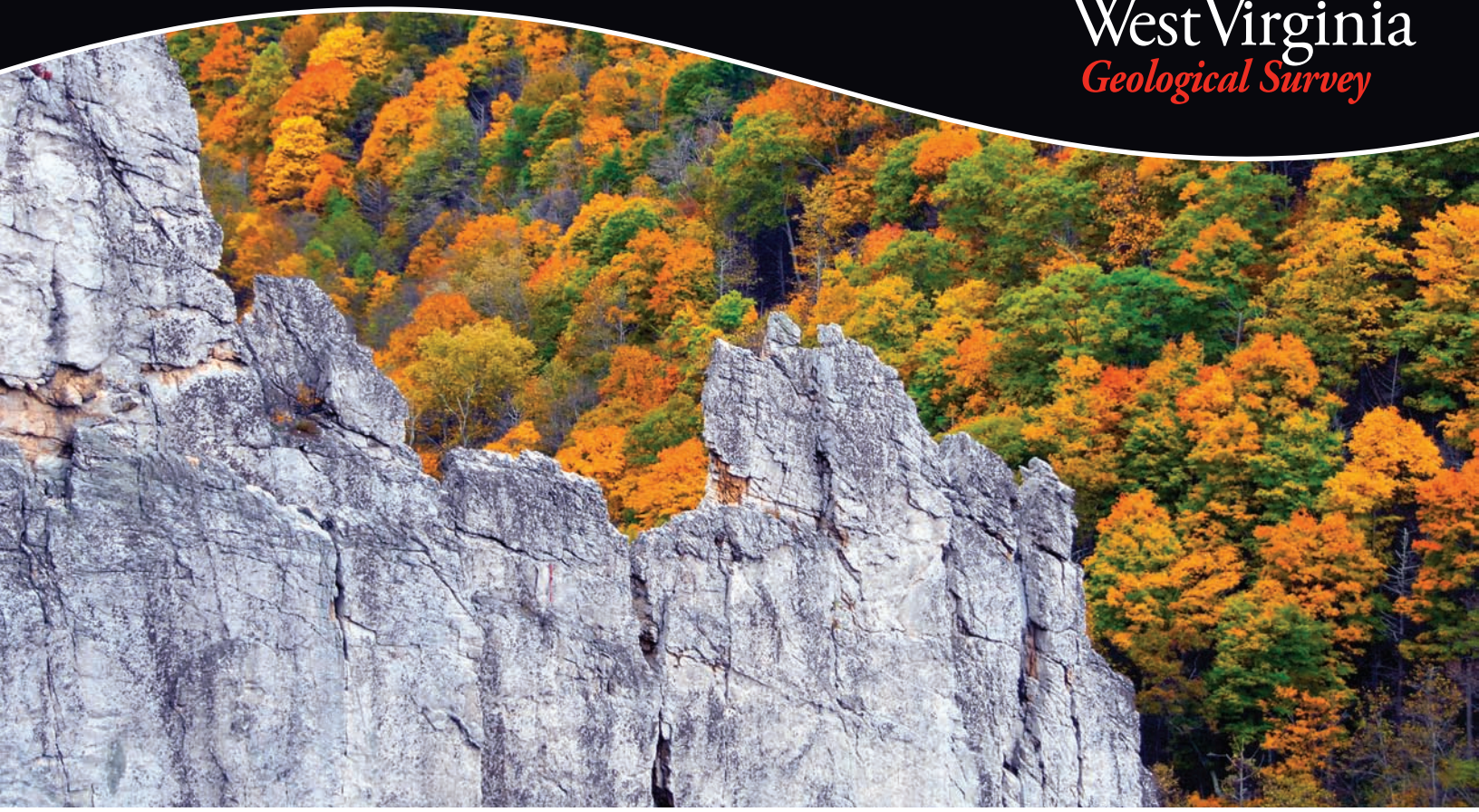
West Virginia
Geological Survey



2012 ANNUAL REPORT

WEST VIRGINIA

MESSAGE FROM THE DIRECTOR

The traditional image of the geologist at work walking up and down hills with a map in one hand and a notebook in the other, a geologists' hammer on the belt, and backpack to carry samples is not far from the truth. The modern geologist might also carry aerial photographs, a GPS unit, portable computer, and cell phone with built-in camera.

Images from airplanes help the geologist spot subtle features such as contacts between rock units, folds, faults, old sinkholes, abandoned mine openings, and other features often difficult to see from the ground. Unconsolidated surficial rocks can prove important to interpreting geologically recent history such as details of the Teays River, locating old landslides, or identifying economically important deposits. Radiometric and geochemical analyses help the geologist determine the age of rocks and whether a rock has economic potential or poses an environmental risk.

A lot of data can accompany a map, including descriptions and geographic distribution of geologic materials, locations and types of geologic structures, age of geologic materials, and an interpretation of how they formed. Supplemental information such as geochemical data can be made available as symbols on the map, listed in a table accompanying the map, or as a public database.

Mapping bedrock units and surficial deposits continues to be an important way of conveying information printed on paper, converted to a graphics file, or stored in a geographic information system. Practical applications of geologic maps for the benefit of society include:

- Providing basic geologic information for land-use planning and siting facilities such as highways, dams, airports, and waste disposal facilities
- Evaluating energy, mineral, and groundwater resources
- Locating sources of limestone for aggregate used in road building
- Helping homeowners locate water wells by knowing the type and thickness of a potential aquifer
- Studying economically-important rock units such as the Marcellus Shale where they crop out on the surface
- Establishing background levels of elements in rocks
- Analyzing geologic hazards by showing the location and extent of geologic units that are prone to karst formation and slope instability: sinkholes and landslides are common hazards in our state
- Assessing environmentally sensitive areas such as karst terrains
- Depicting the areal extent of coal-bearing formations

Combined with information in our oil and gas database and coal seam mapping by our geologists, our geologic maps and cross sections could eventually provide an integrated three-dimensional picture of the rock units at the surface and subsurface for much of West Virginia. This three-dimensional view can help citizens find economic resources, make wise land-use decisions, and protect our environment.

Michael Ed. Hohn

Cover photos: Nelson Rocks Outdoor Center, Pendleton County, W.Va. Inset: Dolly Sods Wilderness in the Monongahela National Forest, Tucker County, W.Va.

GEOSCIENCE PROGRAM

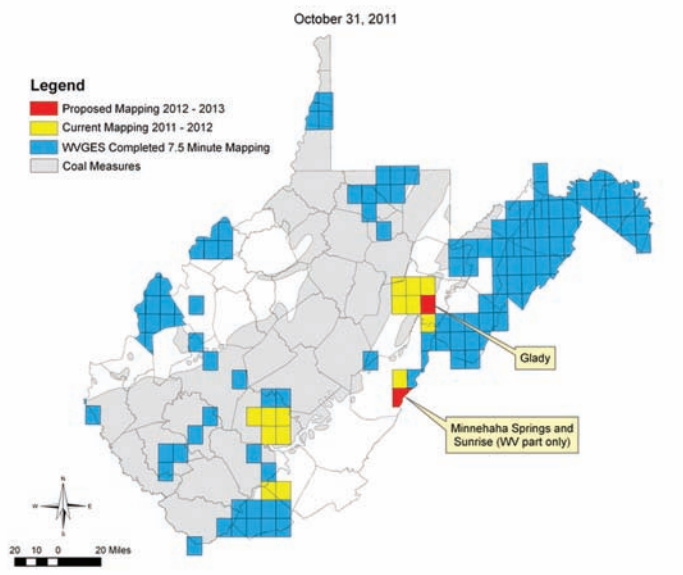
Geologic Mapping

Geologic Mapping at WVGES consists of two major components: the direct acquisition of new geological information through field reconnaissance and the digital conversion of new and existing geological information from hard copy (paper, mylar, etc.).

- Acquisition of new geological data is carried out under the auspices of the STATEMAP program funded jointly by the United States Geological Survey (USGS) and WVGES. During the summer and fall of 2011, field work was conducted on the Clover Lick topographic quadrangle in eastern West Virginia. Available as a WVGES Open File map, digital conversion for Clover Lick is complete and in the process of review. In October 2011, the STATEMAP Advisory Committee, composed of individuals from industry, government, and academia, met to evaluate two new map areas for the upcoming 2012 field season. Mapping of the Minnehaha Springs/Sunrise and Glady quadrangles, was proposed to the USGS in November 2011 and both projects were partially funded. Fieldwork on these two projects began in June 2012.
- In August 2009, WVGES submitted a successful proposal to the National Park Service to map the geology of the Gauley River National Recreation Area, the New River Gorge National River Area, and the Bluestone National Scenic River Area. Over a three-year period, a consortium of geologists from WVGES, West Virginia University (WVU), and Concord University will map the bedrock and surficial geology of 14 topographic quadrangles. Final versions of two of these, the Flat Top and Pipestem quadrangles, were submitted to the Park Service in November 2011. During the third year of this project, WVGES mapping teams performed all of the field work on the Fayetteville, Thurmond, Winona, Danese and Prince quadrangles, and a portion of the field work on the Meadow Creek, Hinton, Meadow Bridge, and Talcott quadrangles
- Digital conversion of existing and future map information is a high priority at WVGES. During FY 2012, digital maps of the Flat Top, Pipestem, Greenland Gap, Spring, Bramwell, Ripley, Sissonville, Big Chimney, Louisa, and Fallsburg quads were completed for the National Park Service project.

Mine Pool Atlas Project

The Mine Pool Atlas project is a two-year study funded by the West Virginia Department of Environmental Protection (WVDEP) to evaluate abandoned coal mines as potential groundwater sources. This study, which addresses the potential for large volumes of groundwater storage based on mine void volume, uses available Coal Bed Mapping Program (CBMP) products to identify underground coal mines having the potential to store large quantities of groundwater, especially those mines located below or near drainage. The study is an initial effort to locate all of the large mine pools in West Virginia both stratigraphically and geographically and to estimate their potential volumes.



Geothermal Resources

WVGES is participating in a three-year project sponsored by the United States Department of Energy (USDOE) and the Association of American State Geologists (AASG) to increase publically available data on geothermal resources in all 50 states. During the second year of the project, WVGES provided GIS-accessible versions of temperature logs, bottom hole temperatures, data on West Virginia springs, and maps of faults and earthquake epicenters for the State. In addition, WVGES continued working with researchers from WVU's Department of Chemical Engineering to measure thermal conductivity taken from drill core and cuttings held by WVGES.

Environmental Geoscience and Geochemistry

Environmental and geochemical work at WVGES deals primarily with the evaluation of geologic site characteristics for Underground Injection Control (UIC) permits, the creation and maintenance of a database of selected metals content of the state's rock formations, and answering public inquiries regarding the state's water resources, geologic hazards, and geochemistry.

Seismic Monitoring

After the massive and extremely destructive Japanese earthquake of March 2011, seismic activity worldwide received increased attention. The issue was brought home to the eastern United States in August 2011 when a Richter magnitude 5.8 earthquake in Louisa County, Va., shook buildings all the way to the Ohio border. WVGES geologists were inundated with inquiries from TV and radio stations, state and local government officials, and private citizens regarding the cause of the quake and an assessment of the potential for such an occurrence in West Virginia. There were also a number of inquiries regarding the possible connection between Marcellus Shale drilling activities, particularly the practice of fracking, and earthquakes in the Appalachian Basin. On the last day of 2011, a Richter magnitude 4.0 earthquake struck the Youngstown, Ohio, area in the vicinity of a well used to dispose of fluids produced by oil and gas wells in Ohio, Pennsylvania, and West Virginia. This raised additional concerns about the drilling-earthquake connection. Concerns became locally focused in January 2012 when a Richter magnitude 2.8 earthquake occurred in Braxton County, W.Va., within 10 miles of the only disposal well in the county.

The state's sole seismic recording station during the 2012 Fiscal year was located at WVGES. Because determining the geographic position of an earthquake's epicenter requires a minimum of three stations, the location of any earthquake within West Virginia currently requires reliance on seismic stations in surrounding states. In addition, because the determination of the depth to an earthquake requires a seismic station to be very close to the epicenter, it became clear that our single station needed to be supplemented. WVGES took a two-pronged approach, pursuing the idea of adding additional permanent seismic stations in the state while also investigating the idea of creating a small network of temporary, portable seismic detectors that could be deployed to areas of particular interest.

WVGES consulted with seismic experts from the USGS and from Ohio and Virginia to get advice on the technical specifications and operation of seismic equipment. Information and pricing was solicited from several vendors of geophysical equipment. In addition, WVGES became involved in the EarthScope Program sponsored by the National Science Foundation (NSF) and a consortium of universities to set up a number of semi-permanent seismic stations within West Virginia. Fourteen stations are to be installed by the end of summer 2012 and, pending additional NSF funding, two to four of these stations will be left in place permanently.

Outreach Activities

- In September 2011, geoscience personnel helped lead an American Association of Petroleum Geologists (AAPG) field trip entitled "Geology of the Marcellus Shale" visiting outcrops in eastern West Virginia and western Virginia. The trip was part of the Eastern Section – AAPG Meeting held in Washington, D.C. In addition, geoscience personnel presented a poster session titled "Dust in the Wind: Aeolian sediment in Middle Ordovician carbonates of North America."
- In April 2012, geoscience personnel presented a poster titled, "Geochemical trends associated with the Tioga Ash and origin of the Huntersville Chert, east-central West Virginia" at the Southeastern Section – Geological Society of America meeting in Asheville, N.C.
- WVGES geologists, in conjunction with West Virginia Division of Natural Resources-State Parks (WVDNR-State Parks), presented the "Geology Rocks" program at eight state parks throughout the summer. The program consists of a talk on the geology of West Virginia and a geology hike within the park.

OIL AND GAS PROGRAM

Interest remains high in oil and natural gas resources of West Virginia. The WVGES continues to track drilling activities while also addressing the varied needs of the scientific community, government agencies, oil and gas operators, and citizens of West Virginia. Acquisitions of and requests for subsurface data encompass Carboniferous to Cambrian strata and range geographically across the state, including new Marcellus Shale activity in the northern panhandle, methane production in southern coals, Utica shale exploration in the west, and gas storage reservoirs to the east.

The Marcellus and Utica Shales

The Marcellus Shale continues to be an important petroleum producer in the state. Marcellus well counts in FY 2012 show 1,979 completed wells and 954 active permits. This reflects an increase in completed wells and a decrease in active permits from FY 2011,

suggesting that activity is moving into the development phase. Most wells are now drilled horizontally into the Marcellus, with multiple wells located on one pad and multiple stages of completion along the lateral legs. This is a major advance in well development, as production volumes from horizontal wells far exceed those from traditional vertical completions. Drilling activity has also shifted west and north, where the Marcellus produces methane as well as ethane and heavier-chain hydrocarbons known as "wet gas."

The presence of ethane in the Marcellus is significant due to its use as a chemical feedstock. West Virginia may locate a facility to thermally "crack" the ethane and process it into ethylene, commonly used in the production of plastics. In support of these efforts, WVGES produced a series of maps detailing drilling trends in gas shales throughout the region. These maps included not only Marcellus activity, but also the increase in production of dry gas, wet gas, and oil from the deeper Utica shale. Utica tests in Ohio have stirred interest, but its potential remains largely untested in West Virginia.

CO_2 Research and MRCSP Participation

The Devonian section above the Marcellus has also experienced a resurgence of interest, especially in oil-bearing reservoirs. These units are included in a study by the Midwest Regional Carbon Sequestration Partnership (MRCSP) to identify fields with potential for enhanced oil recovery (EOR) via CO_2 floods. In this phase of MRCSP, the WVGES will summarize and rank fields throughout the region for their EOR viability. Inclusion of EOR into the MRCSP statement of work results from a federal mandate to shift focus from CO_2 sequestration to projects that utilize CO_2 as a commodity. This paradigm shift transforms the widely-known acronym CCS (Carbon Capture and Storage) into CCUS, or Carbon Capture, Utilization, and Storage. The CCUS efforts of MRCSP also include potential for enhanced gas recovery in shales and coals.

Brine Disposal and RPSEA Participation

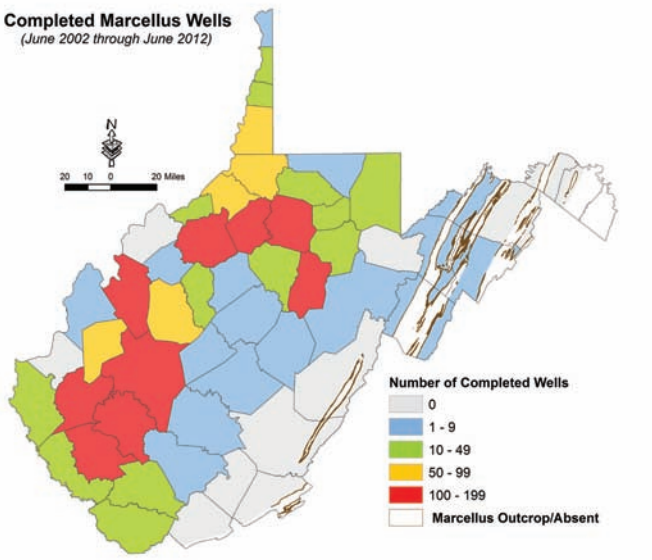
Deep brine-bearing subsurface units, once targets for CO_2 sequestration, are now being examined for their potential to store produced water. WVGES is included in a proposal for a basin-wide study submitted to the Research Partnership to Secure Energy for America (RPSEA). West Virginia is well-situated for analysis of brine disposal, given the proximity to ongoing drilling operations as well as the presence of multiple saline reservoirs and thick confining units in the deep subsurface.

Oil and Gas Database Development

A significant achievement made this year was the database update of oil and gas activity in West Virginia. Escalating Marcellus Shale activity resulted in a surge of permit and completion information submitted to the state. Completion reports contain vital information and require trained geologists to interpret and enter the data. Due to a collective effort, all available permit and completion data have been added to the database, and new data are added upon receipt.

The Oil and Gas Database DVD, a popular product in Publication Sales, also received an update this year with information on hundreds of new wells. Also updated and improved were the Marcellus Shale Interactive Mapping System (IMS), summarized downloads of Marcellus activity, and customizable page-sized maps for printing.

WVGES has also received a seven-seat license of The Kingdom Suite software, valued at over $810,000, as part of the IHS University Grant Program. This industry-grade software enables log analysis and resource assessments as well as creation of detailed maps and cross-sections.



GEOGRAPHIC INFORMATION SYSTEM

This program is responsible for planning, organizing, coordinating and delivering high level Geographic Information System (GIS) services to agencies in state government; it is headed by the statewide GIS Coordinator, based in Charleston.

We continue to make headway in a number of critical areas: promoting data sharing between agencies; providing technical assistance to state, county, and local government and the public; and fostering efficient and effective use of the state's geospatial capabilities.

The GIS Coordinator continues to provide general administrative oversight of the Mineral Lands Mapping Program in collaboration with the Survey's Coal Bed Mapping Project and the State Tax Department, Property Tax Division. During the year, procedures were refined and implemented, producing significant results in the number of mineral parcel outlines and attributes in the Property Tax Division's GIS.

The coordinator provided support to the Division of Homeland Security, Department of Environmental Protection, the Water Development Authority (WDA), the National Guard, the WV Intelligence Fusion Center, Hazard Mitigation section, and other state and local agencies in their search for GIS contract services, funding, and GIS application development.

Data exchange protocols to enhance data sharing and exchange between state and local agencies have been established. The protocol anticipates inclusion of all state and locally produced datasets in the future.

A Statewide Cadastral Data Business Plan was completed. A critical component of the GIS Strategic Plan, the Cadastral Business Plan articulates a vision for developing standards and addresses issues in distribution and use of geospatial cadastral data.

GIS workshops created in collaboration with the WV Association of Geospatial Professionals, WV GIS Technical Center, Rahall Transportation Institute, Property Tax Division, County Assessors, and 911 directors continued to be popular among GIS professionals. These workshops were designed to inform, train and advise county and local government officials that have GIS programs in the latest technology and at the same time educate those officials that have not embraced GIS technology in their own organizations. The workshops emphasize inter-agency collaboration and are given at different locations throughout the state.

The GIS Coordinator attended sessions and presentations at the mid-year National States Geographic Information Council (NSGIC) in Annapolis, Md., and the West Virginia Association of Geospatial Professionals conference in Morgantown, W.Va. The coordinator participated in sessions of the WV GIS Policy Council, the WV Information Technology Council, WV Broadband Deployment Council, the GIS Steering Committee, E911 Council, WV Association of Professional Surveyors, and the Statewide Addressing and Mapping Board.

Broadband Mapping and Planning Program

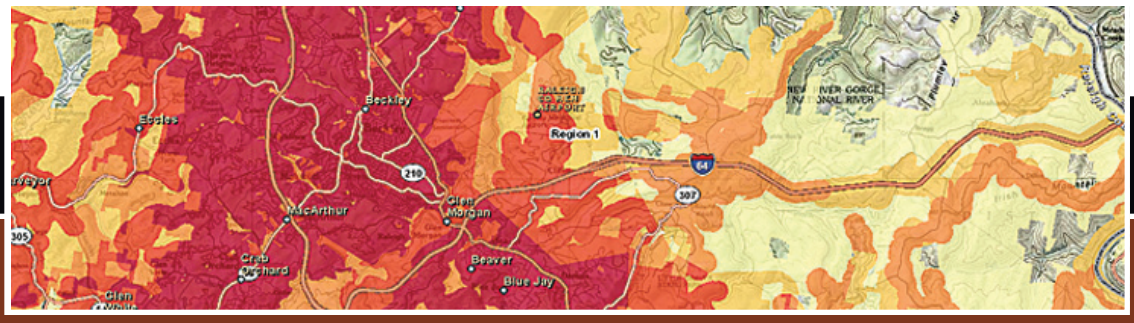
Statewide broadband mapping, planning, and technical assistance continue with the support of a $4.7 million grant from the U.S. Department of Commerce National Telecommunications Information Administration, funded through the American Recovery and Reinvestment Act. The goal of this project is to increase broadband access and adoption through better data collection and broadband planning. Besides being displayed in NTIA's national broadband map, data gathered under this program is displayed on a state interactive mapping application. This tool informs policymakers' planning and build-up efforts and provides West Virginia citizens with improved information on the broadband Internet services available to them.

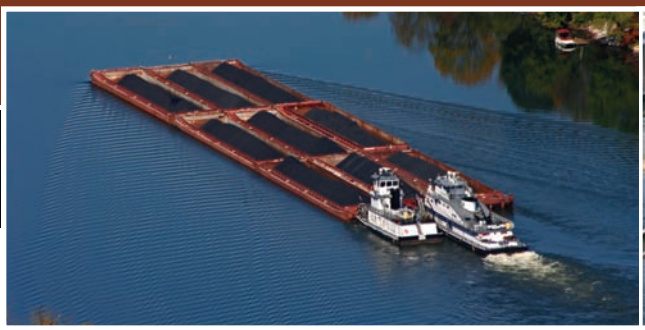
The Survey effort has three components:

Technical Assistance: In partnership with the Appalachian Transportation Institute, the West Virginia GIS Technical Center, and the 11 Regional Planning Councils, the West Virginia Geological and Economic Survey Office of GIS Coordination is conducting community-level research to assess and investigate areas with low broadband adoption rates and develop a statewide Technical Assistance Grant Program to improve broadband adoption. The program will provide direct technical assistance to organizations authorized under the program, as well as to individual municipalities that want to promote broadband demand and adoption.

Regional Broadband Technologies Planning Teams: This project supports local planning groups in each of the 11 West Virginia Planning and Development regions. Each planning and development region currently hosts a regional council that works with stakeholders to develop regional broadband awareness and adoption plans for their individual regions. As part of this work, each regional council administers and analyzes a survey designed to assess the opportunities for broadband-based economic development. The resulting regional plans will serve as foundation for the Statewide Broadband Strategic Plan.

Mapping: Twice during the year, we collected and submitted to NTIA data from the state's broadband providers. This data was verified and then used to update the interactive and static online maps.

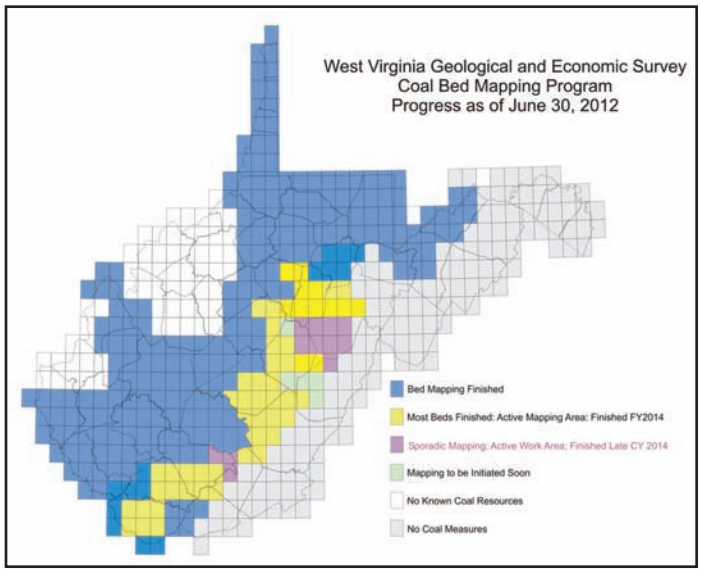




COAL RESOURCES

Coal-bed Mapping Project (CBMP)

Survey coal geologists continue to characterize West Virginia's coal resources through the statewide Geographic Information System (GIS). Seam-based GIS layers include: structural contours; outcrops; mined areas; coal isopachs; percent partings; and coal quality. These products are regularly updated and can be viewed on the Survey's website. These products are provided to the West Virginia Department of Revenue for use in generating state tax revenues, helping to fund the counties' education system. Steady progress has continued within CBMP during the past year which required overcoming the loss of two senior geologists who left state government for the private sector. Their replacements are currently learning the procedures and techniques needed to produce coal maps. Project goals were met and should be met during the coming fiscal year. Additional losses of trained personnel to the private sector or to retirement will adversely impact project productivity.



An important milestone was achieved with the migration of our stratigraphic data into a new Oracle database. Testing has begun and will continue into next year. We continually add new data to our stratigraphic database through cooperation with industrial and governmental agencies, targeting areas of low data density. These additions allow continual refinement of the various models. In addition, all stratigraphic data files have been scanned into a PDF format. We are exploring options of serving permissible data through the Survey's website.

Geologic Mapping Projects

Coal Program geologists have finished geologic mapping (Elk Map) on five 7.5' quadrangles near Elkins in Randolph County; Junior, Elkins, Beverly West, Beverly East, and the Sinks of Gandy. Maps are in various stages of final preparation. In addition, section geologists are participating in the Federally-funded STATEMAP project, mapping quadrangles that lie between Elk Map areas and eastern panhandle areas being mapped by other members of the Survey's staff. Numerous data have been collected, geologic contacts have been drawn and the maps are being reviewed by Survey geologists. The Glady quadrangle was finished in May 2012.

Coal Quality

The Coal Program maintains a large and growing computerized database of various chemical and physical characteristics of West Virginia coals. This valuable database has been very effective in aiding potential customers to identify West Virginia coals that meet their specific requirements for power generation, chemical feedstock, coke production, or as a source of coal-to-liquid applications. A cooperative agreement with the Kentucky Geological Survey to analyze coal samples at a reasonable cost fills a void created when the Survey lost its laboratory due to infrastructural changes at West Virginia University. Under this agreement, several deep coal bed methane cores, donated to the state by an industry partner, were analyzed, adding to our knowledge of deep coal beds.

National Coal Resources Data System (NCRDS)

This long-running cooperative program between the U.S. Geological Survey and the WVGES has enabled both partners to maintain and grow their respective coal databases. In addition to facilitating important research on coal, coal mining, and resource analyses, the cooperation has resulted in the collection of valuable data on the occurrence, distribution and quantities of trace elements found in West Virginia's coal measures. While many federal programs are under economic stress, the NCRDS program in West Virginia has been continued through June, 2013.

Underground Mine Mapping Project

Coal Program geologists, in conjunction with West Virginia's Office of Miners, Health, Safety and Training (MHST), continue to expand the large collection of coal mine maps by obtaining previously unavailable historic underground mine maps from numerous repositories. The footprints of newly obtained maps are digitized and added to the Survey's coal bed GIS. Ancillary information is entered into WVGES' stratigraphic database for use in the statewide coal bed GIS. Recently, coal geologists have been concentrating on obtaining and updating the areal extent of surface mines which are frequently less-well depicted than underground mine maps.

WEST VIRGINIA GEOLOGICAL AND ECONOMIC SURVEY

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January 2013

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