DEPARTMENT OF THE INTERIOR

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Videocassette demonstrating the applications of Geographic Information Systems techniques to basin characterization --Case study for the San Juan Basin, New Mexico--

by

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Videocassette

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The U.S. Geological Survey (USGS) is currently applying Geographic Information Systems (GIS) technology to the development of a geologic knowledge base that can provide the framework for an integrated basin analysis to be used in the assessment of energy resources. GIS technology involves the integration of mapping and data-base functions that enable the user to integrate and manipulate spatial (coordinate) data with attribute (thematic) data. This technology can be used to combine complex geographic, geologic, and geophysical data sets into resultant overlay and composite maps, to conduct multivariate exploratory data analysis, and to have access to a variety of options for analyzing these knowledge bases.

The videocassette provides a computer graphics demonstration of some USGS work in progress that was supported by the Director's "GIS Sweepstakes" funds to encourage the application of GIS to the Survey's traditional geologic missions. The ongoing project is entitled: Three-dimensional analysis of sedimentary basins using Knowledge-based Geographic Information Systems and AI-Expert Systems. This video demonstration briefly addresses only some of the GIS applications used in sedimentary basin analysis and represents a limited set of map coverages and spatial data sets taken from the project's San Juan Basin data base. Some of the represented map coverages for the San Juan Basin illustrated on the tape include the base map for the study area, the surficial geology map, land ownership map, maps showing nearly 21,000 well locations for all oil, gas, and dry holes drilled in the basin, stratigraphic column

and cross section of the basin for the Upper Cretaceous, and isopach and structural contour maps for the major petroleum producing formations. This demonstration focuses upon the four productive formations which include the Pictured Cliffs, Point Lookout, Gallup and Dakota sandstones in the Upper Cretaceous. The Gallup represents the only major oil producer in the San Juan Basin. The other three formations are primarily natural gas producers.

The GIS knowledge base used in the San Juan Basin study for basin analysis focuses on the integration of the multivariate data bases for merging large volumes of surface and subsurface data. This technology, when applied to a sedimentary basin, is used in this project to establish a three-dimensional perspective of the basin's fundamental stratigraphic and structural framework and to aid in the identification of its temporal and tectonic relationships which help to determine the origin and occurrence of its energy resources. Digital data bases being used for surface mapping include the U.S. Public Land Survey System for land ownership; Land Use and Land Cover (LULC); Digital Elevation Models (DEMs) for terrain elevations; and Digital Line Graphics (DLGs) for planimetric information on boundaries, transportation, and hydrography. Additional data bases used for surface mapping include surficial geology; locations of oil and gas wells, including well status, and oil and gas fields; and mining locations for coal, oil shale and uranium. Information data bases providing the attributes for subsurface mapping include those for geologic maps such as structure-contour, isopach, and facies maps for major oil- and gas-producing formations, coal, oil shales and other resources within the basin.

The GIS manipulates data such that an overlay of data layers can produce a new combination of information, or data can be merged from multiple maps into single new maps. Current GIS technology and mapping software being used in the USGS for the three-dimensional analysis of sedimentary basins includes the ARC/INFO GIS software system (Environmental Systems Research Institute) and the Interactive Surface Modeling (ISM) software programs (Dynamic Graphics, Incorporated) using the PRIME computer. The Petroleum Information--Well History Control System (PI-WHCS) data base provides one of the major sources for information on the nearly 21,000 wells used in the study (Petroleum Information Corporation).

All of the graphic coverages used in the video tape were produced either in ARC/INFO or in ISM and then transferred into ARC/INFO. ARC/INFO is a geographic information system used to automate, manipulate, analyze and display geographic data. It is built around a hybrid data model that organizes geographic data using a relational and topological model. This facilitates efficient handling of two generic classes of spatial data: locational data, describing the location and topology of point, line and area features; and attribute data, describing characteristics of these features. Locational data are simply structured with cartographic X,Y coordinate data to identify arc, node, and polygon relationships. As illustrated in the video tape, ARC/INFO allows many different types of coverages to be integrated and overlain for spatial analysis.

The ISM computer program is an automated mapping and analysis tool that allows the user to enter, verify, manipulate, analyze and display multiple surface information. Starting with a scatter-point data set, the ISM program creates a gridded surface from which a

number of possible views of a single surface can be produced. The PI-WHCS well data were used for the scatter-point data set with a total of 20,958 wells representing the drilling in the San Juan Basin. The ISM package can portray three-dimensional data in a number of ways. For example, it can produce a cross section displaying relative depths of multiple surfaces on a two-dimensional plot, or display isopach and structure-contour maps for the producing formations.

The preparation of the video tape consists of using the following sequence of techniques. The images presented on the video tape were first created on the PRIME computer in either ARC/INFO, ISM, or a combination of these two techniques. They were then transferred into a PC-based graphic arts package called Zenographic's Mirage. The graphics files from Mirage were output to a special graphics card, called TARGA 16, that allows transfer of computer-generated images to a video tape recorder.

CONCLUSIONS:

The demonstration presented on the video tape represents only a limited set of map coverages and spatial data sets taken from the data base for the San Juan Basin project. There is no limit to the number or types of data that can be analyzed using these GIS techniques, or to the number and different combinations of data sets that can be integrated for interpretive purposes. The variety of data is dependent only upon the nature of the study and the user's resourcefulness in analyzing multivariate spatial relationships.

GIS technology can provide new analytical tools for innovative research in geological interpretation, for updating information data bases, and for developing new concepts in basin analysis and resource appraisal methodology.