UTAH GEOLOGICAL SURVEY

SURVEY NOTES

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San Rafael Swell

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Design by Vicky Clarke

Cover: *San Rafael Swell, photograph courtesy of Utah Travel Council.*

The Director's Perspective

by Richard G. Allis

In an eleventh-hour decision as the Utah legislature ended its session this March, the "Professional Geologist Licensing Act" was passed, and it has subsequently been signed into law. Utah becomes the 31st state to require professional geologist licensure, and it is the 27th to adopt the National Association of State Boards of Geology (ASBOG) exam as the standard for licensure. The relatively rapid passing of the Act is a tribute to the energy, enthusiasm and lobbying skills of practicing geologists in Utah. This Act should have a major, long-term impact on the practice of geology before the Utah public by requiring minimum professional standards to be met, and providing recourse for aggrieved clients.

In Utah, the Act will be administered by the Division of Occupational and Professional Licensing (DOPL, part of the Utah Department of Commerce), with the assistance of a five-member board appointed by the Governor. The board will consist of three professional geologists, one member representing the general public, and the State Geologist. Details of the Act, associated rules, and the time frame for getting the Act up and running are contained on DOPL's website (see below). Professional licensure for practicing geologists will be required by January 1, 2003, and after January 1, 2004, applications for a license in Utah will require the ASBOG exam to be passed.

Here are some of the general points implied by the Act, based on my initial interpretation; they should not be assumed to be the exact way the Act will actually be administered. A license will be required for all geological work relevant to public welfare, or safeguarding the life, health, property and the environment in Utah. Among several exclusions are subordinates of a licensed professional geologist, individuals engaged in teaching or research in the physical or natural sciences who are not otherwise engaged in practicing geology before the public, employees of companies if their work is solely for internal use, and licensed professional engineers and land surveyors not intentionally representing themselves as professional geologists. All final versions of geologic work presented to a client or a public authority will require the seal of a professional geologist. Reciprocity with similar licenses in other states will apparently be recognized.

At the time of writing this piece, we at the UGS are trying to figure out whether we should make it mandatory for all geologic staff above a certain level (e.g., our project geologist level) to be licensed, or require it only for those "practicing before the public." Also we have not yet decided whether we are required to, or should, use the seal on our publications that fit the definition "public geologic practice," or whether supervision by a licensed professional geologist is adequate. Hopefully the rules that are presently being drafted for this Act will clarify the role of public authorities that carry out geologic work in Utah.

Official progress on implementing the Act at DOPL's website:
http://www.dopl.utah.gov/licensing/geologist.html

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Cache Valley Study Kicks Off New Cooperative Effort to Evaluate Utah's Ground-water Sensitivity and Vulnerability to Pesticides

by Ivan D. Sanderson, Utah Department of Agriculture and Food, and Mike Lowe, UGS

Introduction

The U.S. Environmental Protection Agency (EPA) is recommending that states develop Pesticide Management Plans for four agricultural chemicals that in some areas impact ground-water quality. These chemicals—herbicides used in production of corn and sorghum—are alachlor, atrazine, metolachlor, and simazine. All four chemicals are applied to crops in Utah. In some areas of the United States where these crops are grown extensively, these pesticides have been detected as contaminants in ground water. Such contamination poses a threat to public health, wildlife, and the environment. In many rural and agricultural areas throughout the United States—and particularly in Utah—ground water is the primary source of drinking and irrigation water.

The state of Utah is committed to preserving the quality of its ground-water resources. To aid in this effort, the Plant Industry Division of the Utah Department of Agriculture and Food and the Utah Geological Survey are producing maps to provide federal, state, and local government agencies and agricultural pesticide users with a base of information concerning sensitivity and vulnerability of ground water to agricultural pesticides both statewide and for specific basin-fill aquifers in valleys with extensive agricultural activity. Cache Valley, in northern Utah, is the first of these valleys to be mapped; maps are also being developed for Utah, Goshen, and Pahvant Valleys, with others to follow.

Sensitivity to pesticides is determined by assessing natural factors favorable or unfavorable to the degradation of ground water by pesticides, whereas vulnerability to pesticides is determined by assessing human-induced factors and their response to natural factors. Sensitivity incorporates hydrogeologic setting including vertical ground-water gradient, depth to ground water, and presence or absence of confining layers, along with the soils' vertical hydraulic conductivity (a factor influencing the rate at which water moves downward through the aquifer material) and other physical properties. Sensitivity also includes the influence of pesticide properties such as the capacity of molecules to adsorb to organic carbon in soil and the degradation (chemical breakdown) rate of a pesticide under typical soil conditions. Vulnerability includes human-controlled factors such as whether agricultural lands are irrigated, crop type, and amount and type of pesticide applied. We use and interpret existing data to produce pesticide sensitivity and vulnerability maps through the application of Geographic Information System (GIS) analysis methods.

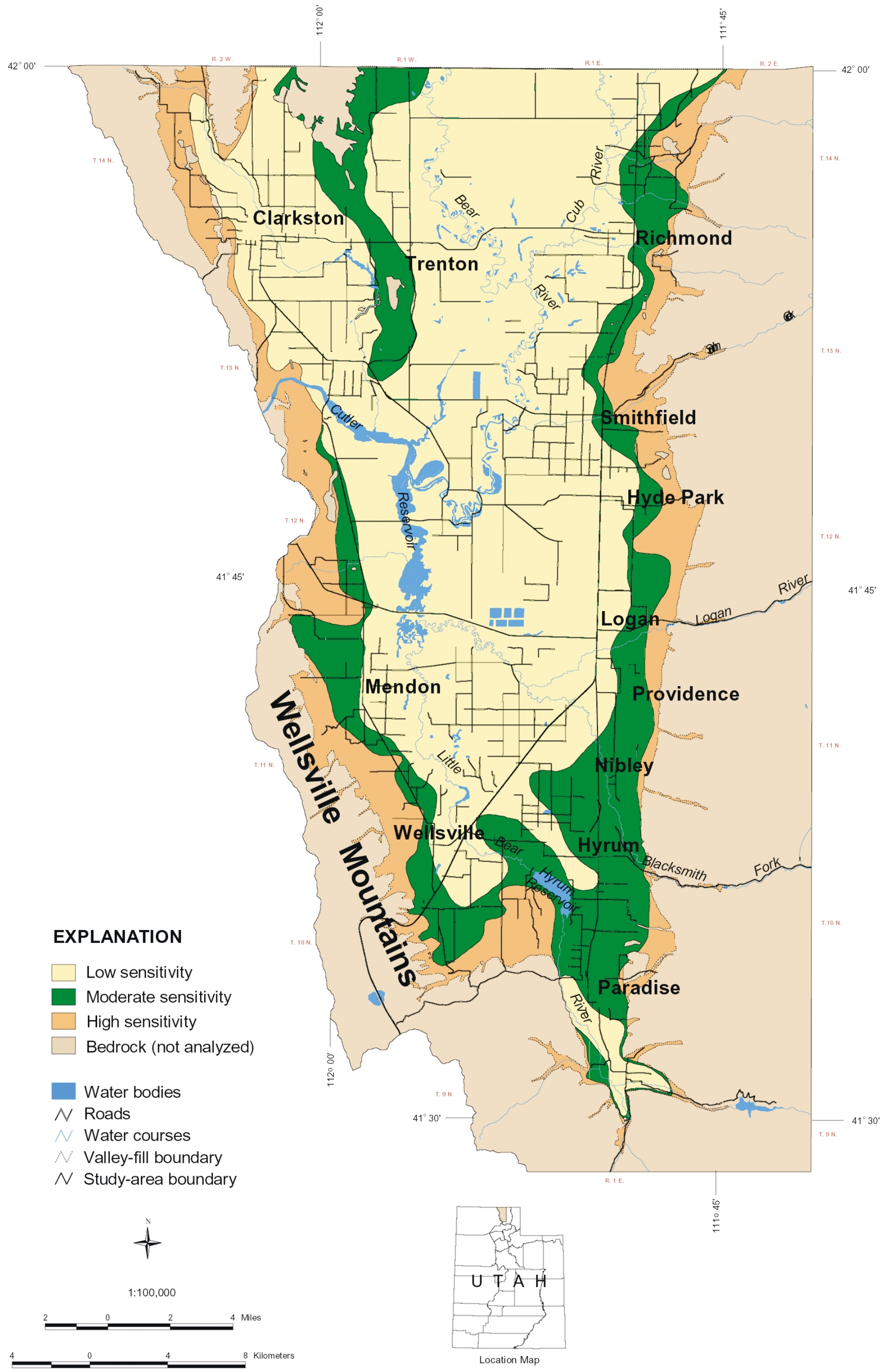
Discussion of Pesticide Issue

In many rural areas, ground water is the primary source of water for human consumption, irrigation, and animal watering. Therefore, the occurrence of agricultural pesticides in ground water represents a threat to public health and the environment. The rise of the United States as the world's foremost producer of agricultural products since the end of World War II may be attributed, to a significant extent, to widespread use of pesticides. Control of insect pests that would otherwise devour the developing crop, together with control of weeds that interfere with growth and optimum crop development, permit higher quality commodities in greater abundance at lower net cost. Effective use of pesticides often means the difference between profitability and financial ruin for an agricultural enterprise.

When evidence shows pesticides are degrading the environment, harming sensitive wildlife, or posing a public health threat, two regulatory courses of action are available: (1) ban further use of the offending chemical, or (2) regulate it so that judicious use mitigates the degradation or threat. Since the four subject herbicides play an essential role in crop production and profitability, banning them outright is unnecessarily severe if the desired environmental objectives can be met by regulation and more judicious use of these herbicides.

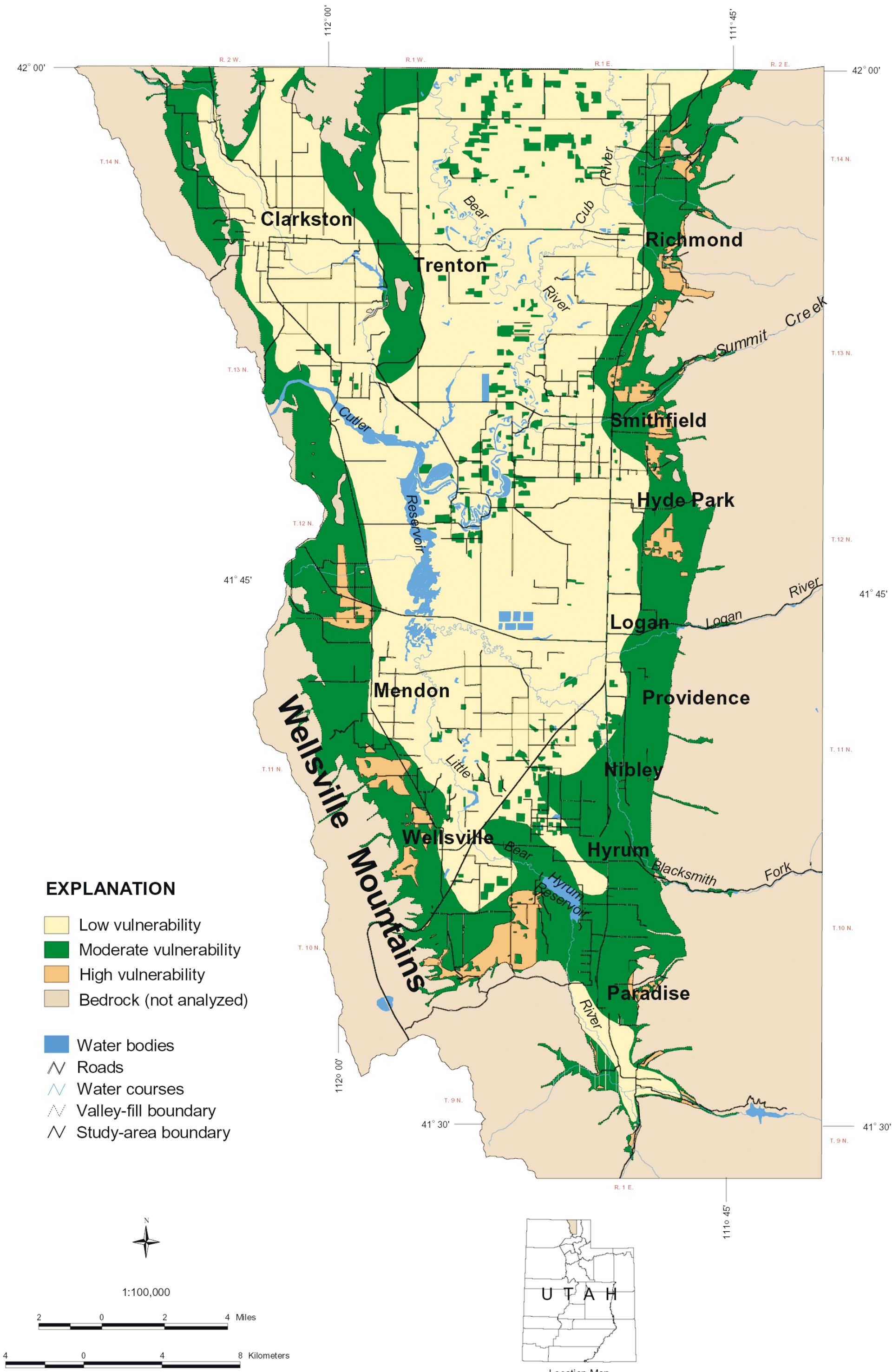
The case of DDT, a once widely used insecticide, illustrates dilemmas faced by pesticide regulators. DDT was removed from widespread use in the United States in the 1970s because of its deleterious effects on bald eagles, ospreys, and peregrine falcons. Populations of these once-endangered species have recovered to a significant extent 25 years later. An ongoing effort to extend the DDT ban worldwide is being hotly contested by advocates of its judicious use as a critical and inexpensive insecticide needed in developing countries to control mosquitoes that transmit the malaria parasite. It is further argued that, given the current regulatory apparatus, were the use of DDT to be re-evaluated today under rigorous scientific and regulatory criteria, it would be restricted to specific uses rather than prohibited.

Federal government agencies have been aware of the growing problem of pesticide contamination of ground water since the early 1980s. In 1984, scientists from the American Chemical Society documented the occurrence of 12 pesticides in ground water in 18 states; in 1986, they reported the occurrence of at least 17 pesticides in ground water in 23 states. By the early 1990s, the EPA began formulating and implementing programs to address the problem.



Ground-water sensitivity to pesticide contamination in Cache Valley, Cache County, Utah.

In 1985, the EPA published a standardized system for evaluating the potential for ground-water pollution on the basis of hydrogeologic setting. The method, known under the acronym DRASTIC, involves assigning numerical values to seven parameters and totaling a score. Under this system, the higher the score, the greater the assumed vulnerability of ground water to pesticide contamination. Ranges in the numerical score are easily plotted on GIS maps. Measured parameters include depth to the water table, recharge, aquifer media, soil media, topography, impact of the vadose zone, and hydraulic conductivity of the aquifer—with the beginning letter of key words in these parameters forming the acronym DRASTIC. Eventually, it became apparent that this method is unreliable in some settings, and that it fails to consider the chemical characteristics of the potential contaminants and their interaction with soil and water in the vadose zone. To address this issue, methods were developed for ranking the potential for pesticide contamination of ground water based on calculation of a retardation factor and an attenuation factor that characterize movement and persistence of pesticides in the vadose zone, respectively, which vary with different soil



Ground-water vulnerability to pesticide contamination in Cache Valley, Cache County, Utah.

properties and different characteristics of specific pesticides.

The EPA has developed guidelines and provided funding for programs to address the problem of pesticide contamination of ground water, including a generic Pesticide Management Plan to be developed by state regulatory agencies having responsibility for pesticides. Utah's generic (non-pesticide specific) Pesticide Management Plan was approved by the EPA in 1997; its implementation involves, among other things, establishment of a GIS database containing results of analyses of samples collected from wells, springs, and drains showing concentrations of pesticides and other constituents that reflect water quality, and development of a set of maps showing varying sensitivity and vulnerability of ground water to contamination by pesticides (this study). Since its inception in 1994, the Utah Department of Agriculture and Food's sampling program has revealed no occurrences of pesticide contamination in any aquifer in over 1,500 samples tested statewide.

GIS Analysis Methods

We divided pesticide sensitivity into "low," "moderate," and "high" categories using the factors described above. Numerical ranking for each attribute category is arbitrary, but reflects the level of importance we believe the attribute plays in determining sensitivity of areas to application of agricultural pesticides; for instance, we believe hydrogeologic setting is the most important attribute with respect to ground-water sensitivity to pesticides, and therefore weighted this attribute three times more heavily than the other attribute categories. A sensitivity attribute of low was assigned when the numerical ranking ranged from –2 to 0, a sensitivity attribute of moderate was assigned when the numerical ranking ranged from 1 to 4, and a sensitivity attribute of high was assigned when the numerical ranking ranged from 5 to 8.

We divided pesticide vulnerability into "low," "moderate," and "high" categories using pesticide sensitivity, areas of irrigated lands, and crop type. Once again, numerical ranking for each attribute category is arbitrary, but reflects the level of importance we believe the attribute plays in determining vulnerability of areas to application of agricultural pesticides; for instance, we believe ground-water sensitivity to pesticides is the most important attribute with respect to ground-water vulnerability to pesticides, and therefore weighted this attribute two times more heavily than the other attribute categories.

Results

The small versions of the sensitivity and vulnerability maps (shown here) show our results. The main sources of recharge to the basin-fill aquifer in Cache Valley are surface streams that originate in areas of higher elevation and then flow into the sediment-filled basins. Areas where rivers and streams cross valley-bounding faults and coarse-grained alluvial fans have the most urgent need for protection to preserve ground-water quality, based on the results of our ground-water sensitivity and vulnerability mapping. Other valley-margin areas (see map), particularly those with unlined or poorly lined irrigation canals, also warrant measures to protect ground-water quality. However, because of relatively high retardation and attenuation of pesticides in water in the vadose zone, it is unlikely that pesticides applied to crops and fields in Cache Valley represent a serious threat to ground-water quality.

Based on these conclusions, we believe ongoing ground-water sampling in Cache Valley should be concentrated in areas of moderate and high sensitivity or vulnerability, typically along valley margins. Sampling in the central area of the valley characterized by low sensitivity and low vulnerability should continue, but at a lower density than in the areas of higher sensitivity and vulnerability. Areas where data are unavailable, particularly areas lacking shallow ground-water data, were treated conservatively (in a manner protective of ground-water quality), by assuming that conditions most susceptible to pesticide pollution of ground water are present. This conservative treatment is particularly evident in valley-margin areas where depth to the water table is generally deep, but where GIS analysis presumed the water table to be shallow due to a lack of map data. Therefore, our maps show higher sensitivity and vulnerability to pesticides than what actually may be the case in those areas. Ground-water sensitivity and vulnerability to pesticides in such areas should be re-evaluated when better data become available.

For more detailed information about pesticide sensitivity and vulnerability mapping for Cache Valley, the UGS Miscellaneous Publication 02-8, "Ground-water sensitivity and vulnerability to pesticides, Cache Valley, Cache County, Utah," is available at the Department of Natural Resources Map & Bookstore, 1594 W. North Temple, Salt Lake City, UT 84116.
Web address: http://mapstore.utah.gov.
Telephone: (801) 537-3320.
FAX: (801) 537-3395.
Email: geostore@utah.gov

New Publications

The geology of the Kamas-Coalville region, Summit County, Utah, and its relation to ground-water conditions, by Hugh A. Hurlow, 55 p., 14 pl., 3/02, ISBN1-55791-656-X, WRB-29 . . . .$21.95

Geologic map of the Moab 7.5' quadrangle, Grand County, Utah, by Hellmut H. Doelling, Michael L. Ross, and William E. Mulvey, 34 p., 2 pl., 1:24,000, 3/02, ISBN 1-55791-580-6, M-181 . . . .$11.00

Geologic map of the Fisher Towers quadrangle, Grand County, Utah, by Hellmut H. Doelling, 4/02, 22 p., 2 pl. 1:24,000, ISBN 1-55791-582-2 . . . .$11.00

Geologic map of the Terrace Mountain East quadrangle, Box Elder County, Utah, by Padhraig T. McCarthy and David M. Miller, 14 p., 2 pl., 1:24,000, 3/02, ISBN 1-55791-662-4, MP-02-2 . . . .$9.00

Geologic map of the Terrace Mountain West quadrangle, Box Elder County, Utah, David M. Miller and Padhraig T. McCarthy, 13 p. 2 pl., 1:24,000, 3/02, ISBN 1-55791-663-2, MP-02-3 . . . .$9.00

Surface and subsurface correlation of the Green River Formation in central Nine Mile Canyon, SW Uinta basin, Carbon and Duchesne Counties, east-central Utah, by David Keighley, Steve Flint, John Howell, Daniel Andersson, Stephen Collins, Andrea Moscariello, and Greg Stone, 2/02, 1 CD-ROM, ISBN 1-55791-664-0, MP-02-1 . . . . $14.95

Geological and petrophysical characterization of the Ferron Sandstone for 3-D simulation of a fluvial-deltaic reservoir, edited by Thomas C. Chidsey, Jr., 2/02, 1 CD-ROM, ISBN 1-55791-668-3, MP-02-6 . . . . .$14.95

Ground-shaking map for a magnitude 7.0 earthquake on the Wasatch fault, Salt Lake City, Utah, metropolitan area, by Ivan Wong, Walter Silva, Douglas Wright, Susan Olig, Francis Ashland, Nick Gregor, Gary Christenson, James Pechmann, Patricia Thomas, Mark Dober, and Robyn Gerth, 3/02, 1 plate, PI-76 . . .$3.00

Technical reports for 2000-01, Geologic Hazards Program, compiled by Greg N. McDonald, March 2002, 140 p., RI-250 $6.75

Movement history and preliminary hazard assessment of the Heather Drive landslide, Layton, Davis County, Utah, by Richard E. Giraud, March 2002, 22 p., RI-251 . . . .$11.00

GeoSights

Little Egypt Geologic Site – Hoodoos of Garfield County

by Mark Milligan

Geologic Information: Why travel around the world when Little Egypt is as close as Garfield County? This geologic area showcases fantastic and sometimes grotesque stone hoodoos that bring to mind the magnificent temples of ancient Egypt, hence its name Little Egypt Geologic Site. Geologically however, the area is more like Goblin Valley State Park and Cathedral Valley of Capitol Reef National Park. Weathering and erosion carves hoodoos (i.e., Egyptian temples, goblins, and cathedrals) in all three areas from the Entrada Sandstone. This is the same formation that also erodes to arches, fins, and spires in Arches National Park.

Joint sets (fractures) within the Entrada's fine-grained sandstone beds play an important role in hoodoo development by creating initial zones of weakness. Unweathered joints intersect to form sharp edges and corners. These edges and corners are more susceptible to weathering because they have a greater surface-area-to-volume ratio than the faces. As a result, they weather more quickly, producing rounded hoodoos through a process called spheroidal weathering. Spheroidal weathering helps shape the hoodoos, but it is only part of the larger erosion process that forms and exhumes the hoodoos.

Interbedded and underlying shale and siltstone beds are less resistant to weathering and erosion than the hoodoo's sandstone beds. Combined with spheroidal weathering of the sandstone beds, these softer shale and siltstone beds can give the hoodoos a stacked appearance, elongated shapes, and flat bottoms.

Additionally, variation in the amount and type of cementation (between grains in sedimentary rocks) may act as a secondary control on the unusual shapes of individual hoodoos.

Similar to rocks all across southeastern Utah, the Entrada's reddish hue comes from minute quantities of hematite (iron oxide). The whiter areas result from bleaching by ground water that chemically removed the hematite (or rendered it colorless) before the rocks were exhumed by erosion.

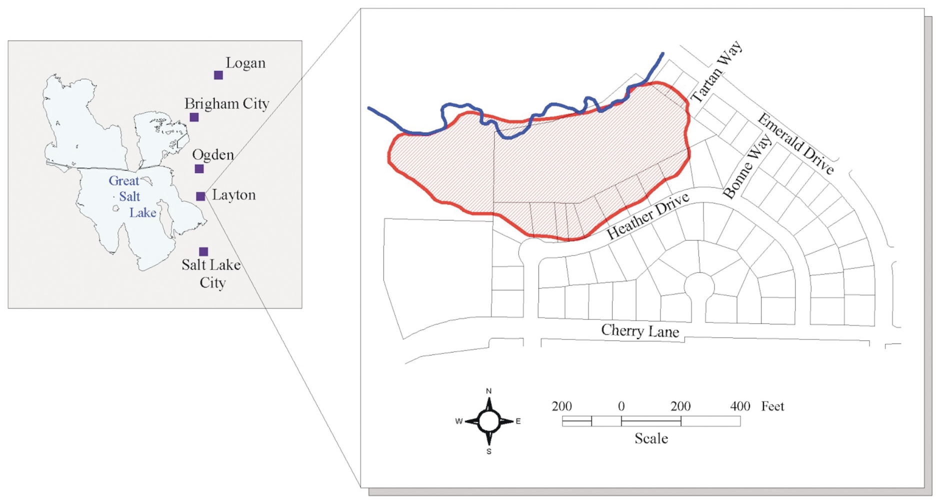
"Temples" in the Entrada Sandstone at the Little Egypt Geologic Site

How to get there: From Hanksville, head south on State Route 95. Approximately 4.2 miles after (south) the Garfield County line, just past (south) mile marker 20, turn right (west) on the "Scenic Backway" road towards North Wash. Just off the highway is a sign to "Little Egypt Geologic Site." Little Egypt is less than two miles off the highway.

Landslide Damaged Six Layton Homes

By Richard Giraud

The Heather Drive landslide in late August 2001 damaged six homes and interrupted utility service, forcing families to evacuate and causing over $1 million in losses. The Heather Drive landslide is on a gentle slope above South Fork Kays Creek in Layton. Movement in 2001 was largely a reactivation of a prehistoric landslide. This was the latest of several recent landslide reactivations in Layton, most of which occurred in 1998. All of these landslides, including Heather Drive, involve the failure of soft, silty and clayey sediments of prehistoric Lake Bonneville. Lake Bonneville sediments in the Layton area are particularly prone to landsliding, and periodic reactivation of existing landslides is a common pattern. In its role in emergency response, the Utah Geological Survey monitored movement, documented landslide features, assessed the hazard, and provided advice and recommendations to Layton City and homeowners.



Location map of the Heather Drive landslide. Red cross-hatched area shows the area of landslide movement in August 2001; blue line is South Fork Kays Creek.

The timing of landslide movement documented by homeowner interviews and movement monitoring indicates a long gradual period of slow or intermittent movement followed by relatively rapid movement and an abrupt stop. One homeowner noticed foundation cracks in 1998 that were likely caused by landslide movement. Another repaired a driveway in July 2000 and noted continual displacement through July 2001. Therefore, the landslide was moving continually but at a very slow rate since at least July 2000. The landslide movement rate increased in late August 2001 and the majority of landslide movement took place between August 20 and 29.

The most dramatic landslide movement occurred between August 27 and 28, when the upper landslide dropped vertically 2 to 2.5 feet along the main scarp separating the top of the landslide from ground along Heather Drive that didn't move. On August 25 and 26 prior to this dramatic drop, the upper landslide was dropping vertically about 1 foot per day along the main scarp.

Nearly all landslide movement had stopped by August 31. The lower landslide moved horizontally at least 7 feet to the north toward South Fork Kays Creek, restricting creek flow.

As movement increased in late August, houses and underground utilities quickly showed landslide-related damage. The houses on the landslide became severely cracked, continually creaked and popped, and the doors, walls, and floors buckled and tilted in response to movement. Water, natural gas, and electricity services were discontinued because of landslide damage to buried lines. In response, the homeowners evacuated their houses and were moved out by August 24.

Movement along the main scarp caused most of the damage to houses and utilities. Of the six houses damaged by the landslide, two straddled the main scarp and four were on the landslide just below the main scarp. Three were eventually moved off the landslide and three were demolished due to landslide-related damage. The electric and natural gas lines were relocated to the south side of Heather Drive.

Preliminary estimates of homeowner equity losses, lending institution losses, costs to Layton City, and costs to relocate utility lines exceed $1 million. A more detailed loss estimate will be made once lending institutions and homeowners complete final decisions on the outstanding mortgages. Standard homeowner's insurance does not cover landslide damage, and none of the homeowners had landslide insurance to cover their losses.

The cause(s) of landslide movement is uncertain. Little is known about subsurface conditions and factors controlling movement because the landslide has not been studied in detail. The most common causes of landslide movement are adding weight to the upper landslide, removing support from the lower landslide, or increasing the ground-water level. These causes could not be documented at the Heather Drive landslide, although movement in 1997 or 1998 following several years of above-normal precipitation indicates increased ground-water levels may have played a role in initiating movement. The landslide then moved intermittently and very slowly for years, perhaps as the sliding surface developed and the silt and clay along the sliding surface gradually reduced in strength until late August 2001 when the majority of movement took place. Even though landslide movement has stopped, the landslide remains potentially unstable and could enlarge, placing additional houses, streets and underlying utilities, and South Fork Kays Creek at risk.

House straddling the main scarp. The house was demolished on August 27, 2001.

Lawns, driveways, and sidewalks displaced by the broad, curving main scarp up to 5 feet high.

Main scarp height of 9 feet with the remains of demolished house at left. Note the displacement increase from photo above.

Basement and foundation straddling the main scarp. The wood frame portion of the house was moved off the foundation on August 25, 2001.

In the left photograph the arrows point to the tilted sidewalk (left) and roll in lawn (right) showing small main-scarp displacements on August 8, 2001. In the right photograph the arrows point to the same locations showing main-scarp displacements of 4 to 5.5 feet on August 27, 2001.

"Glad You Asked"

by Carl Ege

What are minerals used for?

The importance of minerals in everyday life is hardly recognized by the vast majority of people. According to the U.S. Bureau of Mines, the average person consumes or uses 40,000 pounds of minerals every year. Over the course of a lifetime, an individual will use more than 1,050 pounds of lead, 1,050 pounds of zinc, 1,750 pounds of copper, 4,550 pounds of aluminum, 91,000 pounds of iron and steel, 360,500 pounds of coal, and one million pounds of industrial minerals such as limestone, clay, and gravel.

To help illustrate how important minerals are to us, perhaps a trip through a normal working day of a geologist will better explain our reliance on minerals.

Morning

As we wake up in the morning from a restless night of sleep - dreaming of piles of paperwork at the office, we turn off our alarm clock (manufactured from limestone, mica, talc, silica, and clays). After getting out of bed (bed frame and bed springs made from iron and nickel), we make our way into the kitchen. We turn on the electric light switch (copper, aluminum, and petroleum products) and the coffee pot, which is made of glass or ceramics (silica sand, limestone, talc, and feldspar). While waiting for the coffee (coffee beans fertilized with phosphate) to brew, we sit down on a chair (aluminum and petroleum products) and read the local newspaper (kaolin clay, limestone, sodium sulfate, and soda ash). As usual, we don't find any interesting articles concerning geology so we daydream of the time when we can finally try out our new pair of skis (graphite) and boots (limestone, talc, clay, mica, and petroleum products). Thinking about what happened to our previous pair of skis (broken in half after they fell out of the ski rack and were run over by a truck on the freeway), we develop an upset stomach. We decide to take Milk of Magnesia (magnesium and dolomite) or Kaopectate (kaolin clay) for relief of our upset stomach. We look up at the clock (silica sand, steel, and petroleum products) and hurry upstairs on the bright neon green carpeted floor (limestone, selenium, and petroleum products). We jump in the shower (made of ceramic tiles that are composed of silica sand, limestone, talc, and feldspar) and turn on the water (softened by halite). We adjust the shower head and turn the water faucets (iron, nickel, chromium) for warm water. Remembering that this house has no warm water, we take a quick cold shower, using soap (talc) and shampoo (coal tar, lithium clays, and selenium) to clean ourselves. We get out of the shower and brush our teeth with a toothbrush (limestone, mica, talc, clays, and petroleum products) and toothpaste (limestone, phosphate, gypsum, selenite, fluorite, and dolomite).

On the way to work

The truck we drive is composed of many different components that were manufactured from minerals. The tires are made from limestone and clay. All of the glass in the truck is made from silica sand and feldspar. The rusted body of the truck (including the bumper) is made from iron, limestone, mica, talc, silica, clays and petroleum products. The automobile engine and other components under the hood are made out of iron, lead, molybdenum, chromium, nickel, aluminum, and zinc. The red paint flaking off of our truck is made of titanium, kaolin clays, mica, talc, gypsum, sulfur, silica, and limestone.

At work in the field

First, we decide to use our laptop computer (gold, silica, nickel, aluminum, zinc, iron, petroleum products, and thirty other minerals) and digital topographic map software on CD-ROM (aluminum and petroleum products) to help guide us to the correct field location. Once we get to the field area, we begin by pulling out a field notebook (kaolin clay, limestone, and soda ash). We begin writing preliminary information, such as latitude/longitude coordinates we obtained from our Global Positioning System (silica, mica, clay, limestone, and talc) with our pencil (graphite and clays) or pen (limestone, mica, clays, silica, talc, and petroleum products). We see an interesting rock and decide to use our hammer (iron and nickel) and break off a chunk for analysis. For safety, we put on our safety goggles (silica, talc, clays, and mica). We get out our hand lens (iron ore and silica) and view the mineral content of the rock closely. Next, we find our hydrochloric acid (halite) to test for the calcium carbonate content of the minerals. We also pull out our ceramic scratch plate (silica sand, limestone, talc, lithium, and feldspar) to check the streak of the mineral. Finally, we decide to use our camera (silica and petroleum products) and

Continued on page 13...

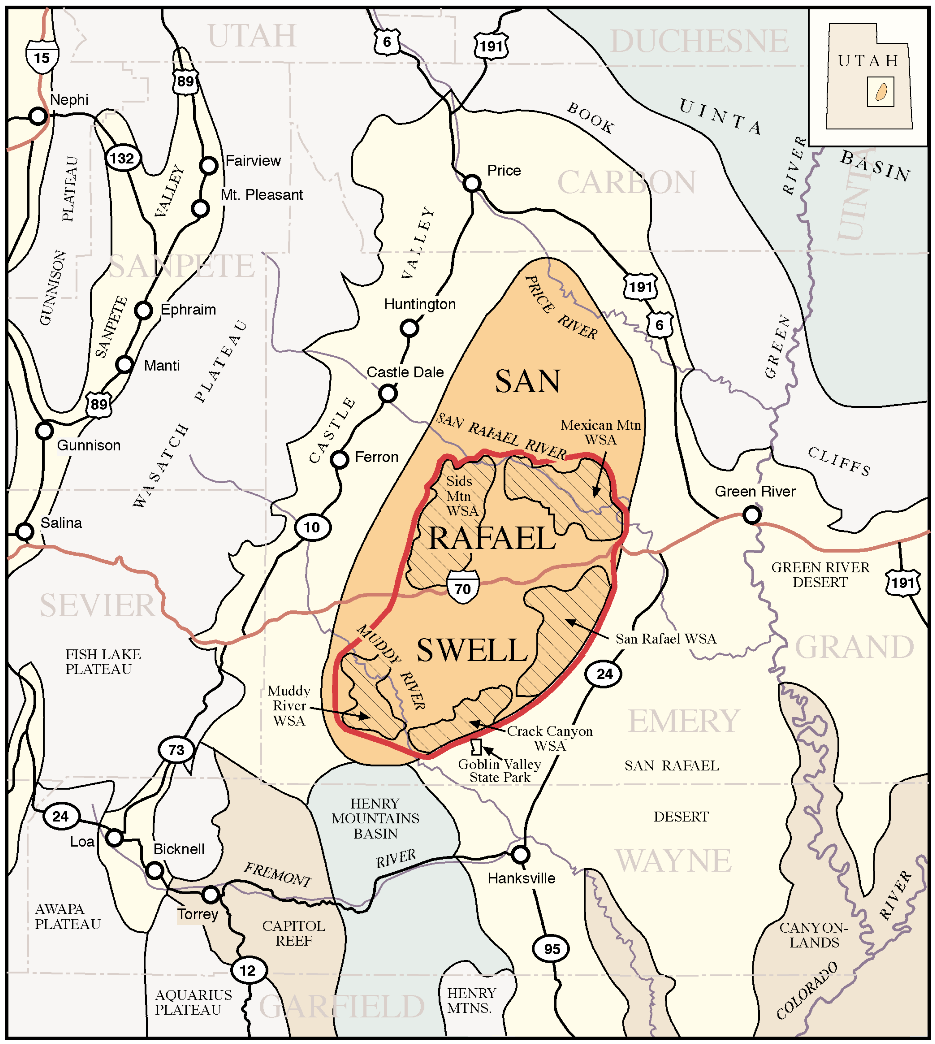
San Rafael Swell Proposed as Site of New National Monument

by Hellmut H. Doelling and Michael D. Hylland

In his January 2002 State of the State address, Governor Leavitt endorsed a preliminary proposal by the Emery County Public Lands Council for the creation of a new national monument in the San Rafael Swell area of east-central Utah. The Swell is an oval geologic feature that covers 1,800 square miles, which equates to about 90 percent of the land area of Delaware. As proposed, the national monument would cover just over half of the Swell area. It would encompass five Wilderness Study Areas presently located in the central and southern parts of the Swell, as well as the Cleveland-Lloyd Dinosaur Quarry in the northern part of the Swell.

Historically, the San Rafael Swell has been the site of a variety of recreational activities as well as livestock grazing, uranium mining, and oil and gas exploration. The Swell is also known for its stark and dramatic scenery, which ultimately stems from spectacularly exposed geology. The Swell has been described as a "land of naked rocks" because the sedimentary strata are so colorfully and well exposed. Travel brochures describe the scenery as "great crumbling sandstone palaces and citadels with endless miles of fantastically carved cliffs inciting a drama of upheaval and erosion." This is a land of overpowering grandeur.

The geologic origin of the San Rafael Swell is tied to compressional tectonic forces responsible for uplift of the Rocky Mountains to the east and Uinta Mountains to the north. During



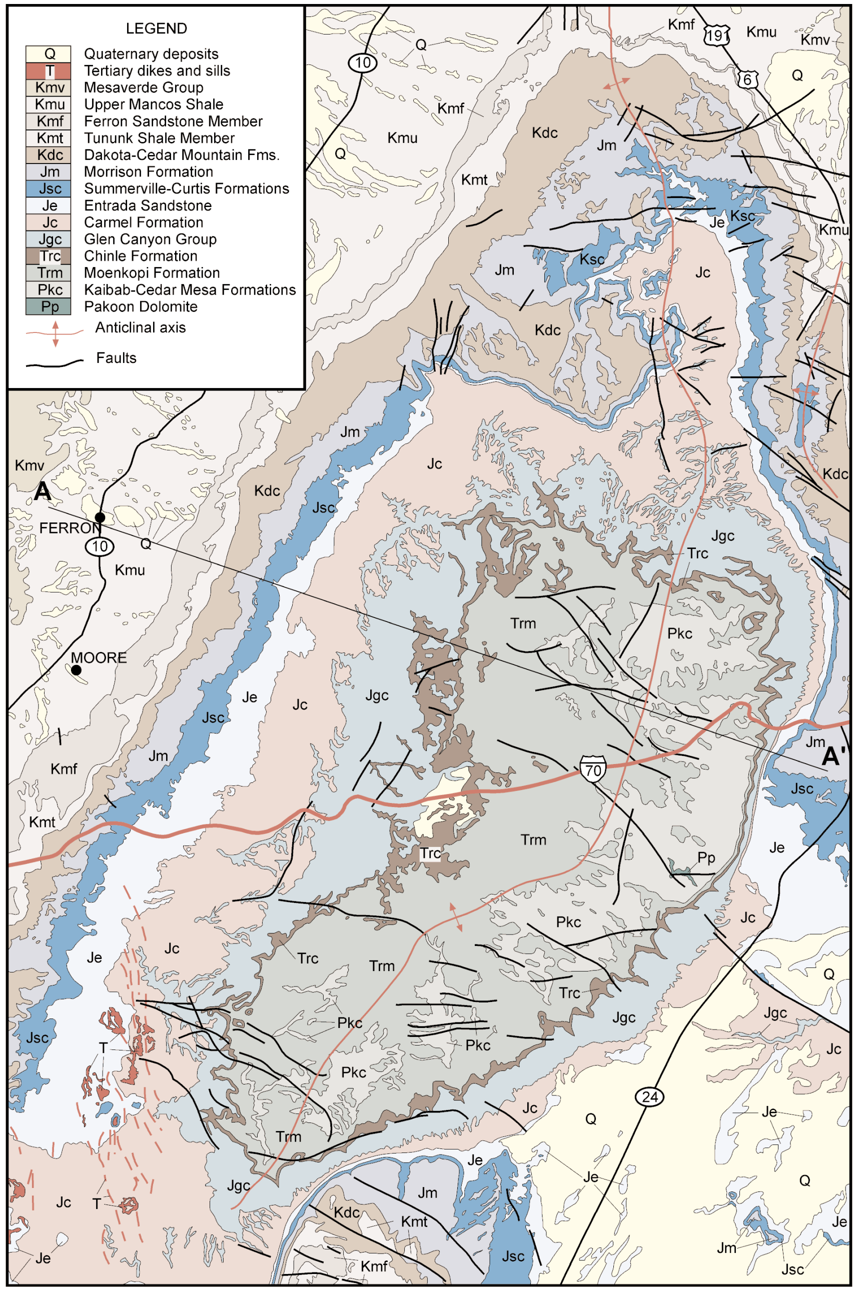
Location of the San Rafael Swell and surrounding physiographic features, existing Wilderness Study Areas (WSAs), and general area of proposed national monument (red outline). Valleys and desert areas are shown in yellow, plateaus and mountains in gray, canyonlands in brown, and basins in green.

this mountain-building episode roughly 40 to 70 million years ago, the rocks of the San Rafael Swell were also uplifted as a broad, arch-shaped geologic structure called an asymmetrical anticline. Sedimentary strata in the west limb of the anticline are gently inclined, whereas they are relatively steep in the east limb, forming the San Rafael Reef. The anticlinal structure, as well as the relative resistance to weathering and erosion of the rocks, controls the topographic form of the Swell; hard layers form the steep cliffs and tops of benches, mesas, buttes, and flatirons or hogbacks (tilted surfaces) around the perimeter of the Swell, and intervening softer formations weather into slopes in the interior of the Swell. Streams have eroded into both hard and soft rock layers to form deep terraced canyons, which cut inward into the Swell from all directions.

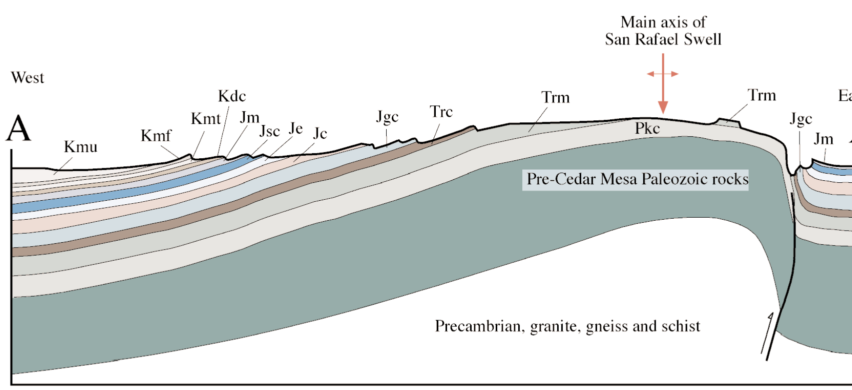
Colorful sedimentary rocks, ranging in age from Permian to Cretaceous, are exposed across the San Rafael Swell. Additionally, Tertiary igneous dikes and sills cut the sedimentary rocks, mostly in the southwest corner of the Swell area. Unconsolidated Quaternary deposits, the weathered and eroded products derived mostly from the sedimentary strata of the area, are ubiquitous in the Swell, especially at the base of slopes and cliffs and along the more active stream courses.

Long ago, the San Rafael Swell was a giant oil field as attested by tar sands in the Moenkopi and Chinle Formations and oil-filled cavities in the Kaibab Limestone. Also, many of the porous sandstone and limestone formations of the Swell are bleached, showing the past influence of hydrocarbons. Most of the oil escaped from the rocks when the anticlinal structure was breached by erosion a few million years ago, so the potential to produce commercial quantities of petroleum is low. Small subsidiary structures along the Swell have been targets for oil and gas exploration. Grassy Trail oil field, located on the eastern flank of the Swell, has produced over 620,000 barrels of oil from the Triassic Moenkopi Formation. Carbon-dioxide (CO_2) gas was discovered in 1924 in the Jurassic Navajo Sandstone at Farnham Dome on the north-plunging nose of the Swell. Production was 4.76 billion cubic feet of CO_2 gas used at a dry ice plant in nearby Wellington, Utah, until 1979.

The San Rafael Swell area contains a variety of rock and mineral resources.



Generalized geologic map of the San Rafael Swell. Line A-A' shows location of diagrammatic cross section below.



Diagrammatic cross section across the middle of the San Rafael Swell. The cross section is not drawn to scale, but the vertical dimension is exaggerated about 80 times relative to the horizontal; the horizontal length of the cross section covers about 50 miles. Symbols and colors of geologic formations correspond to those shown on the geologic map.

One of many natural arches in the San Rafael Swell, Hondoo Arch is formed in the Navajo Sandstone in the southwestern part of the Swell. The Navajo Sandstone is at the top of the cliff-forming Glen Canyon Group, and the underlying slopes consist of the Chinle and Moenkopi Formations.

Native American rock art, such as these pictographs in Buckhorn Draw, can be found in many places within the San Rafael Swell.

Presently, only limited commercial production of industrial rocks and minerals occurs at a few locations outside of the proposed national monument. Uranium and vanadium were mined in and around the Swell, mostly during the uranium boom years following World War II. The principal ore hosts include the Moss Back Member of the Chinle Formation and the Salt Wash Member of the Morrison Formation. A small amount of copper may have been produced from the Navajo Sandstone near the center of the Swell. Copper has also been associated with the uranium mines in the Moss Back Member. Industrial rocks and minerals include gypsum in the Morrison, Summerville, and Carmel Formations; limestone in the Carmel Formation, Moenkopi Formation, and Kaibab Limestone; and sand and gravel in Quaternary terrace and pediment deposits. The Curtis, Morrison, and Cedar Mountain Formations contain local deposits of agate, jasper, and other forms of collectable chalcedony. Various types of concretions, oyster beds, dinosaur bone, petrified wood, and other items of interest are also present in the area.

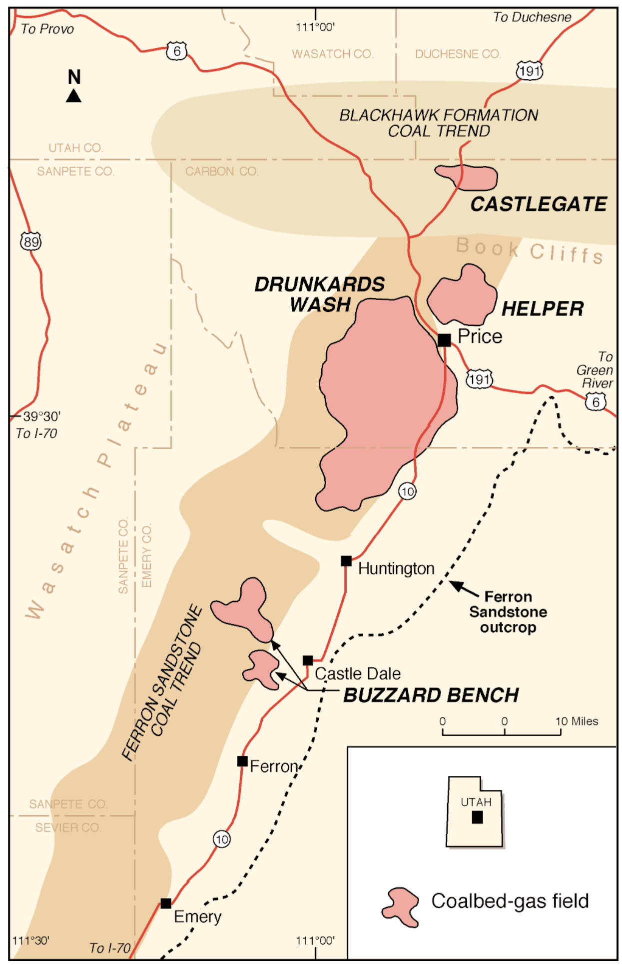
Scenic attractions abound in the San Rafael Swell area. Many narrow canyons cut into the Swell, and are walled by colorful Jurassic and Permian strata including the Glen Canyon Group (Navajo Sandstone, Kayenta Formation, and Wingate Sandstone) and Cedar Mesa Sandstone. Some of the most beautiful areas of the Swell are associated with the colorful Triassic formations that were also the ore hosts for the uranium deposits. Buttes, mesas, overlooks, and other geologic features provide numerous sightseeing destinations. Buckhorn Draw and other localities have excellently preserved Native American petroglyphs and pictographs. Goblin Valley State Park, with its bizarre sandstone hoodoos and goblins, is located along the southeastern flank of the Swell. The Swell is also home to bands of wild horses, mountain sheep and goats, and other wildlife.

The status of the new national monument remains uncertain until the proposal is finalized and a declaration is made by the President. Regardless of the outcome of the national monument proposal, however, the San Rafael Swell will always remain one of Utah's geologic treasures.

Energy News

The Growing Importance of Coalbed Gas to Utah

by David E. Tabet



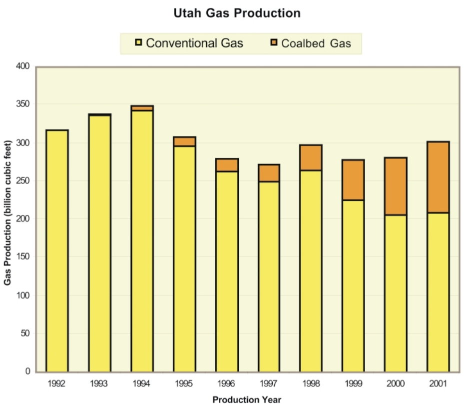
Areas prospective for coalbed gas in the Blackhawk Formation and Ferron Sandstone Member of the Mancos Shale, and the gas fields developed in those areas.

Over the past 10 years, gas recovered from deep coalbeds has become a significant part of Utah's natural gas supply and reserves. The U.S. Energy Information Administration reports that in 2000, coalbed gas made up about 35 percent of Utah's 4.5 trillion cubic feet (Tcf) of proven natural gas reserves. Thus, coalbed gas, once regarded as mainly a safety hazard for underground coal mines, has been transformed from a poorly understood resource to a major new source of natural gas in Utah, and elsewhere in the U.S. The improved understanding of coalbed gas was fostered by government-funded research and tax credits during the 1970s and 1980s that helped petroleum companies develop new techniques to recover this once-unconventional gas resource.

Exploration for coalbed gas in Utah began in the early 1980s; however, the first significant production began in 1992. The earliest exploration tested the gas resources of coals in parts of two formations near Price, Utah: the Blackhawk Formation and the Ferron Sandstone Member of Mancos Shale. The coals of the Ferron Sandstone have become the major coalbed gas-producing area of Utah. As of the end of 2001, Anadarko Petroleum Corporation, Marathon Petroleum Corporation, Phillips Petroleum Company, and Texaco Exploration and Production Company had over 490 wells producing coalbed gas from the Ferron strata. The Utah Division of Oil, Gas and Mining reports that these wells provided over 28 percent of Utah's 2001 gas production, an increase from the 25.6 percent produced in 2000.

Company development plans discussed in two recently released Environmental Impact Statements indicate that the Ferron trend could have 800 to 900 gas wells in production within the next five years, which will probably double the amount of gas currently produced. Originally the coalbed gas wells were projected to have a productive life of 20 years and average recoverable gas reserves of 1 to 4 Bcf. Improved understanding of the nature of these gas reservoirs, gained from testing during the early life of the first wells, indicates that the original productivity estimates are likely conservative. Within the Ferron trend, the Drunkards Wash field is currently the third-largest gas producer in Utah, and this field will likely be the most productive gas field in the state when it becomes fully developed by about 2005.

While the Ferron trend has been the key area helping to maintain Utah's gas productivity levels in recent years, other coal fields in the state are also attracting company exploration efforts. The Blackhawk Formation coals of the Book Cliffs coalfield have an exploration history as long as the Ferron coals, but more problematic water-disposal and well-completion issues have stalled production from the Book Cliffs area. Starting in 2000, a joint venture by J.M. Huber Corporation and Patina Oil and Gas Corporation began revitalizing the dormant



Graph of coalbed and conventional gas production for Utah from 1992 through 2001. Production data are from the Utah Division of Oil, Gas and Mining.

Castlegate project. The wells drilled for this project, which produced gas from 1994 through 1997, were plugged and abandoned by Anadarko Petroleum Company at the start of 1998. Huber and Patina have begun redrilling the 25 original wells, and list the proved reserves for the Castlegate project as 27.5 Bcf of gas. The production for this field was 0.14 Bcf in 2000 from six wells, and production for 2001 will probably be double that as more wells are brought into production. The 62,000-acre Blackhawk trend could contain about 500 Bcf of recoverable gas reserves, or enough gas to supply 500,000 Utah resident's gas needs for about 10 years. Thus, Utah's coalbed gas resources will likely help provide stable long-term gas supply for its residents.

For more information on coalbed gas resources contact David Tabet of the Utah Geological Survey at davidtabet@utah.gov, or 801-537-3373. Information on coalbed gas production can be found on the Utah Division of Oil, Gas and Mining website at dogm.nr.state.ut.us/oilgas/STATISTICS/production/coalbed/ACB_GASPROD.HTM.

Continued from page 8...

film (silver and petroleum products) and take several pictures of the rock outcrop. When we feel like we have analyzed the outcrop thoroughly, we load up the truck and head for home.

EVENING

When we get home at night, we decide to warm up a meal in the microwave oven (silica, copper, gold, iron, and nickel) and enjoy some refreshments (filtered through perlite or diatomite). These refreshments are served in a glass or ceramic mug (silica, limestone, and feldspar). Our day ends with us falling asleep in front of the television (silica, iron, copper, aluminum, and nickel).

IN SUMMARY

A day in the life of a geologist may seem a little strange to some, but there are similarities among all of us in other professions or fields. Everyone relies heavily on minerals to do their job and in their daily life. So, the next time you drive a car or work on the computer at the office, think about how important minerals are to us. What would we do without them?

Survey News

We would like to welcome four new staff members. Becky Wilford is our new receptionist, and Matt Butler is working with our ground water folks, taking over from Allison Corey after she left for a GIS position with Weber County. John Alexander has left, and a new geologist/preparator has been hired, Don De Blieux, most recently from Grand Junction.

Welcome to Jeff Campbell, who is helping out part-time in the bookstore.

At this month's UGS Board meeting, the Board decided to award Doug Sprinkel and Tom Chidsey with the Crawford award for being editors of the very successful "Geology of Utah's Parks and Monuments" (UGA 28). The board recognized that this publication is an outstanding contribution to knowledge about Utah's geology, the main criterion for the award. Although the award is only for UGS scientists, Paul Anderson will also receive a certificate acknowledging his contribution as editor.

TERRA TEK donates core-scanning digital camera to UGS!

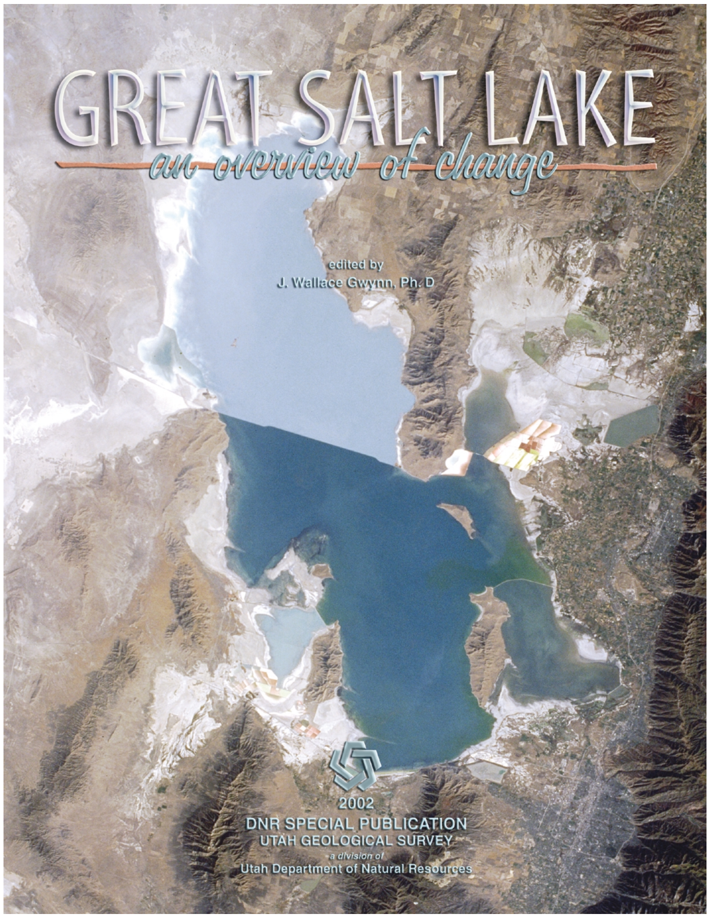
TERRA TEK, a company intimately experienced with drilling core from solid rock, has generously donated a sophisticated digital camera to the Utah Core Research Center (UCRC) of the Utah Geological Survey.

The TERRA-SCAN system scans split core samples and produces digital images of core that can be archived, enhanced, and distributed digitally. With TERRA-SCAN, the UCRC will be able to distribute images of split core in reports and on the web, or on demand to customers worldwide. This capability, combined with an extensive well-log archive from the Division of Oil, Gas and Mining and almost 44 miles of donated core samples, makes the UCRC one of the best public core research facilities in the Intermountain West.

THE GREAT SALT LAKE: DECADES OF CHANGES

Within the last two decades, Great Salt Lake has changed significantly, both physically and chemically, affecting the mineral, brine shrimp, transportation, recreation, and other industries. Culminating in a new 600-page Department of Natural Resources publication, **Great Salt Lake – an overview of change**, are five years of combined efforts from over 60 authors. Now available for $25.00 at the Natural Resources Map & Bookstore (888-UTAH MAP), this volume brings together multi-disciplinary articles on the history, scientific research, artistic aspects, management, development, utilization, and other subjects related to Great Salt Lake and its extended environs including the Bonneville Salt Flats.

"This volume is intended to be: (1) a valuable reference for those managing the lake and planning for its future, (2) a credible springboard for future, lake-related research and information volumes, and (3) an up-to-date reference for all who are interested in Great Salt Lake," states J. Wallace Gwynn, Utah Geological Survey geologist and the publication's editor. Gwynn describes Great Salt Lake as one of Utah's most beautiful treasures and hopes readers will gain a greater appreciation of its beauty, mysteries, complexities, and value as a multifaceted resource. This aspect is extremely well-realized in a 16-page color photograph section.



Note: All of our e-mail addresses will change on July 1, 2002, to:
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