useful in determining the initial qualitative estimates of petroleum potential for the wilderness areas.

A set of three transparent film plots (Wilderness Lands, petroleum provinces, and geologic regions) was produced for each State. These plots, by-products of the quality control procedure for the digitizing activity, depict the boundaries of the data for each theme. Since the graphic is transparent, it can be easily used to view the relationship between the theme of the graphic and the data on an overlaid map.

A paper map containing the boundaries of each petroleum province, the boundaries of each of the Wilderness Lands, and the numeric code for each wilderness area was produced for each State. This graphic has several purposes. The map illustrates which numeric code was associated with which plotted area on the map. Since the statistical reports for each wilderness area are keyed to the numeric code, this map allows the location of the reported data to be determined. This map clearly illustrates the occurrences of the petroleum provinces and Wilderness Lands for each State. These occurrences are an important relationship, since the sum of the petroleum potentials of the wilderness areas in a petroleum province may not exceed the previously determined petroleum potential of the entire province (Dolton and others, 1981). Finally, the maps provide a convenient base map for the plotting of the boundaries of the different zones of qualitative petroleum potential assessments for the Wilderness Lands.

A special map showing the different geologic regions was prepared for each State. On this graphic, the geologic regions thought not to have potential for petroleum (such as volcanic or crystalline rocks) were darkly shaded, and those regions thought unlikely to have potential for petroleum (such as mixtures of sedimentary and crystalline rock terranes) were lightly shaded. When this map is combined with the plots of the Wilderness Lands, the Wilderness Lands that are in these shaded regions (and therefore with a low or zero petroleum potential) can easily be seen.

Finally, a map showing only the Wilderness Lands was plotted for each State. This map illustrated the different categories of Wilderness Lands in each State and the Federal agency administering each tract.

TABULAR REPORTS

Two different statistical reports were generated from the digital data. These reports described the acreage of the data on the individual themes and the acreage of the areas where the different Wilderness Lands, petroleum provinces, and geologic regions were coincident.

The first report contains the acreage calculated for each digitized polygon of the Wilderness Land, petroleum province, and geologic region theme in each State. For the Wilderness Lands, additional acreage summaries by wilderness category and administering Federal agency exist for each State. These figures were used in the potential assessment activities and were compared to the acreages compiled for the Wilderness Lands by other Federal agencies.

The second report describes the occurrence of different petroleum provinces and geologic region combinations coincident with each wilderness area. This document reports the acreage of each unique petroleum province versus type of geologic region occurrence within each Wilderness Land and assists in the determination by the geologists of the petroleum potential of that Wilderness Land. To prepare the report, the data for the different themes in each State were converted to a raster data organization on a common coordinate system. The three raster data sets were then combined into one data set. Each cell in the resulting set has three observations (wilderness tract number, petroleum province number, and geologic region number). The number of unique occurrences of wilderness, petroleum province, and geologic region numbers was calculated. This number of unique occurrences was converted to an acreage based on the size of the cell.

A tabular report of the locations and histories of wells in the vicinity of each wilderness tract was also produced with the aid of the digital data. This work, performed under contract, used the digitized outline of each wilderness tract as the basis for querying a data base of the wells in each State. The location and history of the wells in the vicinity of each wilderness tract were extracted and reported. This technique saved a great deal of time, since the alternative to this automated spatial search was a manual sifting through all of the well records for each State.

QUALITATIVE PETROLEUM ASSESSMENT REPORTING

DIGITAL ACTIVITIES

The geologists performing the assessments used the maps and tables described above to map the qualitative petroleum potential for each of the

Wilderness Lands. A wilderness tract could have one or more qualitative assessment zones (indicating if that portion of the wilderness tract had high, medium, low, low to zero, zero, or unknown petroleum potential). After the maps were compiled, these zone boundaries were added to the Wilderness Lands digital data. These new data allowed the generation of two additional products.

Computer-generated maps showing different combinations of wilderness area petroleum potential, wilderness status, and administering Federal agency information were created at different scales. These maps show the final results of the qualitative assessment activities. These graphics are also the base maps from which the printed petroleum potential map series was compiled.

A tabular report indicating the acreage of the petroleum potential zones for each wilderness area was created. This report included summary statistics describing the number of acres of each qualitative potential category by administering agency and wilderness status.

Due to the interpretive nature of the petroleum assessment information, many revisions of the original digitized assessment data were required. Updated maps and statistical tables were needed with each revision. The digital techniques provided a quick, efficient means to update the information and to provide the needed maps and statistics.

PUBLISHED MAP SERIES

A series of printed maps provides a supplement to this report (Miscellaneous Investigations Series Maps, I–1537—I–1547, in press). These State maps describe the location and qualitative petroleum potential of the Wilderness Lands studied, the USGS petroleum provinces for each State, and other base information about the State. These maps were compiled by using traditional cartographic techniques.

The Bureau of Land Management Wilderness Status Maps (1981a–j) are the bases on which the assessment information was compiled. These maps, which already have the Wilderness Lands and a great deal of other supplemental information compiled, provided a convenient starting point for the new map series. The cartographers transferred the boundaries of the petroleum provinces from digitally produced graphics to the BLM base maps. The qualitative petroleum potential information was transferred from the computer-generated maps previously described.

SUMMARY

The digital cartographic techniques proved to be of great use in the petroleum resource assessment program for the Wilderness Lands. The techniques provided plots for many different maps that illustrated various aspects of the data of interest. In addition to these graphic products, many different statistical and tabular reports were created. The techniques handled the data in a consistent manner and were quicker, more precise, and more versatile than comparable manual methods.

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