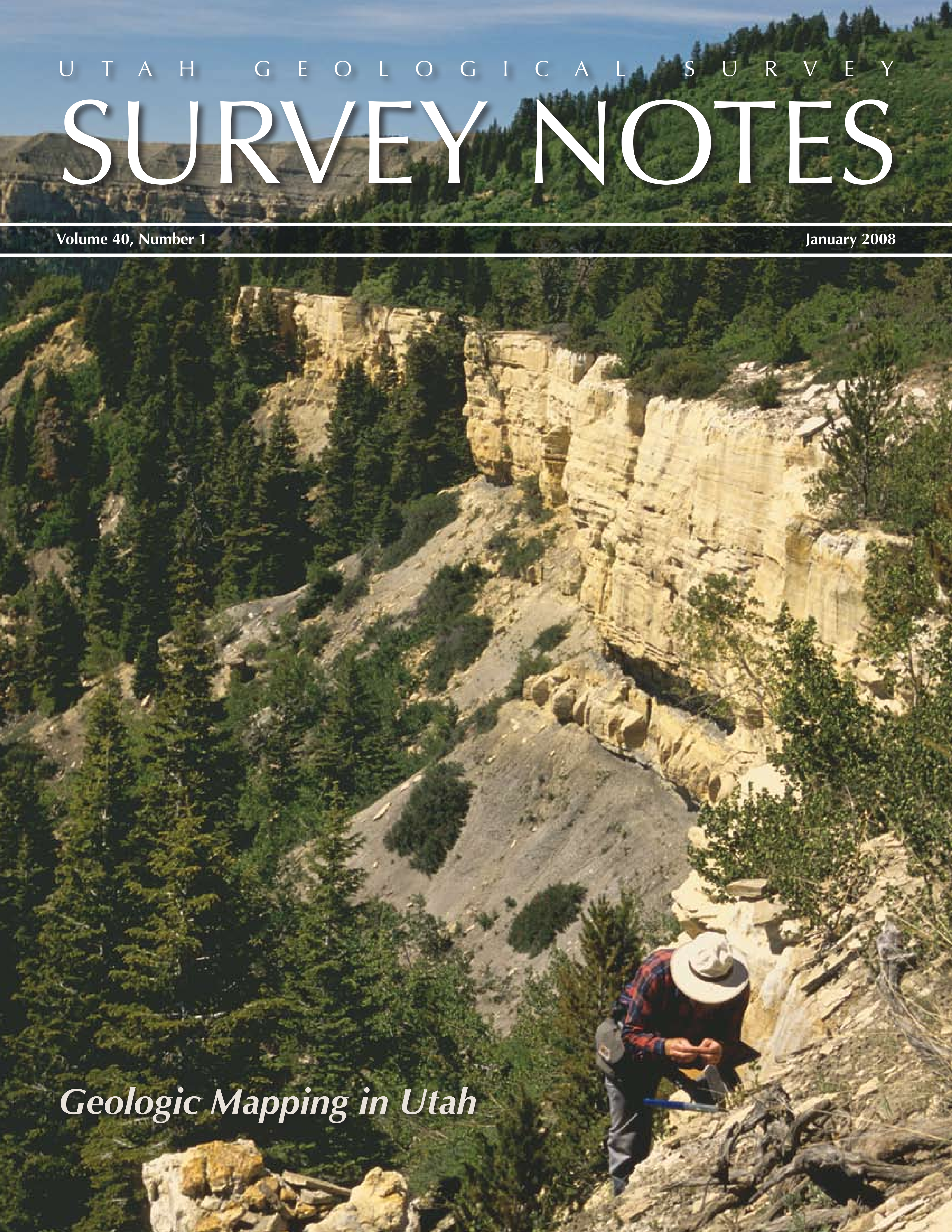
U T A H   G E O L O G I C A L   S U R V E Y

SURVEY NOTES

Volume 40, Number 1 January 2008



Geologic Mapping in Utah

CONTENTS

Design: Liz Paton
Cover: UGS geologist Bob Biek examines Cretaceous outcrop while mapping on the Kolob Terrace near Zion National Park. Photo by Mike Hylland.

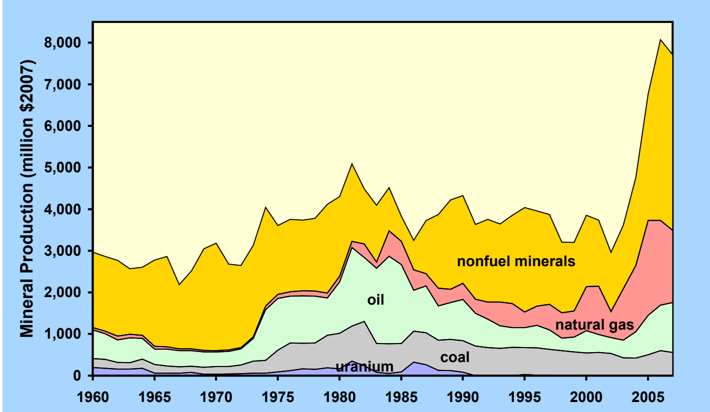
THE DIRECTOR'S PERSPECTIVE

by Richard G. Allis

This issue of *Survey Notes* highlights the digital mapping technologies that the Utah Geological Survey (UGS) is now using to improve the efficiency and accuracy of Utah's geologic maps. In comparison to the country as a whole, the percentage of the state covered by relatively detailed geologic maps is low. At present rates of mapping, we expect to complete geologic mapping of the whole state at a scale of 1:100,000 by about 2015; at the same time we are also mapping high-priority urban growth areas at 1:24,000. With the rapid population and economic growth in Utah, increased awareness of natural hazards by local authorities, and an exploration boom caused by high prices for many natural resource commodities, the demand for geologic information has never been higher.

The UGS has forwarded to the Governor's Office of Planning and Budget (GOPB) its annual summary of mineral resource production value in Utah for 2007 (see graph). Although the total value of $7.7 billion is 4 percent less than the record high value for 2006, the trend for the past two years is about double the average value for the 1980s and 1990s. The slight dip in total value for 2007 is mostly due to a decrease in natural gas prices resulting from a local oversupply in the Rocky Mountain region. In fact, Utah's annual natural gas production increased 14 percent and is a record at 364 billion cubic feet. New pipelines that are planned or under construction connecting this region to other natural-gas-demand regions mean that the price differential should diminish during 2008. Utah's oil production in 2007 increased by 9 percent to 19.5 million barrels, continuing the growth trend that began in 2004 when oil prices started to rise. Coal production in 2007 decreased by 10 percent to 24 million tons due to mine closures. Non-fuel mineral production values continue to be dominated by copper and molybdenum from the Bingham mine. Finally, uranium production resumed in 2007 in southeastern Utah after a 15-year lull. Expected production in 2008 should be sufficient to once again show on the graph of total production value.

The Energy Information Agency's latest compilation of oil and gas reserves in each state has Utah at or near the top for reserve additions in both oil and natural gas (EIA, 2006 annual report, http://www.eia.doe.gov/pub/oil_gas/natural_gas/data_publications/advanced_summary/current/adsum.pdf). Although total oil reserves for the U.S. decreased by 3.6 percent, Utah had the largest reserve additions (78 million barrels, or 30 percent increase) compared to 2005 reserves. Utah also had the third-largest natural gas reserve additions (850 billion cubic feet, or 20 percent increase) to the national total, which increased by 3.3 percent in 2006. The ratio of total reserves to the annual production rate for Utah has risen to 17 years for oil and 14 years for natural gas, which is near the historical maximum for each product. Drilling in Utah has continued at record high levels through 2007, with over 1100 wells spudded (Division of Oil, Gas and Mining, http://oilgas.ogm.utah.gov/Statistics/Statistics.cfm). In 2007, over 50 percent of wells exceeded 8000 feet, compared to only 32 percent of wells just five years earlier. The deeper drilling is finding new gas reserves, particularly in the Uinta Basin. The UGS expects these successes to continue, and for the mineral resources sector to play an important part in Utah's vibrant economy.



Source: GOPB (2008). Economic Report to the Governor, Chapter on "Minerals" by UGS

Survey Notes is published three times yearly by the Utah Geological Survey, 1594 W. North Temple, Suite 3110, Salt Lake City, Utah 84116; (801) 537-3300. The Utah Geological Survey provides timely scientific information about Utah's geologic environment, resources, and hazards. The UGS is a division of the Department of Natural Resources. Single copies of *Survey Notes* are distributed free of charge within the United States and reproduction is encouraged with recognition of source. Copies are available at *http://geology.utah.gov/surveynotes*
ISSN 1061-7930

Using Digital Technology in the Field

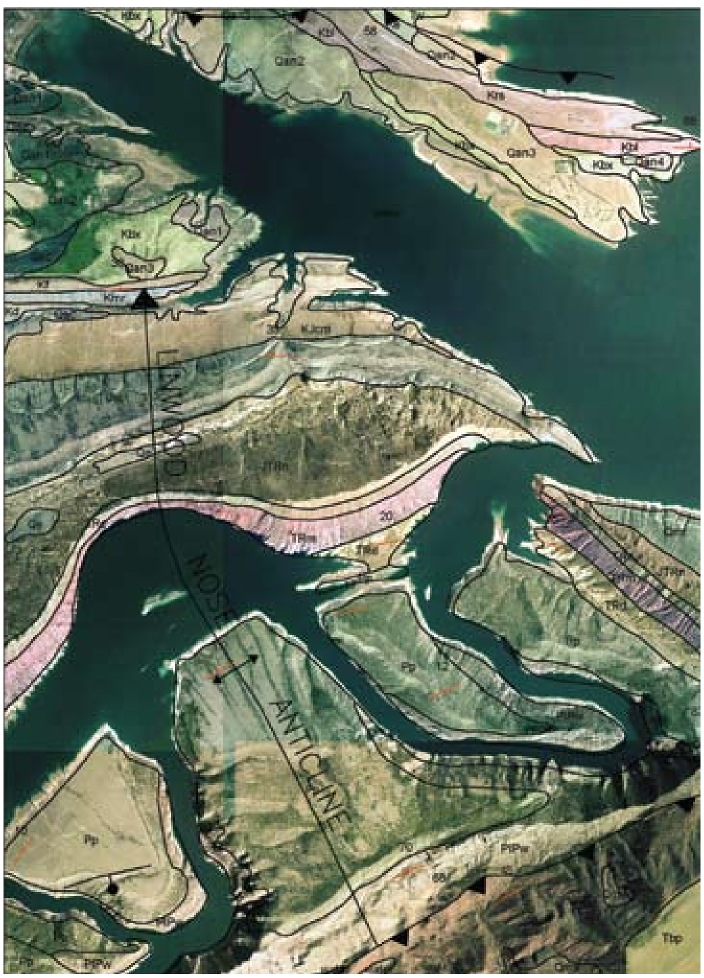
by Douglas A. Sprinkel and Kent D. Brown

The Utah Geological Survey (UGS) works hard to publish high-quality geologic maps of Utah. We have been successful because of the combined efforts of dedicated geologists and cartographers using cutting-edge technologies. Recently, the availability of rugged, portable computer equipment and specialized software has taken our field acquisition of geologic data into the digital age.

Each geologic map that the UGS produces requires fieldwork where geologic information is recorded on aerial photographs, topographic maps, and in notebooks. Through the 1980s, geologic lines were hand-transferred to a polyester film topographic base map, and then the map was finalized using analog cartographic techniques. Since about 1991, however, we have increasingly used digital technologies to transfer field mapping, create an editable geologic map, and prepare final maps for publication (see companion article in this issue). Now, we are beginning to use digital technologies in the field to further streamline map preparation. An ongoing project to geologically map several 30' x 60' quadrangles (1:100,000 scale) in the Uinta Mountains and Uinta Basin in northeastern Utah illustrates how the mapping process has evolved.

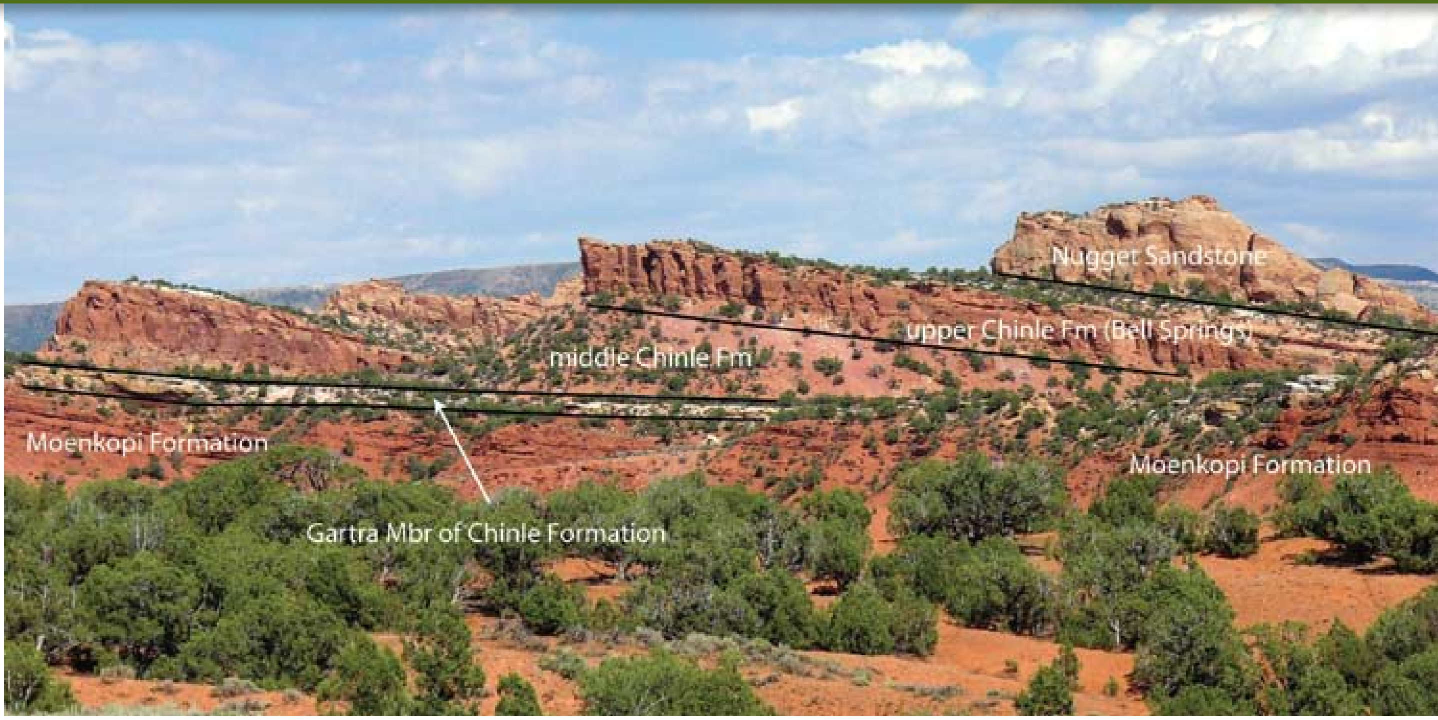
In 1999–2001, we mapped the Dutch John quadrangle using traditional methods; these included inking lines and points on “stereo pairs” of aerial photographs (overlapping aerial photos that, when viewed through a stereoscope, produce a three-dimensional image of the terrain). We then hand-transferred the lines and points onto orthophoto quadrangle base maps. The inked orthophotos were then photographically reduced to the same scale as the polyester film base that would be used to produce the final map. The reduced orthophotos were placed under the polyester film base, onto which the geologic lines and points were then traced. Each line and point, therefore, was redrawn three times to get to this stage! Additional inking was needed during review of the geologic map prior to open-file release.

The next map in the project, the Vernal quadrangle, was the first quadrangle in which field mapping and later steps were done digitally. In the field, we used a portable computer called a tablet to record geologic information. Specialized



Above: A UGS geologist uses a tablet computer to record field data on the outcrop.

Left: A screen-captured image from the tablet computer showing the geology of part of Flaming Gorge overlain on a color digital orthophoto.



This picture of the "Red Fleet" in the Dutch John quadrangle was taken with a digital camera, transferred to the tablet computer, and then annotated in the field from where it was taken.

software allows the user to draw lines and points on digital base maps and then transfer the data directly into the office computer used to finalize the map. This eliminates the several steps of hand-transferring and re-inking required by the traditional methods. We are continuing to refine the digital methods during our current mapping of the Seep Ridge quadrangle.

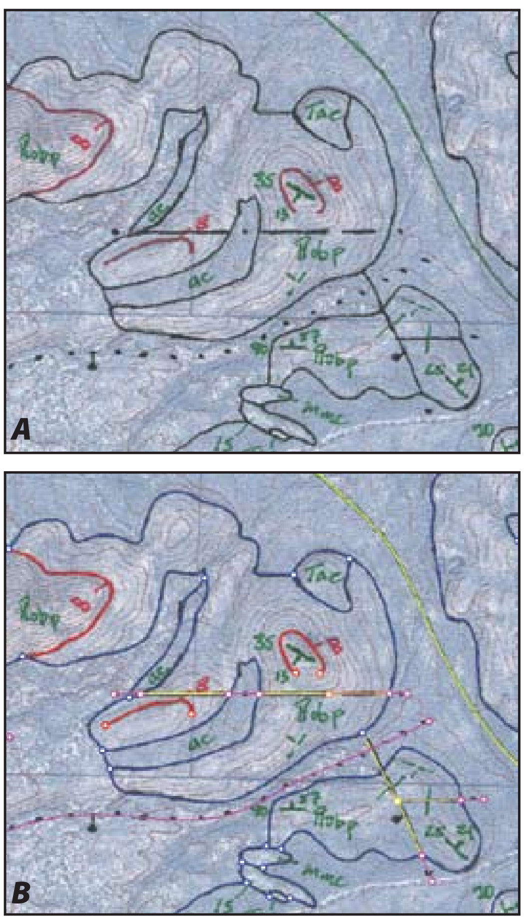
For the most part, geologic mapping using digital field techniques is similar to traditional methods. A geologist still goes to the field with a rock hammer, hand lens, pocket transit compass, and stereo pairs of aerial photographs to map formation contacts and faults, measure bedding attitudes (strike and dip), collect samples, and take field notes. However, instead of drawing lines on aerial photographs or topographic base maps, the geologist draws lines on digital images (digital raster graphic [DRG] topographic or digital orthophoto base maps) displayed on the tablet's screen. The screen is touch-sensitive, allowing the geologist to draw lines using a stylus or digital pen. In addition, geologic features can be added to the map "on the fly" as the geologist walks the contact or fault with an integrated global positioning system (GPS) receiver. Other geologic features such as bedding attitudes and sample locations are also easily and accurately recorded using the GPS receiver and are immediately displayed on the tablet's screen. Field notes are electronically written into word-processing files using the stylus or portable external keyboard. Finally, digital photography permits the geologist to take a picture of a scene, transfer the image to the tablet computer, and then annotate the photograph in the field.

Digital geologic field mapping offers several advantages over traditional methods, but some of the "old" techniques are still needed. For example, the tablet cannot display stereo images, so stereo pairs of aerial photographs and a stereoscope are still needed to see the geology "from the air" in three dimensions. Compared to traditional methods as a whole, however, digital geologic mapping is more accurate, permits the geologist to consistently attribute data in its final form, and reduces errors, all of which save time. Ultimately, digital mapping techniques help us in our goal to provide accurate geologic maps in a timely manner for effective understanding and stewardship of Utah's geologic resources.

From Field Mapping To Published Map

by Kent D. Brown

Most of us are familiar with photographs of early explorers of the American West, fighting for their lives trying to maneuver overloaded wooden boats down the raging Colorado River. Some of these explorers were geologists determined to map the rugged expanse of unknown territory. Not only did they map the geology, but they also spent long periods of time making relatively crude topographic maps on which the geologic maps were constructed. Today, geologic mapping in Utah continues with the same spirit of exploration and discovery, but of course is being done using vastly superior tools and techniques.



In one method of geologic map production, a geologist's original mapping on a paper base map (A) is scanned, the resulting raster image is geospatially corrected, and then the raster image is converted to vector lines (B).

Geologic mapping techniques have undergone major changes since those early days of lugging unwieldy equipment to remote locations in boats and on the backs of men and beasts. As with most technological advances, over the next half century equipment got better, smaller, and less expensive. A major advance came in the 1940s when aerial-photography technology greatly expanded and aerial photos became available to geologists. Drawing geologic features on stereo aerial photos (paired photos that produce a three-dimensional [3-D] image) became commonplace after World War II, and complex machines used to transfer this information onto an accurately scaled map were available; this stereo process is known as photogrammetry. Today this technology continues to advance with digital aerial cameras and photogrammetry accomplished using computer software.

The Geologic Mapping Program of the Utah Geological Survey uses a combination of up-to-date software technologies and proven traditional methods to prepare geologic maps for publication. Field mapping techniques used by geologists are numerous, but producing a preliminary geologic map suitable for open-file release generally involves one of three methods: (1) direct mapping on aerial photographs and then redrawing the geologic features on paper topographic maps (base maps with or without superimposed photographic images), (2) direct mapping on aerial photographs and then using photogrammetry software to digitally transfer the geologic features, in stereo, to a Computer Aided Design (CAD) file compatible with Geographic Information System (GIS) software, or (3) digitally collecting and attributing geologic data in the field using a rugged tablet computer with integrated Global Positioning System (GPS) receiver and geospatial software, which creates GIS data. The term "geospatial" is used here to describe geographic data that are accurately referenced to a precise location on Earth's surface. Each of these methods has its strengths and weaknesses, and the need for flexibility and individual mapping style make them all valid techniques.

In the first method, we scan and geospatially correct the paper map drafted by the field geologist. Scanning the paper map converts it to a raster image much like a digital camera converts a scene to a file of image pixels. For our maps, this image is then corrected to make it fit a real-world coordinate system. From this geospatially corrected image, the geologic map is digitally vectorized. We use software that converts the raster image to vectors—in other words, it makes lines from image pixels. The result is a multi-layered CAD file that can be imported into GIS software to create a fully attributed geodatabase (computer database of geographic map features) of the geologic map.

The second method is the most precise and technically advanced way we create geologic maps and reduces errors caused by copying lines twice in the paper map method. Two aerial photographs having 60 percent overlap are referred to as a stereo pair; this overlap is needed to use photogrammetry. When positioned correctly this pair of photos can be viewed in stereo showing 3-D depth of view. However,

Top: For some mapping projects, geologists compile geologic data in stereo on a computer monitor with the help of special glasses.

Bottom: Another method of geologic data collection uses a rugged tablet computer and GIS software. Images of topographic maps and orthophotos are displayed on the screen to aid the geologist when recording geologic data in the field.

this stereo view is considered raw or distorted. To accurately map using this photo pair, we scan them at high resolution (1000+ dpi) and save the images as Tagged Image Format (TIF) files. Then, we use photogrammetry software to perform spatial orientations on the TIF images to correct all distortion, accurately scale them, and assign real-world coordinates to this stereo image. When completed, these steps allow the geologist to view the map area on the computer monitor, in stereo, through special glasses. The geologic features are then drawn on the 3-D surface the geologist sees using a software input device known as a "3-D Mouse." With this process we create a very precise and feature-rich 3-D CAD file that is then imported into GIS software to create a geodatabase of the geologic map.

The third method allows the mapping geologist to use a rugged tablet computer and GIS software in the field (see companion article in this issue). Digital base map images are displayed on the screen for positional reference; among them are topographic, geospatially corrected photographic (orthophoto), and shaded-relief maps, as well as images of other geologic maps. The GIS software is configured to use data input forms, with pull-down pick-lists, to simplify and standardize the collection of geologic data. It can also store field notes and digital photographs of sights in the field mapping area. This method allows the geologist to create a digital map in the field with attributed and colored map-unit polygons, geologic symbols, and feature labels. Although the tablet computer cannot display stereo images, and geologic lines drawn using the tablet tend to be less precise than when using photogrammetry, use of the tablet can save significant amounts of time in the overall mapping process.

Regardless of which method is employed, the preliminary data are used to make inkjet plots of the maps for review. After the geologist's review, GIS analysts in the UGS Geologic Mapping Program create GIS geodatabases conforming to UGS data standards. From these geodatabases, files are created to use in publication software to make formal geologic map layouts and map explanation sheets. Then, after UGS review and approval, final-version map files are sent to a printing company or are used to print maps in-house on inkjet plotters.

About the Authors

Doug Sprinkel is a Senior Geologist within the UGS Geologic Mapping Program. His principal responsibility is to map the geology of the Uinta Mountains and Uinta Basin. In addition to his mapping efforts in northeastern Utah, Doug has mapped quadrangles in the central Utah thrust belt. Other ongoing projects include a study of Middle Jurassic strata and unconformities and regional correlation of Lower Jurassic rocks. Doug has co-edited two popular books on Utah geology and authored or co-authored 6 geologic maps, 54 professional articles, and 25 abstracts.

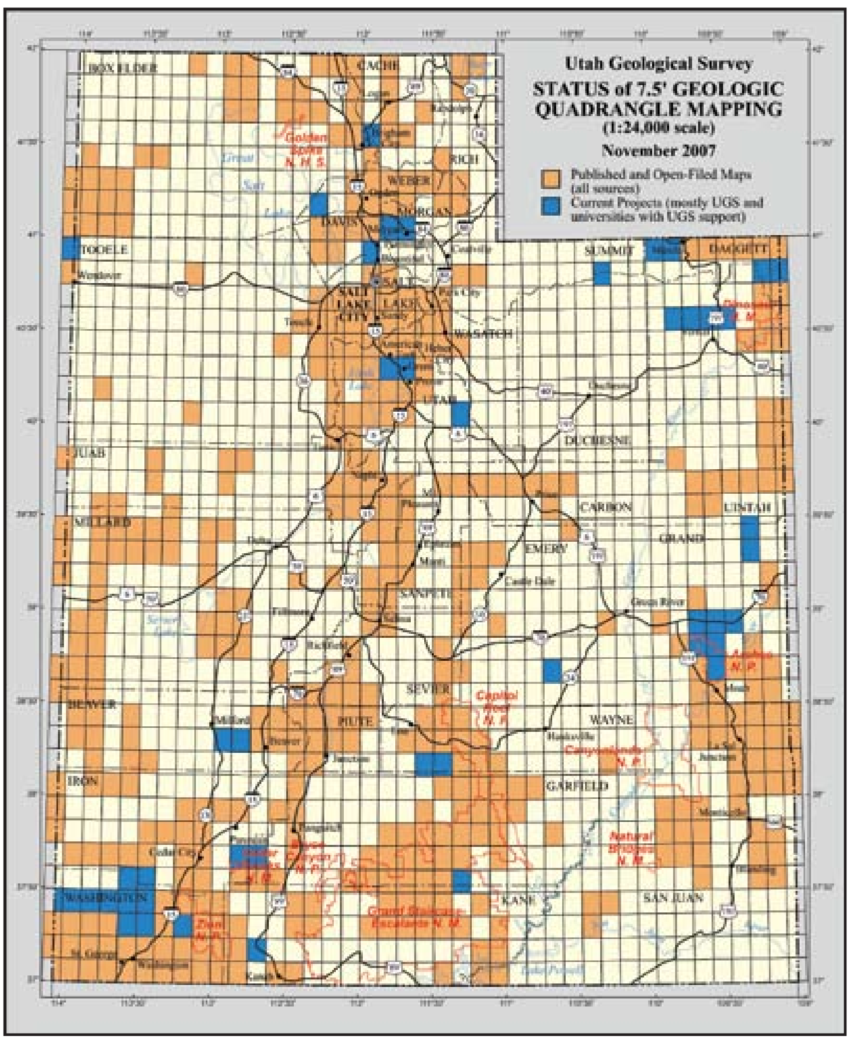
Kent Brown is a GIS analyst and photogrammetrist with the UGS Geologic Mapping Program and has been instrumental in the development of the program's geologic map publication methods. He joined the UGS in 1983 and served as Senior Cartographer in the Editorial Program before transferring to the Geologic Mapping Program in 1990 to manage a newly acquired photogrammetry system. Since 2002, up-to-date digital photogrammetry methods have been used and he has developed a system for standardized geologic data creation that is compatible with GIS software.

News and Short Notes

by Grant C. Willis

Status of 7.5' and 30'x60' Quadrangle Series

The UGS Geologic Mapping Program produces geologic maps at two primary scales—1:24,000 (7.5' quadrangles) and 1:100,000 (30'x60' quadrangles). All maps are released as published maps or open-file reports as soon as possible after completion, and are available in printed (press run) or plot-on-demand formats from the DNR Map and Bookstore, and for viewing and downloading from the UGS Web site (geology.utah.gov). All 30'x60' quadrangles, and a few 7.5' quadrangles and other maps, are also produced in Geographic Information System (GIS) format (menu-driven CDs are available for purchase from the DNR Map and Bookstore; "bare-bones" GIS files are available for downloading from the UGS Web site—see "GIS Maps Online").



Utah is covered by 46 U.S. Geological Survey (USGS) 30'x60' quadrangles (plus a narrow strip of 10 more along the western border with Nevada). We are systematically mapping the geology of all 1:100,000-scale quadrangles with a goal to complete the state by 2015. Each quadrangle takes a geologist about three years to complete by compiling existing maps where suitable and conducting new mapping where needed. Currently, about 26 quadrangles have been completed (20 in color and the rest in black and white), and GIS database files have been completed for about 19 quadrangles.

Utah is covered by 1512 USGS 7.5' quadrangles (excluding a few tiny slivers where the state boundary jogs). Currently, geologic mapping of 458 quadrangles has been completed (though some need to be updated) and mapping of 47 is in progress by UGS, USGS, and university geologists. Each quadrangle requires about a year of work, including field mapping, compilation, writing, and reviews. At this rate, the daunting task of mapping the entire state will require nearly 100 years, so the UGS focuses on areas that the State Mapping Advisory Committee (representatives from federal, state, and local land-management agencies, geologic associations, universities, and others interested in geologic mapping) designates as top priorities. Most top-priority quadrangles are in the Wasatch Front and St. George/Cedar City/Kanab areas, though a few are near other growing cities and in popular recreation and economic resource areas.

GIS Maps Online

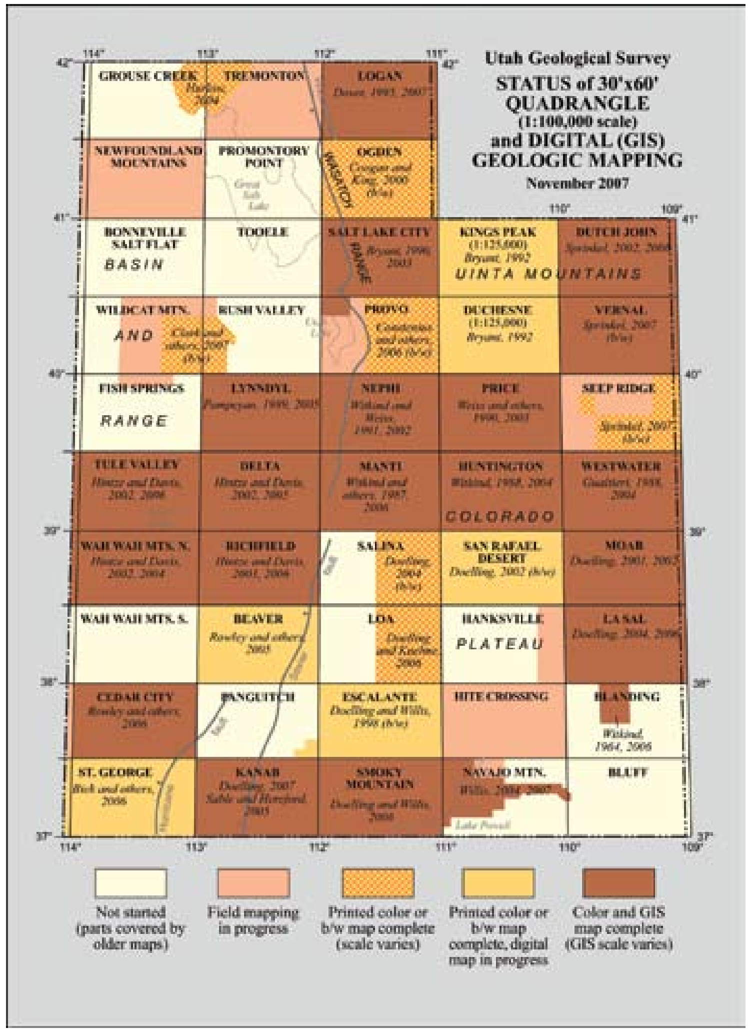
In the September 2006 issue of *Survey Notes*, we announced the start of a new initiative to make Geographic Information System (GIS) files of geologic maps available online. Recently, we posted our 20th GIS map, making our Web site the premier source of GIS geologic map data for Utah. The site is growing fast—five more maps should be posted over the next six months. Check out our Web site at geology.utah.gov; click on: maps and publications/online maps/GIS.

STATEMAP, FEDMAP, EDMAP

The National Cooperative Geologic Mapping Program, which is funded by an act of the U.S. Congress, forms the backbone of geologic mapping in the United States. First passed in 1992 through the lobbying efforts of many geologists and geologic organizations, state and local governments, the USGS, educators at all levels, and large and small industries of many types, this popular program has been reauthorized twice. It contains three mapping components: STATEMAP, FEDMAP, and EDMAP. The STATEMAP component funds a large percentage of UGS geologic mapping, FEDMAP funds USGS geologic mapping, and EDMAP makes funds available to universities.

Through the FEDMAP program, the USGS recently funded David Miller, a USGS geologist who has produced many maps for the UGS, to complete the Newfoundland Mountains and Tremonton 30'x60' quadrangles, and the Miners Canyon 7.5' quadrangle on the border with Nevada. He started these projects in the early 1990s, but was then transferred to other parts of the country when the USGS suffered a large financial cutback. We are pleased that these important projects will soon be completed.

The EDMAP program provides funds for graduate and undergraduate students and their professors to complete geologic mapping and mapping-related projects. About a dozen EDMAP projects have been completed in Utah in the past decade. Five new projects were funded in early 2007: Jessen Butte 7.5' quadrangle in Daggett County (Brigham Young University), Kings Peak 7.5' quadrangle in Summit and Duchesne Counties (Idaho State University), Brian Head 7.5' quadrangle in Iron County (Southern Utah University), parts of Stockton and South Mountain 7.5' quadrangles in Tooele County (University of Utah), and a study of the Proterozoic rocks of the Uinta Mountains (Utah State University). We recently wrote letters supporting eight new proposals for 2008, and are hopeful that all of these new projects will be funded.



UGS Garners Top STATEMAP Proposal Award

Each year the UGS competes with about 45 other state geological surveys for matching STATEMAP funds that support about one-third of our geologic mapping effort. A national committee of state and USGS geologists scores proposals and awards funds. The UGS has traditionally done very well—generally we are one of the top five states. Recently, we were notified that we received the top score and largest award for 2007–08 mapping—$246,075. With the state match, this nearly half-million-dollar project is funding continued geologic mapping in the Seep Ridge (Uintah, Duchesne, and Carbon Counties), Wildcat Mountain (Tooele County), and Caliente (westernmost Iron and Washington Counties) 30'x60' quadrangles; Orem, Pelican Point, and Rays Valley (Utah County), Farmington (Davis County), Mount Pisgah (Cache and Box Elder Counties), Temple Mountain (Emery County), and Mount Carmel (Kane County) 7.5' quadrangles; and GIS database production of the St. George and narrow strip of Clover Mountain 30'x60' quadrangles (Washington County).

GEOSIGHTS

THE ONION CREEK SALT DIAPIR, GRAND COUNTY, UTAH

by Carole McCalla

Introduction: What's that smell? Located in southeastern Utah's slickrock country is a unique geologic feature with a distinct smell of its own. Aptly named, the Onion Creek salt diapir is near the Fisher Towers Recreation Site northeast of the town of Moab (for a description of Fisher Towers, see the "Geosights" article in the July 2004 issue of *Survey Notes*). Flowing through the diapir is Stinking Spring, a naturally occurring sulfur-rich spring.

Geologic Information: During the Pennsylvanian Period (about 300 million years ago), most of Utah was covered by an ancient sea. The Moab area was located in an enormous depression called the Paradox Basin. As sea levels fluctuated over millions of years, multiple cycles of flooding and evaporating occurred in the basin, leaving thousands of feet of salt behind. The resulting Paradox Formation is 65 to 85 percent salt and is interbedded with layers of gypsum and anhydrite.

These salt beds eventually became buried by other rock layers. Because salt deposits are less dense than overlying rock deposits, they behave buoyantly and rise toward the surface. The salt squeezes upward and intrudes into the overlying rocks through zones of weakness such as fractures and faults. As the salt moves, it bends and penetrates the overlying rock. The intruding "salt bubbles" are called salt diapirs. (See "Teachers Corner" in this issue of *Survey Notes* for an illustration of a salt diapir.)

So, what about that stinky smell? Sulfur is present in the area, which results in the smell. Where did the sulfur come from? Salt diapirs develop a cap rock of relatively insoluble anhydrite and gypsum (calcium-sulfate minerals) which accumulate as the result of leaching during the diapir's rise toward the surface. The cap rock contains sulfate-reducing bacteria that produce sulfur and hydrogen-sulfide gas. Stinking Spring carries the foul-smelling sulfurous gas to the surface.

In most environments, salt that reaches the surface weathers rapidly because salt is very soluble. The salt of the Onion Creek diapir is still exposed and visible, at least for now. However, probably only a small amount is visible compared to what has already been dissolved away.

The Onion Creek diapir is about 2 miles long and 1 mile wide. The white-colored salt and gypsum beds of the diapir are in striking contrast with the surrounding red rocks of the Triassic Moenkopi Formation (approximately 245 million years old) and the reddish-brown sandstone, mudstone, and conglomerate of the Permian Cutler Formation (approximately 290 million years old). The diapir contains numerous small faults and folds that resulted from the salt movement.

The rocks and terrain of the area record a long history of deposition, deformation, and geomorphic change related to movement of the Onion Creek diapir. Several pulses of salt flowed into the diapir between about 2–3 million and 250,000 years ago, and the diapir may still be active today. Nearby Fisher Creek once flowed along the present course of Onion Creek to the Colorado River. The rising salt diapir created a natural dam that resulted in the deposition of over 400 feet of basin-fill sediments in Fisher Valley. After the basin filled up, Fisher Creek established a new course to the Dolores River. Today, Onion Creek flows toward the Colorado River, through both the basin-fill sediments and the diapir. Eventually, continued headward erosion may allow Onion Creek to capture Fisher Creek, restoring the original drainage course.

How to get there: From Moab, travel approximately 2 miles northwest along U.S. 191 to the turnoff for Utah State Highway 128. Turn right (northeast) and travel approximately 20 miles to the turnoff at Onion Creek Road (just past Sorrel River Ranch Resort). Fisher Towers can be seen to the east at the turnoff. Turn right (east), leave the pavement, and proceed 5 to 6 miles to The Narrows and Stinking Spring. Continue 13 miles to Fisher Valley and the end of the graded road.

View of the Onion Creek salt diapir looking northwest. Note the tilted rock layers on the right. These deposits were folded upward as the salt penetrated through the Cutler Formation.

"GLAD YOU ASKED"

What is Magnetic Declination?

by Jim Davis

The Earth produces a magnetic field similar to that produced by a bar magnet, as illustrated in this model using iron filings. The iron filings align themselves along the lines of magnetic force generated by the magnet.

Many people buy topographic maps to aid in backcountry navigation, but some do not know what to make of the rather cryptic information regarding magnetic declination. If it is printed in the map margin, it must be important. But what exactly is magnetic declination?

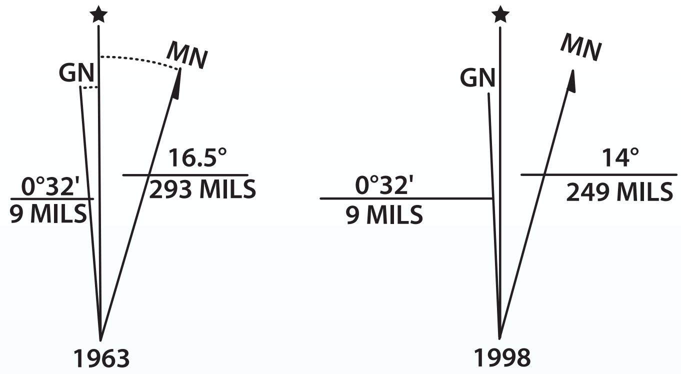
To understand magnetic declination, it helps to first consider Earth's magnetism. Molten iron circulating within the Earth's hot outer core generates electrical currents, which in turn generate a magnetic field similar to that of a giant bar magnet. The magnetic field arises in Earth's interior and extends over the surface, into the atmosphere, and far into space. The Earth's magnetic field serves a number of useful and interesting purposes, such as protecting the Earth from incoming solar wind particles, generating the spectacular polar auroral light displays, and assisting many animal species in global navigation (for example, sea turtles, honeybees, whales and dolphins, tuna and salmon, pigeons, sparrows and robins). The magnetic field is also important because it determines what direction a compass needle will point—the needle aligns with lines of magnetic force at the Earth's surface, lines that converge at the magnetic poles.

The Earth's magnetic and geographic poles are in different places, and magnetic declination is the angular difference between the direction a compass needle points and the direction to the geographic North Pole. For most of the populated world, this angle is between zero and 30 degrees. Currently, Salt Lake City has a magnetic declination of about 12.5 degrees east (in other words, true north is 12.5 degrees west of the direction a compass needle points), but the angle has been getting smaller over time.

The geographic North and South Poles, located at 90° latitude, are stationary and coincide with the axis of Earth's daily rotation. Conversely, the magnetic poles migrate over time. First located in 1831, the North Magnetic Pole has since moved hundreds of miles closer to the geographic North Pole. The North Magnetic Pole wobbles every day in an elliptical path as much as 50 miles across, and it continuously drifts about 2–30 miles or more per year, occasionally changing direction. The rate of movement also changes. Over the past three decades the North Magnetic Pole's rate of movement has greatly increased (the South Magnetic Pole, just off Antarctica, has moved sluggishly by comparison). For a century the North Magnetic Pole has moved northwest over northern Canada—it has accelerated, deserted Canada, and is trekking across the Arctic Ocean toward Siberia. By 2018 it is expected to pass within 250 miles of the geographic North Pole.

A wandering magnetic pole corresponds to a changing magnetic declination for any particular location. The change of the magnetic declination was first recognized nearly four centuries ago when discrepancies were noticed in compass readings over time at the same location. For Salt Lake City, declination is currently decreasing at a rate of about 7 minutes of a degree per year. Besides updating declination maps, magnetic field changes bring about such actions as the occasional renumbering and repainting of airport runways, which are characteristically named based on magnetic heading.

Knowing the current magnetic declination of your position allows you to determine compass bearings from a map that match what the actual bearings are in the real world. This is critical for cross-country navigation from point A to point B. Declination is included in the explanatory information of U.S. Geological Survey (USGS) topographic quadrangle maps and maps intended for navigational or wilderness use. On USGS maps, the declination diagram shows geographic north as a vertical line with a five-pointed star (★) at the top. The direction of magnetic north is indicated by a line at an angle to the right (here in Utah) with an arrowhead and is marked "MN." The diagram includes the size of the angle between geographic north and magnetic north in degrees, or mils, or typically both. Unrelated to declination, USGS maps also include a third line (yes, a third north!) on the diagram marked "GN" or grid north,



Magnetic declination for the Sugar House quadrangle (Salt Lake City area) in 1963 and 1998, showing a 2.5-degree decrease in magnetic declination over this time period. Since 1998, it has decreased an additional 1.5 degrees.

which refers to the Universal Transverse Mercator (UTM) grid. For more information on the UTM grid see USGS Fact Sheet 077-01 at http://erg.usgs.gov/isb/pubs/factsheets/fs07701.html.

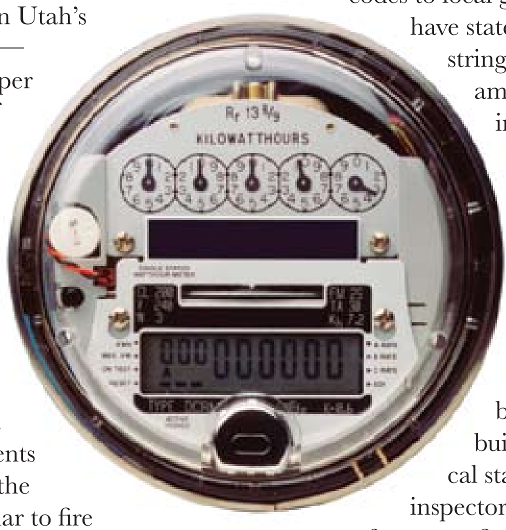
The present magnetic declination can be computed for any location by using an online tool of the National Geophysical Data Center, a division of the National Oceanic and Atmospheric Administration (NOAA), at http://www.ngdc.noaa.gov/seg/geomag/jsp/Declination.jsp. Enter latitude and longitude, or zip code, and the current magnetic declination for any location, as well as the rate of change, is calculated.

Historical reconstruction of the location of the North Magnetic Pole since the year 1831 and projected through the year 2010 (pole locations from NOAA's National Geophysical Data Center, December 2005).

SEP and Energy Codes Training—Saving Energy for the Long Term

by Philip Powlick

Do you know what's inside the walls of your home? How much insulation is in your attic? How efficient your furnace is? Most people have no idea how energy efficient their home is, even if it is new. Yet the energy we use for heating and cooling our homes accounts for a significant part of our overall energy use. According to U.S. Department of Energy household consumption data, 57 percent of all the energy consumed by households in Utah's climate zone is used for space heating—energy worth nearly $1,000 annually per household—and another 4 percent of all energy is used for cooling. Many states, including Utah, try to achieve a baseline level of energy efficiency in buildings through the use of energy codes.



Energy codes are a rather obscure topic, but they have a major impact on the economy of both individual households and the nation as a whole. Energy consumed in buildings represents about one-third of all energy used in the United States. Energy codes are similar to fire and safety codes—they set standards that contractors must meet to ensure at least a minimal level of energy efficiency in a building. Energy codes typically focus on systems that will affect the energy use of a building for years—if not decades—to come. For instance, a building's envelope (the combination of exterior and interior walls and the spaces between them) will rarely, if ever, be modified after it is built. If the envelope is poorly sealed or underinsulated and air handling systems are installed poorly, energy is wasted for years. Over the life of even a small house, thousands of dollars can be lost.

Energy codes cover commercial buildings as well. Have you ever stopped to think that the lights above your desk may really be small space heaters—most incandescent lights are—and how that affects the cooling load on the building? Did you know that revolving doors are often installed in large buildings to comply with energy code requirements? Energy codes for commercial buildings cover a wide variety of topics including lighting density (watts per square foot), envelope requirements, air handling (heating, cooling, ductwork, motors, etc.), doors, and windows.

Energy code standards in the United States are established by the International Codes Council (ICC). Using a stakeholder input process, the ICC revises the International Energy Conservation Code (IECC) every 2–3 years. The IECC is intended to be a relatively easy to understand set of rules for designers and contractors to follow when they construct new or expand existing buildings. The latest version, IECC 2006, became effective on January 1, 2007. An alternative, more complex and technical set of standards (ASHRAE 90.1) is established by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers. The two standards are complimentary and the IECC makes provision for alternative compliance using ASHRAE methods.

States vary widely in the stringency and enforcement of energy codes. Some (e.g., Wyoming, Tennessee) set no statewide standards and leave adoption and enforcement of codes to local governments. Others (e.g., California) have state-specific standards that are even more stringent than the 2006 IECC. Utah's law is among the most progressive in the nation in mandating use of the latest version of the IECC statewide. Though local amendments are allowed, they may only make the energy-saving components of the code more, not less, rigorous. However, enforcement of codes is left to local governments and it is here that Utah has historically seen mixed performance. Local building code officials also enforce other building codes (e.g., plumbing and electrical standards) for health and safety. Some inspectors follow a hierarchy where health and safety come first and energy efficiency is not a major enforcement priority. Because of periodic code revisions, it is also difficult for inspectors to keep abreast of the latest energy code requirements. Because some localities do not strictly enforce the latest IECC, some builders have been lax in voluntarily complying with the energy code. As a result, code compliance has historically been spotty across the state. This represents a lost opportunity for the state's economy and environment.

In autumn of 2006, several factors merged to create a chance to improve Utah's energy code compliance and save the state millions of dollars in energy costs. Both of Utah's major utilities (Rocky Mountain Power and Questar Gas) began to design demand-side management programs aimed at reducing energy use in homes. At the same time, the UGS' State Energy Program (SEP) staff, realizing that the new IECC 2006 was soon to become effective, saw an opportunity. SEP approached both utilities and suggested a joint program of energy codes training for 2007. The program would highlight changes in the newly adopted code and would be designed for contractors, engineers, architects, and local code officials. SEP would manage the program, and the utilities (with the approval of Utah's Public Service Commission) would provide the funding ($90,000) to hire a nationally known codes expert to conduct training sessions around the state.

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The Dome/ Diapir/ Dome Mountain Dilemma

by Sandy Eldredge

An average of 270 inquiries about dome mountains reach our Web site every month. Utah teachers who address landforms often identify mountain types formed by different processes. Up until the 1990s, some curricula materials listed four types of mountains (although there are more): fold, fault, volcanic, and dome. Teachers often defined a dome mountain as forming from rising magma that pushed the overlying rock layers upward to form a dome shape, without the magma breaking through the surface.

However, geologists have a broader dome-mountain definition that includes any region of flat-lying sedimentary rocks warped upward to form a roughly circular shape, as well as accumulations of lava that pile up over a volcanic vent. Adding to the confusion is that many mountains that do not fit the formal definition above are called dome mountains just because of their rounded shapes. These mountains should be referred to as just "dome-shaped" mountains.

To help unravel some of the ambiguities, let's take a look at several dome features and how they are formed.

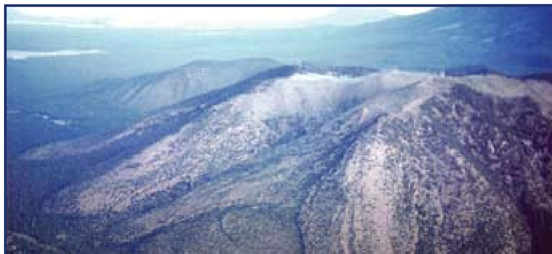
What is a dome?

A dome is a circular or elliptical uplifted geologic feature on which the rock layers slope gently downward in all directions from a central high point. Generally the term is used for any dome-shaped landform.

What are some of the dome structures?

Lava domes, salt domes, salt diapirs, dome mountains, and laccoliths are several of many dome features.

Southeastern Utah's laccoliths are the La Sal, Henry, Abajo, and Navajo Mountains that rise above the flat sedimentary rock expanses. The La Sals, Henrys, and Abajos have aggregations of peaks composed of the igneous rock now exposed after the overlying sedimentary rock layers were eroded off. Navajo Mountain, a solitary dome mountain, is different in that the sedimentary rocks still cover the probable underlying igneous intrusion.



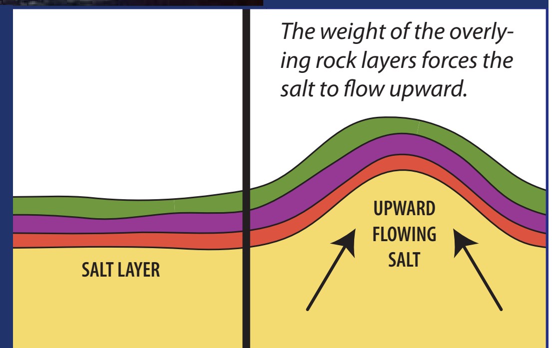
Elden Mountain is a lava dome in the San Francisco volcanic field in Arizona. Photo courtesy of U.S. Geological Survey.

LAVA DOME

Lava (volcanic) domes are rounded, steep-sided mounds built by the accumulation of viscous lava that typically does not move far from the volcanic vent before cooling and crystallizing.

SALT DOME

Salt domes are formed by upward-flowing salt that warps the overlying rock layers. Salt domes are common along the Gulf Coast where salt beds are covered by a thick sequence of sedimentary rocks.



The weight of the overlying rock layers forces the salt to flow upward.

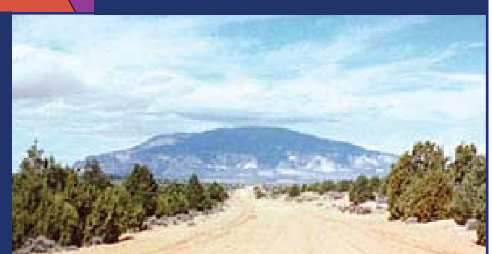
The salt core breaks through the overlying rocks, and possibly the surface, creating a salt diapir.

SALT DIAPIRS

Salt diapirs are "pierced domes," where the overlying uplifted rocks have been pierced or ruptured by the rising salt core. A Utah example is the Onion Creek salt diapir (see the "GeoSights" article in this *Survey Notes* issue). Diapirs can also be formed by flowing shale or magma.

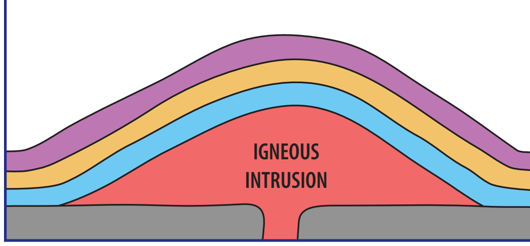
DOME MOUNTAIN

Dome mountains form in areas of flat-lying sedimentary rocks that are warped up to create a roughly circular shape. A Utah example is Navajo Mountain, which most likely has a core of igneous rock that arched up the overlying sedimentary rock layers.



Navajo Mountain in San Juan County is a dome mountain that was probably formed by a laccolith.

Example of a laccolithic intrusion arching overlying sedimentary rock layers that still cover the igneous rock (similar to Navajo Mountain).



LACCOLITHS

Laccoliths are large bodies of igneous rock that were injected as magma between sedimentary rock layers, arching the overlying layers into a domelike form while leaving the rock layers below relatively flat.

Dr. Lehi Hintze and Dr. Robert B. Smith

2007 LEHI HINTZE AWARD

The Utah Geological Association and UGS presented Dr. Robert B. Smith the 2007 Lehi Hintze Award for outstanding contributions to the understanding of Utah geology. Dr. Smith has spent over 40 years studying the seismicity, earthquake hazards, crustal structure, and seismotectonics of western North America. He has been a remarkably productive and distinguished earth scientist, an effective and respected educator, and has helped popularize geology and geophysics through his publications. Dr. Smith is currently professor of geophysics with the Department of Geology and Geophysics at the University of Utah.

Named for the first recipient, Dr. Lehi F. Hintze of Brigham Young University, the Lehi Hintze Award was established in 2003 by the Utah Geological Association and the UGS to recognize outstanding contributions to the understanding of Utah geology.

EMPLOYEE NEWS

Charles Bishop announced his resignation after working for the UGS for 21 years, most recently as a hydrogeologist with the Ground Water and Paleontology Program. Charles accepted a position with the Department of Environmental Quality. Best of luck, Charlie!

Sharon Wakefield retired after 22 years with the UGS. Sharon worked in several different positions since she started in 1986, the last being GIS Information Analyst for the Energy and Minerals Program. We wish Sharon well in her retirement!

Dianne Davis is the new Administrative Secretary, replacing **JoLynn Campbell** who left in October after accepting a position with the Division of Forestry, Fire and State Lands. Dianne comes to us from the Division of Fleet Services.

Welcome to **Will Chatwin**, the new Energy Efficiency Specialist in the State Energy Program. Will comes from the University of Utah where he received his bachelor's degree in Technology Assessment.

Liz Paton, our graphic designer, has accepted a position as Art Director with a local magazine. Liz has been responsible for the design and layout of *Survey Notes* since September 2006. She has been a great asset to the UGS, and we will miss her creative talent. Best of luck, Liz, in your new endeavor.

NEW PUBLICATIONS

Landslide susceptibility map of Utah, by Richard E. Giraud and Lucas M. Shaw, DVD (11 p., 1 pl., 1:500,000 [contains GIS]), ISBN 1-55791-780-9, M-228 .... $19.95

The preliminary landslide history database of Utah, 1850–1978, by Ashley H. Elliott and Michael J. Kirschbaum, CD, OFR-514 ... $14.95

Annotated bibliography of Utah tar sands and related information, by J. Wallace Gwynn and Francis V. Hanson, CD (115 p.), OFR-503 .... $14.95

A plan to reduce losses from geologic hazards in Utah—Recommendations of the Governor's Geologic Hazards Working Group 2006–2007, compiled by Gary E. Christenson and Francis X. Ashland, 30 p., ISBN 1-55791-786-8, C-104 .... $19.95

Geologic map of the Spanish Fork quadrangle, Utah County, Utah, by Barry J. Solomon, Donald L. Clark, and Michael N. Machette, 3 pl., 1:24,000, ISBN 1-55791-776-0, M-227 .... $13.95

Recommended septic tank soil-absorption-system densities for the principal basin-fill aquifer, Sanpete Valley, Sanpete County, Utah, by Charles E. Bishop, Janae Wallace, and Mike Lowe, CD (28 p. + 8 p. appendix, 1 pl., 1:100,000), ISBN 1-5579-774-4, RI-259 .... $14.95

Interim geologic map of the Vernal 30' x 60' quadrangle, Uintah and Duchesne Counties, Utah, and Moffat and Rio Blanco Counties, Colorado, by Douglas A. Sprinkel, CD (3 pl., 1:100,000 [contains GIS data]), OFR-506DM $19.95

Interim geologic map of the Henrie Knolls quadrangle, Garfield, Iron, and Kane Counties, Utah, by Robert F. Biek, David W. Moore, and L. David Nealey, 2 pl., 1:24,000, OFR-502 .... $7.50

Active landslides in the Creekside Drive area, Mountain Green, Morgan County, Utah, between June 2005 and December 2006, by Francis X. Ashland, 25 p., ISBN 1-55791-777-9, RI-260 .... $9.95

Interim geologic map of the Goldstrike quadrangle and east part of the Docs Pass quadrangle, Washington County, Utah, by Peter D. Rowley, R. Ernest Anderson, David B. Hacker, Jonathan T. Boswell, David J. Maxwell, Dennis P. Cox, Ronald Willden, and Don H. Adair, 27 p., 1 pl., 1:24,000, OFR-510 .... $8.00

Progress report geologic map of part of the Seep Ridge 30′ x 60′ quadrangle, Uintah, Duchesne, and Carbon Counties, Utah, and Rio Blanco and Garfield Counties, Colorado (year 1 of 2), by Douglas A. Sprinkel, 2 pl., 1:100,000, OFR-507 .... $7.50

Progress report geologic map of Dugway Proving Ground and adjacent areas, parts of the Wildcat Mountain, Rush Valley, and Fish Springs 30′ x 60′quadrangles, Tooele County, Utah (year 1 of 2), by Donald L. Clark, Charles G. Oviatt, and David Page, 3 pl., scale 1:100,000, OFR-501 .... $9.95

Annual review and forecast of Utah coal production and distribution—2006, by Michael D. Vanden Berg, 37 p., ISBN 1-55791-783-3, C-103 .... $12.95

Interim geologic map of the Thompson Point quadrangle, Kane County, Utah, and Coconino County, Arizona, by Janice M. Hayden, 2 pl., 1:24,000, OFR-511 .... $8.00

The 2005–06 Creekside Drive area landslides, Mountain Green, Morgan County, Utah, by Ashley Elliott, 2 p., PI-91 .... Free

(Energy News continued from page 10)

The codes training program was launched in June 2007 with Eric Makela (Boise, Idaho) providing 42 training sessions spread over 22 days to nearly 800 students. Locations have ranged widely across the state, from Brigham City to St. George and to Moab. Sessions have been offered focusing on residential code basics, IECC 2006 updates, and commercial buildings. Feedback from attendees suggests that there is a demand among Utah's building community for more information, not only about energy codes, but about energy efficient building practices in general. As a result, SEP and our partners are already planning to continue the codes training program in 2008. Over time, we hope to transform the way buildings in Utah are constructed, making code compliance—and even building beyond code—standard practice. The energy efficient buildings that we hope to see built today should help Utah homeowners and businesses to save energy for many years—and many dollars—to come.

An example of energy savings built into a new home: Raised heel roof trusses that extend the top of exterior walls allow for a uniformly thick layer of insulation. Ordinary roof trusses that come to a point at the exterior wall do not allow for thick insulation layers on the sides, resulting in energy losses over the lifetime of the house. Photo source: National Renewable Energy Laboratory.

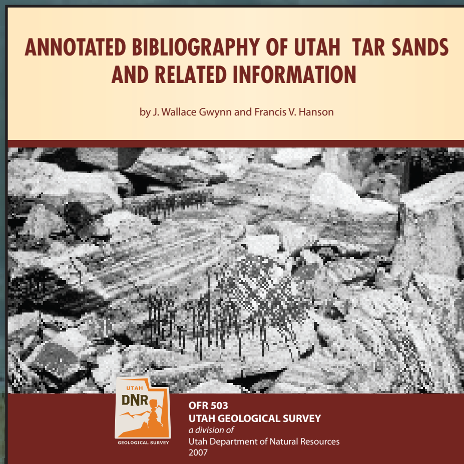
Earth Science Week Kicks Off with Ceratopsian Unveiling

Jim Kirkland and Don DeBlieux unveil the reconstructed Last Chance ceratopsian skull during Earth Science Week.

Reporters from T.V. stations and newspapers were on hand the first day of Earth Science Week (ESW), celebrated October 15–17 at the UGS's Core Research Center. During a break in ESW activities, UGS paleontologists Jim Kirkland and Don DeBlieux unveiled the reconstructed skull of the Last Chance ceratopsian, discovered by DeBlieux in 2002 near Last Chance Creek in southern Utah. Some of the 4th-grade students present were even interviewed by several reporters (see the September 2007 issue of *Survey Notes* for a detailed illustration and more information about of the Last Chance ceratopsian).

During this year's ESW, 685 students participated in activities such as panning for "gold" and identifying rocks and minerals.

View more ESW photos and the 2007 declaration signed by Governor Huntsman at http://geology.utah.gov/teacher/esweek.htm.



ANNOTATED BIBLIOGRAPHY OF UTAH TAR SANDS AND RELATED INFORMATION

by J. Wallace Gwynn and Francis V. Hanson

Utah's tar sand resources are the largest in the United States. The Uinta Basin hosts the majority of Utah's tar sands, both in terms of the number of deposits and resources in-place (measured and estimated). Despite unsuccessful past attempts to develop this heavy-oil resource, the current period of sustained high oil prices is stimulating renewed interest. Advances in oil extraction from tar sands in other countries make the vast Utah deposits an attractive target.

This publication provides an annotated reference list of Utah's tar sand literature and technical information on nearly 100 individual deposits, as well as extraction and upgrading processes. Some other references related to patents, oil shale, and other hydrocarbon resources are also included. This compilation will be valuable to those interested in the exploration for, and development of, Utah's tar sand resources. The bibliography, consisting of digital text files on compact disk, is searchable for specific deposits or general terms. A brief introductory section describes the past, present, and future of Utah's tar sand industry.

Open-File Report 503 .... $14.95

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