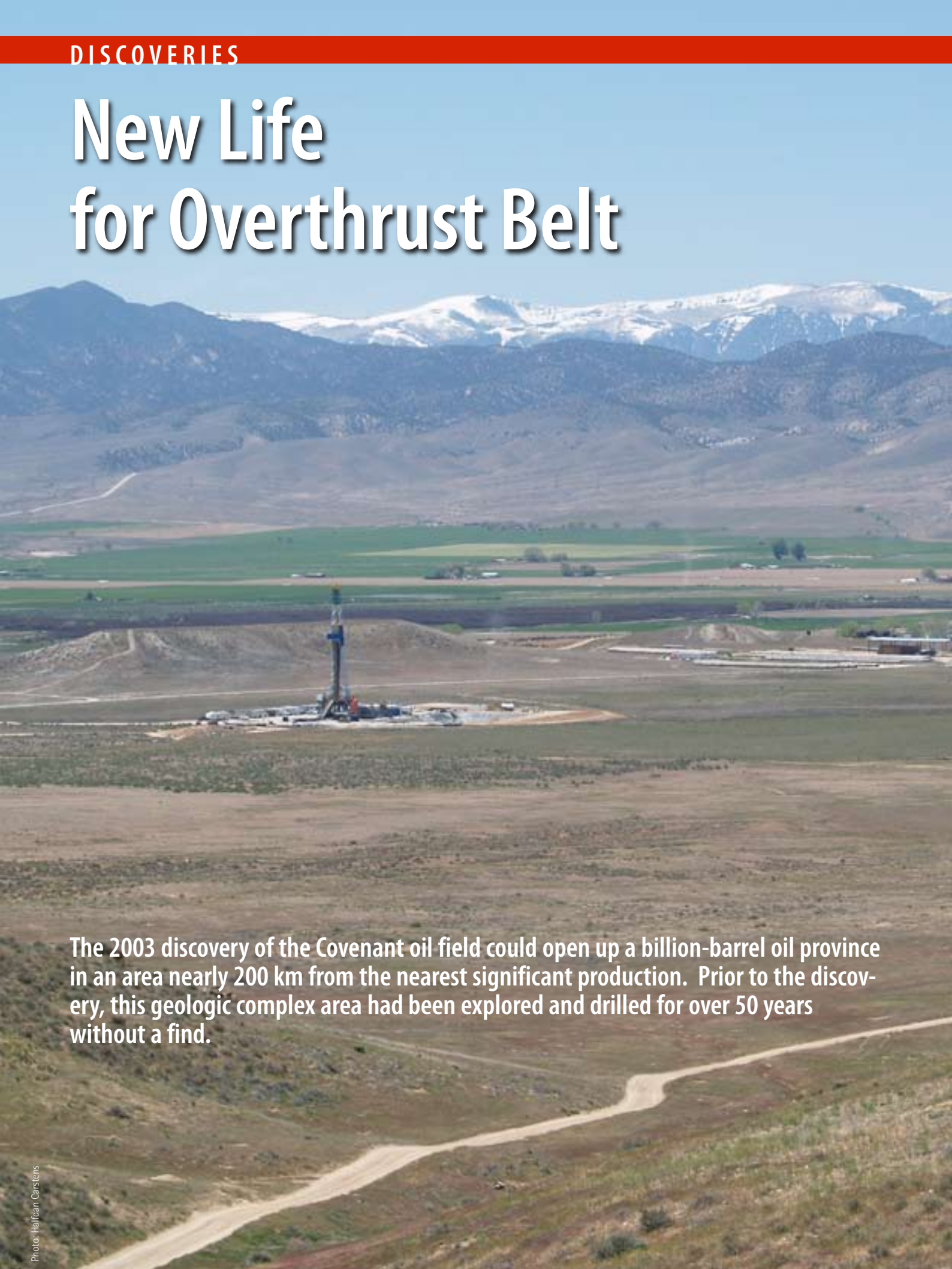
New Life for Overthrust Belt



The 2003 discovery of the Covenant oil field could open up a billion-barrel oil province in an area nearly 200 km from the nearest significant production. Prior to the discovery, this geologic complex area had been explored and drilled for over 50 years without a find.

Photo: Halfdan Carstens

Wolverine Gas and Oil's Cedar Ridge 18-1, located about 80 km north of the Covenant discovery well 17-1 Kings Meadow Ranch No. 1, is the first well drilled on a new structure after this successful test. Well drilling operations are completed, but the well is suspended and it may be reentered at a later date. To date, six additional wells have been permitted in this area. In the area to the south nearer the discovery, Wolverine has drilled two wildcat wells, the company is currently drilling a third, and three new well permits have been applied for.

The Rocky Mountain Foreland fold and thrust belt now has three productive salients. The Canadian segment has the longest production history starting with the discovery of the Turner Valley field in 1924. The discovery of the Pineview field in 1975 started a major exploration phase in the northern Utah-Wyoming segment where several giant oil and gas fields have been found. Now, with the late 2003 discovery of the Covenant field, the central Utah segment becomes the focal point of exploration for this trend.

The Cretaceous to Early Tertiary compression, involving the formation of the foreland basin, led to large-scale thrust sheets and locally complex and highly deformed areas. It is these thrust faults and associated anticlines that form most of the traps for oil and gas in Central Utah and the hingeline area to the north where the Pineview and Anschutz Ranch East fields are found. Now, the hingeline roughly marks the boundary between the Basin and Range and the Colorado Plateau provinces.

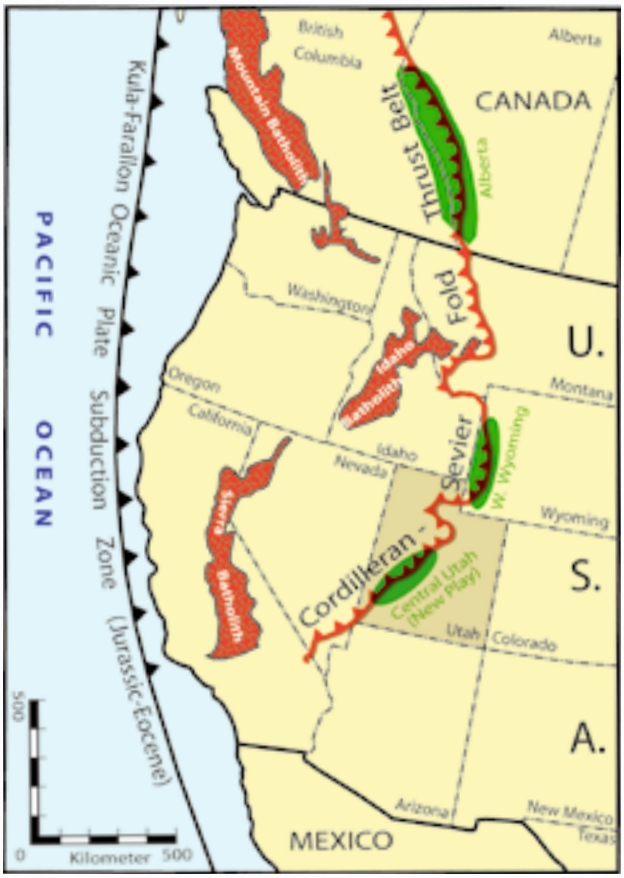


Illustration: Energy & Geoscience Institute; Modified from GEO ExPro No. 4/5, 2006

Thomas Smith, Associate Editor

The Covenant oil field lies along the Rocky Mountain Foreland fold and thrust belt that extends from the Canadian Arctic through the United States and into Central America. Prior to its discovery in late 2003, the complex geology of the central Utah thrustbelt had frustrated explorationists for over 50 years with 115 wells drilled without a discovery.

Numerous discoveries have been made in Canada and the United States along this belt, including 18 giant (using international terminology, proved reserves exceeding 500 million bbls oil (80 mill. m^3) or 3 trillion ft^3 gas) oil and gas fields.

The nearest of these giant fields is the Anschutz Ranch East field (discovered in 1980) located in northeast Utah next to the Wyoming border, over 300 km to the northeast. The Covenant discovery lies 200 km to the southwest of the nearest production, that being in the Uinta Basin. This discovery thus opens up a promising new onshore play containing numerous undrilled structures in an area that is at least 240 km long and 60 km wide.

The discovery

Hard work and persistence paid off for Wolverine Gas and Oil, a private independent out of Grand Rapids, Michigan. Doug Strickland, exploration manager for Wolverine, worked the Utah hingeline for 25 years, keeping a close eye on leasing and drilling activity for the area. Their opportunity came in 1999 when Chevron decided to pull out of the Rockies and offered Wolverine their large acreage position. Prior to that, Chevron held most of the exploration leases and seismic data in the area. Wolverine ended up obtaining a 260 km^2 Federal unit and Chevron's 2-D seismic data.

Wolverine geophysicist Keith Johnson reworked the seismic data identifying a series of hanging-wall anticlines. Consultants Dan Schelling worked the structure and David Wavrek developed the petroleum system model. According to Strickland "The data from the 5,200 m well Chevron drilled in 1981 would prove to be a key piece of information to identify the prospect that led Wolverine to drill the 17-1 Kings Meadow Ranch No. 1." Using dipmeter data from the Chevron well and conventional 2D seismic data, geoscientists

determined they could get much higher on the structure.

The highly deformed and salt-rich Jurassic Arapian shale that forms the cap rock also makes drilling difficult. Wolverine used downhole drilling motors and the latest in mud systems to keep the well on target. The Navajo Sandstone was encountered 425 m higher than anticipated. The well is believed to have been drilled to 3,270 m total depth.

The well was completed and started producing good quality light crude (40 degree API gravity (0,83 g/cm^3) in May 2004. The Navajo Sandstone here is 360 m thick, with the top 150 m oil bearing. A second reservoir, the Twin Creek Limestone, with little primary porosity is likely to produce from fractures.

Thomas Chidsey, petroleum section chief for the Utah Geological Office, says "Wolverine has ten productive wells with one dry hole. These wells are producing 4,900 barrels per day. Total production through April 1, 2006 was 1.5 million barrels oil (238,000 m^3), 200,000 barrels of water (32,000 m^3) and no gas."

Doug Strickland says that at least two additional wells will be drilled to develop the 650 hectare (6,5 km^2) field but would not elaborate on total reserves. Other sources put reserves between 75 and 200 million barrels (12 and 32 million m^3). Pinnell and Moulton, in a 2005 Oil and Gas Journal paper, estimate from Wolverine's own seismic structure map that 896 million bbl (142 million m^3) may be recoverable.


Photo: Wolverine Gas and Oil

Pictured in the Rattle Snake Range in eastern Nevada is Doug Strickland, the man who did not give up on the Central Utah Thrust Belt. He has worked the area since 1978, first with Chevron and finally with Wolverine Gas and Oil since 1999. In between, he worked as exploration manager with W. R. Grace and as a consultant.


Photo: Thomas Smith

The Navajo Sandstone is an aeolian derived, quartzose and cross-bedded sandstone that forms the spectacular cliffs found in many of the national parks in Utah, as here in southern Utah's Zion National Park.

Reservoirs

The primary reservoir objective is the Lower Jurassic Navajo Sandstone, called the Nugget, to the north in Wyoming. It is an aeolian, quartzose sandstone that is over 360 m thick and in most producing areas considered an exceptional world-class reservoir. This sandstone also forms some of the most spectacular outcrops in southern Utah and particularly those in Zion National Park. Other reservoirs include the fractured Twin Creek limestone that directly overlies the Navajo and deeper Paleozoic carbonates that could have enhanced porosity from karsting as well as fractures.

Cap rock

The cap rock is the Jurassic Arapian Shale, 1,700 m of mudstone with layers of halite, gypsum and anhydrite. These highly reflective layers make seismic interpretation more difficult and make drilling to a precise spot challenging.

Source rocks

The source rock for the area is believed to be organic rich Mississippian (Lower Carboniferous) and Permian rocks. The Utah Geologic Survey has taken oil samples from the Covenant discovery well and will do more work on source typing in the near future.

Renewed activity for the area

Seventy-plus dollar oil and the recent Covenant discovery have sparked record drilling and leasing activity. A similar Utah discovery in the thrust belt to the north, Pineview, set off five years of exploration activity where 175 wildcats were drilled and 11 new fields discovered including two giant fields (Anschutz Ranch East and Whitney Canyon-Carter Creek). Most of the discoveries were across the state line into Wyoming. Kent Hoffman, Deputy State Director of Lands and Minerals for the Bureau of Land Management (BLM), anticipates a record of 1,000 drilling permits this year, most of which deal with the Uinta Basin.

The central Utah thrust belt is receiving its share of exploration attention. Strickland said that two exploration wells have been suspended, one abandoned and a fourth is currently under way. The Cedar Ridge 18-1 and the Peter Ridge well are currently suspended and may be reentered

Photo: Wolverine Gas and Oil

The discovery well, Wolverine's 17-1 Kings Meadow Ranch No. 1, encountered nearly 150 m of Navajo Sandstone pay trapped in an anticlinal fold associated with Cretaceous to Early Tertiary compressional deformation. The well flowed good quality, 40 gravity oil from 130 m of net pay with an average porosity of 12 percent and 100 mD of permeability. Currently, the field is producing 4,900 bopd from 10 wells.

in the near future. No data is currently available on these wells. He also said Wolverine has five to six additional exploration wells planned. In addition to drilling, they have acquired over 760 km of 2-D seismic data. Other companies are actively leasing with some leasing fees now over $1,000 an acre (4,000m^2). Some of the other independents leasing in this area include Pioneer Oil and Gas, International Petroleum LLC, Armstrong Petroleum, Petro Hunt, and Craig Settle. In addition to the wells Wolverine has planned, nine more exploration wells are being permitted.

The BLM August 2006 Lease Sale (sales are held quarterly) netted more than 8 million dollars and 154 of the 200 parcels were sold. The sale covered 1350 km^2 across the state, but typically in historically non-producing areas. Nearly half of the parcels in this lease sale were in the Cedar City Field Office, an area that has seen little development. Prior to the Covenant oil discovery, BLM had rarely received nominations by the industry for oil and gas parcels in central Utah. Since then, Utah BLM has leased over a million acres (4,000 km^2, or 2/3 of a North Sea quadrant) in its central Utah field offices. Iron County Commissioner, Dennis Stowell, said they are very supportive of leasing and potential new development in their area.

Geochemical leads

Pinnell and Moulton report (Oil and Gas Journal) that using similar satellite techniques used by Dr. Greg Nash (described in the remote sensing box) to measure relative amounts of kaolinite in the surface rocks could be useful in identifying potential exploration targets. Microseepage of hydrocarbons is believed to stabilize kaolinite in a reducing environment, creating higher levels over hydrocarbon bearing structures.

Pinnell and Moulton, who mapped such

Utah Geological Survey, Energy and Minerals Program

The Utah Geological Survey, Energy and Minerals Program provides general geologic information through research, oil and gas well logs, a core research center, and data analysis to government agencies, industry and individuals.

The research, using mineral lease funds, includes a new program titled "Characterization of Utah's Hydrocarbon Reservoirs and Potential New Reserves". One of the reservoirs currently under study is the Navajo Sandstone, the reservoir for the Covenant field. In cooperation with Brigham Young University, geologists will study outcrops in the San Rafael Swell in southern Utah to determine the lateral and vertical characteristics of this important reservoir.

Scanned oil and gas well logs are available for viewing and downloading over the Internet. Many of the logs were scanned and made available to the state of Utah from a generous donation by A2D Technologies. Currently over 25,000 logs from 8,000 wells are available and more images are being added to their web collection.

The Utah Core Research Center offers the region's only publicly available and most complete collection of geologic cuttings and core from Utah. The facility currently holds cuttings form more than 3,500 drill holes, core samples from over 700 drill holes, a collection of type oils, coal, and miscellaneous samples from many other sources. Material may be examined on-site or borrowed for a fee. In addition, the facility offers core workshops benefiting both university and industrial research.

Photo: Thomas Smith

Tom Dempster of the Utah Core Research Center.


Photo: Halfdan Carstens

The Jurassic Arapian Shale with EGI's Greg Nash taking samples.

a geochemical anomaly over the Covenant discovery, are seeing this trend repeated across the area. This geochemical data indicate more potentially productive structures along several of the thrust trends. They have identified at least 30 geochemical anomalies located on gravity-defined structures.

The story unfolds…

Fifty years of exploration without a discovery wrote the introduction. The Covenant oil discovery is just the first chapter of what could be a long and productive saga. Wolverine's Doug Strickland should know - he has worked this area off and on for nearly 30 years - sums it up this way "I am very fortunate to have been involved in the discovery of Covenant Field, as these events happen only once in the lifetime of a geologist. The discovery was built from the work of several geologists since the 1950's, and the persistent efforts of a few over the last 15 years."

"The discovery of Covenant is by far the highlight of my career, and I intend to be involved in the discovery of several more fields in central Utah," says Doug Strickland, having made himself famous as a true, old-fashioned oil finder.

Remote sensing

The image shows the area of the central Utah Thrust Belt near the recent Covenant field discovery. Energy and Geoscience Institute (EGI) created the image by fusing a one m digital orthophoto with a multispectral ASTER (Advanced Spaceborne Thermal Emission and Reflectance Radiometer) image.


Illustration: Energy & Geoscience Institute

The Arapien Shale cap-rock is easily discriminated from surrounding Tertiary volcanic rocks by color. The different colors within the Arapien Shale are related to mineralogical differences that can be mapped using band ratios and multivariate analysis. Blue polygons outline Arapien Shale and dark red polygons outline Tertiary volcanics. Grid coordinates are UTM Zone 12 (NAD83).

Dr. Greg Nash of EGI is using a variety of remote sensing techniques to study Utah's central thrust area. "Detecting mineralogical differences, like the presence or lack of illite, gypsum, calcite, and hematite, can be accomplished using image analysis. These differences are, in part, caused from the effects of hydrocarbon microseepage creating a reducing environment," he says.

For example, microseepage can alter illite to kaolinite. Using ASTER to map the presence of kaolinite in the Arapien Shale, will facilitate microseepage mapping. Combining ASTER with multispectral satellite imagery and 1m spatial resolution black and white digital orthophotos aid in structural characterization and refine the area's geologic maps. Using the spectral character of ASTER imagery and increasing the spatial resolution with the digital orthophotos down to 1m, the analyst can use 3D visualization to map faults, folds, and other geologic features.

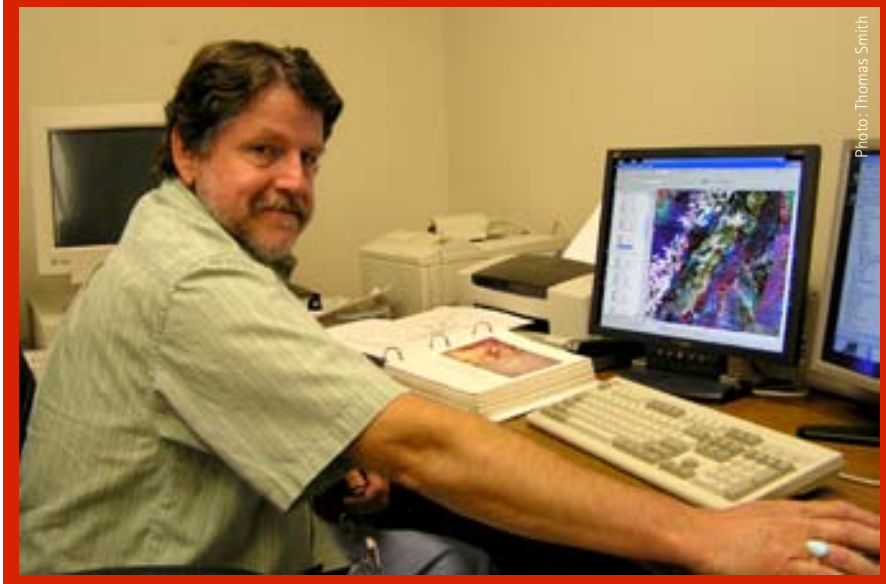


Photo: Thomas Smith

Dr. Greg Nash at his workstation in the Energy &Geoscience Institute.