Petroleum GIS *Perspectives*

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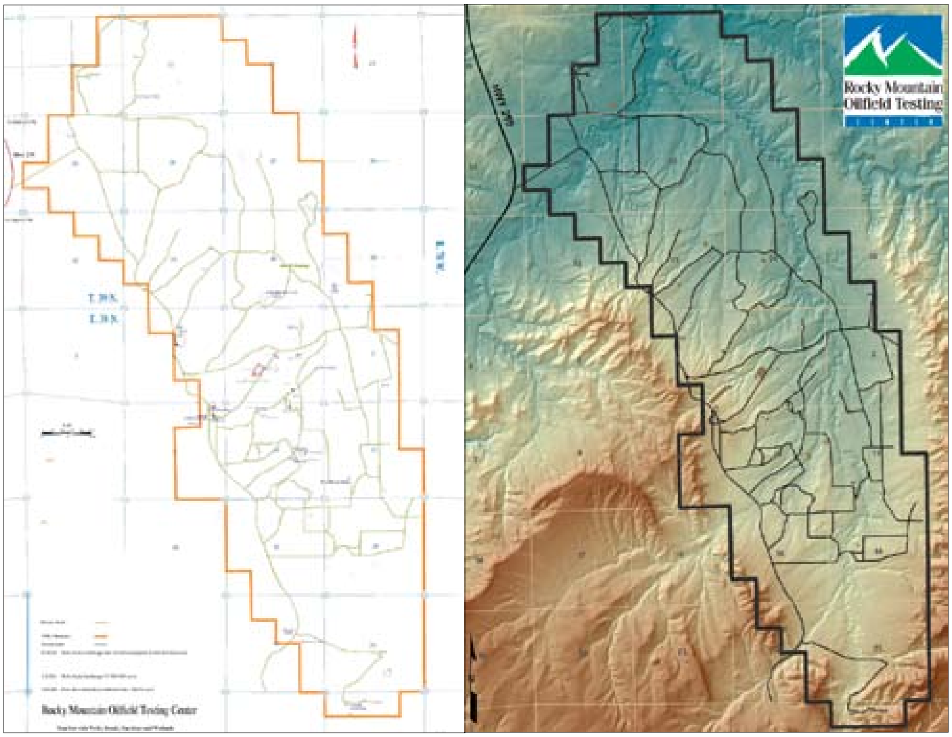
In This Issue

Novel Approach to Mapping Helps DOE Research Oil Field

By Jeanette Buelt, Connie Wallace, Tom Anderson, and Mandy Cepeda, Rocky Mountain Oilfield Testing Center

The Rocky Mountain Oilfield Testing Center (RMOTC) is researching exploration and production (E&P) best practices at Teapot Dome oil field near Casper, Wyoming. The Department of Energy (DOE)-operated site offers a full complement of state-of-the-art, on-site facilities and equipment to aid industry research efforts in its 10,000-acre oil field. In recent years, RMOTC has implemented ArcGIS to map 1,350 well bores ranging in depth from approximately 250 to 7,000 feet. It includes data on producing and nonproducing wells along with new well-drilling opportunities. Geographic information system (GIS) technology is also being used for some not-so-common applications at RMOTC.

RMOTC offers a place for industry and government to meet and partner to explore emerging and developing technologies to address critical energy issues through research, testing, demonstration, and deployment. Several years ago, RMOTC acknowledged its need to expand its data management capabilities and began migrating its CAD mapping system data to GIS. RMOTC can now create more complex and in-depth visualizations of its operations and research (figures 1 and 2).



Figures 1 and 2. The CAD-generated map on the left and the GIS-generated map on the right highlight the value of adding topography and other data layers as needed for oil field research.

The Teapot Dome oil field is a primary research site for RMOTC. Prior to GIS, Teapot Dome data had been housed in a CAD system, and well CAD drawings had stand-alone engineering coordinate systems with no spatial references. Several well locations in that database had incorrect location data. In the changeover, the first step was to convert the CAD drawings of modern surfaces and pipeline maps to shapefiles. Hand-drawn maps were also scanned and converted to a digital format, then georeferenced to their field locations. Next, the data was converted to the Wyoming State Plane East Central Zone Coordinate System, NAD 1927, a standard of geographic information for the government.

Since 2006, RMOTC has been using ESRI's ArcGIS software as its primary field mapping system. The software stores and processes information used in a variety of oil field applications such as creating basemaps for field infrastructure and facilities, displaying well production data, incorporating geological and geophysical interpretations, monitoring environmental requirements, and tracking oil field

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Novel Mapping Helps DOE Research Oil Field

operations. ArcGIS supports RMOTC's digital elevation model (DEM) and aerial photo data layers and has improved analysis by allowing the incorporation of hillshade, topographic contours, and many other geographic layers. These user-friendly maps are easily customized to fit any oil field application. This has made it possible for RMOTC to develop some interesting research maps.

In 2007, RMOTC hired a GIS specialist to expand the role of GIS in RMOTC projects. For example, GIS was used to create a visual inventory of specific project areas that were included in a sitewide environmental assessment (figure 3). A small-scale topographic map of Teapot Dome included proposed pipelines. Geologists used GIS to generate a map of pipeline paths that included environmental stipulations. This visualization was included in RMOTC's environmental report.

On the business side, RMOTC demonstrates how GIS can be used to manage operating costs and increase revenues. It determines the optimized use of well production units and assesses gas gathering systems. The GIS user can put a 1.5-mile buffer around wells that are top producers to determine areas on which operators should be focusing their attention. Then a layer of the gas flow lines data is overlaid, and nodal analysis is performed to identify where improvements can be made to the routing, pipeline sizing, boosters, and compressor stations.

Another means to assess production is to determine the relationship of production elements to subsurface structure layers and faults. A network of fractures within a producing formation, for instance, can significantly influence production rates. The gas cap that sits atop the Teapot Dome structure can be mapped to help field crews avoid gas production when drilling.

Even the efficiency of drilling tools can be assessed with GIS. RMOTC has several partners that use its drilling rigs to test rotary steerable drilling tools. Using ArcGIS to plot the down-hole well surveys and ArcGIS 3D Analyst to calculate z-coordinates and create 3D maps, engineers are now able to show a cut surface of the test well location and see well path deviations caused by the drilling tool. GIS provides a worm's-eye view of the hole from the surface DEM down through the subsurface to the well bottom. A spider diagram is another way GIS creates a presentation of drilling effectiveness—this is a visualization method to display the map view of deviated well bore trajectories (figures 4, 5, and 6 are a DEM/cutaway map/spider diagram, respectively).

Remote-sensing data can also be input into the GIS to create visualizations of play area features. For example, RMOTC used GIS to study natural magnetic anomalies detected by sensors mounted on booms suspended from a helicopter. Oil and gas wells modify the earth's magnetic field to generate their own peculiar magnetic signatures, but other magnetic oddities were showing up in the sensing data. The captured anomaly data was added as a data layer in the GIS. By combining this with additional layers about facilities and other

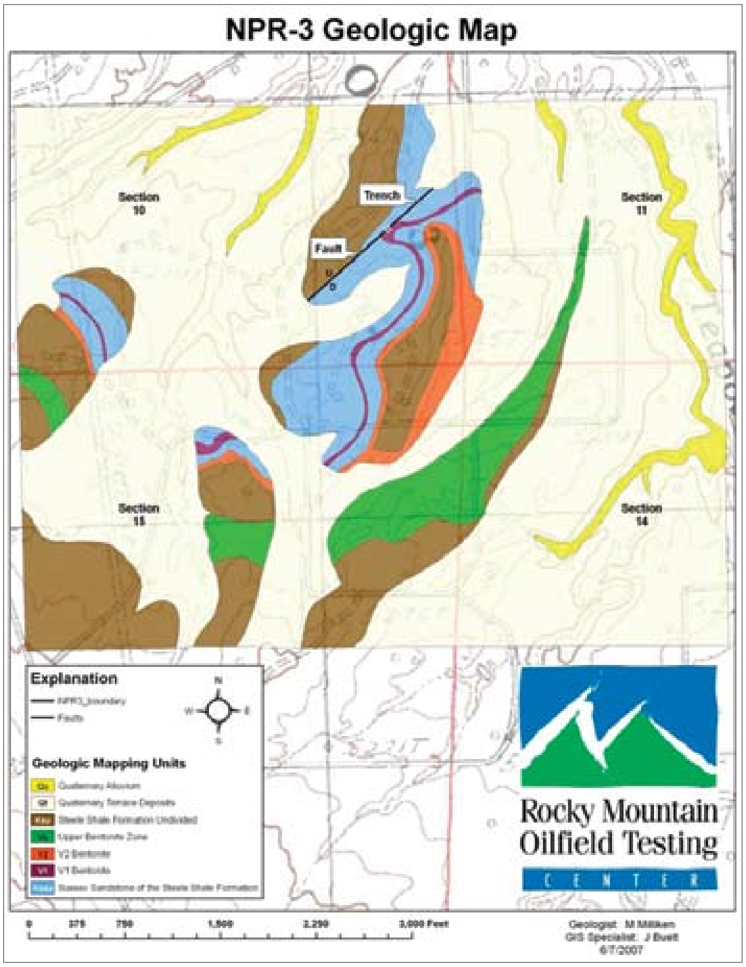


Figure 3. Detailed geologic map data layers include information about boundaries, faults, and geologic units such as quaternary alluvium (yellow), quaternary terrace deposits (eggshell), and Sussex sandstone of the Steele shale formation (blue).

Department of Energy E&P Datasets

Seismic Dataset

- 2D seismic data
- 3D seismic data
- 3D SEGY file
- NPR-3 field boundary
- Select time/depth tables
- Synthetic seismogram image
- Teapot Dome reservoir information sheet

Core Dataset from Well 48-X-28

- Core pore/perm analysis
- FMI data
- LAS files
- Mud log
- Core descriptions
- Core photos

Well Log Dataset

- Teapot Dome well headers
- Directional surveys
- Formation log tops
- Teapot Dome basemap
- Key to understanding formation codes
- NPR-3 type log
- Teapot Dome geologic column

GIS Dataset

- Shapefiles: Field boundary, roads, streams, facilities, pipelines, wells, geology
- Rasters: DEM, hillshade, aerial photos, subsurface structures

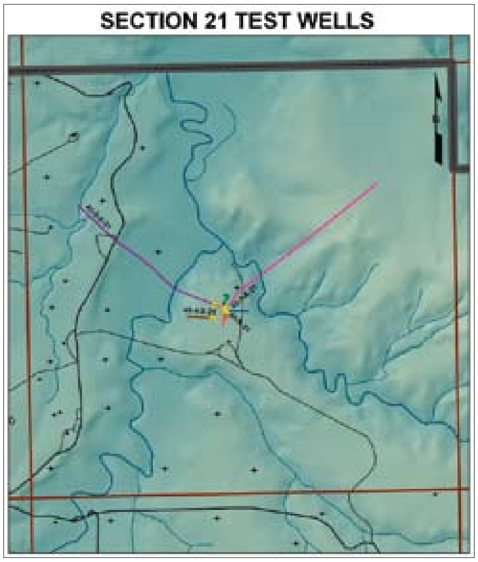


Figure 4. Teapot Dome test well location and deviated well bores

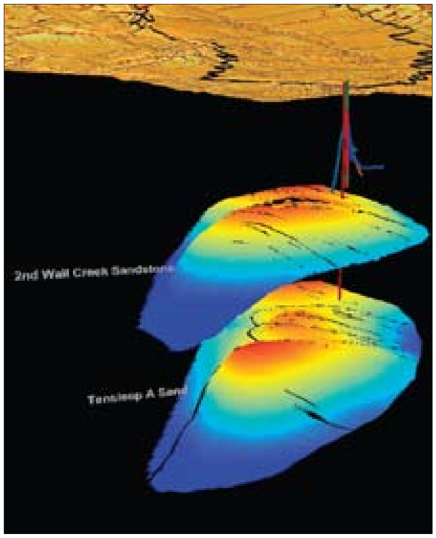


Figure 5. ArcGIS 3D Analyst depicts a 3D subsurface of the test well. The data layer provides a worm's-eye view of the surface DEM.

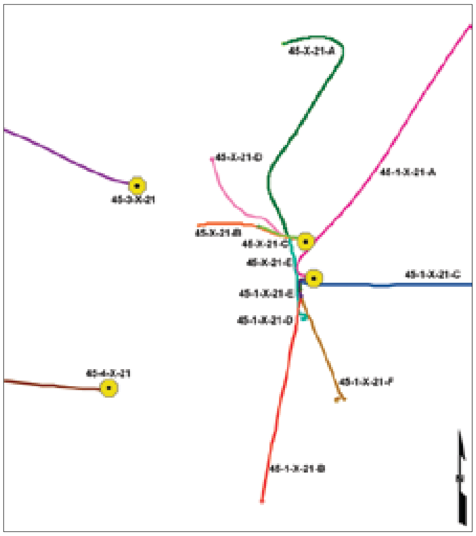


Figure 6. The accuracy of the drilling tools map shows a surface location in yellow and black. Well bore trajectories are symbolized by lines and labeled.

ground attributes, the staff was able to depict the source of magnetic occurrences created by high concentrations of iron and metal. These included wells, the gas plant, the pipe yard, a tank battery, a bridge, and a pump jack storage area. Still, some anomalies were not readily identified from the database, suggesting that perhaps a well had gone undocumented or had been inaccurately plotted. The mapmaker easily noted these on a map and sent it to a ground crew that could investigate these sites. This helped to make corrections to the database.

Continuing to grow its GIS capabilities, RMOTC is working on developing a comprehensive geodatabase that incorporates well locations, production data, well history, open-hole and case-hole logs, core data, facility information, and images. All this data will eventually be hyperlinked to a location on an interactive map hosted on the RMOTC Web site.

The U.S. Department of Energy has made its RMOTC datasets available on CD-ROM for use in scientific research, testing, demonstration, and training. Nonproprietary seismic, well log, core, and GIS data is available at no charge with some restrictions.

For more information about RMOTC datasets, visit www.rmotc.doe.gov or call 1-888-599-2200.

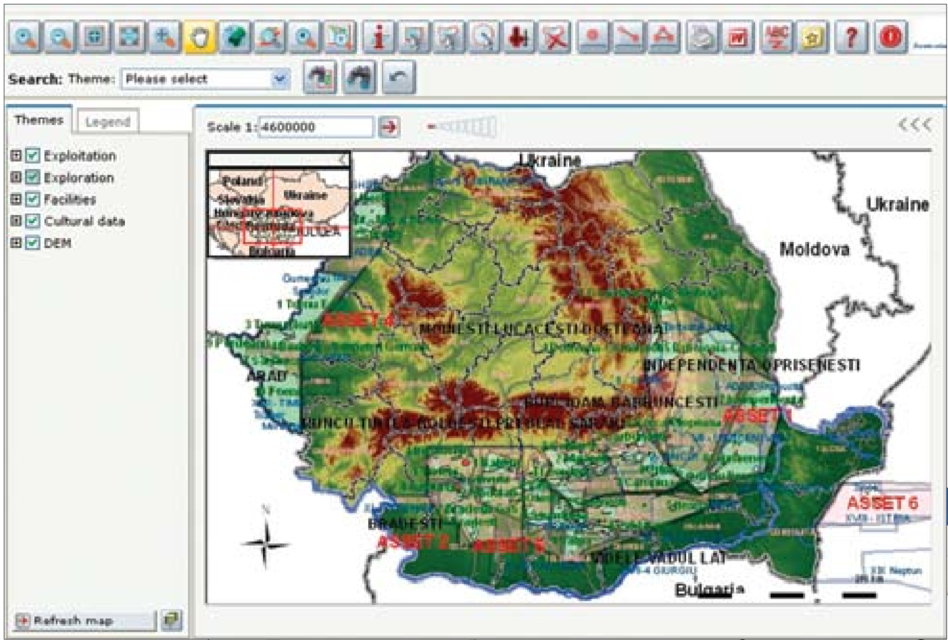
GIS Aids Exploration and Reservoir Analysis in Romania

By Manuela Badea and Elena Nedelcu, Petrom

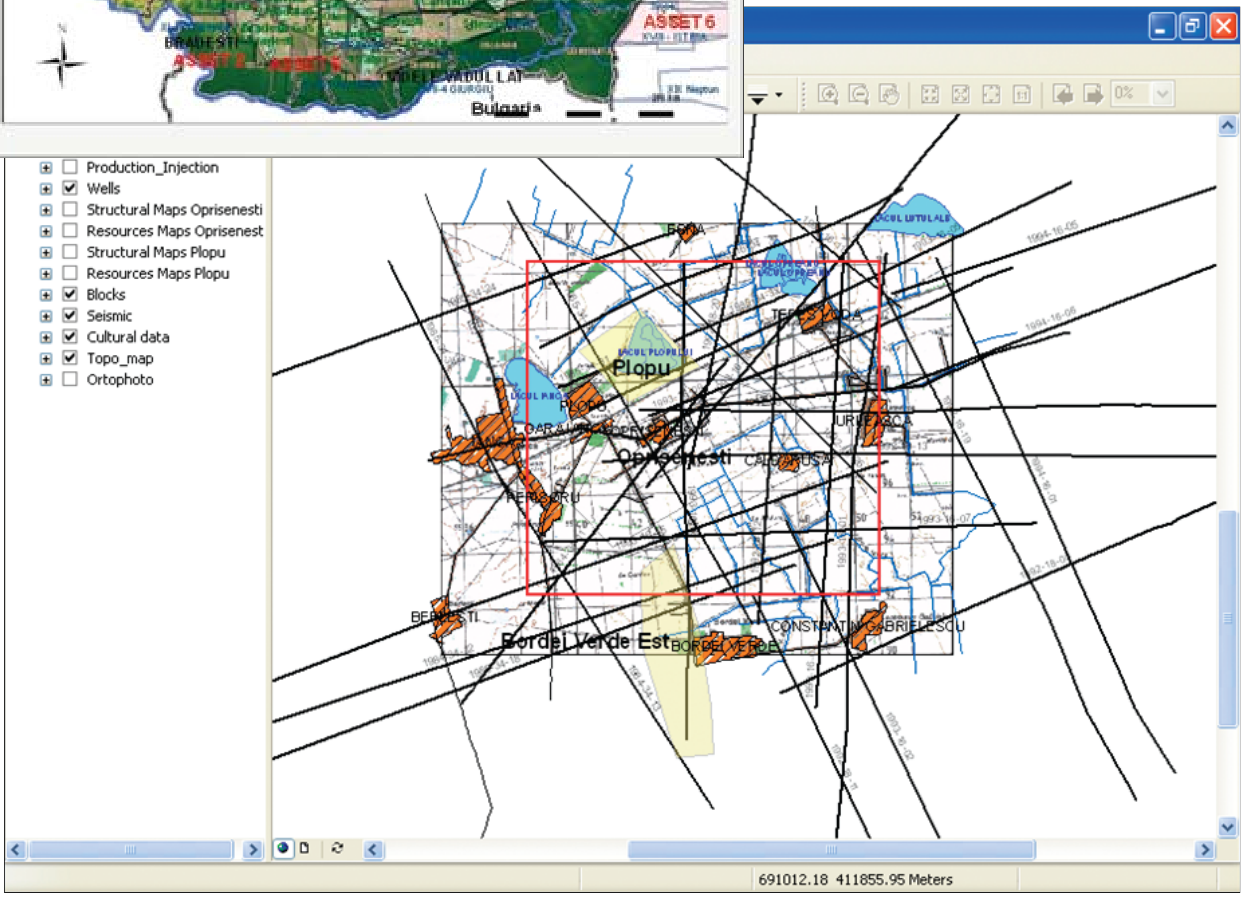
Some historians espouse that the oil industry was birthed in Romania. Potter's pots from the second century are marked with symbols for crude oil. It was the first country in recent history whose oil production was recorded in an international statistics registry. Romania continues to produce. The largest oil and gas group in Romania and a member of OMV Group, Petrom S.A. uses GIS for exploration and production (E&P).

In 2006, Petrom S.A. defined its database structure and began scanning and organizing data to the Petrom Geo Data Base. This database holds a wide variety of data including geological maps (1:200,000 scale), exploration and exploitation blocks, organization assets, field clusters, sectors, seismic lines and seismic 3D contours, and offshore and onshore surfaces. Structural resource maps and situation plans for the east region exploitation blocks have been scanned, georeferenced, and loaded in the geodatabase. E&P site assets are also included such as the treatment water stations, oil processing, oil deposits, injection stations, gas tank farms, gas facilities, and compressor stations. Cultural datasets such as localities, roads, lakes, the River Danube attributes, county and country boundaries, and a digital elevation model are included. Orthophotos for the entire country have been put into the database as well.

Using a Web application, the data is served via Petrom's intranet so that staff can visualize data relevant to their projects. This application is an ArcGIS extension called WebOffice, which was developed by SynerGIS Informationssysteme GmbH, ESRI's distributor in Austria, and runs on ArcGIS Server. It



Petroleum field data is accessible on Petrom's intranet for Web visualization.



A Web map viewer allows staff to see well information data on a map. Here, layers for block, seismic, cultural, and topographic data are turned on.

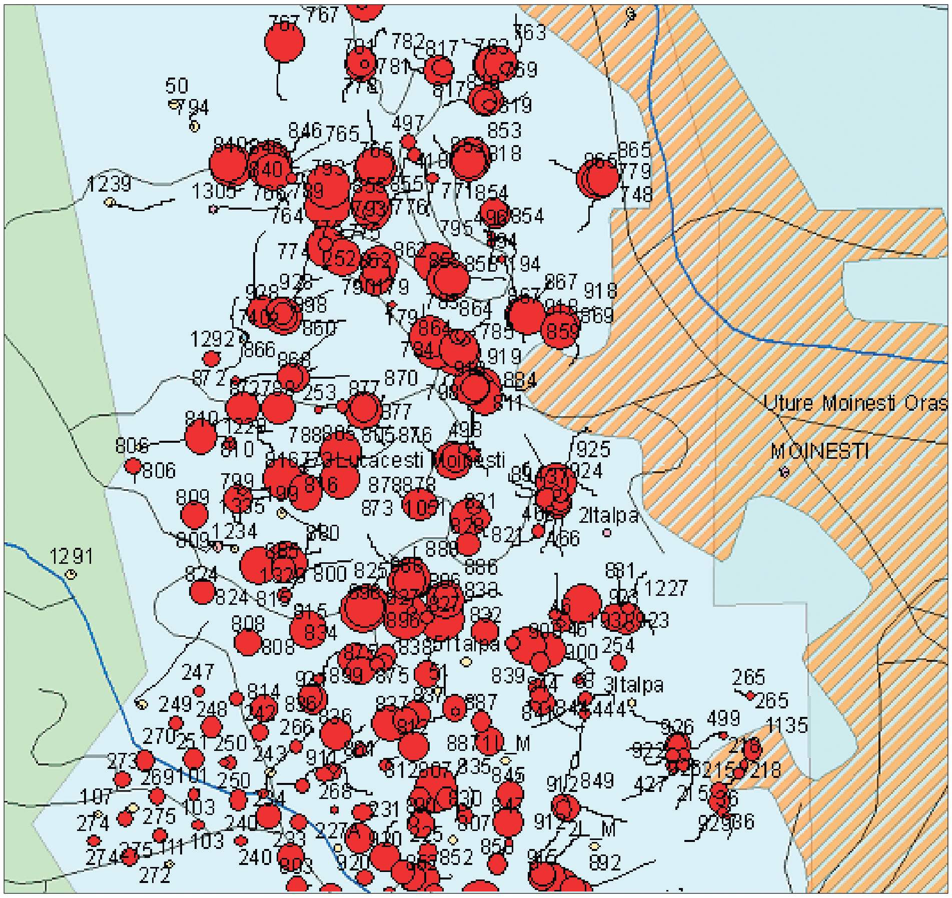
offers seamless integration in the GIS server with the company's core IT systems. Moreover, the system makes it possible for users to readily access important files and onshore/offshore data for local projects. It offers a Web data viewer via ESRI's ArcReader, which is a read-only viewer that allows the user to interact with the corporate database and use basic GIS tools such as zoom and pan. The majority of users at Petrom access the data to work with reservoir and commercial field projects.

For example, geologists will use GIS to perform an analysis on the potential of a new well. GIS offers well coordinates in the context of structural, geological, and cadastral data layers that can be viewed in an open GIS project. Geologists can also bring other data into the project such as seismic lines and orthophotography.

Field analysts use the company's GIS to create structural and resource maps and cumulative production of oil and gas and injection water maps. They can perform well analyses and create both geographic and table reports. Data on maps can be further linked to other data in the legacy database. Users can quickly view files with presentation and well analysis data along with scanned images.

An advantage that Petrom found with ArcGIS is that it allows users to analyze many different types of data. This includes satellite imagery, digital aerial photomosaics, seismic surveys and interpretations, surface geology studies, subsurface and cross-sectional interpretations and images, well locations, and existing infrastructure information. This ability to use a variety of data formats removes limitations on data types and opens a wide vista of research resources for GIS use. Moreover, it makes it possible to overlap and analyze data from many sources in a comprehensive and effective way.

Because data integration is a powerful function of ArcGIS, Petrom has been able to use it beyond the standard E&P requirements for geographic data visualization. It is used with many of the company's E&P databases and applications to create new results. For example,



GIS lets users easily understand well data such as this map showing cumulative production per well.

the user can select wells on the digital map and access extended attributes from a wide array of tables in the well database. Simultaneously, the user can display a data log and visualize cross-sectional information.

Working with external companies, such as agencies and contractors, Petrom receives and delivers data in a variety of file formats such as CAD. This data is migrated to a GIS format so that it can be processed. This incoming data is validated in the GIS so that it is accurate and useful for geospatial processing. Thus, a wide range of data can be used for field and business practices such as understanding asset infrastructures, business conditions, and environmental factors.

Petrom's petroleum and facility engineers, geologists, and geophysicists can now combine many pieces of information, including well profiles, surface topography, surface maps, and other features, that allow them to test multiple scenarios for selecting and designing field assets.

When the GIS project was launched in 2006, it was initially accessed by five users working on exploration and reservoir projects. Since then, the GIS user group at Petrom has grown. GIS applications now include health, environment, safety, and quality (Promigas HESQ) as well as regulatory compliance, pipelines, electrical lines, and land management.

For more information about Petrom S.A.'s GIS, contact Elena Nedelcu, GIS senior application expert, at elena.nedelcu@petrom.com.

Aera Energy LLC Finds More Uses for GIS

By Bill Bird, Aera Energy LLC

People in the oil industry traditionally use GIS for exploration, determining rights-of-way, routing pipelines, and selecting the best locations for service stations. Oil companies are now finding advantages of GIS in production operations from single well completions to monitoring whole reservoirs.

The main business of Aera Energy LLC, one of California's largest oil and gas producers, is in oil production, which means getting the oil out of the ground and into pipelines. Aera uses GIS to improve oil field production efficiency by enabling petroleum professionals to easily access production data in a spatial format.

Aera uses ArcGIS for its Spatial Enabled Reporting (SER) project. SER is used to merge spatial data with the company's Reporting Data Warehouse (RDW), thereby allowing users to create a multitude of map documents and view their data with an added dimension—location.

In 2000, Aera developed the Location Manager Application (LMA), which created a place in Aera's data warehouse to capture spatial data. Over the next five years, Aera's Information Management and Technology (IM&T) team created and populated the RDW with production data. In 2006, the SER project became the catalyst to combine spatial data with LMA and RDW data. Because ArcGIS brings together different datasets, users can create a variety of E&P maps such as production volumes, injection rates, and recovery efficiency.

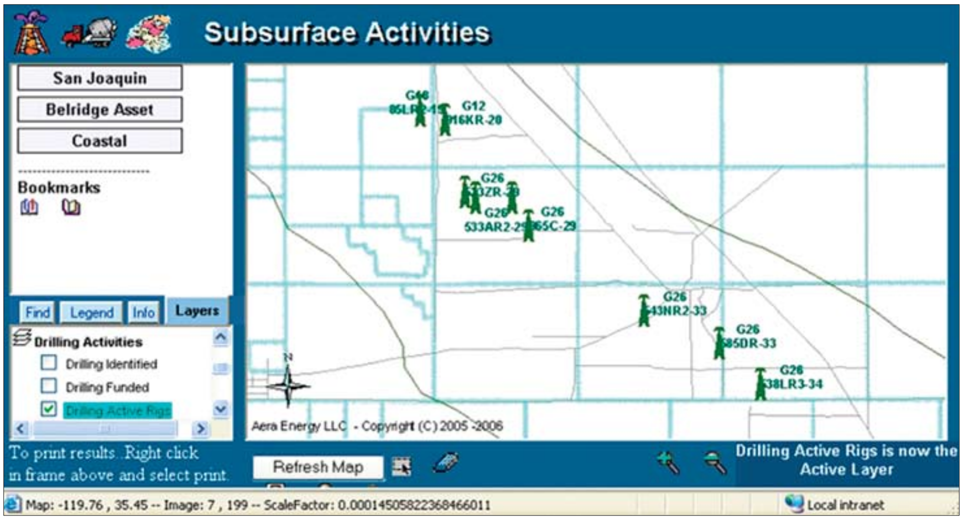


Figure 1. A GIS-enabled Web site provides subsurface data about drilling active rigs.

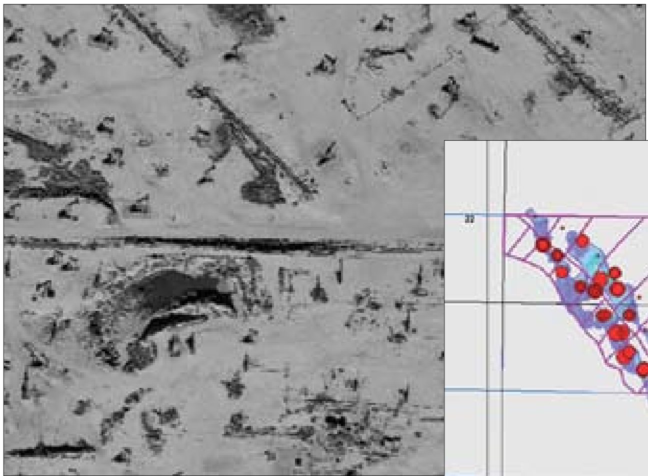


Figure 2. A planned survey database includes aerial orthographic photos managed and accessed by GIS.

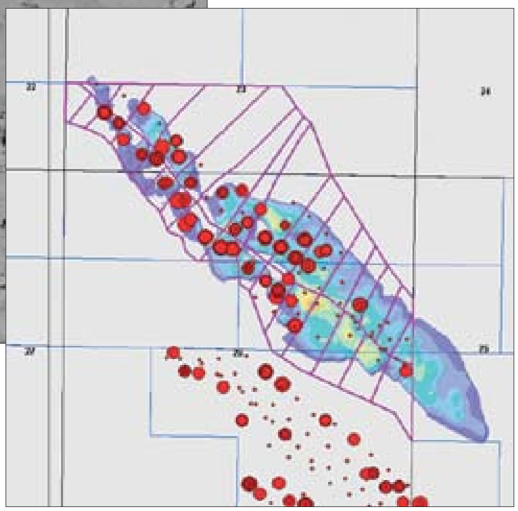


Figure 3. Many different users at Aera can access the data they need and bring it into GIS to create map configurations for their special projects.

Aera's investment recovery and drilling teams use ArcIMS to view maps showing rig activities. This allows much more efficient planning by coordinating equipment and personnel to rig sites. By joining with systems in the field used to track changes, the data shown on the Web site is automatically updated every 30 minutes (figure 1).

Another production GIS application Aera uses creates imagery of an extremely active area. Aera needed to determine the type of equipment to use and where to place it to get the best seismic data within the field. The GIS team coordinated aerial orthographic photos of more than 150 square miles across the field in advance of the planned survey (figure 2).

Perhaps the most important contribution of ArcGIS at Aera is how it is being used for injection management. Hundreds of premade geographic data layers are stored in a geodatabase, which is like a geostore. People with little or no experience can go geoshopping, pulling in different data layers to build their own maps (figure 3).

The GIS approach to oil production is helping workers throughout the company access pertinent information, create maps that show specific layers of information, and plan and evaluate projects. By interfacing with its business systems and providing production data online, Aera is leveraging its existing systems and extending the use of its GIS for a wider range of applications for analysis and development of its production operations.

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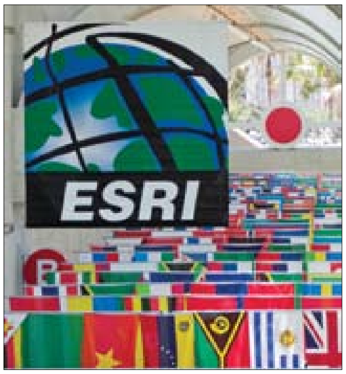

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