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Snake Valley, Millard County, Utah

contents

Design: Vicky Clarke

Cover: View west across Snake Valley to southern Snake Range (see article on p. 1).

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the director's perspective

This issue of Survey Notes has several articles with environmental themes: potential hydrological impacts in Snake Valley, western Utah, from proposed ground-water extraction in Nevada; the sensitivity of Tooele Valley wetlands to future ground-water extraction and drought; a new initiative by the Utah Geological Survey (UGS) to geophysically log ground-water wells; and an update on remediation of the historic Rozel Point oil seep area on the shore of Great Salt Lake.

The UGS has increased the size of its ground-water section in recent years because of increasing demand for impartial scientific information and advice on the potential size of the resource and possible impacts due to development. This trend was recognized during this year's legislative session, when ongoing general funding was appropriated for two additional positions in the section. The UGS has strengthened its capabilities in numerical modeling of flow in ground-water basins, and in wireline (geophysical) logging of wells. Interpretation of wireline logs improves understanding of aquifers and confining beds, and constrains the rock property assumptions required for the numerical models. The ground-water section works closely with the Division of Water Rights in deciding which areas of the state have the greatest priority for additional ground-water study.

The increasing demand for ground water in Utah over the past 40 years has mainly been due to the need to augment the public water supply, for which ground water presently comprises 55% of the total supply. According to the Utah State Water Plan (Division of Water Resources, 2005), some ground-water basins are over-appropriated, and are experiencing significant declines in water levels. Other effects of excessive pumping include decreased spring flows and diminished wetlands with associated ecological impacts, as discussed in the first two articles of this issue. Another possible effect is subsidence of the ground surface and associated ground fissuring (see Survey Notes, September 2005, p. 8-9 for article on the Escalante Valley earth fissures). Ground water will continue to be an important component of the state's water usage, and the UGS looks forward to continued assistance with the wise use of this precious resource by improving understanding of its hydrogeological controls.

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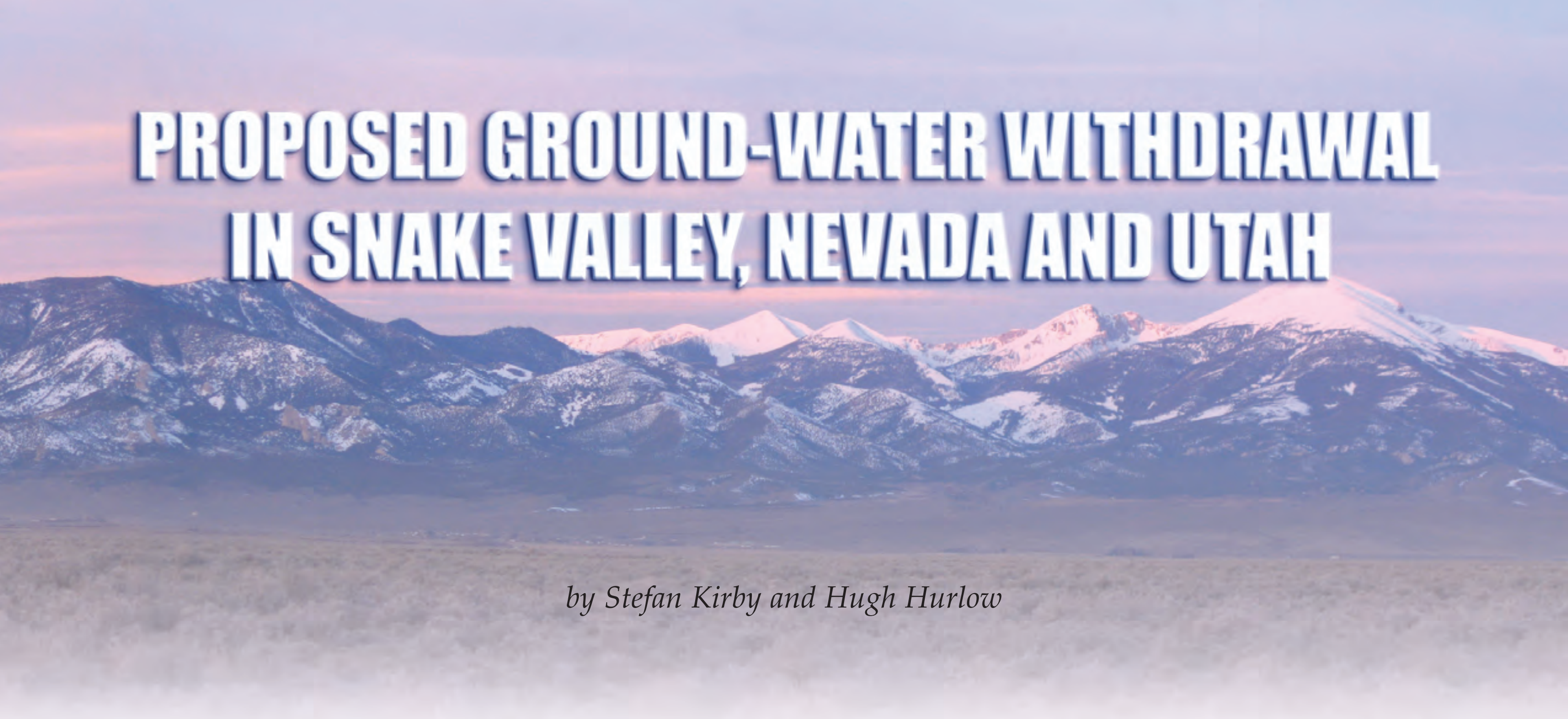
PROPOSED GROUND-WATER WITHDRAWAL IN SNAKE VALLEY, NEVADA AND UTAH



by Stefan Kirby and Hugh Hurlow

INTRODUCTION

Water is a scarce resource in the Great Basin, which covers large sections of Nevada and Utah, the two driest states in the U.S. Existing surface- and ground-water supplies have met historical needs and allowed both states to grow and prosper, but future growth, particularly in the Las Vegas, Nevada, area, will require water conservation and allocation of additional water resources. One plan of Las Vegas water managers is to extract significant amounts of ground water from east-central Nevada and pipe this water south to augment existing supplies. Snake Valley, in western Millard County, Utah, is hydrologically connected to the proposed wells. Water users and managers in Utah are concerned about the potential impacts, and as a result the Utah Geological Survey is collaborating with federal and state agencies to study the hydrogeologic characteristics of the region.

"To supply part of the future water demand, the Southern Nevada Water Authority (SNWA) has proposed a system of 146 water-supply wells and interconnecting pipelines in south-central and southeastern Nevada..."

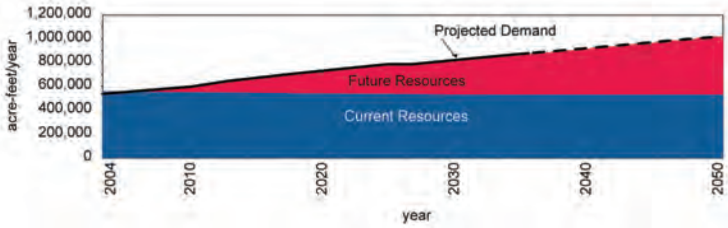
BACKGROUND

Water demand in Las Vegas will soon exceed current resources, requiring water managers to look elsewhere for water. To supply part of the future water demand, the Southern Nevada Water Authority (SNWA) has proposed a system of 146 water-supply wells and interconnecting pipelines in south-central and southeastern Nevada to supply up to 180,000 acre-feet of water per year to the Las Vegas area. All of the wells will be located in Nevada, most more than 30 miles from the Utah-Nevada state line. Nine applications, with a total potential withdrawal of approximately 50,000 acre-feet per year, are located along the eastern flank of the southern Snake Range within 5 miles of the state line (application details available from the Nevada Division of Water Resources). The proposed wells are to be completed in the regionally extensive Paleozoic carbonate aquifer, local unconsolidated basin-fill aquifer, and in volcanic rocks. Local and regional characteristics of these aquifers are controlled by a complex geologic history.

GEOLOGIC AND HYDROGEOLOGIC OVERVIEW

Bedrock of Snake Valley and surrounding ranges consists primarily of late Precambrian to early Mesozoic sedimentary rocks up to 33,000 feet thick. Paleozoic-age carbonates dominate the middle and upper parts of the section, and quartzites of Early Cambrian and Precambrian age dominate the lower part of the section. The carbonates form an important aquifer covering much of the eastern and southern Great Basin.

The bedrock was initially deformed during Late Jurassic to early Tertiary time by slip on underlying, east-directed thrust faults of the Sevier fold and thrust belt. Following Sevier crustal shortening, extension and widespread volcanism began during the latest Eocene and early Oligocene. Extension and crustal thinning during the Oligocene through Miocene was accommodated along the Snake Range decollement, a regionally continuous, shallowly east-dipping fault exposed in the Snake Range and imaged in the subsurface by seismic-reflection lines. A later period of extension involving slip on both the low-angle Snake Range decollement and high-angle faults to the north and south occurred in the Miocene; volcanic rocks and coarse-grained basin fill were deposited and regional doming of the Snake Range occurred. The tectonic history of the consolidated rocks has produced complex faulting and fracturing, which may control



Water demand in the Las Vegas area. To meet projected demand, the Southern Nevada Water Authority must find additional sources of water. SNWA has filed applications on ground-water rights on approximately 180,000 acre-feet per year of in-state ground water. This water would be produced and supplied to the Las Vegas area via a series of interconnected wells and pipelines that would extract water from basins in east-central Nevada. Source: Southern Nevada Water Authority, http://www.snwa.com.

ground-water movement.

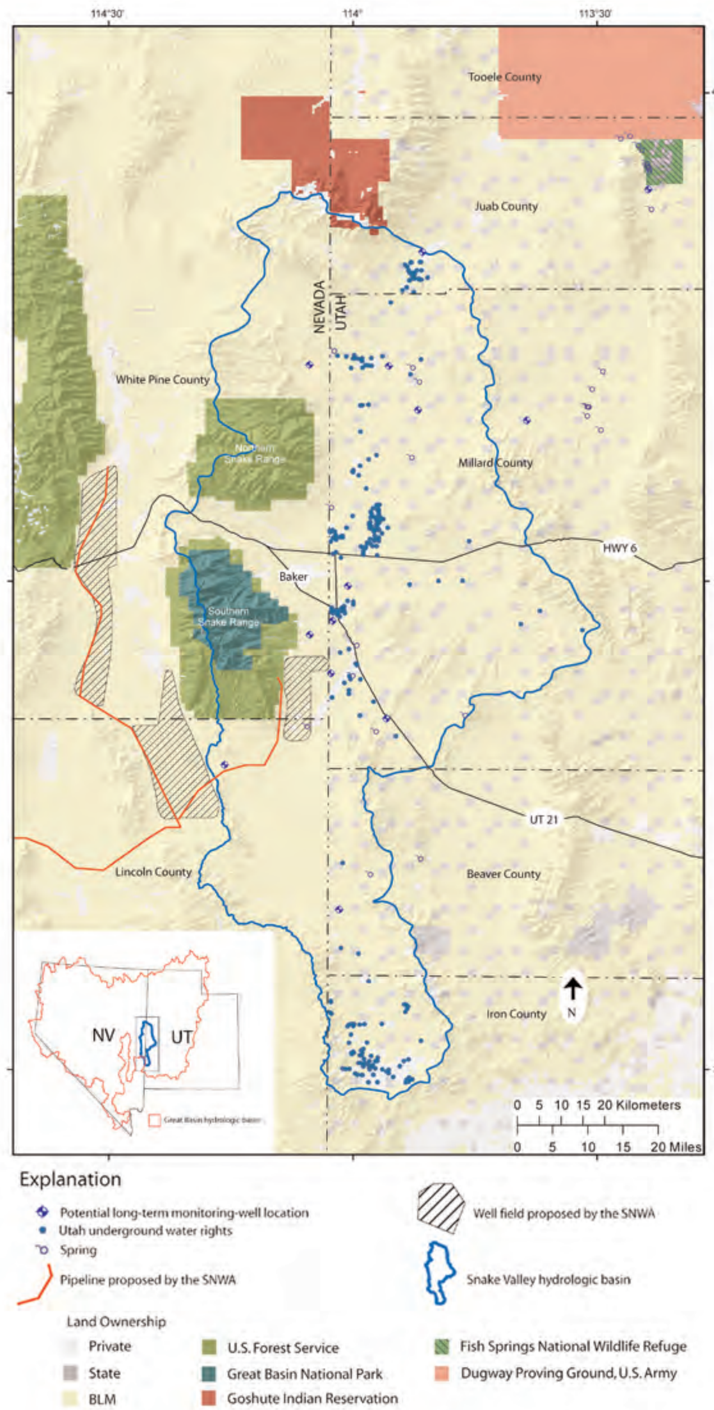
Modern sedimentary basins, filled with sand, gravel, and lesser fine-grained deposits derived from the nearby basin-bounding ranges, developed in the late Miocene. The youngest basin-fill deposits form an extensive aquifer beneath the Snake Valley floor and margins.

In the Snake Valley hydrologic basin, recharge of the basin-fill and carbonate aquifers occurs primarily locally from surface infiltration and runoff, and secondarily from inter-basin flow in the carbonate aquifer. Based on previous work, the southern part of the Snake Range upslope of the proposed well field may supply 40,000 acre-feet per year to aquifers below Snake Valley through surface runoff and direct infiltration in the exposed carbonate rocks, and other recharge may occur via interbasin flow from Spring Valley to the west, another area of proposed SNWA wells. Based on previous studies, most of the recharge of the Snake Valley aquifers likely occurs along mountain-front areas of the Snake Range, and wells proposed by the SNWA would be in or very near these important recharge areas.

WHAT IS BEING DONE

The Lincoln County Conservation, Recreation, and Development Act of 2004 streamlined establishment of pipeline rights of way and mandated the Environmental Impact Statement (EIS) process necessary for construction of pipelines, pumping stations, and wells. As part of the act, Congress appropriated funding for the Basin and Range Carbonate Aquifer System Study (BARCASS) covering much of the area potentially affected by the proposed SNWA wells and pipelines. The BARCASS study is being conducted by the U.S. Geological Survey (USGS), Desert Research Institute (DRI), and the State of Utah represented by the Division of Water Rights.

BARCASS will characterize water levels and ground-water chemistry; refine estimates of precipitation, evapotranspiration, and recharge; and delineate the subsurface extent and hydrogeologic properties of the basin-fill and carbonate aquifers in Lincoln and White Pine Counties, Nevada,



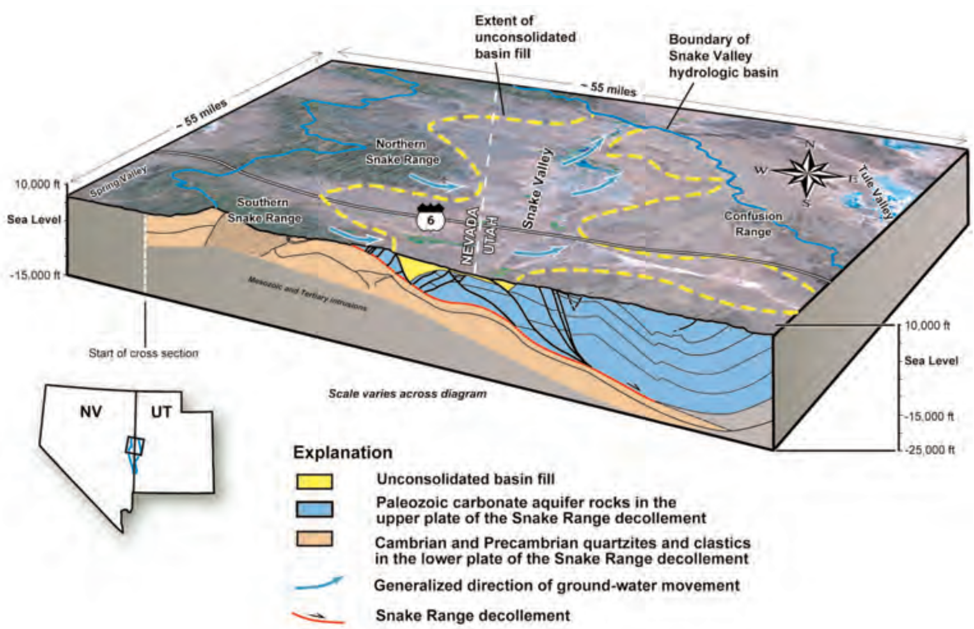
Land ownership, Utah wells, springs, and proposed SNWA facilities.

and adjacent areas in Utah. The work includes compilation and synthesis of existing data, sampling of selected wells and springs, and acquisition of geophysical data.

At the request of the Utah Department of Natural Resources administration, the Utah Geological Survey (UGS) is performing geologic and hydrogeologic work to supplement BARCASS, particularly in parts of Utah that will receive little or no attention from BARCASS but may be affected by the proposed pumping. Hugh Hurlow and

Stefan Kirby of the UGS are part of a Department of Natural Resources team monitoring the many aspects of the SNWA project, including studies by the SNWA, the U.S. Bureau of Land Management's EIS process, rulings of the Nevada State Engineer, and BARCASS. Specific UGS tasks include (1) preparing a proposal for 13 new observation wells to provide baseline data on ground-water levels and chemistry prior to installation of the SNWA wells and monitoring changes in these parameters after the wells are in production, (2) compiling a regional geologic map and constructing geologic cross sections and structural-contour maps to delineate the subsurface structure and extent of the carbonate aquifer below Snake Valley and adjacent areas, (3) collecting new gravity data and calculating the thickness of the sedimentary basin fill, in coordination with the USGS, and (4) collecting general chemistry, isotope, and dissolved gas samples from selected wells and springs in Utah thought to be connected to the regional carbonate aquifer.

In summary, the UGS is working cooperatively in Snake Valley and other areas in west-central Utah to address concerns about the long-term viability of ground water shared by Utah and Nevada. Ongoing work by the UGS and BARCASS will better define and monitor ground-water resources beneath Snake Valley and adjoining parts of western Utah, and provide tools to assist in management and allocation of shared ground water now and in the future. ❖



Simplified Snake Valley hydrogeology. Ground water generally moves from upland recharge areas of the northern and southern Snake Range, east and northeast into unconsolidated basin-fill and Paleozoic carbonate aquifers. Cross section modified from A.J. McGrew, Tectonics, v. 12, no. 1, 1993.

Twin Spring in the northern part of Snake Valley. This and other nearby springs in Utah are an important part of the Snake Valley ground-water system.

Additional sources of information on the SNWA project:

Basin and Range Carbonate Aquifer System Study
http://nevada.usgs.gov/barcass/

Hydrogeologic Setting of the Snake Valley Hydrologic Basin, Millard County, Utah, and White Pine and Lincoln Counties, Nevada – Implications for Possible Effects of Proposed Water Wells
http://geology.utah.gov/online/ri/ri-254.pdf

Clark, Lincoln, White Pine Counties Groundwater Development Project EIS
http://www.nvgroundwaterproject.com

Southern Nevada Water Authority
http://www.snwa.com

Nevada Office of the State Engineer
http://water.nv.gov

Tooele Valley Wetlands–

A Valuable but Potentially Endangered Resource

by Neil Burk, Charles Bishop, and Mike Lowe

Vegetated (background) and non-vegetated (foreground) mineral flats in Tooele Valley wetlands.

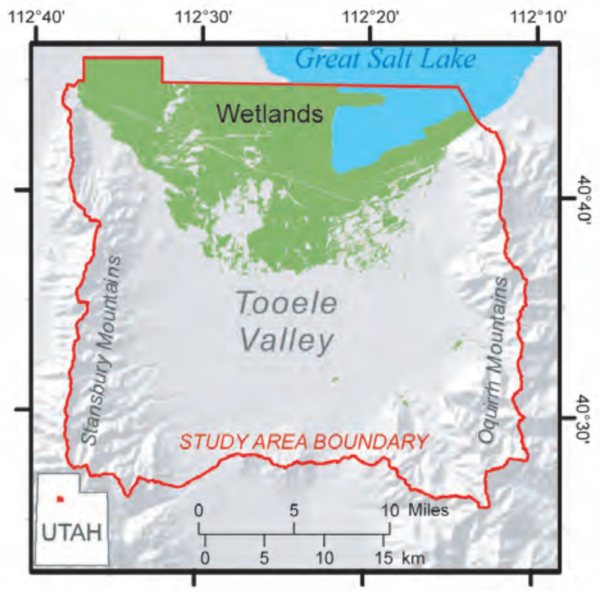
Wetlands are one of the most important ecosystems on Earth. They have numerous functions and are a valuable resource to communities. Wetland functions include wastewater treatment or water filtration, flood-water control and storage, wildlife habitat (about 45% of the species listed as threatened or endangered under the Endangered Species Act use wetland habitats), biologic productivity, and food-chain support.

Approximately 80% of the wetlands in Utah (about 400,000 acres) surround Great Salt Lake. An estimated 30% of Utah's wetlands have been lost since the mid-1800s, mostly due to construction of land drains and changes from agricultural to residential land uses.

The Utah Geological Survey (UGS) recently completed an evaluation of the potential impacts of residential development and climatic conditions on wetlands in Tooele Valley, Tooele County, Utah. The U.S. Environmental Protection Agency's Wetland Protection Program partly funded the project. This is the first in a series of proposed and ongoing similar UGS studies of the wetlands surrounding Great Salt Lake.

The wetlands in Tooele Valley are in the northern part of the valley near Great Salt Lake and occupy about 79,000 acres, or almost 50% of the valley-floor area. Tooele Valley is mostly rural, but a rapid increase in residential development is resulting in less agricultural land use. The change from agricultural to domestic water use and concomitant increase in water-well pumping could significantly decrease the amount of ground water discharged from the confined aquifer system, where most wells are completed, to the shallow unconfined aquifer system, which provides water to springs and wetlands in ground-water discharge areas. Additionally, drought conditions over the past six years have reduced the amount of recharge to these aquifer systems.

As part of our evaluation, we documented the current status of the Tooele Valley wetlands by performing a functional assessment of three discrete wetland areas, and by installing shallow monitoring wells in these areas. We also used a regional, three-dimensional, steady-state MODFLOW ground-water flow model created by the U.S. Geological Survey (USGS) for Tooele Valley to determine the amount of ground water presently



available to these wetland areas. Our findings suggest that the wetland hydrology has been impacted mostly by the numerous roads, canals, and ditches in the area, and that agricultural land use is more beneficial to wetland health and functionality than industrial or urban land use.

To determine the potential impacts of increased ground-water development and continued drought, we modified and used a regional, three-dimensional, transient MODFLOW ground-water flow model, also created by the USGS for Tooele Valley, to estimate potential changes in the water available to the wetland areas. The evaluation suggests that increasing water-well withdrawals in Tooele Valley from 11,200 acre-feet per year to 16,800 acre-feet per year reduces the modeled subsurface flow through the wetland areas, but does not significantly reduce the modeled spring discharge. However, continued drought conditions would reduce the discharge from springs in the wetland region. Wetland health depends on maintaining both subsurface inflow and spring discharge; therefore, the worst-case scenario for the wetlands would be a combination of both increased water-well withdrawals and prolonged drought conditions. Flow volumes currently available to the wetlands, necessary to maintain the current health of the wetlands, are estimated in the steady-state ground-water flow model to be 98,000 acre-feet per year as subsurface inflow, and 6600 acre-feet per year as discharge from springs in the wetland region.

Wetlands in Tooele Valley are potentially endangered from drought and increased development, which could reduce the amount of water they receive. However, land-use planning can be used to mitigate the detrimental impacts of increased residential development. To balance development with wetland conservation, Tooele County is in the process of creating a Special Area Management Plan for the wetlands in Tooele Valley. Examples of protective land-use planning measures that could be implemented include (1) restricting areas available for development, such as allowing development only in upland environments or placing a non-development buffer around the wetland areas, (2) requiring municipal sewer and water lines in new developments and designing these sewer systems so that, where possible, the treated water is reused or discharged upgradient of the wetlands, and (3) enacting water conservation practices beneficial to the wetlands.

The UGS report, "Wetlands in Tooele Valley, Utah – An Evaluation of Threats Posed by Ground-Water Development and Drought," can be purchased on CD from the Utah Department of Natural Resources Map & Bookstore (http://mapstore.utah.gov) or viewed on the Internet at http://geology.utah.gov/online/ss/ss-117/ss-117.pdf. ❖

New Publications

Geologic map of the Tule Valley 30' x 60' quadrangle and part of the Ely, Fish Springs, and Kern Mountains 30' x 60' quadrangles, northeast Millard County, Utah, by Lehi F. Hintze and Fitzhugh D. Davis, scale 1:100,000 (CD [contains GIS data]), ISBN 1-55791-744-2, 1/06, M-222DM $19.95

Utah! 100 years of exploration...and still the place to find oil and gas, 24 p., ISBN 1-55791-655-1, 3/06, updated PI-71 . . . . $2.50

Small mines in Utah 2005, compiled by Roger L. Bon and Sharon Wakefield, 6 p., 1 pl., 1:700,000, 2/06, updated OFR-405 . . . .$5.00

Coal resource map of Utah, by David Tabet and Sharon Wakefield, CD (1 plate 1:750,000), ISBN 1-55791-750-7, 5/06, M-226DM $14.95

Ground-water sensitivity and vulnerability to pesticides, Upper Bear River Valley, Rich County, Utah, by Mike Lowe, Janae Wallace, Stefan Kirby, Justin Johnson, Anne Johnson, and Rich Riding, CD, ISBN 1-55791-745-0, 5/06, MP-06-1 . . . . $14.95

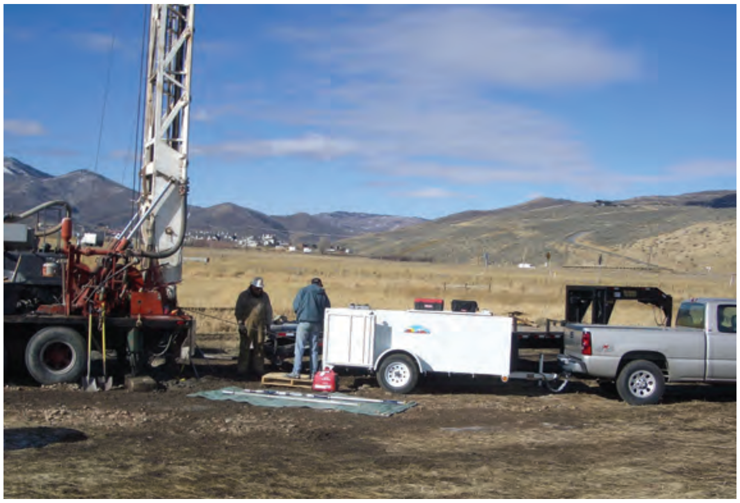
Geologic map of the Smokey Mountain 30' x 60' quadrangle, Kane and San Juan Counties, Utah and Coconino County, Arizona, by Hellmut H. Doelling, ISBN 1-55791-732-9, 5/06, M-213 . . . . $12.95

Utah's New Borehole-Geophysical Logging Program for Water Wells

by Kevin Thomas

The Utah Geological Survey (UGS) and the Utah Division of Water Rights (UDWR) recently began a borehole-geophysical logging program to increase the amount and quality of subsurface data for ground-water aquifers in the state. Previously, well drillers' reports had commonly been the only available down-hole data for a given region; the borehole-geophysical logging program is providing much-needed subsurface information to state and federal agencies, well owners, and water-well drillers.

Borehole-geophysical logs measure the physical properties of subsurface materials penetrated by the well, such as natural gamma radiation, resistance to electric current, and sonic wave travel time. These measurements allow us to interpret the types of subsurface sediments and rocks present at the well site. Borehole-geophysical logs can be used for identifying (1) low-permeability layers, such as clay or shale, (2) water-bearing intervals, and (3) water-quality changes. These data can be used to correlate well-to-well information in cross sections, aid in construction of ground-water models, and help guide well drillers in completing wells.



The UGS borehole-geophysical logging trailer at a well near Park City, Summit County, Utah.

The UGS purchased a borehole-geophysical logging system that includes a caliper tool, a sonic tool, and a multi-parameter tool. The system also includes a draw-works to lower and raise the tools in a well (maximum depth of approximately 980 feet) and a data logger to record the measurements. The entire system fits into a trailer that can be easily hauled to a well site.

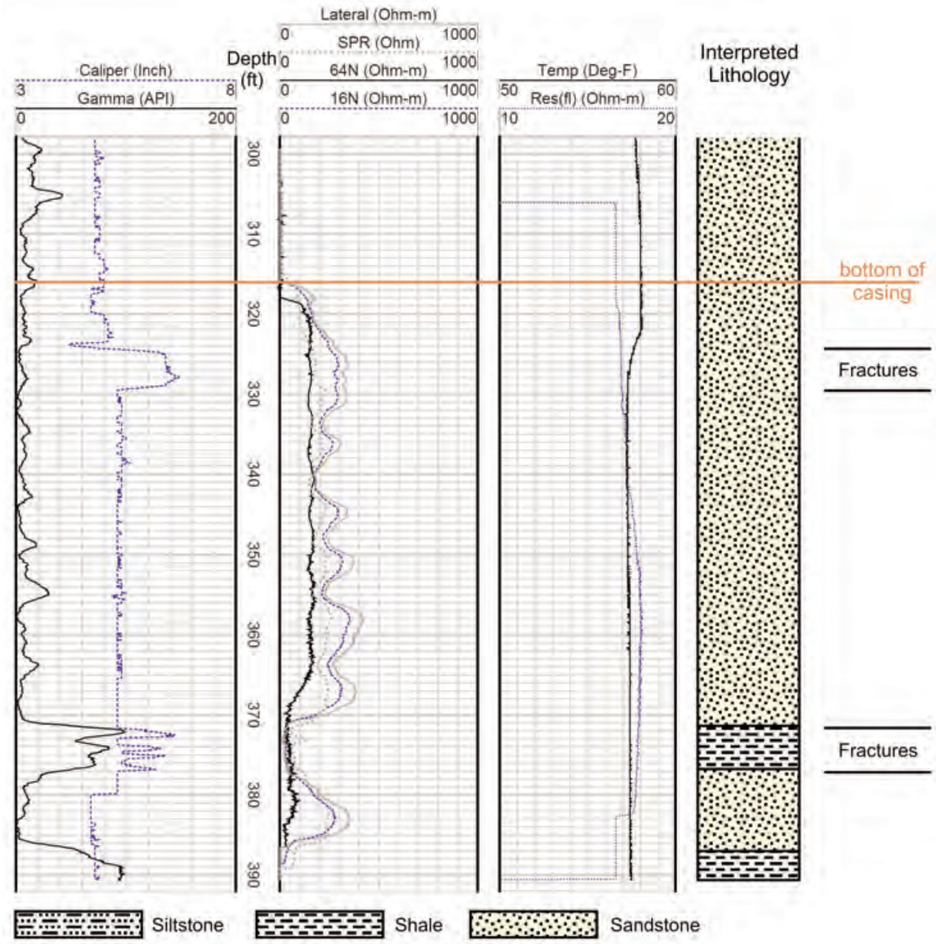
The caliper tool measures the diameter of the well, which can be used to determine borehole conditions, identify fracture zones, and locate washouts (where the borehole has eroded away to a larger diameter). Knowing the borehole diameter allows us to assess the stability of the borehole walls. Since some logging tools are affected by the diameter of the well (e.g., the natural gamma log), the caliper log permits us to account for variations in borehole diameter when interpreting those logs.

The sonic tool measures the time it takes a sound wave to travel one foot through the material surrounding the well. The travel time is dependent on the density of the material and can be used to estimate porosity. Porosity data are useful for identifying water-bearing layers and fracture zones.

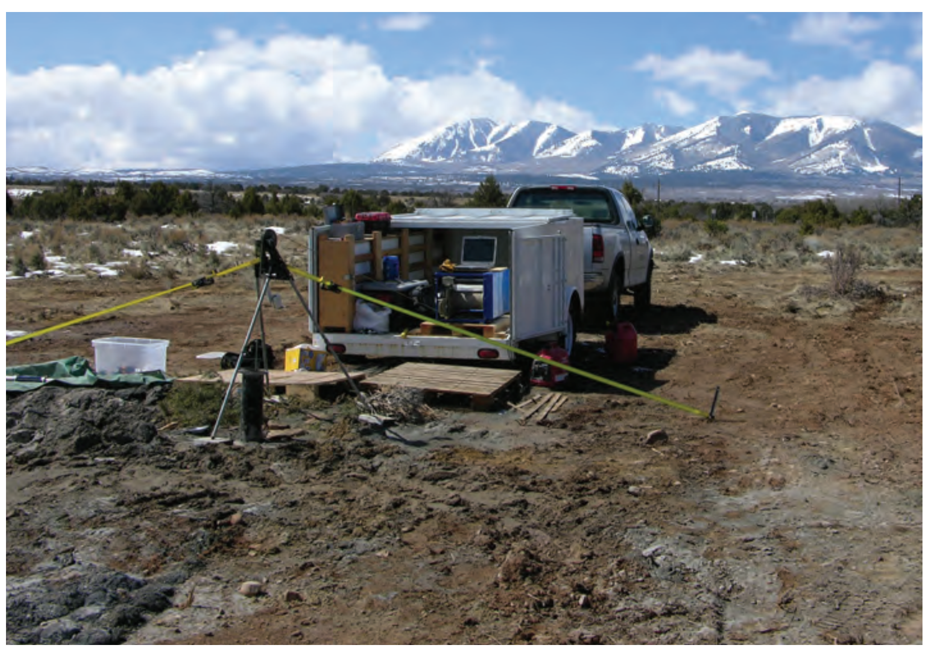
The multi-parameter tool collects natural gamma, temperature, and electric logs (E-logs). The natural gamma log records the amount of naturally occurring gamma radiation inside the well. Since clay minerals generally contain relatively high concentrations of radioactive elements (typically potassium, uranium, and thorium), the natural gamma log can be used to identify low-permeability clay and shale beds. The temperature log records the temperature of the fluid inside the well; temperature gradients help geologists identify layers where water is flowing into or out of the well, trace movement of injected water or waste, and define the geothermal gradient. The electric logs measure the resistance to electrical current (called resistivity). Unaltered rocks and sandy sediments are generally poor conductors of electricity, so most of the current will flow through water in the pore spaces. The response will depend on the amount of water present (which is related to the porosity) and the quality of the water (more dissolved solids in the water results in lower resistivity). Therefore, E-logs can be used to determine lithology, identify fracture zones, and estimate water quality. By using several different electrode spacings, the depth to which the current penetrates the surrounding material can be varied, reducing the effects of the borehole on the log.

The UGS and UDWR will select wells for borehole-geophysical logging based on the potential for a particular well log to add to our understanding of ground-water aquifers in Utah. We will focus mainly on single-family domestic wells, which generally are not logged, rather than public-supply wells, which commonly are logged using geophysical tools operated by private contractors. Once completed, the logs will be available to the public through the UDWR Web site.

Through this initiative, we will gain a more thorough understanding of the complexities of Utah's hydrologic systems. For the initiative to be successful, the UGS and UDWR rely on the drilling community to be partners in the program. Borehole-geophysical logging provides valuable information on aquifer properties that would otherwise remain unknown; this will be of great value to the drillers as well as scientists and water-resource managers. ❖



Example of a borehole-geophysical log and interpreted lithology for a water well near Monticello, San Juan County, Utah. The gamma log shows radiation in units defined by the American Petroleum Institute (API). The electric logs measure resistivity in ohms and ohm-meters. Interpreting the lithology is aided by discussions with drillers and examination of the well cuttings.



The UGS borehole-geophysical logging trailer in action while logging a well near Monticello, San Juan County, Utah.

New Discoveries of Fossil Mammals Are Providing Important Information About Utah's Geologic Past

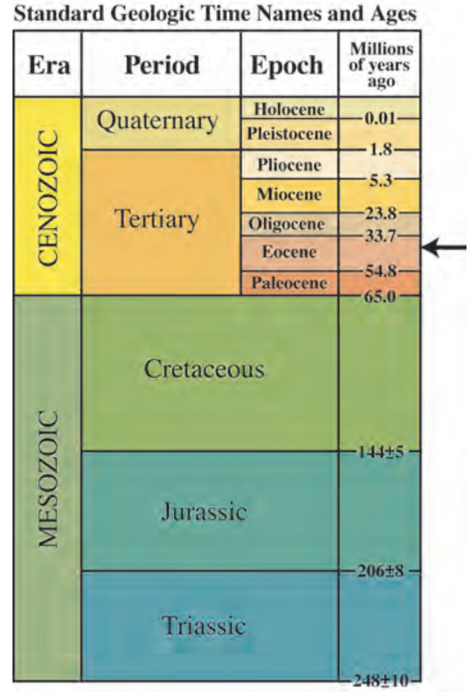
by Don DeBlieux

Lower jaw of the fossil rhinoceros Teletaceras *from central Utah in medial (top), lateral (middle), and occlusal (bottom) views.*

When one thinks of vertebrate paleontology in Utah the first animals that typically come to mind are dinosaurs. Utah is justifiably famous for its many dinosaur fossils found in rocks of the Mesozoic Era (known as the Age of Dinosaurs). However, Utah has also played an important role in deciphering the evolutionary history of the group of animals to which we belong – mammals. Though mammals became prominent during the Cenozoic Era, they actually appear in the rock record with the first dinosaurs late in the Triassic Period. Utah has many early mammal fossils and has been a magnet for researchers interested in the study of these small mammals that shared their world with the dinosaurs. Other researchers have focused on the many fossil mammals found in Utah's Cenozoic-age rocks.

Following the extinction of the dinosaurs 65 million years ago, mammals proliferated to fill the ecological void. The Uinta Basin of northeastern Utah preserves an important record of this diversification, especially in the Uinta Formation that dates from the middle Eocene Epoch (49-37 million years ago). Research on the Uinta Formation over the past 130 years has revealed a varied assemblage of fossil mammals, including early members of groups that are still with us today such as horses, rhinoceroses, tapirs, carnivores, rodents, and primates. Also found are members of extinct groups such as the large rhino-like uintatheres and brontotheres. The study of fossil mammals from the Uinta and other western basins led to the recognition that distinctly different mammals lived during successive time periods. The importance of this finding was formally recognized by the naming of a number of "land mammal ages" for these basins. For example, the fossil mammals from the Uinta Basin are the basis for the Uintan Land Mammal Age (LMA), and fossils from the overlying Duchesne River Formation, also found in the Uinta Basin, are the basis for the Duchesnean LMA.

A new discovery by UGS mapping geologists illustrates how the study of fossil mammals is not only interesting in its own right but can provide valuable geologic information. While working on the Thousand Lakes Plateau north of Capitol Reef National Park in Wayne County, Bob Biek, Paul Kuehne, and Grant Willis were investigating a rock unit of unknown age. This rock is composed of sand and gravel and lies below volcanic rocks dated as early Oligocene (beginning approximately 34 million years ago). Based on this, they knew that the rock unit is older than Oligocene, but could possibly be as old as Late Cretaceous. That covers a period of over 30 million years! They found no datable rocks within this unit to allow them to determine its age more precisely. However, a small landslide had exposed a fresh area of this rock. While examining the rock, Bob Biek noticed a small piece of bone, which he later showed me. It was covered in sand and gravel and didn't look like much of anything, but as I looked more closely I realized from its shape that it was part of a mandible (lower jaw). On closer inspection, I saw a small bit of tooth enamel, which confirmed that it was indeed part of a mandible. The mapping geologists had scored nicely; just like in police forensics, dental remains are the most useful parts of a fossil mammal. Jaws with teeth are one of the few parts of the body that can be identified to species. The jaw had been abraded by flowing water and sediment but preserved three molar teeth. I could tell that the jaw was from a perissodactyl, the group that includes modern-day horses, rhinoceroses, and tapirs. Soon after its discovery, I was able to show it to many of the world's fossil perissodactyl experts while attending the Society of Vertebrate Paleontology meetings in Arizona. They helped to identify it as belonging to a small extinct rhinoceros named *Teletaceras*. This animal has been found in western North America and Asia, and is thought to be one of the first members of the family that contains the living rhinoceroses. *Teletaceras* is known only in rocks of the Duchesnean LMA, so we can greatly narrow down the age of the rocks that the geologists were mapping to approximately 42-37 million years old. This provides important data regarding the Eocene history of central Utah and will aid our mapping geologists in their work. It is also a significant paleontological discovery since this is the first time this animal has been found in Utah. ❖



Part of the geologic time scale showing the periods of the Mesozoic and Cenozoic Eras (earlier Eras have been omitted). Arrow points to the approximate time that the fossil rhinoceros Teletaceras *lived.*

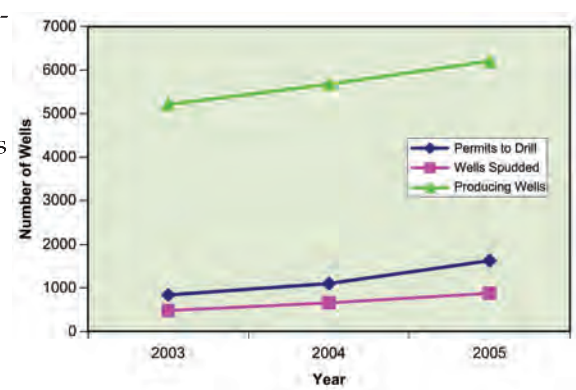
UGS geologists Grant Willis and Paul Kuehne studying deposits of unknown age high atop the Thousand Lakes Plateau. The discovery of a partial jaw from an extinct rhinoceros enabled accurate identification of the rocks. View southeast. Photo by Bob Biek.

Increased oil and gas drilling in Utah starting to produce dividends

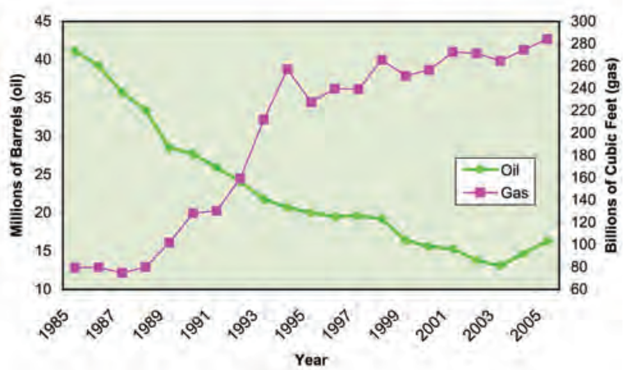
by David Tabet

Utah is experiencing a petroleum exploration boom, fueled in part by prices that have been on the increase since 2003. Petroleum prices in 2003 averaged about $25 per barrel of oil and $4.50 per thousand cubic feet (Mcf) of natural gas, but by the end of 2005, prices had risen to $60 per barrel of oil and $11 per Mcf of gas. Levels of drilling for petroleum in Utah increased dramatically in 2004 and 2005 in response to the increasing prices, and also because oil and gas exploration companies believed that higher price levels would continue for some time into the future.

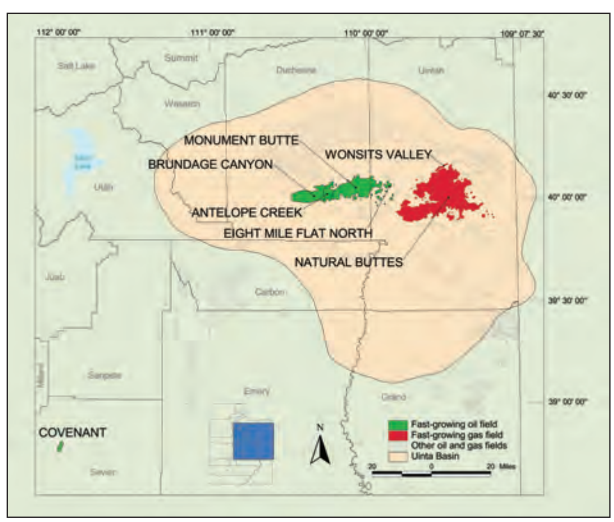
Drilling permit applications are often the first indicator of an exploration boom. Petroleum exploration companies generally try to keep an inventory of more than one year's worth of sites to drill in order to provide flexibility in their drilling programs should initial test results turn out positive or prices increase. Accordingly, an increase in drilling-permit applications indicates that companies expect well drilling activities to increase. Records available on the Utah Division of Oil, Gas and Mining (DOGM) Web site (2006) indicate that applications for permits to drill issued for new petroleum wells jumped from 838 in 2003 to 1629 in 2005. Mirroring this growth, DOGM reports that actual well starts (called spuds) also rose from 480 new wells in 2003 to 877 in 2005. Correspondingly, the number of producing oil and gas wells in Utah increased from 5211 at the end of 2003 to over 6200 in 2005.



Annual petroleum well drilling statistics for Utah, 2003-05 (data from DOGM Web site, 2006).



Annual Utah oil and marketed gas production from 1985 through 2005 (data from DOGM and Utah Geological Survey Web sites, 2006).



Location of the Uinta Basin and Utah's fastest-growing oil and gas fields during 2004 and 2005 (data from DOGM Web site, 2006).

Now, after two years of increased exploration and development drilling, preliminary production numbers for 2005 indicate that the increased drilling efforts are starting to pay off in terms of increased oil and natural gas production in Utah. Production of oil had been in a relatively steady decline since annual production peaked at 41.1 million barrels in 1985, and reached a low of 13.1 million barrels in 2003. Meanwhile, marketed gas production peaked later at 272.5 billion cubic feet (Bcf) in 2001 and then declined slightly for the next two years before rebounding to a new high of 274.6 Bcf in 2004. Production numbers from DOGM indicate that 2005 annual oil production was 16.7 million barrels, a level not seen since 1999, and annual marketed natural gas production increased to over 300 Bcf, a level never seen before.

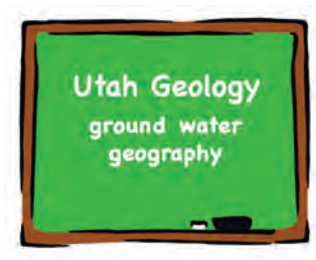
Most of this increased petroleum drilling and

Continued on page 17...

Teacher's Corner

by Nancy Carruthers and Sandy Eldredge

Workshops and Classroom Topics



Workshops
5th-grade teachers; see geology.utah.gov/teacher/workshops.htm

Classroom Topics
7th-grade, 9th-grade, and other teachers; see below.

Integrating *Survey Notes* Articles in the Classroom

Looking for current and relevant geologic information to use in your class? In the first of a series, we will provide discussion items on *Survey Notes* articles and suggest ways to integrate these articles into your teaching, focusing on appropriate grade level and core curriculum standards. This approach can build synergy between field-based science and classroom education.

The timely geologic topics of *Survey Notes* articles can be integrated into several curriculum areas including Utah history and social studies. For example, the article "Proposed Ground-Water Withdrawal in Snake Valley, Nevada and Utah" in this issue is particularly relevant to topics taught in 7th-grade Utah Studies and 9th-grade Earth Systems.

7th-grade Utah Studies: Standard 1 - interaction between Utah's geography and its inhabitants. Objective 3, 4th indicator - assess the importance of protecting and preserving natural resources.

• Relate surface and ground-water availability and use to population growth in the U.S.

• What measures regarding water use will future population growth require?

• How might Utah be affected by the Las Vegas proposal to pump and pipe large amounts of ground water from just west of the Utah/Nevada border (e.g., potential impacts to ground-water levels in western Utah)?

9th-grade Earth Systems: Standard 4, Objective 1 - water reservoirs. Indicator e - analyze how communities deal with water shortages, distribution, and quality in planning long-term water use.

• What is a hydrologic basin? What is an aquifer? Where/how are the Snake Valley aquifers recharged?

• Discuss the relationships between various Earth systems. How is the geosphere related to the aquifer beneath Snake Valley? What is the relation between the atmosphere (particularly the climate in the two driest states) and the hydrosphere?

• When is Las Vegas estimated to exceed existing water supplies relative to projected water demand? See diagram on page 2.

• Discuss the long-term viability of states sharing ground-water resources. Will ground-water resources need to be allocated via interstate compacts in the future (similar to surface-water allocations, such as Colorado River water)?

• See a related article on a wetlands ecosystem, "Tooele Valley Wetlands – A Valuable but Potentially Endangered Resource," in this issue of *Survey Notes*.

• Read about "Earth Fissures in Escalante Valley, Iron County, Utah," in the September 2005 *Survey Notes* (v. 37, no. 3), which you can access on our Web site at geology.utah.gov/surveynotes/snt37-3.pdf. Use the information in that article to discuss the impacts of ground-water withdrawal in this area, including a decline in ground-water levels that in part likely contributed to earth fissures (cracks up to 1300 feet long, 10 feet wide, and 6 feet deep) that became noticeable after widespread flooding in January 2005.

GLAD YOU ASKED

When I find a mineral or fossil in the field, why doesn't it look similar to specimens in museums or at mineral and fossil shows?

by Carl Ege

Nearly every mineral or fossil on display at a museum or offered for sale at a mineral and fossil show has been "prepared." Preparation is the process of cleaning and (or) restoring specimens to reveal their true beauty. Methods of preparation include washing, trimming, chemical treatment, mechanical treatment, repairing, and cutting and polishing. Practically all specimens need at least one form of preparation, while others need a combination of treatments.

WASHING

Washing removes dirt or clay that may cover the specimen. Using a scrubbing brush or toothbrush under running water is the best method, and soaking the specimen in water may also help. Disappointments generally occur during washing because the specimen may look much better wet than dry. This is the time to inspect your specimen and determine if you should proceed or just throw the specimen away.

TRIMMING

There are two types of trimming: hand trimming and heavy trimming. Hand trimming is accomplished by using a rock hammer and chisels to reduce the size of the specimen to enhance its display value. Heavy trimming is done by a device similar to an old-fashioned printing press, but with a hardened steel chisel attached to the screw shaft. The tool's advantage over hand trimming lies in its ability to apply greater force and pressure at the precise place to properly trim the specimen. During trimming, it is important to use safety goggles to protect the eyes from rock chips, and wear gloves to protect the hands.

CHEMICAL TREATMENT

Chemical cleaning methods are used when washing and trimming are unable to remove undesirable material that may cover your specimen. Sometimes solutions such as acids, or even water, can be used to dissolve unwanted mineralized coatings without damaging the specimen. When handling any acids remember to wear rubber gloves, eye-protective goggles, and old clothes. Also avoid inhaling any fumes during acid treatment. Listed below are the most commonly used chemical solutions for specimen

CHEMICAL SOLUTION	WHAT IT REMOVES
Hydrochloric acid (also called muriatic acid)	carbonates (such as calcite) and iron oxides
Acetic acid (in vinegar)	calcium carbonate (calcite)
Formic acid	calcium carbonate (calcite), used mainly in fossil prep.
Oxalic acid	iron oxide rust stains on quartz and pyrite
Hydrofluoric acid	silicates (quartz and clay minerals)
Nitric acid	iron oxides and other metallic substances
Water	water-soluble minerals such as nitrates, borates, & sulfates

Limonite specimens found in the field coated with clay.

Limonite specimens after vigorous wash and scrub with brushes.

Quartz before oxalic acid treatment. Notice iron oxide coating quartz crystals.

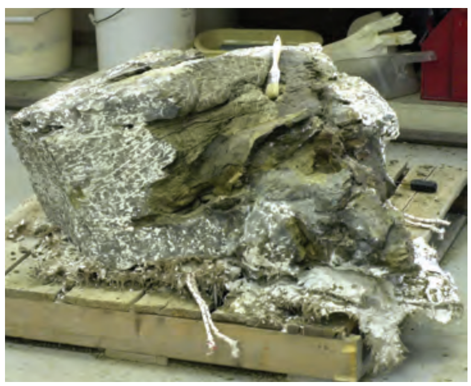
Prepared quartz after being trated with oxalic acid.

preparation.

MECHANICAL TREATMENT

Mechanical treatment pertains to the steel tools and electrical hardware used to clean specimens. These methods have the potential to damage specimens by scratching or fracturing, so it is important to test on lesser specimens to see if any damage will result. Mechanical methods are commonly used when preparing dinosaur bone. Remember to always use safety goggles, gloves, dust mask, and proper ventilation. Listed below are the most commonly used mechanical tools for preparation.

TOOL OR DEVICE	FUNCTION
Ultrasonic cleaner	Cleaning fragile, delicate mineral specimens
Rotary tool (dremel)	Removing unwanted material to expose mineral or fossil
Dental pick, sewing needle	Removing dirt or material in the crevices of specimens
Air abrasive unit (sandblaster)	Removing rock to expose mineral or fossil
Air engraver (airscriber)	Commonly used by fossil preparers to expose fossils



Fossil preparation after removal of the plaster jacket using brushes and dental picks.

Exposed bone, outlined in red, after airscribe cleaning.

REPAIRING

Some specimens found broken in the field or damaged during other forms of preparation can be repaired. In mineral preparation, only minerals with clean breaks or fractures should be repaired. In vertebrate fossil preparation, repairs are very common because most vertebrate fossils are found broken or crushed. Adhesives, such as balsams, glues, and cements work well to repair specimens.

CUTTING AND POLISHING

Some specimens cannot be fully appreciated unless they are cut to display their internal structure. For example, the outside of a geode is pretty plain, but when cut open, a beautiful crystallized cavity may be exposed. Massive specimens, such as agate, jasper, or variscite should be cut and polished to reach their full potential. Sometimes polishing will bring out details that would have otherwise been overlooked.

More detailed information on preparation can be found on the Internet under searches such as "mineral and fossil cleaning" or "˙mineral preparation." There are also books on the subject that may be found at your local rock shop or bookstore. ❖

Fully prepared dinosaur bone (Ceratopsian frill).

GeoSights

Rozel Point and Spiral Jetty Revisited, Box Elder County, Utah

Rozel Point in winter. Without the debris, it is nearly unrecognizable (photo courtesy of the Division of Oil, Gas and Mining).

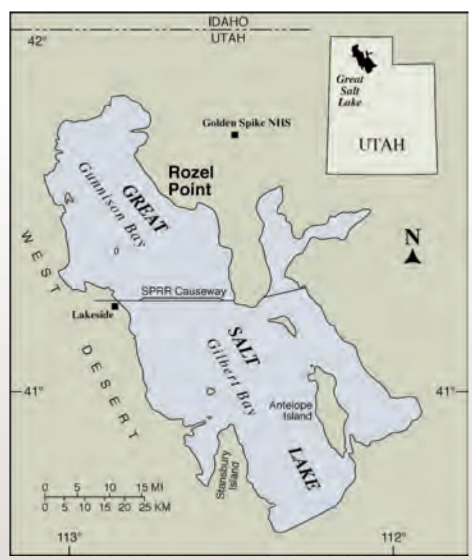
by Mark Milligan

Several past editions of Survey Notes have run GeoSights articles on the oil seeps found at the Rozel Point oil field (August 1995, September 2005) and the Spiral Jetty earthwork art (January 2003) located several hundred yards to the north. In addition to the earthwork art and natural wonders such as red brine, white salt, black basalt, and crude oil seeps, tons of industrial debris left from decades of activity at Rozel Point was obvious to anyone who visited the area. Although the natural oil seeps continue to flow, we are pleased to report that the debris is now a thing of the past!

Two UGS sister agencies, the Division of Oil, Gas and Mining and the Division of Forestry, Fire, and State Lands, completed a cleanup project at Rozel Point in December 2005. They removed rubbish including gathering lines, boilers, tubing, pump jacks, tanks, the skeletal remains of a single-wide trailer, and even the rusted hulk of a military amphibious vehicle. Within 16 days, a total of eighteen 40-cubic-yard dumpsters full of junk were hauled away! Only some old wood pilings and historic stone building foundations were left behind. Funds from the Division of Oil, Gas and Mining's "orphan well" program were used to pay for the cleanup. So, if you have ventured to the area before, either to see Rozel Point or Spiral Jetty, you may not recognize it when you return!

How to get there: Drive to the Golden Spike National Historic Site (GSNHS), 30 miles west of Brigham City, Utah, by following signs on Utah State Route 83 through Corinne. From the GSNHS Visitor Center follow the small white signs toward the Spiral Jetty, about 16 miles. (The landmark rusted military amphibious vehicle that once signaled you were almost there has been hauled off with the rest of the debris.)

For more geologic and historical information see pages 12 and 13 of the September 2005 edition of *Survey Notes* and the article on the Rozel Point oil field in *Great Salt Lake, an Overview of Change* (2002) edited by J. Wallace Gwynn.



Location map for Rozel Point.

The cleanup was not without problems. A muddy lakebed temporarily swallowed up a track hoe (left) and three Bobcats (above) (photographs courtesy of the Division of Oil, Gas and Mining).

As seen in these four photos, a wide variety of debris was hauled away (top left and two right photographs courtesy of the Division of Oil, Gas and Mining).

Before and after. The historic wood pilings were left in the ground (photos courtesy of the Division of Oil, Gas and Mining).

New Utah Minerals

by Carl Ege

Holfertite, $U^{6+}_{2-x}Ti(O_{8-x}OH_{4x})[(H_2O)_3Ca_x]$

Holfertite is a calcium-uranium-titanium hydrated oxide/hydroxide found at Starvation Canyon and other areas of the Thomas Range, Juab County. The mineral is found as crystals up to several millimeters long, but only a few microns thick. Holfertite is lemon-yellow to orange-yellow with a yellow streak. The mineral has a hardness of 4, density of 2.93 g/cm^3, and is radioactive.

Holfertite (orange-yellow) with hematite (black). Holfertite is approximately 2 to 3 mm long. Photo courtesy of Joe Marty.

Holfertite is found in lithophysae cavities within rhyolite along fracture zones. The mineral is associated with hematite, sanidine, quartz, calcite, topaz, and red beryl. Holfertite is named for John Holfert, a geologist and mineral dealer who specializes in minerals from the Thomas Range.

The Thomas Range, where holfertite was recently discovered.

Nukundamite, $(Cu, Fe)_4S_4$

Nukundamite is a rare copper iron sulfide found at the Bingham mine in the West Mountain (Bingham) mining district, Salt Lake County. However, it was first identified at the Undu mine (the type locality) in Nukundamu, Fiji, hence the name. At the Bingham mine, the mineral is disseminated or fine grained and is impossible to tell apart from bornite in a hand sample. Nukundamite is brownish-purple with a dark-gray streak. The mineral has a hardness of 3.5 and a density of 4.3 g/cm^3.

View of the Bingham mine, where nukundamite was recently found. Photo courtesy of Ken Krahulec.

At the Bingham mine, Nukundamite is found in the quartzite unit of the Pennsylvanian Bingham Mine Formation. The mineral is associated with bornite, chalcopyrite, quartz, covellite, digenite, pyrite, and enargite.

For more information:

Barthelmy, David, 2000-2005, Holfertite mineral data: Online, <webmineral.com/data/Holfertite.shtml>, accessed Aug. 5, 2005.

Ford, E.E., Chirnside, William, Davis, A.M., Lichte, F.E., and Esposito, K.J., 1995, A new U-Ti-Ca-HREE hydrated oxide and associated niobian rutile from Topaz Valley, Utah: The Mineralogical Record, v. 26, no. 2, p. 123-128.

Inan, E.E., and Einaudi, M.T., 2002, Nukundamite (Cu3.38Fe0.62S4)-bearing copper ore in the Bingham porphyry deposit, Utah–result of upflow through quartzite: Economic Geology, v. 97, no. 3, p. 499-515.

Ralph, Jolyon, 1993-2005, Holfertite: Online, <mindat.org/show.php?id=11514>, accessed Aug. 10, 2005.

... continued from page 10

Energy News

production activity is occurring on the gently inclined southern flank of the asymmetrical Uinta Basin of northeastern Utah. While much attention has been focused on central Utah's new producing area that includes the Covenant field, where there are seven significant new oil wells, several existing fields in the Uinta Basin have seen much greater activity in terms of the total number of new wells. The six fastest-growing petroleum fields in Utah during 2004 and 2005 were Natural Buttes (+463 wells), Brundage Canyon (+111 wells), Eight Mile Flat North (+102 wells), Monument Butte (+99 wells), Wonsits Valley (+18 wells), and Antelope Creek (+14 wells). Several other fields in the eastern Uinta Basin near Natural Buttes field, including Pariette Bench, Kennedy Wash, Gypsum Hills, and Red Wash, have each added five to eleven new wells during this same period. Other prospective areas in the state where limited drilling is taking place include continued development of the coal-bed gas fields of Carbon and Emery Counties, and expansion of several small fields in the southern Uinta Basin, where significant gas reserves have been found in Mesozoic reservoirs below the previously developed Tertiary and Upper Cretaceous reservoirs. Aggressive drilling plans announced in 2005 and early 2006 by Kerr-McGee, EnCana Oil & Gas, and EOG Resources (Natural Buttes field), Berry Petroleum (Brundage Canyon field), Newfield Rocky Mountain (Monument Butte and Eight Mile Flat North fields), and Questar Exploration and Development Company (Red Wash, White River, and Wonsits Valley fields), indicate that petroleum drilling and development activity in Utah will continue at a strong pace in 2006, and probably for several years beyond. ❖

Survey News

Joel Frandsen (left) presenting Wally Gwynn with the FFSL Director's Sovereign Land Award.

Utah's Division of Forestry, Fire and State Lands (FFSL) recently named **Wally Gwynn** as the first recipient of the Director's Sovereign Land Award for his outstanding achievements and contributions to the history, science, and well-being of Great Salt Lake. This new annual award recognizes contributions towards administration of the state's sovereign lands. FFSL Director Joel Frandsen said, "Dr. Gwynn has been a living institution within the Department of Natural Resources, with an insatiable appetite for acquiring the knowledge we all need to manage the Great Salt Lake, the crown jewel of our sovereign land system." Wally has edited two books on the Great Salt Lake and made numerous other contributions to its management. Wally is a mineral (salines) geologist and has worked for the UGS for over 30 years.

Linda Bennett

Congratulations to **Linda Bennett,** who was named the Utah Geological Survey's Employee of the Year. Linda is our accounting technician and has worked for the Survey for 11 years.

Rick takes the plunge!

On January 21st, UGS Director **Rick Allis** joined other members of the DNR leadership team and took the Polar Plunge. Donations were pledged to benefit a great cause, the Special Olympics. Thanks to everyone who donated.

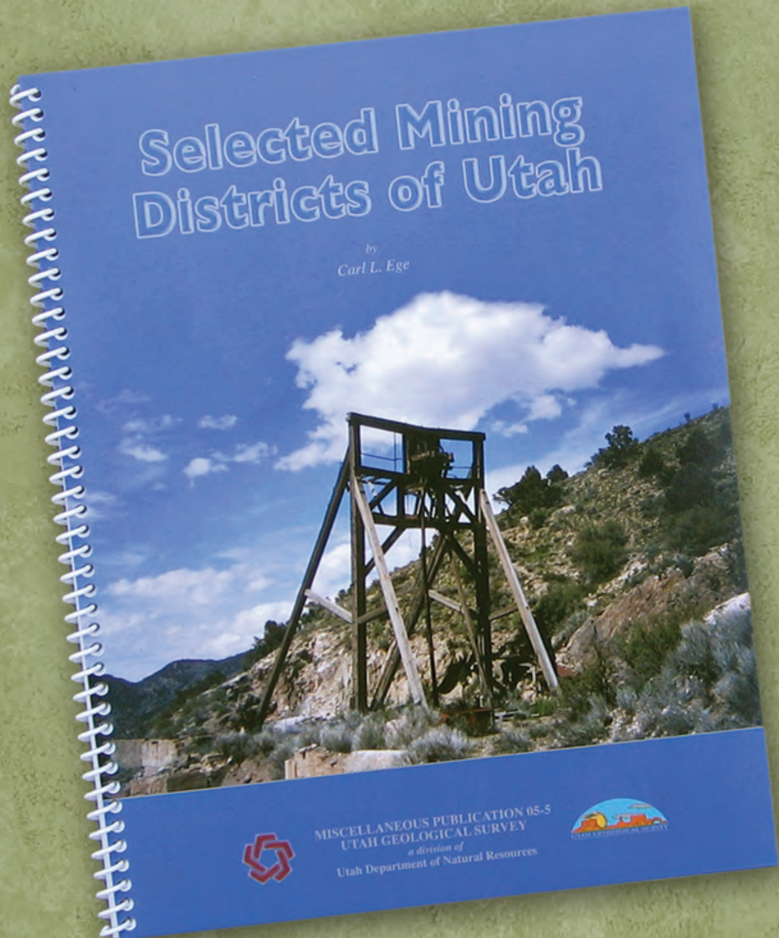
Welcome to **Kathi Galusha,** who replaces Dan Kelly as our fiscal analyst. Kathi worked for the Utah Department of Transportation before joining the UGS.

The State Energy Program bid farewell to **Kim Mellin** and **Nykole Littleboy**. Kim accepted an IT position with the State Office of Education, and Nykole returned to New York.

Tyler Knudsen is the new geologist in our Cedar City office. Tyler has a B.S. from the University of Utah and an M.S. from the University of Nevada, Las Vegas.

Walid Sabbah and **Scott Horn** recently joined the Ground-Water and Paleontology Program. Walid has a Ph.D. from Brigham Young University and significantly strengthens our numerical modeling capabilities. Scott is the new information analyst.

Vicky Clarke was promoted to manage the Editorial Section, replacing Jim Stringfellow, who retired.



Selected Mining Districts of Utah

Whether you are a geologist, history buff, or rockhound, this booklet will be a helpful guide to Utah's mining districts. The booklet is divided into three parts: the first part provides general information on what a mining district is, how many mining districts are in Utah, types of mineral deposits found at these districts, and landownership issues. The second part includes individual mining-district discussions containing information on location, production, history, geology, mineralogy, and current/future operations. The third part includes a glossary of geologic terms and other useful resources in the appendices, such as a descriptive list of minerals found in the districts, geologic time scale, and a list of mineral resources of the mining districts.

Miscellaneous Publication 05-5 . . . . $11.49

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