UTAH GEOLOGICAL SURVEY

SURVEY NOTES

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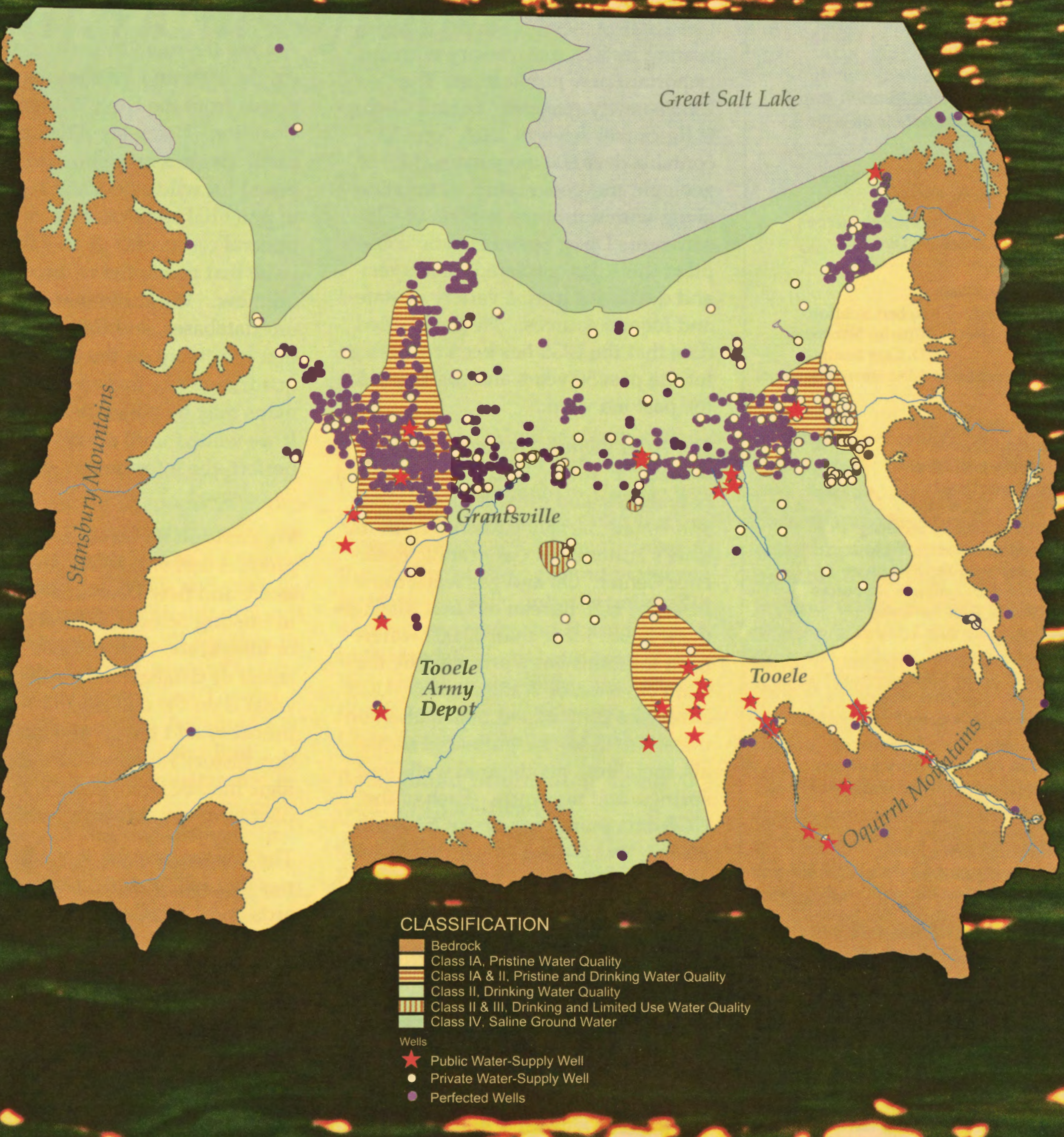

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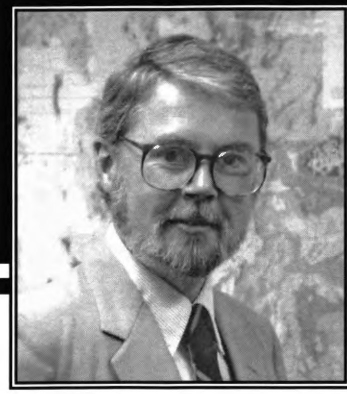


The Director's Perspective

by M. Lee Allison

The Utah Geological Survey is celebrating its 50th anniversary with an important new publication. The UGS's newly released "Digital Geologic Resources Atlas of Utah" on CD contains over 600 megabytes (Mb) of geologic and geographic information along with a runtime version of GIS software. Doug Sprinkel, who compiled the Atlas, gathered data layers and databases from a variety of state and federal sources. He then added data that the UGS has been collecting for the past 50 years and digitizing for the past ten years.

The Atlas includes topography, land ownership, roads, land status, political boundaries, and other layers for the entire state, largely gathered from the state's Automated Geographic Reference Center. Oil and gas wells came from the U.S. Bureau of Land Management files. More than 80,000 water-right locations were provided by the Utah Division of Water Rights. UGS databases contributed information on minerals (uranium, industrial minerals, metallics), geothermal wells and springs, and tar sands. Each of the UGS data points has up to 254 attributes.

The CD allows you to construct maps for the entire state or any specific area that interests you. By clicking the computer mouse onto a data point such as an oil well, water right, or mineral location, you can bring up the associated information available, such as ownership, precise location, dates, commodity, geologic unit, production, and more. We expect the energy and minerals communities will find the Atlas more than useful in identifying new exploration targets around the state.

Among the more interesting GIS layers are the 1996 and 1998 wilderness proposals from the Utah Wilderness Coalition. Using the Atlas, one can easily create a map showing areas proposed for wilderness and their relation to potential conflicts such as roads and mineral resources. It was this type of issue that prompted us to put the Atlas out now. We know there are gaps in our databases, and that some roads don't show up on the USGS digital quadrangles or that some roads on the maps may be mislocated or don't exist. If we waited until every data set was perfect, the information would never be released.

We envision the Atlas as an evolving product that will be routinely updated as we add new locations, fill in voids in existing records, correct incomplete or inaccurate data, and add entire new layers or databases. In addition to what is on the current CD we will probably add the oil and gas production history for all wells, a digital geologic map of Utah, and the UGS Sample Library core catalog, among others.

The Resources Atlas is the first in a series that will include Geologic Hazards and Utah Geology as companion volumes. The digital atlas series is the platform for what are expected to be our flagship products for the next decade. After all, having cabinets and files full of geologic data and maps does no one any good unless we get them out to people who can use them. The CD format is a powerful and effective way to share the information.

Survey Notes is published three times yearly by Utah Geological Survey, 1594 W. North Temple, Suite 3110, Salt Lake City, Utah 84116; (801) 537-3300. The UGS inventories the geologic resources of the state, identifies its geologic hazards, disseminates information concerning Utah's geology, and advises policymakers on geologic issues. The UGS is a division of the Department of Natural Resources. Single copies of *Survey Notes* are distributed free of charge to residents within the United States and Canada and reproduction is encouraged with recognition of source.

Preserving the Quality of Utah's Ground-water Resources Through Aquifer Classification

by Mike Lowe and Janae Wallace

Introduction

The Utah Geological Survey (UGS) is currently involved in cooperative projects with the Utah Department of Environmental Quality's (DEQ) Division of Water Quality (DWQ) and various local governments to classify ground-water quality in valley-fill aquifers in Cache Valley, Cache County; Ogden Valley, Weber County; and Tooele Valley, Tooele County. An aquifer is a porous geologic formation that stores and/or transmits water and is capable of yielding economic quantities of water to wells or springs. In these three valleys, the aquifers mainly consist of unconsolidated sand and gravel.

Ground water is the most important source of drinking water in Utah, the second most arid state in the nation. About half of Utah's population uses wells or springs as the drinking water source. Depending on site conditions, ground water can be extremely vulnerable to contamination. Although there are many means of remediating contaminated ground water, they are very expensive and commonly time consumptive. Aquifer classification is a relatively new and little-known tool for local governments in Utah to use for managing potential ground-water contamination sources and protecting the quality of their ground-water resources. To date, only the valley-fill aquifers of Heber and Round Valleys in Wasatch County have been classified. Much of the following information is from the DWQ's 1998 Aquifer Classification Guidance Document.

Background Information About Aquifer Classification

On October 4, 1984, Utah Governor Bangerter issued an Executive Order stating, "The quality of ground water will be protected to a degree commensurate with current and probable future uses. Preventive measures will be taken to minimize contamination of the resource so that current and future public and private beneficial uses will not be impaired." Based on public comments, the former Division of Environmental Health (now DEQ) implemented an anti-degradation approach using differential protection based on the quality or value of the ground-water resource. The policy of differential protection recognizes possible impacts on ground water from human activities, but limits any adverse impacts to pre-established acceptable levels tied directly to ground-water quality. Aquifer classification is one of the principal means for implementing the differential protection policy, because it establishes the quality of the ground-water resource.

The Utah Ground Water Quality Protection Regulations, initially adopted in 1989, contain a provision allowing the Utah Water Quality Board to classify all or parts of aquifers as a method for maintaining ground-water quality in areas where sufficient information is available. This includes having a comprehensive understanding of the aquifer system supported by factual data for existing water quality, potential contaminant sources, and current uses of ground water. Aquifer classification (or re-classification) may be initiated by either the Utah Water Quality Board or by a petition submitted by a person,

Ground-Water-Quality Class	TDS Concentration	Beneficial Use
Class 1A/1B[1]	0 to 500 mg/L[2]	Pristine/irreplaceable
Class 2	500 to 3000 mg/L	Drinking Water[3]
Class 3	3000 to 10,000 mg/L	Limited Use[4]
Class 4	more than 10,000 mg/L	Saline[5]

[1]Irreplaceable ground water (class 1B) is a source of community water for which no other reliable supply of comparable quality and quantity is available due to economic or institutional constraints; it is the only ground-water-quality class not based on TDS.
[2]For concentrations less than 7,000 mg/L, mg/L is about equal to parts per million (ppm).
[3]Water with TDS levels in the upper range of this class must generally undergo some treatment to be used as drinking water.
[4]Generally used for industrial purposes.
[5]May have economic value as brine.

company, or government entity (such as the UGS). At least one public hearing is required before the Utah Water Quality Board rules on the proposed classification. Once an aquifer is classified, commensurate protection levels are applied to classified areas based on the differential protection policy.

Classes of ground water quality, under the Utah Water Quality Board classification scheme, are based largely on total-dissolved-solids (TDS) concentrations (the amount of solid residue measured after water evaporates, in milligrams per liter [mg/L]; see table below). If any contaminant exceeds Utah's ground-water-quality (health) standards (and, if human caused, cannot be cleaned up over a reasonable time period), the ground water is classified as Class 3, Limited Use ground water.

In order to classify the quality of ground water in an aquifer, water samples should be obtained and analyzed by laboratories certified by the Bureau of Laboratory Improvement for the Utah State Health Department's Division of Epidemiology and Laboratory Services. The data should provide sufficient coverage, spatially (geographic distribution and depth) and temporally (at various time periods), to adequately characterize the area(s) being classified. The amount of data required to classify depends on the complexity of the aquifer system. Common chemical constituents analyzed for aquifer classification are listed in the following table. Analyses of radiologic and organic constituents are costly, thus, only a few samples for carefully selected sites are collected and analyzed for these constituents as part of aquifer classification.

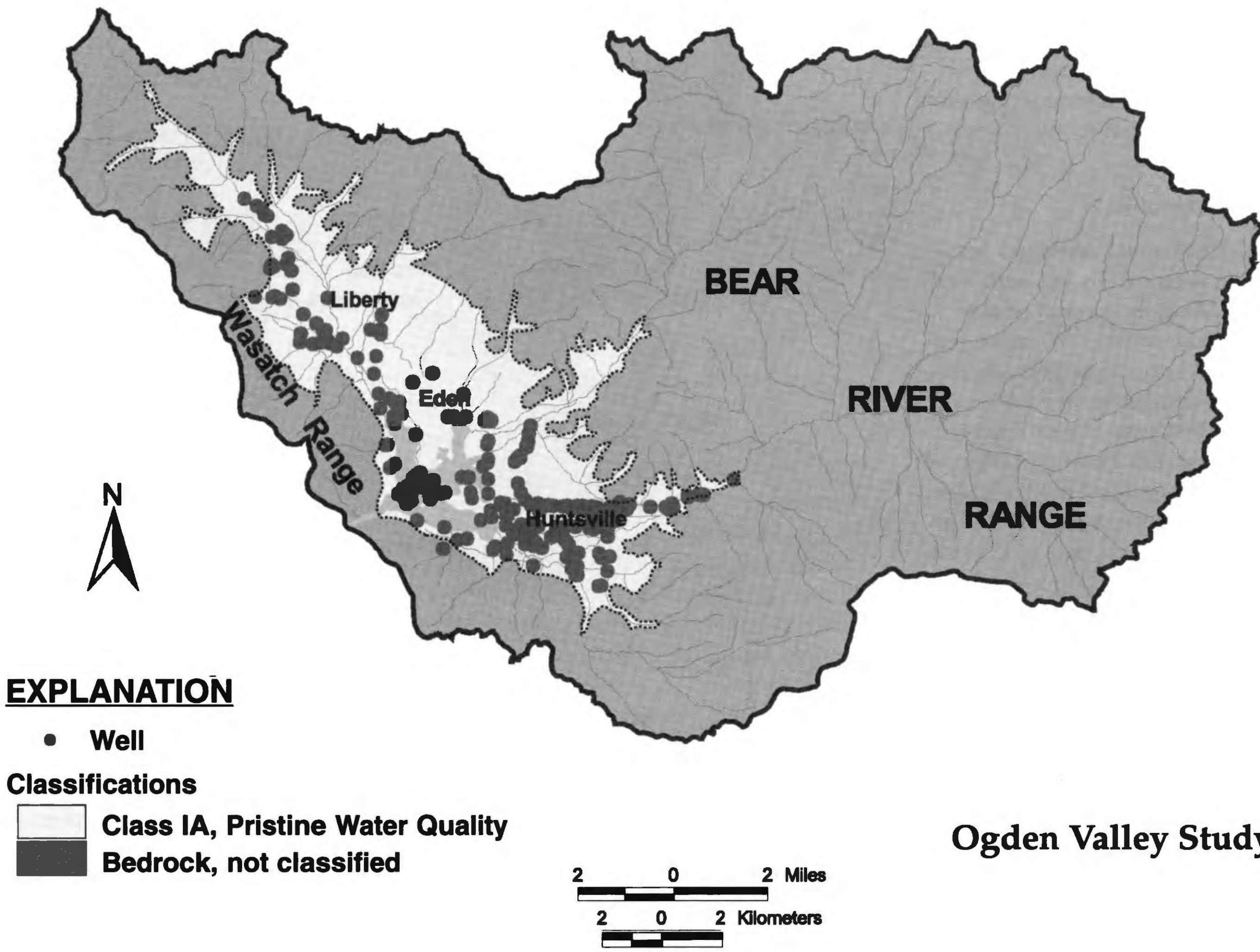
Aquifer Classification: A Planning Tool

Aquifer classification is a planning tool for local governments to use in making land-use management decisions. It allows local governments to use ground-water quality as a reason for permitting or not permitting a proposed activity or land use based on the differential protection policy. Many facilities and/or activities exist which can and do have an impact on ground-water quality, but may not be regulated by state or federal laws. Examples of such facilities/activities include septic tanks, animal feed lots, land application of animal wastes, and the siting of industrial/manufacturing development. Many of these facilities and/or activities are permitted through local land-use management programs. From this perspective, aquifer classification can be a useful tool for local governments, if they so desire, to manage their ground-water resources based on the beneficial use established by aquifer classification.

There are many potential applications of aquifer classification as a land-use management tool. One example is to establish zoning to locate industrial

Basic Constituents for Ground-Water Analysis

Field Measurements: pH, Conductivity, Temperature					
Total Dissolved Solids (TDS)					
Major Ions:	Calcium	Bicarbonate/Carbonate		Magnesium	Chloride
	Nitrate	Potassium		Sodium	Sulfate
Dissolved Metals:	Barium	Copper	Arsenic	Chromium	Cadmium
	Mercury	Selenium	Lead	Silver	Zinc
Organic Analysis:	Pesticides, Fuels, Solvents				
Radionuclides:	Gross Alpha and Gross Beta particles				



Ogden Valley Study

facilities in areas where ground-water quality is already low, such as in some areas around Great Salt Lake. Additionally, aquifer classification can be used as a basis for determining the density of development in areas that use septic tanks for waste-water disposal (Wasatch County used aquifer classification as one basis for limiting septic systems to lots larger than five acres). Aquifer classification can also be used as a basis for encouraging developers to invest in the infrastructure needed to connect a proposed subdivision onto an existing sewer line, rather than dispose of domestic waste water using septic-tank systems. However, aquifer classification does not result in any mandatory requirement for local governments to take specific actions, such as land-use zoning restrictions, technical assessments, or monitoring.

Preliminary Results of Aquifer Classifications for Three Utah Valleys

Cache Valley in Cache County, Ogden Valley in Weber County, and Tooele Valley in Tooele County are areas experiencing an increase in residential development. Most of the development is on unconsolidated deposits of the valley-fill aquifers, which provide the primary drinking-water supply for the communities. Classifying the ground-water quality of the principal aquifers will formally identify and document the beneficial use of each valley's ground-water resource. The quality of water is generally good for all three valley-fill aquifers. In Cache Valley, 85 percent of the ground water in the valley-fill aquifer is classified (see map) as Class 1A and and 15 percent is classified as Class 2, based on chemical analyses of about 150 wells sampled during fall 1997 and winter/spring 1998 (TDS range of 178 to 1,010 mg/L). Ogden Valley ground water is classified (see map) as Class 1A, based on chemical analyses of about 90 wells sampled during 1985-86 and spring/fall 1997 (TDS range of 42 to 629 mg/L). Tooele Valley ground water has a more varied chemistry due to its proximity to the Great Salt Lake (see front cover). There, 26 percent of the ground water in the valley-fill aquifer is Class 1A, 46 percent is Class 2, 22.5 percent is Class 4, and 5.5 percent of the valley-fill aquifer has more than one class of ground water (classification changes with depth). In Tooele Valley, TDS ranges from 256 to 37,800 mg/L, based on samples taken over a 30-year period from 1964-95.

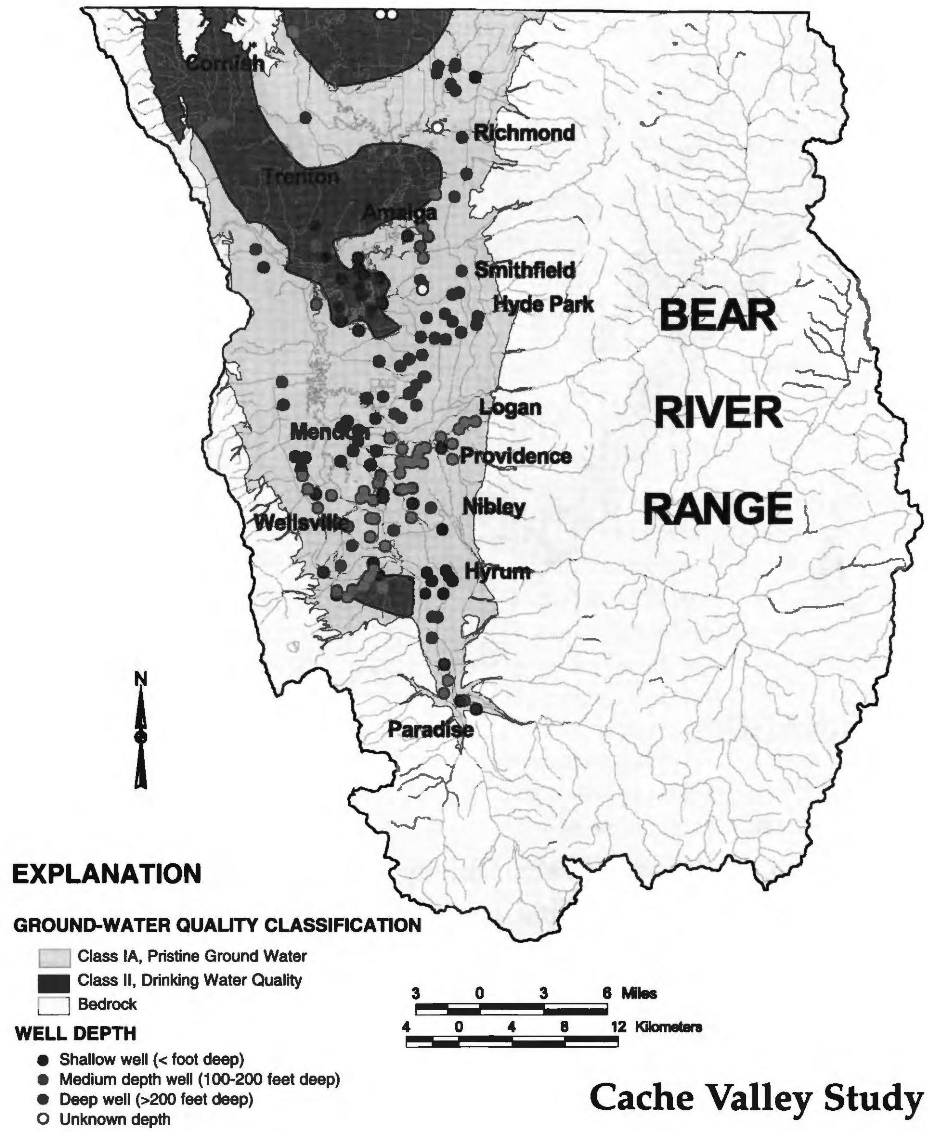
Summary

Ground water is the most important source of drinking water in Utah.

Aquifer classification is a relatively new tool that is now beginning to be used in Utah to manage potential ground-water contamination sources and protect the quality of ground-water resources.

Acknowledgments

DWQ collected and analyzed samples from water wells in Cache and Ogden Valleys in support of our classification studies, and arranged for a U.S. Environmental Protection Agency Nonpoint Source Program grant for the Cache Valley study. Additionally, Bill Damery, DWQ, reviewed and provided helpful suggestions regarding this article. The Tooele County Engineering Department funded the Tooele Valley study. The U.S. Geological Survey provided water-quality data and GIS files for Tooele Valley. The Weber-Morgan District Health Department, Ogden City, and the Central Weber Sewer District funded the Ogden Valley study. The Weber Basin Water Conservancy District collected and analyzed additional water samples for the Ogden Valley study. Thanks to everyone involved for their support of these studies. For additional information regarding aquifer classification contact Mike Lowe (801) 537-3389.



Cache Valley Study

UGS Report Helps Water Rights Set Policies in Fast-Growing Snyderville Basin

The Snyderville Basin area, which includes Park City in Summit County, hosts one of the fastest growing populations in the state -- and it is rapidly running out of water.

At a public meeting in September, Robert Morgan, State Engineer and Director of the Water Rights Division of the Department of Natural Resources, told the citizens of the region, "Water will now govern land use, and you are going to have to find a new source of water. We have gone along in ignorant bliss for too many years and now the hard decisions have to be made."

Morgan imposed a ban on transferring so-called "paper" water rights into the basin. Paper rights are water allocations that exist only on paper and are not backed by any real water supply. In November, Morgan finalized the restrictions on allocations, saying, "If they continue to grow houses up here, they are going to have to import water into this basin."

In pointing out the need for restrictions, Morgan referred in part to a study recently concluded by the Utah Geological Survey. The investigation found that the bedrock underlying the basin contains either thin, shallow unconsolidated aquifers or fractured-rock aquifers. The first type is close to the surface and almost entirely dependent upon snowmelt and rainfall for recharge. The second is compartmentalized and bordered by low-permeability shale or fault zones, creating a complex system of aquifers that partially overlie one another. Because of the poor storage capabilities of these fractured aquifers, wells drilled miles apart could tap into the same aquifer, meaning less water might be available to other users.

Ground-water Study Underway in Cedar Valley, Iron County

by Mike Lowe, Hugh A. Hurlow, and Janae Wallace

Introduction

Utah Geological Survey (UGS) geologists and U.S. Geological Survey (USGS) hydrologists are collaborating on a major, multi-year ground-water study in Cedar Valley, Iron County. Cedar City and the surrounding areas are experiencing a significant population growth accompanied by increasing demands on surface- and ground-water resources. The basin-fill deposits in Cedar Valley are the main source of ground water for the area and are the principal focus of this cooperative study, which is being funded by many agencies including the newly formed Central Iron County Water Conservancy District, the Utah Division of Water Resources, the Utah Division of Water Quality, the U.S. Geological Survey, the U.S. Environmental Protection Agency, Iron County, Cedar City, and the town of Enoch. Both ground-water quantity and quality will be evaluated as part of the study. The study is truly a cooperative effort because geologic information collected by the UGS in early phases of the study will be used by the USGS to evaluate the ground-water hydrology of the basin, and water-chemistry data and a ground-water flow model produced by the USGS will be used by the UGS in later phases of the study to characterize ground-water quality and susceptibility to pollution.

Ground-Water Quantity

Issues of ground-water quantity are inevitably associated with population growth. Growth means more people, more and different types of industrial and commercial development, and the accompanying need for more water. Local government officials in Cedar Valley want the necessary information to plan for that growth and ensure an adequate water supply for the future. To help evaluate water quantity, the UGS is conducting a geologic-framework study to assess the relationship of geology to ground-water conditions. Products produced by the UGS will include geologic cross sections, maps, and geologic logs of water wells showing the nature and thickness of the basin-fill deposits. The UGS will also produce maps of geologic units surrounding the valley and evaluate how rock types and fracture (breaks in rock masses) characteristics affect the flow of ground water from the surrounding bedrock into the basin-fill deposits. The USGS will evaluate ground-water quantity using the UGS geologic data and their own data from water-level measurements and aquifer (water-production) tests of wells. The USGS will calculate a water budget that estimates the amount of water recharging to, discharging from, and in storage in the basin-fill aquifer. The USGS will also develop a computer model simulating ground-water conditions in the aquifer.

Ground-Water Quality

The quality of ground water in the valley-fill deposits is highly variable in terms of total-dissolved-solids (TDS; the amount of solid material dissolved in water) concentrations. Water suppliers need to develop strategies to maximize ground-water withdrawals without causing high-TDS ground water to migrate into areas that provide water to their public-supply wells. In addition, public officials would like to determine the source and extent of elevated nitrate levels near Enoch. Although septic-tank systems are one potential source of nitrate, the UGS is currently evaluating geologic units in the area to determine if natural sources of nitrate also exist. The USGS is currently collecting water-chemistry data from wells and mapping nitrate and TDS concentrations in the basin-fill aquifer. The UGS will use the USGS water-chemistry data to classify the basin-fill aquifer based on ground-water quality (see article on aquifer classification), and inventory potential contaminant sources. The UGS will soon begin a case study for selected subdivision sites to determine recommended septic-tank-system densities based on ground-water flow available for nitrate dilution. During the final phase of the study, the UGS will perform a valley-wide septic-system density study to determine appropriate lot sizes for different areas based on calculated ground-water flow available for nitrate dilution using the USGS ground-water computer model.

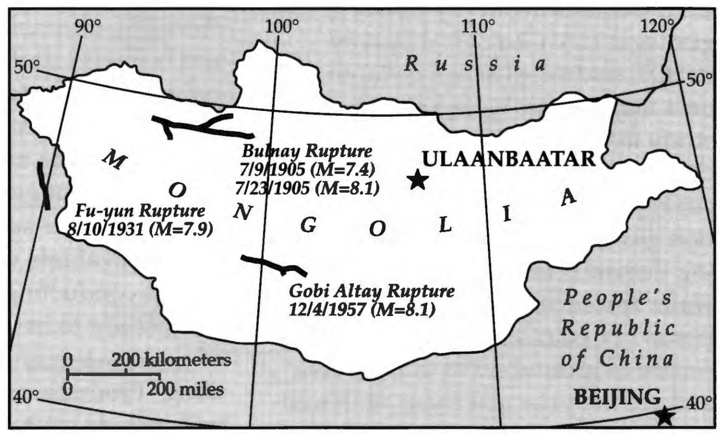
Utah Geological Survey Participates in 1998 Bulnay Fault Expedition to Northwestern Mongolia

by William Lund

Utah Geological Survey geologist William Lund recently traveled to remote northwestern Mongolia on a U.S. Geological Survey-led expedition to study the Bulnay fault for clues about future large earthquakes in the continental United States. Mongolia, a country with approximately the same population as Utah but with an area almost as large as the western U.S., provides a spectacular natural laboratory for studying faults and great earthquakes that occur in the interior of continents far from the earth's more seismically active plate boundaries. During the 20th century, western Mongolia has experienced three earthquakes of approximately M8 (magnitude 8) and six events of about M7, resulting in a larger amount of seismic-energy release than has occurred in California during the same period. The three great earthquakes were the 1905 Bulnay event in northwestern Mongolia, the 1931 Fu-yun earthquake just across Mongolia's western border in China, and the 1957 Gobi-Altay event in the northern Gobi Desert.

The 1905 Bulnay earthquake was actually a sequence of large events. The first occurred on July 9, 1905, and ruptured 130 kilometers (80 miles) of the left-lateral Testerlig strike-slip fault. Based on rupture length, we estimate the magnitude of that earthquake to be 7.4. The Testerlig event was followed fourteen days later on

Map of Mongolia showing the Bulnay, Gobi-Altay, and Fu-yun ruptures. The Testerlig fault branches to the northeast from the Bulnay fault; the Teregtiyn fault branches to the southeast.



July 23 by an estimated M8.1 earthquake that produced 350 kilometers (216 miles) of left-lateral, strike-slip surface rupture on the Bulnay fault, and simultaneous rupture of the shorter Teregtiyn thrust fault. The types of faulting (left-lateral strike slip and thrusting), geologic setting (deep within a continental interior), and event timing (two large earthquakes within a few tens of days of each other) all bear a strong resemblance to the great 1811-1812 New Madrid earthquakes of the central U.S. The New Madrid seismic zone is largely buried under the Mississippi River and therefore the details of its rupture pattern and history cannot be studied directly. Conversely, the arid, cold climate of Mongolia preserves fine features of surface faulting for long periods after the earthquake. Because the 1905 Bulnay earthquake is so similar to the New Madrid events, we hope that the information obtained on the Bulnay fault will improve our understanding of the seismic hazard associated with the New Madrid seismic zone, as well as the Wasatch fault and other potentially active faults within the continental U.S.

The goals of the 1998 Bulnay fault expedition were to find evidence of the pre-1905 (penultimate) earthquake, to examine the rupture complexity of that event, and to determine its age. Three days of hard travel from Ulaanbaatar, Mongolia's capital, over rough, sometimes non-existent roads were required to reach the Bulnay fault. Once there, we spent two weeks working our way west along the fault trace, hand-excavating trenches across the fault at several locations (backhoes are nonexistent in remote areas of Mongolia), making detailed profiles of fault scarps and

View to the west along the Bulnay fault near Bu'st Nur. Large tension gashes are filled with water.

Hand-excavated trench across the Bulnay fault showing the complex internal structure (recumbent folding and thrust faulting) in a large mole track created by the 1905 event. (Note: "mole track" is the term given to a small ridge formed by the humping up and cracking of the ground associated with movement along a large strike-slip fault.)

fault-related stream terraces, and sampling buried soils, peat deposits, and rock units for age dating. We also made careful measurements of the offset produced by the 1905 earthquake, which averaged around 8 meters (26 feet), about twice the average offset produced by the 1906 San Francisco earthquake. Stream-terrace relations and trench data provided evidence of at least two pre-1905 events; we are now awaiting the results of laboratory testing to determine their ages. Additional information on the 1998 Bulnay Fault Expedition is available on the World-Wide Web at http://quake.wr.usgs.gov/study/mongolia/1998.

New Publications of the UGS

UGS 50th anniversary calendar . Free

12 different postcards - Minerals of Utah .... 25¢ each

Geologic map of the Big Bend quadrangle, Grand County, Utah by Hellmut H. Doelling and Michael L. Ross, 29 p., 2 pl., 1:24,000, 12/98 M-171 .... $7.95

Surficial geologic map of the West Cache fault zone and nearby faults, Box Elder and Cache Counties, Utah, by Barry J. Solomon, 20 p., 2 pl., 1:50,000, 3/99 M-172..... $6.95

Map of recharge and discharge areas for the principal valley-fill aquifer, Sanpete Valley, Sanpete County, Utah, by Noah P. Snyder and Mike Lowe, 21 p., 1 pl., 1:125,000, 10/98 M-174 .... $6.00

Proceedings volume, Basin and Range Province Seismic-Hazards Summit, edited by William R. Lund, 204 p., 12/98, MP-98-2 .... $15.00

Large mine permits and plants in Utah, by Roger L. Bon, 4 p., 1 pl., 1:750,000, 12/98, PI-61 ...... $3.40

Map of recharge and discharge areas for the principal valley-fill aquifer, Sevier Desert, Millard County, Utah, by Noah P. Snyder, 21 p., 1 pl., 1:175,000, 10/98 M-175 . . $6.00

Coal resources of the Henry Mountains coalfield, by David E. Tabet, 32 p., 6 pl., scale 1:100,000, 1/99 OFR-362 .... $12.85

Technical reports for 1998, Applied Geology Program, compiled by Greg N. McDonald, 219 p., 3/99, RI-242 .... $12.50

Order form on back cover

Energy News

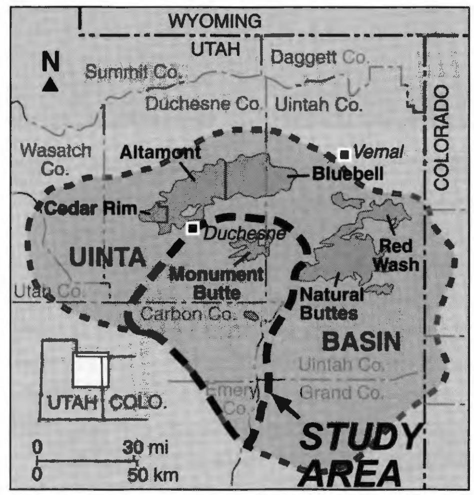
New DOE Project Targets Green River Formation

The Economic Geology Program of UGS, along with its academic and industry partners, will receive $842,000 from the U.S. Department of Energy for a three-year study of ways to increase oil production in existing reservoirs in the Uinta Basin. The grant is part of continuing research being funded by the Fundamental Geoscience for Reservoir Characterization Program of the U.S. Department of Energy's National Petroleum Technology Office in Tulsa, Oklahoma.

The UGS proposal, entitled "Reservoir Characterization of the Lower Green River Formation, Southwest Uinta Basin," is a three-year investigation of the subsurface and surface geology of the Green River Formation in the Monument Butte and Roan Cliff areas of the Uinta Basin. The study should help increase the knowledge of the Green River oil reservoir and help locate areas for further development.

In a letter announcing the grant, Patricia Godley, DOE Assistant Secretary for Fossil Energy, said, "As domestic crude oil becomes harder to produce, the likelihood that the nation will have to rely more on foreign imports increases. The Office of Fossil Energy's research and development program includes a major effort to assist U.S. producers in developing advanced technologies that can slow, or perhaps reverse, the decline in domestic oil production. The selection of the Utah Geological Survey is a key step in that program." She also noted that oil reservoirs commonly leave behind more than half of their original deposits. A similar project recently completed in the Monument Butte area "increased production dramatically," she said.

Partners in the study are Milind Deo, Ph.D., University of Utah, Department of Chemical and Fuels Engineering, Salt Lake City; S. Robert Bereskin, Tesseract Corp., Salt Lake City; Inland



Resources Inc., Denver; and Halliburton Energy Services, Denver. Barrett Resources Corporation, Celsius Energy Company, Inland Resources Inc., McCullis Resources Company, Petroglyph Operating Company, and Sego Resources have agreed to serve on a Technical Advisory Board to help guide the investigation. The project manager is UGS senior geologist Craig D. Morgan.

Exchange Makes Trust Lands a Major Player in Coal Production

When President Clinton signed H.R. 3830 into law on October 31, 1998, Utah's School and Institutional Trust Lands Administration became a formidable player in the immediate future of coal production in the state. The bill gave Utah cash and land, from which resources can be developed, in return for land inside national monuments, parks, recreation areas, forests, and Indian reservations where resource development was handicapped or prohibited.

In addition to $50 million in cash and $13 million in royalty payments, Trust Lands received more than 120,000 acres of land having potential for tar sands, limestone, coalbed methane, and coal resource development as well as potential for surface development. Trust Lands also gained more than 156 million tons of recoverable federal coal reserves from four federal coal tracts. With these acquisitions, Trust Lands could easily account for 50 percent of the state's total annual coal production as the properties come on-line, according to John T. Blake, mineral resources specialist with Trust Lands.

Survey News

Apologies to Mike Hylland for last issue's cover photo caption. SNTS vol. 31, no. 1 had his great shot of South Sixshooter Peak and Permian Cedar Mesa Sandstone, but we gave the caption inside as North Sixshooter and the Triassic Moenkopi Formation - a double error.

Personnel Moves

David Gillette, senior scientist with UGS, and State Paleontologist for the past 10 years, has taken a position with the Museum of Northern Arizona in Flagstaff. He is the recipient of the prestigious Colbert Chair [for Dr. Edwin H. Colbert].

Greg McDonald switched from the Economic section to Applied to take Bea Mayes' job as Senior Geotech.

Kelli Bacon of the Mapping section took her GIS skills to UDOT.

Ron Neely left the rigors of hauling core at the Sample Library for the job of Records Coordinator for Park City - lots lighter material, but it's still hundreds of boxes.

Governor Leavitt has appointed **Robert Robison** and **Charles Semborski** to replace UGS Board members Russell Babcock and Jerry Golden, whose terms expired. Robison is assistant plant manager of Continental Lime Co.'s Cricket Mountain Plant near Delta. Semborski is geology and permitting supervisor for Energy West, a subsidiary of PacifiCorp.

Presentations

Francis Ashland presented "Irrigation-Induced Piping and Slope Failure, Spanish Fork, Utah" to the Association of Engineering Geologists meeting in Seattle, Washington, in October and to the AEG Utah Section meeting in September. He also presented a poster session, "The Shurtz Lake Landslide, Utah County, Utah: Investigation and Monitoring of a Composite Landslide," to the AEG meeting in Seattle.

Kelli Bacon, **Kent Brown**, and **Grant Willis** presented posters on "New Extrusions: Digital Geologic Maps of Utah" at the Utah Geographic Information Council Conference '98 in St. George in November.

Craig Morgan presented posters on "Increased Oil Production and Reserves from Improved Completion Techniques in the Bluebell Field, Uinta Basin, Utah" at "Fractured Reservoirs: A Symposium on Current Research, Modeling, and Enhanced Recovery Techniques." The October meeting was hosted by UGS and the Petroleum Technology Transfer Council, Rocky Mountain Region.

Field Reviews & Field Trips

Francis Ashland and **Tom Chidsey** were co-leaders of a field trip to Spanish Fork Canyon to view exposed fractured and folded formations in the Wasatch Range. The excursion was part of the fractured reservoirs symposium hosted by UGS and the Petroleum Technology Transfer Council, Rocky Mountain Region.

Bob Biek and **Barry Solomon** co-led geologic mapping field reviews of the Clarkston and Portage quadrangles, Box Elder and Cache Counties, Utah.

Bill Case led a field trip for teachers to Big and Little Cottonwood Canyons as part of Earth Science Week in October.

Bill Lund participated in the expedition to the Bulnay fault, northwestern Mongolia (see related article).

Upcoming Meetings

In May 1999, the Economic Geology Program will host the 35th Forum on the Geology of Industrial Minerals. The Forum's purpose is to promote discussion of industrial mineral geology, production, uses, economics, and marketing. Members of the Economic Program are also involved in planning the annual meeting of The Society of Organic Petrologists, scheduled for September 1999 at the Snowbird Resort and Convention Center. TSOP's meetings attract international scientists who study petrology and nomenclature of coal and other organic materials.

Members of the Applied Geology Program are involved in planning the annual meeting of the Association of Engineering Geologists, which will be held at the Little America Hotel in Salt Lake City, also in September 1999.

More information about professional meetings involving members of the UGS staff can be found on the Internet at www.ugs.state.ut.us.

Contribution

UGS received a $50,000 donation from Amoco Production Company as a contribution to the UGS Sample Library Trust Fund. This is the largest contribution ever made to the UGS and the interest from the fund can be used to benefit the Sample Library.

On the Web

The U.S. Bureau of Land Management's new re-inventory of proposed Utah Wilderness lands is now available on the web at: http://www.access.gpo.gov/blm/utah/liv.html

"Glad You Asked"

Mark R. Milligan

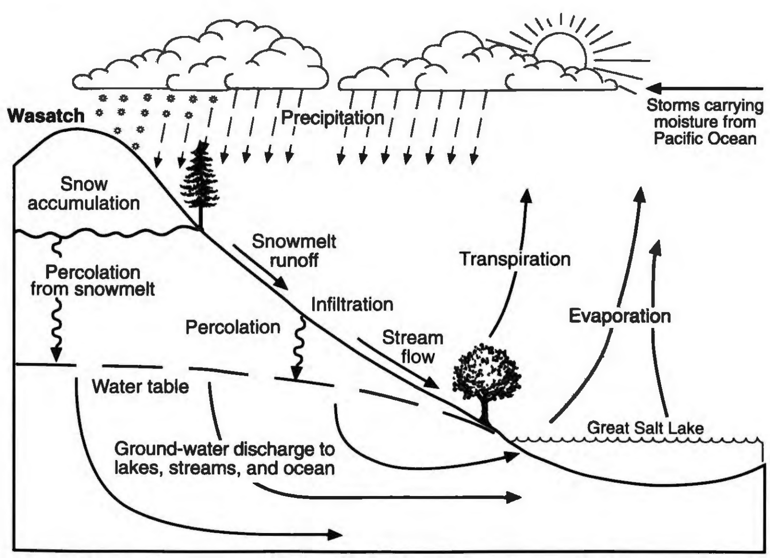
"Do You Have Any Information on the Hydrologic Cycle Specific to Utah?"

Before I address the peculiarities of Utah, what is the hydrologic cycle? The hydrologic cycle is the continuous circulation of water among the oceans, continents, and atmosphere. It can be thought of as a machine endlessly in motion, powered by the sun's energy and assisted by gravity. Essentially the same water has been circulating in this machine since the first clouds formed and the first rains fell on our earth; very little is ever lost or gained.

The continents contain about 2.5 percent of our planet's water, mainly in the polar ice caps and ground water. The atmosphere accounts for only about 0.0001 percent. The oceans hold the remaining 97.5 percent of our planet's water. About 90 percent of the water entering oceans is in the form of precipitation - rain and snow falling directly on the oceans. Runoff from the land accounts for the remaining 10 percent. The only significant outlet for ocean water is evaporation via the sun's energy (heat). On average, a molecule of water will remain in the oceans about 3,000 years before being transferred back to the atmosphere by evaporation.

Water evaporated into the atmosphere stays there an average of only 10 days before being dropped as rain, snow, or condensation back into the oceans or onto the land. In general, water precipitated onto land can (1) infiltrate the ground, becoming ground water that slowly flows to the sea, (2) flow across the surface, entering a system of streams and lakes which eventually flows to the sea, or (3) become glacial ice, eventually flowing to the sea. Of course, this is a simple description of a complex system and not all water travels completely through the cycle every time. Some water evaporates from streams and lakes, and even glacial ice, before reaching the sea, and plants use a relatively large amount of water and transfer it directly back to the atmosphere by a process called transpiration. While the system does not lose or gain water, the distribution in various parts of the cycle over different areas of the globe does change, causing floods and droughts.

Along the Wasatch Front and for most of northwestern Utah, a special circumstance exists where the surface runoff and ground-water components of the hydrologic cycle cannot flow to the ocean, but are limited to Great Salt Lake's closed basin. Storm tracks bring us summer rainfall and winter snowfall all the way from the Pacific Ocean, but this precipitation cannot flow back to the Pacific Ocean.



Schematic diagram showing hydrologic cycle with western Utah's closed basin sub-cycle.

Wasatch Front near Brigham City. "B" marks the horizontal bench created approximately 14,500 years ago by Lake Bonneville at its highest level, evidence of a wetter and/or cooler local climate.

Mountains and other topographic highlands contain the water within the basin (a sub-cycle within the larger hydrologic cycle). For a molecule of water to leave this basin, it must be evaporated and carried in clouds beyond the Wasatch Range, where it might fall as rain or snow, eventually flow into the Colorado River, and, with luck, on to the Pacific Ocean.

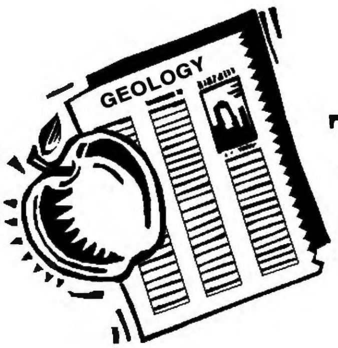
A Wasatch Front hydrologic sub-cycle contains many complexities and feedback loops. Great Salt Lake, through a process called "lake effect," can increase precipitation along the Wasatch Front. This lake effect contributes to "the Greatest Snow on Earth" at the ski resorts in the Cottonwood Canyons. At least two major phenomena control lake-effect precipitation: added moisture to the air due to evaporation from the lake's surface, and atmospheric instability caused by the temperature contrast between the air and lake water. In prehistoric times, the lake effect may have played even more of a role in the weather. A look around hillsides all across western Utah reveals the bathtub-like rings marking the shorelines of ancient Lake Bonneville. Lake Bonneville existed approximately 12 to 28 thousand years ago, covering much of western Utah and even parts of Nevada and Idaho at its highest level. This enormous surface area, up to approximately 19,800 square miles, could have contributed to greater lake-effect precipitation. Increased precipitation, especially on the Wasatch Front, caused increased runoff to the lake, helping to maintain Lake Bonneville's high level, in turn increasing lake-effect precipitation, and so on (a feedback loop).

The hydrologic cylce is complex. The precipitation component of the Wasatch Front hydrologic sub-cycle is not the sole control of the level of Great Salt Lake and its predecessor, Lake Bonneville. The interplay of precipitation and evaporation largely controls lake level. When the amount of water entering the lake (precipitation, surface water, and ground water) exceeds the amount of water leaving the lake (evaporation), lake level falls and vice versa. Many factors influence the evaporation portion of our hydrologic cycle, including temperature and wind. Decreases in temperature or wind speed decrease lake evaporation, thereby promoting lake-level rise. Some evidence, including that of glaciers in the Wasatch, suggests that the earlier climate in Utah was colder, and this may have been partially responsible for Lake Bonneville's rise.

This article barely scratches the surface of the complexities of our hydrologic cycle and geologic consequences such as lake levels. For example, we have not considered salinity, which can retard evaporation and slow the fall of Great Salt Lake. Salt crystals from Great Salt Lake and the surrounding salt flats can also become airborne and act as natural cloud seeding to enhance precipitation. Regardless of the specific details of our local hydrologic cycle, our water and all of the world's water continuously and endlessly circulates though the hydrologic cycle. On a global scale little water has been lost or gained over eons of geologic time. It has just been redistributed through various phases of the hydrologic cycle over various areas of the planet.

Wendy Hassibe

The UGS lost a good friend on March 11 with the passing of Wendy Hassibe. She worked for the USGS Public Information Office in Salt Lake, and then ran it for twenty years before being tapped to run the Information Services at USGS headquarters in Reston, Virginia. After that heavy stint, Wendy went to Denver, Colorado to head a team under the Office of Vice President Al Gore. A wonderful person and real professional - there are too few like her.



Teacher's Corner

by Sandy Eldredge

Geological Features and Processes in Utah

Part I: Volcanoes

This is the first in a series on Utah's geological features and processes, with activities included when possible. What are geological features and processes? Well, the features constitute anything from major landforms such as mountains or plateaus, to ripple marks or glacial striations (grooves) on a rock. The geological processes, such as volcanic eruptions, earthquakes, erosion, and deposition, are what create or change geological features.

Part I: Volcanoes. When teaching about Utah's mountains, don't forget this type!

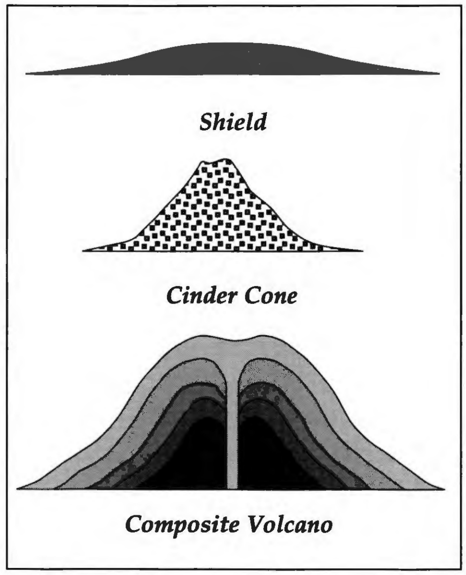
Volcanoes are created by internal forces within the Earth that cause heated, melted rock (magma) to rise to the surface. First collecting in magma chambers, some of the magma eventually pushes upward through cracks (vents) to the Earth's surface. As the magma reaches the surface, it loses some of its gases and turns into lava. Volcanoes are created by the release and build-up of lava and other materials. Volcanoes have varied shapes and sizes, but are divided into three main kinds depending on the type of material that reaches the surface and the type of eruption that ensues. Utah has all three types!

Three Types of Volcanoes

Composite volcanoes **(stratovolcanoes)** develop from repeated explosive and nonexplosive eruptions of tephra (airborne lava fragments that can range in size from tiny particles of ash to house-size boulders) and lava that build up layer by layer. These volcanoes are the largest and form symmetrical cones with steep sides. Some composite volcanoes in Utah are in the Tushar Mountains (Mt. Belknap, for example) in Piute County. Now extinct, they are too old (between 32 and 22 million years) to maintain the classic volcanic shape of their modern-day counterparts, such as Mount Hood and Mount St. Helens in the Cascade Range along the northwestern coast of the United States.

Shield volcanoes form from "gentle" or nonexplosive eruptions of flowing lava. The lava spreads out and builds up volcanoes with broad, gently sloping sides. The low-profile shape resembles a warrior's shield. In Utah a good example is the 1-million-year-old Fumarole Butte in Juab County. Currently active volcanoes of this type are found in the Hawaiian islands.

Cinder cones build from lava that is blown violently into the air and breaks into fragments. As the lava pieces fall back to the ground, they cool and harden into cinders (lava fragments about 1/2 inch in diameter) that pile up around the volcano's vent. Cinder cones are the smallest volcanoes and are cone-shaped. Cinder cones are found in many areas of Utah including Millard, Iron, Garfield, Kane, and Washington Counties, and they vary in age. The youngest, only about 600 years old, are in the Black Rock Desert in Millard County.



Activities (for 3rd grade)

1. Students can make models of the three volcanoes with clay or play dough of several colors on cardboard or cardstock.
2. Students can investigate different types of eruptions.

(a) **Materials** for pairs of students: Plaster of Paris, water, one small plastic zip-lock bag, food coloring or dry paint, one index card, scissors.

Procedures: Punch a small, pencil-size hole (*vent*) in the index card. Mix a small amount of Plaster of Paris with water in a zip-lock bag. Seal the bag, then cut a corner off of it to make a small hole. While one student holds the index card, the other student places the bag (*magma chamber*) under the hole in the card and squeezes slowly so that the Plaster of Paris mixture erupts (*lava*) through the hole onto the surface of the card. Add food coloring or dry paint to the bag mixture and create another eruption. You may have to re-open the vent from your first eruption.

Results/discussion: Depending on the water/Plaster of Paris ratio, the "lava" will range from liquid to viscous, which is true to nature. Some "lava" may take on a rope-like appearance, which is called pahoehoe (pa-hoy-hoy) lava. Have the students share their results, and explain if their eruption was explosive or not. Ask what type of volcano they created (*shield*).

(b) **Materials** for teacher: hair dryer/blower, sieve, paper holes (from a paper punch).

Procedures: Half-fill a sieve with paper holes. Place the hair blower underneath the sieve, turn it on, and watch the "eruption."

Results/discussion: Share observations. Discuss what type of eruption happened (*explosive*). Ask the students what type of material this may represent in a real volcano (*cinders or tephra*).

Some of this information was taken from a 3rd-grade Utah Core teaching packet called *Investigate Geological Processes that Shape Landforms - Earthquakes, Volcanoes, Erosion, Deposition*. For information on this packet and accompanying workshops, call Sandy Eldredge (UGS) at 801-537-3325 or Paula Wilson (Earthquake Education Services) at 801-585-5613.

Other resources:

For excellent information on volcanoes, currently erupting volcanoes, and for pictures (including a photo of Fumarole Butte), visit the web site http://volcano.und.nodak.edu/

A super teaching packet called *Volcanoes!* (includes a poster and activities) is offered free of charge to teachers through the U.S. Geological Survey. To order, call 1-800-USA-MAPS, or fax 703-648-5584.

Celebration Marks Official Opening of New Sample Library

The Utah Geological Survey in October officially opened its new home for Utah's only repository for geologic samples taken from holes drilled in the search for petroleum and mineral resources in the state. The Sample Library, established in 1951, now occupies a 12,000-square-foot warehouse designed and built to house a collection of cuttings (rock fragments that are extracted from a drill hole), and cores (solid rock samples extracted using special hollow drills).

The Sample Library currently holds cuttings from more than 3,500 holes and core samples from more than 650 holes drilled in resource exploration efforts in Utah; a collection of oil samples from all producing formations in the state; representative coal samples from Utah's producing coal mines; dinosaur and other fossils; miscellaneous examples of metallic minerals, industrial rocks and minerals, tar sands, and oil shale; and geologic materials from geothermal wells and surface stratigraphic sections.

The library's function is to provide a service to all interested individuals, universities, and companies requiring direct observation of actual samples for their research or investigations. It acts as a repository for irreplaceable geologic samples, and is being used more and more for educational purposes such as training sessions for oil company personnel, college thesis work, and sample evaluations for UGS/industry cooperative projects.

The new Sample Library is easier to find and more spacious, which should increase its use by scientists interested in Utah's core and cuttings history, such as this group at a recent workshop sponsored by UGS and the American Association of Petroleum Geologists.

The Rockhounder

Birdseye Marble in the Manti-La Sal National Forest, Utah County

by Carl Ege

Geologic Information: Approximately 58 to 66 million years ago (Paleocene epoch), a large body of water known as Lake Flagstaff covered parts of northeastern and central Utah. This lake deposited a sequence of sediments that formed rocks known as the Flagstaff Formation. Although these rocks are technically a limestone, the building stone industry has termed this deposit a "marble." The rocks are rich in algal ball structures commonly known as "birdseyes." These birdseye features were formed by algae that grew around snail shells, twigs, or other debris. The algae used these objects as a nucleus, forming into unusual, elongated, concentric shapes.

How to get there: From Salt Lake City take I-15 south approximately 50 miles to Spanish Fork (exit 261). Travel east and proceed up Spanish Fork Canyon (Rte 6) for about 13.5 miles to Hwy 89. Make a right onto Hwy 89 and go south about 5.8 miles until you see a gravel road to your left. Make the left turn and proceed up the road until you reach a gate. This gate marks the beginning of Forest Service Road 126. Before you proceed up the road, remember to close the gate after yourself. Continue up this road for about 1.5 miles until you see a sign indicating that you have crossed into the Forest Service lands.

Where to collect: Specimens can be found along the road just after crossing the Forest Service boundary. If you feel adventurous, this road can be followed up to the abandoned birdseye marble quarry (roughly 2.5 miles), but four wheel drive is highly recommended. Some of the birdseye marble contains cores of snail fossils, which have been replaced by the mineral calcite. This material takes a great polish and is ideal for making unusual decorative bookends.

Useful maps: Nephi 1:100,000-scale topographic map; Birdseye 1:24,000-scale topographic map; Manti-La Sal Forest Service map covering the Sanpete, Ferron, and Price ranger districts; and a Utah highway map. Topographic and Forest Service maps can be obtained from the Natural Resources Map & Bookstore, 1594 W. North Temple, Salt Lake City, UT, (801) 537-3320 (or 1-800-UTAH-MAP).

Birdseye marble of the Flagstaff Formation (rock hammer for scale).

Land ownership: Manti-La Sal National Forest.

Forest Service collecting rules: Rock, mineral, and fossil collecting on lands managed by the U.S. Forest Service requires a permit, which is free to the public. The permit allows one to collect small amounts of material for personal use. This permit can be obtained at the Manti-La Sal National Forest office, Monday through Friday from 8:00 a.m. to 4:30 p.m. at 599 West Price River Drive, Price, UT, (435) 637-2817 or (435) 637-3521.

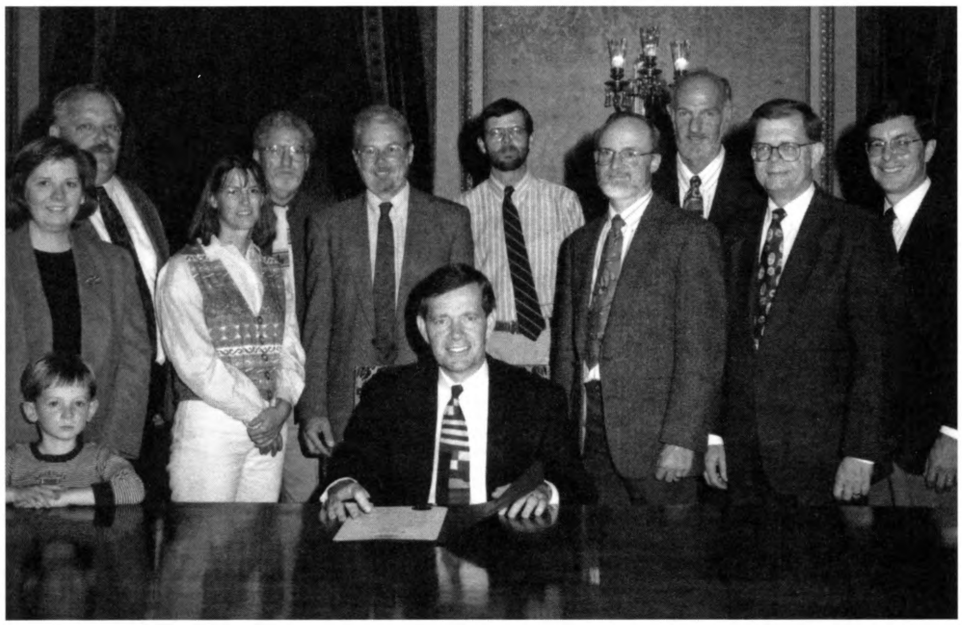
Miscellaneous: Remember to bring plenty of water and a first aid kit in case of emergencies. The usual rockhounding tools are needed: gloves, hammer, wrapping paper, and safety glasses. Most importantly, be patient and have fun!

Utah Joins Others in Recognizing Earth Science Week

With a stroke of a pen and an acknowledgment that earth sciences are fundamental to the understanding and appreciation of our natural world, Governor Michael O. Leavitt officially proclaimed the week of October 11 to 17 as "Earth Science Week" in Utah. He joined governors of 33 other states, including Arizona, Colorado, New Mexico, and Nevada, in making this observance in an effort to encourage every geoscientist in the country to become involved in community programs designed to promote the earth sciences.

"Earth Science Week has enormous potential for increasing public awareness and understanding of the importance of this scientific discipline in our lives," he said in signing the proclamation.

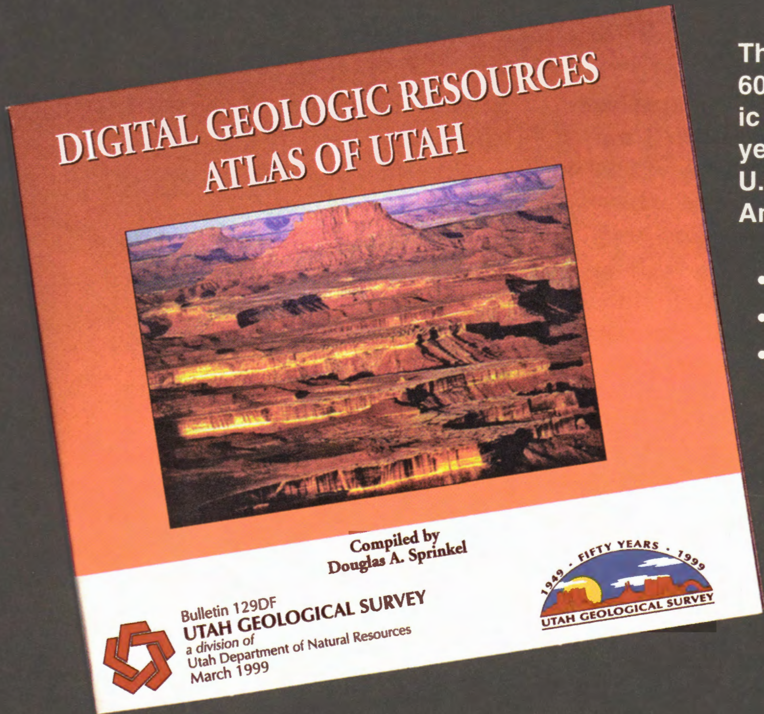
The earth sciences -- which include geology, geography, paleoecology, meteorology, hydrology, oceanography, and paleontology -- contribute to stewardship and development of natural resources. In addition, as the proclamation noted, earth sciences are fundamental to the safety, health, and welfare of Utahns and to the economy of Utah because they are integral to finding, developing, and conserving mineral, energy, and water resources needed for Utah's continuing prosperity; provide the basis for preparing for and mitigating natural hazards such as earthquakes, floods, and landslides; are crucial to environmental and ecological issues ranging from water and air quality to waste disposal; are vital to land management and land-use decisions; and contribute to our understanding and appreciation of, and our respect for, nature.



During the signing ceremony in the Gold Room at the State Capitol, witnesses watched Governor Michael Leavitt sign a proclamation designating the second full week of October as Earth Science Week. Looking on were (from left) Paula Wilson, Ph.D., adjunct professor of geology at the University of Utah and president of the local chapter of the Association for Women Geoscientists (accompanied by her son, Jonathan, who was representing the future of earth science education); Robert Ford, Ph.D., environmental scientist with the Utah Division of Air Quality and president of the local chapter of the American Insitute of Professional Geologists; Sandy Eldredge, program manager, Geologic Extension Service, Utah Geological Survey; Bill Case, geology instructor, Westminster College; Lee Allison, Ph.D., State Geologist and Director, UGS; Governor Leavitt (seated); Rich Giraud, Association of Engineering Geologists; John Bartley, Ph.D., chair of the Geology and Geography Department, U of U; Frank Brown, Ph.D., Dean of the College of Mines and Earth Sciences, U of U; Steve Church, president of the Utah Geological Association; and Don Harris, chair of the Public Education Committee, Utah Geological Association.

At a separate ceremony in Washington, D.C., President Bill Clinton released a presidential message saluting the earth sciences and encouraging "all Americans, especially our young people, to participate in the different Earth Science Week activities occurring in the schools and communities across the country."

"Earth scientists are the stewards and caretakers of our environment, and this week offers a special chance to learn about the miracles and mysteries they study each day," Clinton's statement continued:,"All of us are indebted to these dedicated men and women whose contributions to research, innovative technologies, and new knowledge have improved the quality of our lives and the well-being of our nation."



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