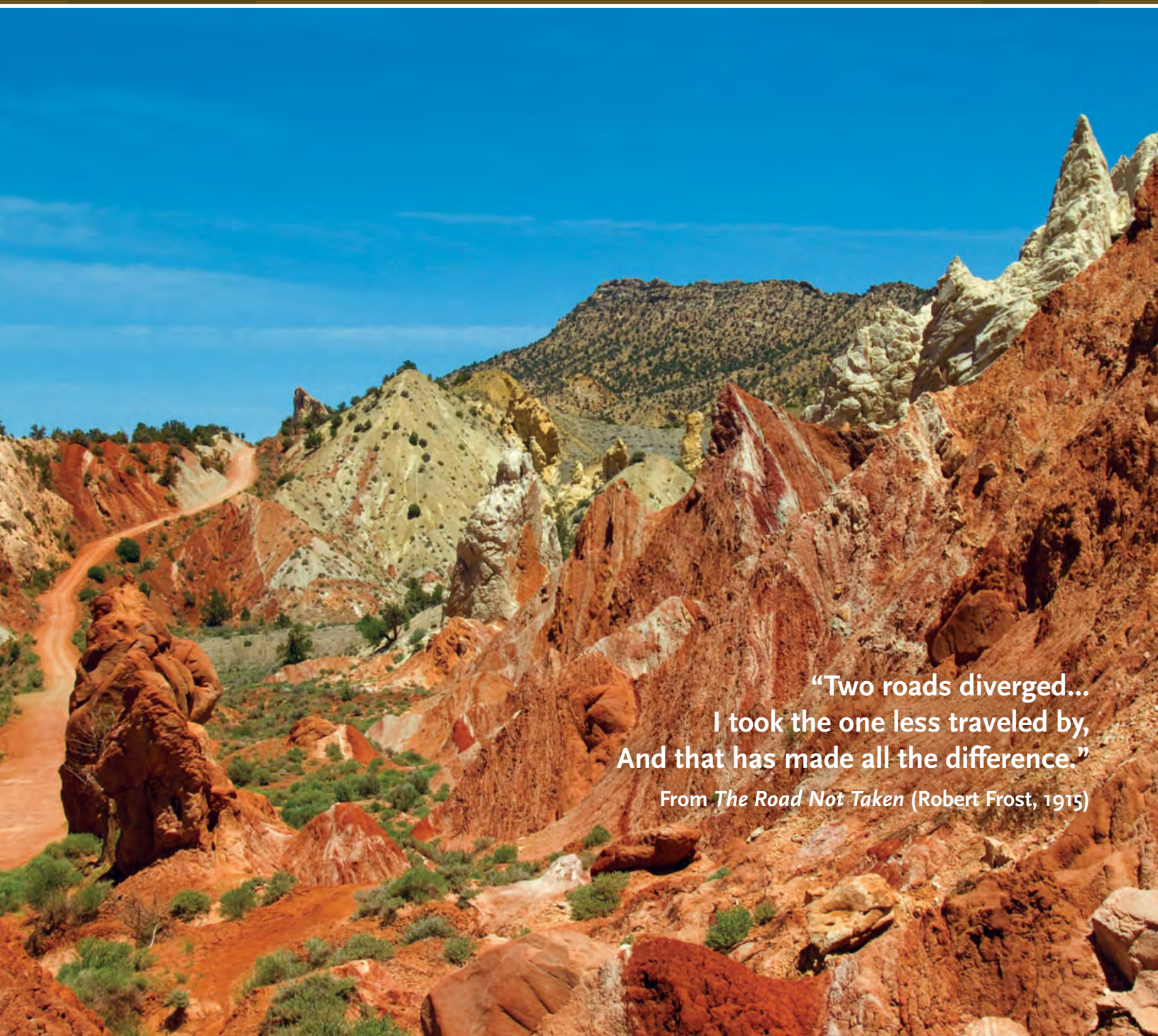


U T A H G E O L O G I C A L S U R V E Y

SURVEY NOTES

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“Two roads diverged...
I took the one less traveled by,
And that has made all the difference.”

From The Road Not Taken (Robert Frost, 1915)

THE DIRECTOR'S PERSPECTIVE



by Richard G. Allis

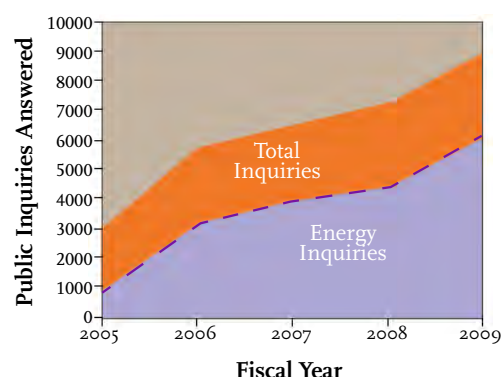
This issue of *Survey Notes* highlights the breadth of energy expertise within the Utah Geological Survey (UGS). In addition to conducting research in the traditional fossil energy areas of oil, gas, and coal, and non-traditional resources such as oil shale and tar sands, the UGS also manages the Utah State Energy Program (USEP) which is responsible for administering local federal initiatives to stimulate energy efficiency and renewable energy projects in Utah. The largely non-regulatory role of the UGS enables us to focus on providing the best possible objective information about resource potential within the state. We maintain the statistics on historical energy use trends in the state (visit geology.utah.gov/emp/energydata/index.htm), provide the energy chapter for the Annual Economic

Report to the Governor, and provide regular input on resource production trends to the Revenue Assumptions Committee of the Governor's Office of Planning and Budget. The major challenge for the USEP at the moment is ramping up the programs to disperse \$50 million in federal "stimulus" funds within the state over the next two years.

The economic boom-to-bust cycle over the past two years continues to ripple through Utah's energy sector and can be seen in the energy statistics. Natural gas prices remain depressed compared to what is needed to sustain production, the number of active drilling rigs is now only 35 percent of what it was 16 months ago, and total energy consumption in the state for 2009 will likely be down by at least 5 percent compared to 2008. However, total production of oil and gas in Utah for 2009 is projected to continue the upward trend of previous years (see page 4), with marketed gas production setting a new record of about 455 billion cubic feet (bcf) compared to 432 bcf in 2008. Half of this gas is exported for use in other states. Not all new production has been in fossil fuels. Two renewable energy power plants were commissioned this year—the 10 megawatt Hatch geothermal power plant near Minersville, and First Wind's 240 megawatt wind farm near Milford.

The national challenges of sustaining a secure and affordable energy supply for

the future will ensure that energy issues remain center stage, especially with the concerns that carbon dioxide emissions need to be managed. Two relevant areas where the UGS is active are the feasibility of geological sequestration of CO₂, and improving energy efficiency and the use of renewable energies. Both areas have the potential to significantly reduce the state's CO₂ emissions.



One dramatic trend that the UGS has seen over the past five years is the number of inquiries we receive about energy-related issues. There are a number of reasons for the progressive rise in inquiries, but overall it demonstrates the growing importance of energy issues to all sectors of Utah's economy. It also shows the important role that the UGS is now playing in supplying critically needed energy information.

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Design: Stevie Emerson

Cover: Vertical beds of the Middle Jurassic Carmel Formation are displayed along The Cockscomb, part of the East Kaibab monocline in Grand Staircase-Escalante National Monument.

Photo by Michael Vanden Berg.

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UTAH POTASH

RESOURCES, PRODUCTION, AND EXPLORATION

by Bryce T. Tripp

INTRODUCTION

The word potash refers to a group of naturally occurring potassium-bearing minerals, the most common of which is sylvite (potassium chloride). Potash is used to manufacture a variety of products including soap, glass, synthetic rubber, and explosives. Potash is also an essential plant nutrient, and 93% of the potash mined in the world is used as plant fertilizer. The word originates from the historical practice of burning wood to obtain potassium carbonate-bearing ash which was then leached and precipitated in iron pots—"pot ash." This nutrient is contained in all balanced fertilizer mixes. Bags of fertilizer are labeled with an N-P-K code like 30-10-10; the first number indicates the nitrogen content (N), the second number indicates the phosphorous content (P), and the third number indicates the potassium content (K).



Horticultural test plot in Brazil showing growth of soybeans with no added potash fertilizer (yellow, stunted plants in foreground) versus potash-fertilized plants (vigorous green plants in background). Photo credit: International Potash Institute.

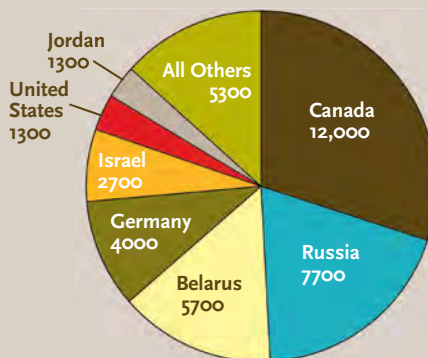
Potassium is found in a variety of salts, is a common element in many rock-forming minerals, and is the 7th-most common constituent of the Earth's continental crust (about 2%). It is most concentrated and in a water-soluble form in (1) surface and sub-

surface brines of closed-basin lakes and (2) restricted marine basin (evaporite) deposits. Evaporite deposits worldwide are the most economically important sources of potash. Evaporite minerals precipitated out of concentrated sea water in geologic basins that were partially restricted from the open ocean. Minerals dissolved in sea water precipitate sequentially from solution (during evaporation) based on their solubilities so carbonate minerals precipitate first, then sulfates, and finally chlorides. Sylvite is one of the last salts precipitated; almost all of the water in brine has evaporated before sylvite starts to precipitate.

In 2008 the U.S. Geological Survey (USGS) reported that world production of potash was about 40 million tons (K_2O equivalent); seven countries

produced most of that amount. Canada, Russia, and Belarus are the three largest potash producers. The USGS estimates a world resource of 276 billion tons (K_2O), a U.S. resource of 7.7 billion tons (K_2O), and a Utah resource of 2.2 billion tons (K_2O).

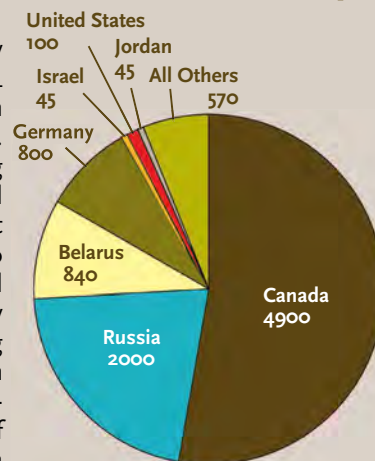
WORLD POTASH PRODUCTION, 2008
(THOUSANDS OF SHORT TONS K_2O)



U.S. Geological Survey data.

Potash prices have historically been very stable; between 1994 and 2003 the price remained in the range of \$146 to \$179 per ton. The potash price started rising in 2005 and during 2008 spiked to more than \$900 per ton, but by mid-2009 had declined to about \$500 per ton. Increased potash prices were caused by an increased standard of living in developing countries (with increased use of chemical fertilizer) and also increased use of fertilizer for ethanol production from corn.

WORLD POTASH RESERVES, 2008
(MILLIONS OF SHORT TONS K_2O)



U.S. Geological Survey data.



Utah's potash resources, including resource areas (colored polygons) and individual alunite deposits (colored circles). Potash production locales shown by yellow crosses.

POTASH DEPOSITS OF UTAH

Utah contains substantial potash resources, and potash has been an important mineral product in the state since 1917. Significant quantities of potash are contained in (1) surface brine of Great Salt Lake, (2) subsurface brine of the Great Salt Lake desert, (3) subsurface brine of the Sevier Lake playa, (4) potash beds and associated subsurface brines of the Paradox Basin, and (5) alunite (potassium aluminum sulfate) vein and replacement deposits distributed across southwestern Utah.

Two companies currently produce potash in Utah. Great Salt Lake Minerals Corporation produces more than 400,000 tons of potash (potassium sulfate) each year by solar evaporation of surface brine of the north part of Great Salt Lake at their plant west of Ogden. They are currently trying to obtain permits for 80,000 acres of additional solar evaporation ponds to increase their production. Intrepid Potash, Inc., processes shallow subsurface brines through its solar evaporation ponds and plant at Wendover. Intrepid also solution mines Paradox Basin bedded potash and processes it through their Moab (Cane Creek) solar ponds and mill.

The high potash prices of the past few years have encouraged a flurry of potash exploration and development worldwide, including in Utah. The Paradox Basin has received more interest than other Utah potash resources because it is the largest resource with the most opportunities for new developments.

PARADOX BASIN POTASH

Structure and Stratigraphy

The Paradox Basin bedded potash is contained in the northwest-trending Paradox Basin of Pennsylvanian to Permian age (about 300 million years ago). The Paradox Basin is bounded on the northeast by the Uncompahgre uplift, an uplifted fault block of the Ancestral Rockies. As the Uncompahgre began to rise in Pennsylvanian time, the adjacent Paradox Basin began to subside with the deepest part of the basin adjacent to the Uncompahgre. Salt was deposited in this basin during Pennsylvanian time. A combination of variable salt thickness and salt flowage after burial warped the salt into a series of northwest-trending salt anticlines where the salt is thickened (and often folded and faulted), separated by synclines where the salt is dramatically thinned.

As the Paradox Basin began subsiding, a few hundred feet of predominantly carbonate sediments were deposited as the Pennsylvanian Pinkerton Trail Formation of the Hermosa Group. The basin then became partially restricted from the open sea and as much as 5000 feet of predominantly evaporite sediments (gypsum, halite, potash, and magnesium salts) were deposited as the Paradox Formation of the Hermosa Group. Fluctuations in sea level, and probably in basin subsidence rates, resulted in deposition of 29 rhythmically bedded evaporite cycles; in 18 of the cycles, evaporation proceeded to the point of potash deposition. The salt cycles in the Paradox Formation are often laterally continuous and can be traced, through interpretation of well logs, in the subsurface for tens of miles. The depositional center of the basin shifted over time and the basin floor had varied topography, so not all 29 salt cycles are stacked vertically at any one point in the basin. In the 1960s, Robert Hite (with the USGS) devised a stratigraphic framework for the salt cycles, numbering them from 1 (shallowest) to 29 (deepest) and correlated them across the Paradox Basin. Intrepid Potash, Inc., solution mines the potash of salt cycles 5 and 9 at its Moab mine.

Potash Resource

The salt-bearing zone in the Paradox Basin is about 4000 feet thick and is composed of 10 percent potash beds, 25 percent shale beds (with anhydrite and dolomite), and 65 percent halite beds. Usually eight to 10 potash zones underlie the potash resource areas of the basin and have an aggregate thickness ranging from 220 to 460 feet. In 1965 the U.S. Bureau of Mines estimated the Paradox Basin known potash reserves to be 254 million tons (K_2O equivalent) with an inferred reserve of 164 million tons (K_2O equivalent). This estimate was based on underground mining of potash beds greater than 4 feet thick, containing more than 14 percent K_2O content, and at depths less than 4000 feet. Due to potash deposit complexity, safety issues with underground mining in the Paradox Basin, and improvements in horizontal drilling technology, any future development will likely be by solution mining. Solution mining through drill holes may make potash from beds as deep as 9000 feet recoverable, greatly expanding the potash resource. Some of the oil and gas wells drilled between 1965 and the present penetrated the potash zone; this additional information would probably increase the U.S. Bureau of Mines potash reserve estimates listed above.



Great Salt Lake Mineral's potash evaporation ponds and plant looking north from Little Mountain.



Intrepid Potash's Wendover plant looking north across the solar evaporation ponds to the plant with the Silver Island Mountains in the background and snow-covered Pilot Range in the distance.



Intrepid Potash's solar evaporation ponds near Moab. The blue color is caused by dye added to the brine to increase evaporation. The dry potash is harvested and hauled for processing at the plant located in the upper-right part of the image. Photo credit: Intrepid Potash, Inc.

Future Development

The Utah School and Institutional Trust Lands Administration and the U.S. Bureau of Land Management (BLM) have met with many companies about exploration and leasing of land in the Paradox Basin. However, there are a few hurdles to new development: (1) the BLM needs to re-examine their Known Potash Leasing Area boundaries before granting new leases, (2) the recent world credit crisis has made funding for new developments difficult to obtain, and (3) the price for potash has declined from its peak at the end of 2008. Even with these hurdles, development of new solution mines in the Paradox Basin seems possible if potash prices remain at their relatively high level or increase. ■

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ABOUT THE AUTHOR



Bryce Tripp has worked with the Utah Geological Survey since October 1979 as an industrial mineral geologist, project manager, section chief, and program manager. He graduated from the University of Utah, Department of Geology, with a B.S. degree in 1977. Bryce has studied tar sand, zeolite, high-calcium limestone, dimension stone, gypsum, sand and gravel, gilsonite, and potash resources of Utah. He has also worked on long-term projects provid-

ing industrial mineral information to state and federal land management agencies. He is a member of the American Association of Petroleum Geologists and Society for Mining, Metallurgy, and Exploration Inc., and is a member and past president of the Utah Geological Association. Bryce retired from state employment in December 2009.

MAJOR OIL PLAYS

IN UTAH AND VICINITY

by Thomas C. Chidsey, Jr.

Introduction

One of the benefits of Utah's diverse geology is a wealth of petroleum resources. Three oil-producing provinces exist in Utah and adjacent parts of Wyoming, Colorado, and Arizona—the thrust belt, Paradox Basin, and Uinta Basin. Utah produces oil from eight major “plays” within these provinces, where a play is defined by the U.S. Geological Survey as a set of known or postulated oil accumulations sharing similar geologic, geographic, and temporal properties such as hydrocarbon-generating source rocks, oil migration pathways, trapping mechanisms, and hydrocarbon types. The Utah Geological Survey (UGS) has recently completed a study, funded in part by the U.S. Department of Energy, that describes concisely and in new detail each of these major oil plays.

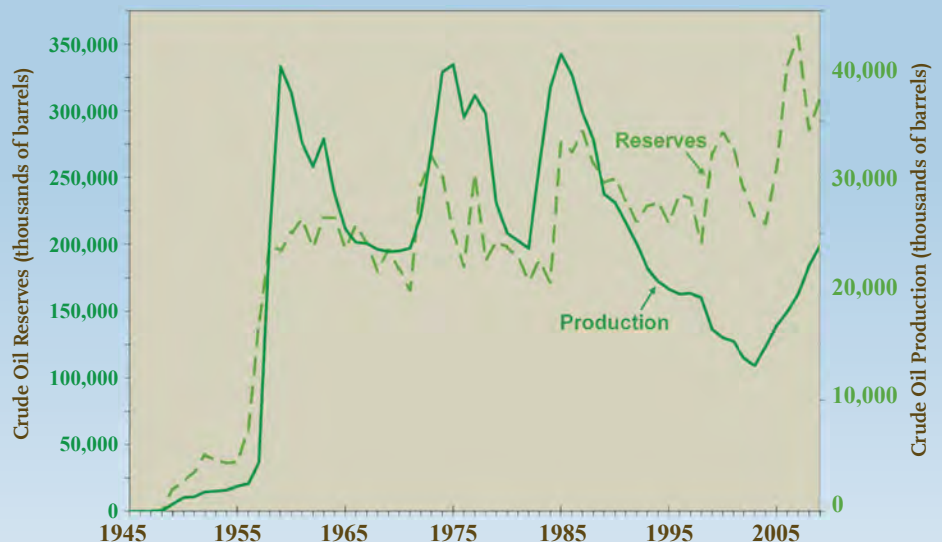
Utah Oil Production and Proven Reserves

Utah oil fields have produced over 1.36 billion barrels since production began in the 1940s. Although production declined from the mid-1980s to 2002, when it reached a 40-year low, the trend has since reversed. Discovery of Covenant oil field in the central Utah thrust belt (“Hingeline”) play and increased development drilling in the Uinta Basin have stimulated the increased production. Among oil-producing states, Utah currently ranks eleventh in domestic oil production. There are over 200 active oil fields in Utah.

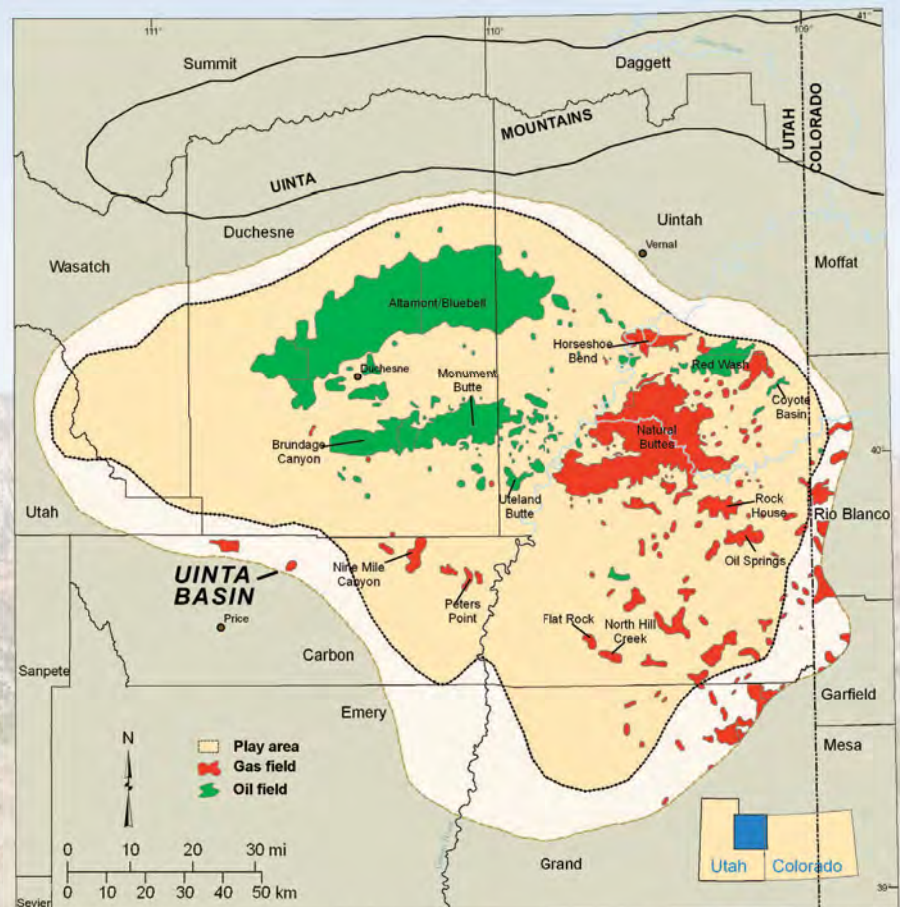
Despite over 40 years of production at rates that have varied by a factor of three, Utah's proven oil reserves during this time have remained above 200 million barrels, indicating significant oil remains to be produced. As of 2009, proven reserves are relatively high, at 355 million barrels. With higher oil prices now prevailing, state-of-the-art horizontal drilling and secondary and tertiary recovery techniques should boost future production rates and ultimate recovery from known fields.

Potential Increased Recovery/ New Technology

While Utah still contains large areas that are virtually unexplored, there is also



Oil production and reserves in Utah as of January 1, 2010, showing an increase since 2002 due, in part, to the discovery of Covenant field in the new central Utah thrust belt play.



Oil and gas fields in the Uinta Basin of Utah and Colorado. Significant amounts of by-passed oil in many of the basin's fields could be produced using special well-evaluation and stimulation techniques.



Oil and gas fields in the Paradox Basin of Utah, Colorado, and Arizona. New regional subsurface maps, evidence of deep hydrothermal activity, and innovative exploration methods suggest large areas of untested oil potential.

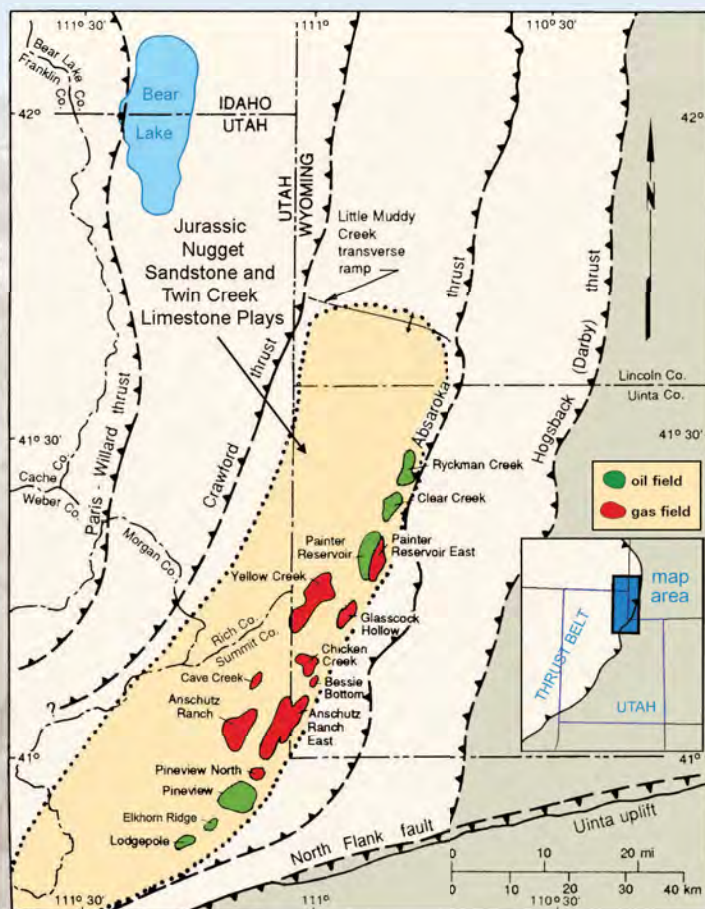
significant potential for increased recovery from existing fields by improved understanding of reservoir (the oil-producing rock layers) characteristics and use of the latest drilling, well-completion, and secondary/tertiary production technologies. New exploratory targets may be identified and better defined using advanced technologies such as three-dimensional (3-D) seismic surveys or soil-gas surveys. Development of potential prospects is within the economic and technical capabilities of both major and small independent companies.

New UGS Study

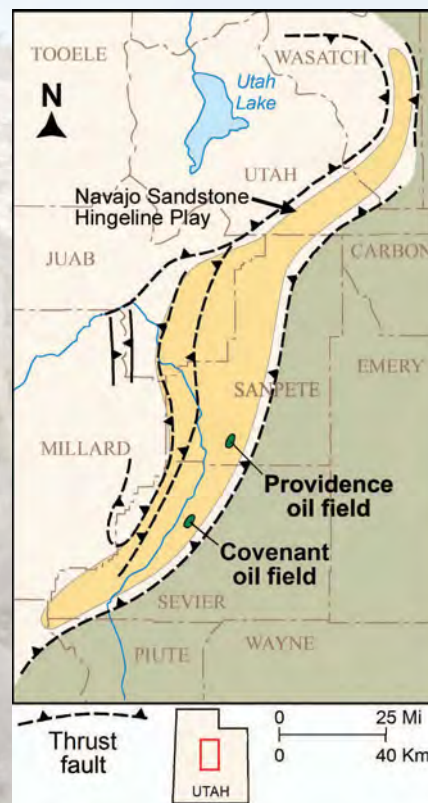
The new UGS study will help increase recoverable oil reserves from existing field reservoirs and new discoveries by providing play portfolios for the major oil-producing provinces. The play portfolios include the following descriptions: (1) tectonic setting, (2) reservoir stratigraphy, thickness, and rock types (lithology), (3) type of oil traps, (4) rock properties, (5) oil and gas chemical and physical characteristics, (6) source rocks including timing of generation and migration of oil, (7) exploration and production history, (8) case-study oil field evaluations, (9) summaries of the state-of-the-art current and potential best drilling, completion, and production practices, and potential for new secondary/tertiary enhanced oil recovery, (10) descriptions of reservoir outcrop analogs for each play, (11) exploration potential and trends, and (12) maps of the major oil plays and subplays.

Significant Findings

- The 2004 discovery of the 100-million-barrel Covenant field in the central Utah thrust belt changed the oil development potential of the Jurassic (176 million years) Navajo Sandstone Hingeline play from hypothetical to



Oil and gas fields, uplifts, and major thrust faults (sawteeth) in the Utah-Wyoming thrust belt. Future exploration could focus on more structurally complex and subtle, thrust-related traps using 3-D seismic surveys with any new fields developed by horizontal drilling.



Location of Covenant and Providence oil fields, uplifts, and selected thrust systems in the central Utah thrust belt. Numerous structures in the region have untested oil potential.

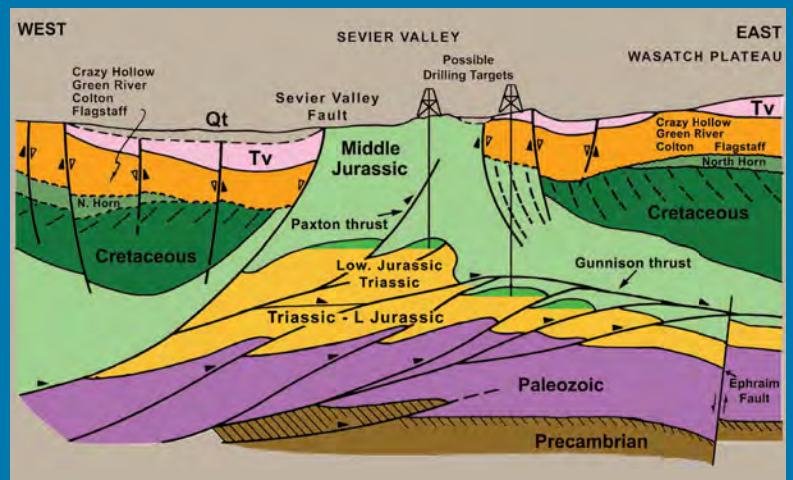
proven (another field, Providence, was discovered in 2008). Deep, Paleozoic-cored thrust structures (folds developed along low-angle faults where older rocks have been pushed over younger rocks) represent numerous future drilling targets.

- The best reservoir properties associated with the Mississippian (340 million years) Leadville Limestone Paradox Basin play were developed during late (34 million years), deep subsurface hydrothermal activity. Relatively low-cost surface geochemical surveys, hydrodynamic analysis, and other innovative techniques can identify potential Leadville hydrocarbon migration patterns and oil-prone areas in this environmentally sensitive region.
- Mapping the environments in which the reservoir rocks were deposited in the Paradox Formation (Pennsylvanian age—308 million years) play delineated very prospective trends in the Paradox Basin that may contain untested, ancient reef-like and Bahamas bank types of carbonate buildups that are potential hydrocarbon traps.
- In the Uinta Basin, the current production practices in several oil plays will leave a significant amount of oil unproduced in older wells. Special cased-hole well logs can identify by-passed oil in individual beds (40 or more in many wells). These beds can then be selectively stimulated to recover additional oil.
- Utah has numerous production-scale outcrop analogs that provide an excellent view of reservoir properties, environment of deposition, and lateral and vertical changes in these characteristics for each oil play. They can be used as a “template” for evaluation of data from rock core taken from wells, geophysical well logs, and seismic surveys, and the development of reservoir models for field development.

Who Benefits from the Study?

The Utah play portfolios in this study provide a comprehensive geologic, engineering, and geographic reference to help petroleum companies plan exploration, land-acquisition strategies, and field development. These portfolios can also help pipeline companies plan future facilities and pipelines. Other potential users of the portfolios include petroleum engineers, petroleum land specialists, landowners, bankers and investors, economists, utility companies, manufacturers, county planners, and numerous government resource management agencies.

The UGS plans formal publication of this study in the near future. Contract quarterly reports are available on the UGS project Web site geology.utah.gov/emp/pump/index.htm. ■



Schematic east-west structural cross section through Sevier Valley within the Hingeline area showing potential drilling targets in folds created by stacked thrust faults. Modified from Villien and Kligfield, AAPG Memoir 41, 1986.



Soil sampling for geochemical analysis in the Lisbon field area of the Paradox Basin. Geochemical surveys analyze soil samples for trace amounts of hydrocarbons that have naturally seeped to the surface from undiscovered oil traps.



The Jurassic Nugget/Navajo Sandstone was deposited in an extensive dune field that extended from Wyoming to Arizona. Outcrop analogs for thrust belt oil fields are found in the Navajo which display large-scale dunal cross-strata in sandstone with excellent reservoir properties. Example outcrop is along Lake Powell in Glen Canyon National Recreation Area.

THE MERCUR DISTRICT

A HISTORY OF UTAH'S TOP GOLD CAMP

by Ken Krahulec

Historically, most gold has been produced from veins, placers, or as a by-product from base metal mines. However, in the early 1960s a new type of gold deposit was recognized at Carlin, Nevada. These Carlin-type sedimentary-rock-hosted gold deposits are unique in that the gold occurs primarily as microscopic particles disseminated in dark-gray to black, platy, carbonaceous, silty limestone. The gold grains are too small to see with the naked eye or even a magnifying hand lens (generally less than 0.0002 inch across), and eroding gold deposits do not form placers that a prospector could identify in the field. What was not recognized until 1968 is that the gold deposits at Mercur, Utah, which had been successfully mined in the 1890s, also belong to the Carlin deposit type.

The Mercur mining district lies on the southwestern flank of the Oquirrh Mountains in eastern Tooele County. The district was originally organized in 1870, and the initial production was from high-grade silver pockets. However, this early boom quickly faded and the camp was reorganized and renamed Mercur after a cinnabar (mercury sulfide) discovery in 1879. In 1883, a “gold ledge” was discovered, but the gold could not be recovered economically (because the grains were too small to concentrate) until the mine began using the “new” cyanide process in about 1890. In 1897, the 1000-ton-per-day Golden Gate mill at Mercur was the largest cyanide mill in the U.S., and it operated very successfully until about 1913 when decreasing gold grades from the mine made the operation unprofitable.

The history of the Mercur camp is enriched by a couple of important figures who were there during this 1890 to 1913 boom period. George H. Dern was general manager and superintendent of the Mercur Gold Mining and Milling Company and later the Consoli-

dated Mercur Gold Mines Company. Dern went on to positions with mining companies in the Park City, Tintic, and Little Cottonwood mining districts before becoming the two-term governor of Utah from 1924 to 1933. Daniel C. Jackling was the metallurgical and construction superintendent of the Golden Gate mill, which was one of the first successful cyanide mills in the U.S. After his success at Mercur, Jackling (1) was a founder of the Utah Copper Company (Bingham), (2) became president of Kennecott Copper Company, (3) was recognized as the “father” of open pit copper mining, (4) developed the “Jackling porphyries” in Utah, Arizona, New Mexico, and Nevada, and (5) was inducted into the National Mining Hall of Fame.

Production from the Mercur district after 1913 was minor and intermittent until continuous gold production resumed with increased gold prices from 1933 until 1942. Then the U.S. government closed all gold mines (Order L-208) to conserve manpower and materials for World War II. Following the brief mining of some silver-rich silica flux for the Garfield copper smelter at the north end of the Oquirrh Mountains, production in the Mercur district ceased again in 1945.

In 1968, Newmont Mining Corporation recognized the similarity of Mercur to their Carlin gold mine, indicating that Mercur was a Carlin-type deposit. They acquired the old Marion Hill and Sacramento mines as well as adjoining areas in the southern part of the Mercur district. Newmont drilled a series of unsuccessful exploration holes before dropping their interest in the district. Gold Standard, Inc., then consolidated the major land holdings in the central part of the district in the early 1970s, including some property owned by Charlie Steen, Utah's uranium king, and sold the property to Getty Oil Company in 1973. Getty revived production in the old camp, following the escalating gold price, in 1983 with a large open pit mine—heap leach operation. Barrick Gold Corporation acquired the mine in 1985, an autoclave was added in 1989 to improve gold recovery, and the mine produced over 100,000 ounces of gold per year until 1995 when the economic reserves were exhausted. Currently, the mines are nearly completely reclaimed.

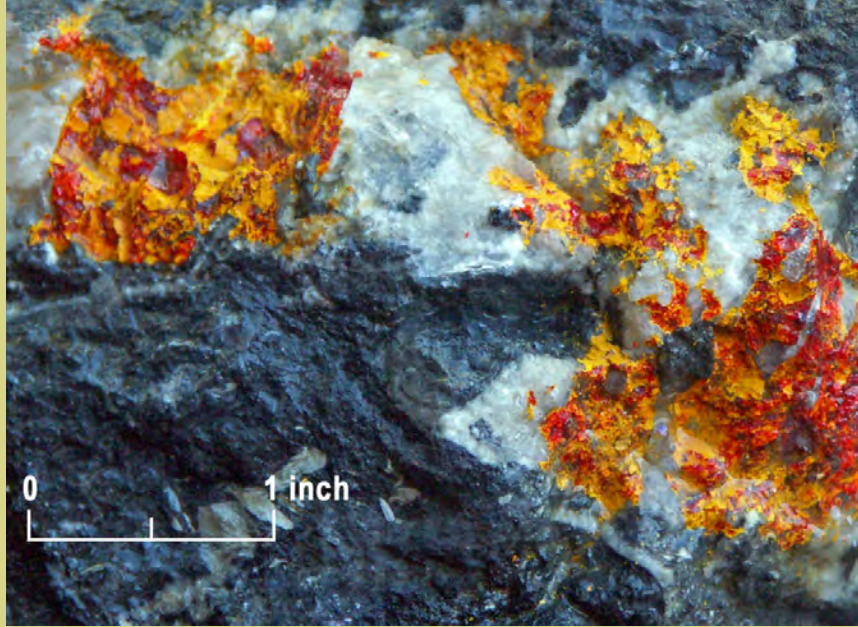
The Mercur gold ores are largely confined to a sequence of black, thin- to medium-bedded, carbonaceous, fossiliferous, and iron-

*Panoramic view of the Mercur district, looking southeast, in the early 1900s (from *The Ore Deposits of Utah*, 1920).*



rich limestone, calcareous sandstone, calcareous siltstone, and shale. Most of the mineralization in the Mercur district is concentrated near the crest of the Ophir anticline and localized near an east-northeast-trending set of normal faults. The most obvious alteration associated with the gold ores in the Mercur district is the extensive silicification (jasperoid) at the base of the Mercur member. The individual gold deposits occur as lenses associated with the destruction of carbonate minerals (decalcification) and clay alteration of the limestone host rocks above this basal jasperoid. The most common minerals associated with the gold ore are pyrite, marcasite, orpiment, realgar, barite, stibnite, cinnabar, and a few very rare thallium minerals.

The Mercur district ultimately produced about 2.5 million ounces of gold, making it Utah's largest primary gold mining district, despite the fact that no gold was ever recognized in hand specimen. The price of gold during the years Mercur was recently in production ranged from under \$300 to about \$450 per ounce. It is too early to tell if the current \$1000 per ounce gold price will again revive the original sedimentary-rock-hosted gold mines at Mercur. ■



Sample of Mercur gold ore showing orpiment (orange), realgar (red), and calcite (white) in dark gray limestone.

SURVEY NEWS

EMPLOYEE NEWS

J. Wallace Gwynn retired after 34 years with the UGS. His doctoral dissertation was on the tar sand deposits of the Sunnyside area, and he continued research on the tar sand resources of Utah. However, most of his studies focused on Utah's saline resources, particularly Great Salt Lake, but also the saline resources of Sevier Lake and the bedded deposits of the Paradox Basin. He edited two comprehensive volumes on the scientific, historical, and economic aspects of Great Salt Lake, and helped the Department of Natural Resources in the formulation of a management plan for the lake. Wally's knowledge and expertise will be missed.

Bryce Tripp also retired from the UGS after 30 years of service. His work focused on the

industrial mineral resources of Utah, particularly limestone, zeolites, potash, building stone, and sand and gravel, but he also investigated Utah's tar sand deposits. Bryce was instrumental in establishing the Utah Mineral Occurrence System database and getting it converted from the original paper files to digital form. We wish Bryce well in his retirement!

The Geologic Hazards Program bid farewell to **Francis Ashland** who accepted a position with the U.S. Geological Survey in Reston, Virginia. Best of luck, Francis, in your new endeavor.

The Utah State Energy Program (USEP) has hired additional staff with funding from the

American Recovery and Reinvestment Act. **Jerriann Ernsten** has a Ph.D. in biology (Utah State University), **Alex Dalphé-Charron** has an M.S. in Environmental Policy (University of Utah), and **Chris Tallackson** has an M.P.A. in Public Administration (University of Utah). Also joining USEP is **Larry Hendrick**, who has a B.S. in Computer Science, and **Deborah Boren**, who accepted the secretarial position and has worked in the private sector for 20 years.

The Ground Water and Paleontology Program welcomes geologist **Paul Inkenbrand**. Paul has an M.S. from Utah State University in hydrology/ground water.

continued on page 11...

TEACHER'S CORNER

Earth Science Week Returns!

After last year's activities at the UGS were canceled due to building renovation, Earth Science Week is back and so are the teachers and students. In October of this year, 680 excited students descended on the UGS to celebrate Earth Science Week.



School classes, some having as many as 100 students, were divided into five groups, which then rotated through five 15-minute activity stations. The activities included panning for gold, observing stream erosion and deposition, identifying rocks and minerals, and learning about dinosaur fossils.

Thanks to the many volunteers from various agencies and organizations, the week was a success. We were pleased to see participants gain a better understanding and appreciation for the Earth sciences, which has been the mission of Earth Science Week since its inception in 1998 by the American Geological Institute. The methods we use to accomplish this mission—engaging students in discovering the Earth sciences, reminding people that Earth science is all around us, and motivating geoscientists to share their knowledge and enthusiasm about the Earth—appear to be effective!

LEGISLATIVE DIRECTIVES TO THE UTAH STATE ENERGY PROGRAM 2009

by Elise Brown and William Chatwin

When the gavel falls on the final day of the Utah Legislative General Session, much of the work is just beginning on bills that have passed into law. If there are energy implications of new laws, frequently the Utah Geological Survey's Utah State Energy Program (USEP) has a role in bringing the legislature's intentions to fruition.

The 2009 General Session resulted in two legislative actions that required USEP's assistance to implement. First, Senate Joint Resolution 1 specifically tasked the USEP to examine and develop model renewable energy ordinances. Second, Senate Bill 211 changed the way Utah adopts building codes by vesting the ultimate decision with elected officials. The USEP coordinated with the Utah Uniform Building Code Commission (UBCC) to conduct an analysis of changes to the International Energy Conservation Code (IECC).

MODEL RENEWABLE ENERGY ORDINANCES

Senate Joint Resolution 1 charged the USEP with holding consensus-building stakeholder meetings to produce model wind, solar, geothermal, hydroelectric, and biomass ordinances, as the USEP deems necessary. Emerging technologies, such as renewable energy systems, are often uncharted territory for local planners. As a result, the permitting process can be cumbersome for energy developers and governments alike. The purpose of model ordinances is to provide a template that cities and counties may consider when writing local rules and regulations.

The USEP found wind and solar to be important to examine. Through the ongoing functions of the Wind and Solar Working Groups and Resource Development Coordinating Committee, stakeholder comments were gathered. Interested parties such as the League of Cities and Towns, city and county planners, environmental groups, utilities, and others were invited to participate. The model wind ordinance provides language for both large and small wind developments that can be adopted with or without modification by cities and counties. The initial feedback the USEP gathered from the Solar Working Group suggests that a model ordinance may

not be as helpful to city and county planners as a list of topics and questions pertaining to solar. This list, like the wind ordinance, will function as a tool for planners to help ensure that they address possible conflicts that may arise if a solar ordinance is passed.

Regarding other renewable energy sources, the USEP and stakeholders determined that model ordinances are unnecessary at this time. Utah's leading geothermal electricity developers have all agreed that processes are already in place for their developments. Hydroelectric developments require water permits and may also necessitate a building permit from the local jurisdiction. Hydroelectricity is rarely installed on a residential scale in Utah, and thus is unlikely to require a local government ordinance. Biomass or bioenergy varies dramatically from installation to installation, and there are very few in Utah. As such, a unified code on a city or county level would not be helpful; these types of systems are better assessed for permitting on a case-by-case basis.

ENERGY CODE ANALYSIS

For the past 20 years, the code adoption process in Utah has been accomplished through administrative rule changes proposed by the UBCC. Utah updated all of its building codes on a regular interval that coincided with the publication of new national or international building codes. During the one-year lag between publication of the new codes and adoption in Utah, the UBCC would analyze the upgraded codes and possible amendments through their group of six advisory committees. Any interest groups who opposed provisions of the new codes were obligated to propose amendments through an explicit process within the advisory committees.

Following controversy about how codes are developed at the national level, Utah passed Senate Bill 211 to increase accountability for adoption of all state-level building codes, including the IECC. The change requires a legislative act for adoption, involving more layers of political process than for an administrative rule change. Additionally, there are two other main implications. First, the State Legislature requested more industry input to identify controversial provisions in

the new codes. Second, the burden of proof has been shifted to proponents of upgraded codes to justify why Utah ought to adopt, rather than opponents making proposals for amendments.

Over the past several years the USEP has administered free energy code training that has included technical assistance for timely responses to code clarifications. This technical assistance was invaluable for quantifying the benefit to the State from adopting upgraded energy codes. We worked closely with our energy code trainer to conduct computer simulations showing the annual energy savings of different types of houses built to the proposed code upgrade. We also worked with other partners to illustrate different types of benefits and costs. For example, positive cash flow analysis shows the threshold where monthly energy cost savings are more than the increased monthly mortgage costs for an upgraded-code house, leaving more money in the homeowner's pocket.

CURRENT STATUS AS OF FALL 2009

The USEP reported the initial results of the model renewable ordinance process to the Utah State Legislature in fall of 2009. Stakeholder meetings for solar and wind are being held at the time of this writing, so no conclusions have yet been determined. Please see geology.utah.gov/sep/renewable_energy/index.htm for updated information on outcomes and participating parties.

The UBCC has made substantial progress in meeting the burden of proof for adopting upgraded energy codes. After numerous UBCC, advisory committee, and industry ad hoc meetings, a recommendation was made to adopt the upgraded provisions for commercial buildings and to conduct further analysis of the residential provisions (to be completed by June 30, 2010). The Legislature's Business and Labor Interim Committee has voted to forward a draft bill into the General Session setting the stage for the Legislature to formalize adoption. That is, until the UBCC completes the residential analysis and generates additional recommendations. ■

GLAD YOU ASKED

WHAT ARE THOSE LINES ON THE MOUNTAIN? FROM BREAD LINES TO EROSION-CONTROL LINES

by Mark Milligan

Sometimes I get a public inquiry that leads to a “Glad You Asked” article, and sometimes I see something interesting in the field and wish I would get a question about it. This time it was a case of the latter. A gentleman called and asked, “What are the lines up on the side of the mountain?” Along the Wasatch Front we have fault lines, shorelines, lines from rock layers (bedding planes), lines formed by volcanic dikes, and lines formed by other natural phenomena. The caller gave a location for the lines that was above the elevation of the Wasatch fault zone and the highest shoreline of ancient Lake Bonneville. He described sets of lines that marched up the mountainside, nearly horizontal and regularly spaced. Bedding planes, perhaps? No, these lines were not a feature of exposed bedrock but rather rocky soil. Ah ha! I had previously seen such features along the Wasatch Front and elsewhere in Utah and discovered they are not a natural feature. These “lines” are erosion control terraces dug by machines and men of the Civilian Conservation Corps (CCC).

The Great Depression had hit Utah particularly hard. By 1932, wages for those Utahns who had not lost their jobs had declined by 45 percent. While the nation’s unemployment rate peaked in 1933 at a whopping 25 percent, Utah’s unemployment rate peaked at 36 percent, the fourth highest in the nation. The unemployed and dispossessed first turned to private charities and local governments for relief, but the demand was too great, and it was the federal government that provided the bulk of needed aid. By the spring of 1933, 32 percent of Utahns were receiving government relief. During the 1930s, for every dollar Utahns sent to Washington, D.C., in taxes, Washington sent \$7 back. Much of this spending was in the form of New Deal programs of the Franklin D. Roosevelt administration.

The CCC was a prominent New Deal agency in Utah. The Utah CCC worked on a wide range of conservation projects including dam and canal building, range reseeding, infrastructure improvements in national and state parks, and erosion-control projects such as the construction of the “lines” found on Wasatch Front and other Utah mountainsides. Beginning in May 1933 and lasting for over nine years, the CCC opened a total of 116 camps in Utah, with 30 to 35 operating at any given time. Across 27 of Utah’s 29 counties, 22,074 Utah men plus 23,833 men from out-of-state worked on Utah projects—large numbers, especially considering Utah’s labor force had only reached 181,244 by the 1940 census. Men of the CCC received room, board, and \$30 a month, of which they could keep \$5 to spend on themselves while the remaining \$25 was mailed to their families (adjusted for inflation that equates to about \$480, \$80, and \$400, respectively).

Debris flows have impacted Wasatch Front cities and towns since pioneer settlement. With increased development and poor watershed management, numerous damaging episodes occurred

between 1912 and 1930. Davis County was particularly hard-hit by these disasters where multiple flood and debris-flow events in 1912, 1923, and 1930 caused major damage to houses, roads, and other infrastructure. Seven people died in the 1923 Farmington Canyon debris flow, making it one of Utah’s deadliest. All of these debris flows were triggered by intense summer thunderstorms on steep slopes denuded of vegetation by fire, overgrazing, and to a lesser extent logging. With little vegetation to promote water infiltration and hold soil and rock in place, the runoff flowed downslope, eroding soil. When this surface water flowed into gullies and stream channels its erosive power increased and scoured the channels of stored sediment, which was then transported and deposited beyond the canyon mouths, causing damage and loss of life. Although stream channels provided most of the sediment in these destructive debris flows, the process started with mountainside erosion.



Homes damaged by a 1930 debris flow in Centerville below the mouth of Parrish Canyon (top) and unknown location (bottom), Davis County. Photos courtesy of the J. Willard Marriot Library.



Laborers from the CCC Hobble Creek Camp constructing erosion-control terraces (left) and completed terraces (right). Location unknown but presumably in Utah County near Springville and the Hobble Creek drainage basin. Photos courtesy of the Utah Historical Society.

Recent photo of erosion-control terraces constructed by the CCC in the 1930s, above the Bonneville shoreline in North Salt Lake, Davis County.

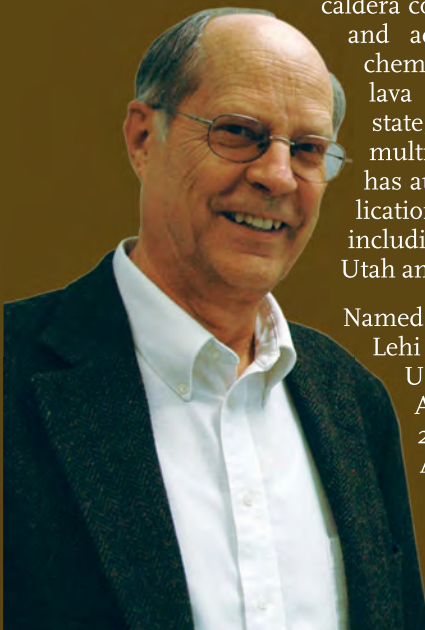
In response, the CCC was put to work on erosion-control projects that included mountainside contour terracing along the Wasatch Front and elsewhere. The terracing consisted of horizontal trenches dug across the slope such that they would catch or slow surface runoff and allow water infiltration into the soil, thereby limiting erosion. Contour terracing with reduced grazing appears to have been effective, as evidenced by the small number of debris flows between

1935 and 1982. However, in the spring of 1983 and 1984, record rainfall and rapid snowmelt saturated soil on steep mountainsides and caused small landslides that transformed into debris flows that charged down gullies and stream channels all along the Wasatch Front. Thus, reducing the risk of damaging debris flows in complex natural systems remains a challenge, even in areas with erosion-control measures. ■

SURVEY NEWS continued from page 8...

2009 LEHI HINTZE AWARD

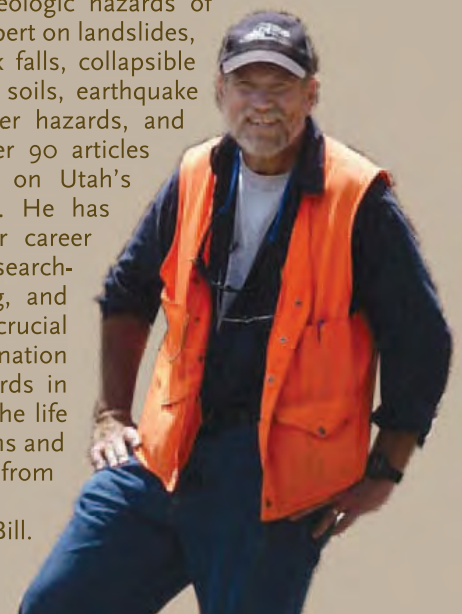
The Utah Geological Association and the Utah Geological Survey presented the 2009 Lehi Hintze Award to Myron G. Best, emeritus Professor of Geology, Brigham Young University. Myron has devoted much of his 50-year career to sorting out the volcanic and tectonic history of Utah. He has discovered and named a series of large ignimbrites (pyroclastic flow deposits) and their associated caldera complexes in southern Utah and adjacent Nevada; mapped, chemically analyzed, and dated lava flows across much of the state; and provided training to a multitude of geologists. Myron has authored more than 50 publications of the geology of Utah, including many geologic maps of Utah and adjacent areas of Nevada.



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

2009 GOVERNOR'S MEDAL FOR SCIENCE AND TECHNOLOGY

Bill Lund was awarded the Governor's Medal for Science and Technology for his scientific contributions in the field of geologic hazards of Utah. Bill is an expert on landslides, debris flows, rock falls, collapsible soils, expandable soils, earthquake faulting, and other hazards, and has authored over 90 articles and publications on Utah's geologic hazards. He has spent his 30-year career with the UGS researching, documenting, and disseminating crucial scientific information on geologic hazards in Utah, to protect the life safety of its citizens and reduce the risk from geologic hazards. Congratulations, Bill.



GEO SIGHTS

CASCADE FALLS, KANE COUNTY, UTAH

by Lance Weaver

The Pink Cliffs escarpment at the southern margin of the Markagunt Plateau viewed from the Cascade Falls Trail.

Nestled in the northwestern corner of Kane County is a geologically unique feature that receives relatively few visitors. Although most people in Utah have seen caves and waterfalls, it is peculiar for a waterfall to emerge from a cave system. Cascade Falls does just that, as an underground river emerges from a deep cave system and cascades down a steep cliff face. The cave system is the product of sinkholes within the water-soluble rocks of the Claron

limestone) of the Claron Formation, eventually forming a cave system that extends a little over a mile from below the southeastern end of Navajo Lake to the Pink Cliffs escarpment at Cascade Falls.

Depending on the level of Navajo Lake, the waterfall can range from a small trickle to a raging torrent. During dry years, Navajo Lake is kept from completely draining into the

water-soluble rocks such as limestone or marl. Sinkholes and collapse features are common within the Claron Formation of the Markagunt Plateau and can be seen in abundance along State Highway 14 between Midway Valley and the Duck Creek Sinks. Navajo Lake itself is fed by numerous springs along its western margin that are likely recharged by snowmelt flowing into sinkholes in adjoining Deer Valley.



Cascade Falls just below the cave opening, forming the headwaters of the North Fork of the Virgin River.

Formation of the Markagunt Plateau. This incredible cascading waterfall first formed when an ancient lava flow dammed the drainage in a narrow valley, creating Navajo Lake. Water from this lake found its way through the water-soluble marl (freshwater



Cascade Falls as it emerges from the limestone cave system of the Claron Formation.

sinkhole that feeds Cascade Falls by an engineered earthen dam. In wet years, however, when the lake inundates the small dam and fills the entire valley, the sink acts like a bathtub drain, allowing lake water to flow southward through the underground cave system and emerge at Cascade Falls as the headwaters of the North Fork of the Virgin River. When the lake level is low enough for the dam to be exposed, the overflow can be seen draining into the cave system through a small opening in the bottom of the sinkhole.

Sinkholes, also known as sinks, are depressions caused by the collapse of subterranean caverns, often formed by the dissolution of



Oblique aerial view taken from Google Earth looking northwest over Cascade Falls and Navajo Lake.

The distinctive Claron Formation is the same geological layer that forms the picturesque towers and hoodoos of Bryce Canyon National Park and nearby Cedar Breaks National Monument. The rocks of the lower part of this formation were deposited on a broad alluvial plain with shallow lakes and ponds around 50 million years ago, during the Paleocene and Eocene Epochs. The formation contains alternating layers of limestone, marl, calcareous sandstone, and minor conglomerate; the layers are vividly colored orange, red, pink, and white by a combination of sediment composition, weathering (oxidation) of iron-bearing minerals, and soil-forming processes. ■

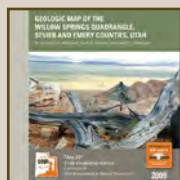


How to get there:

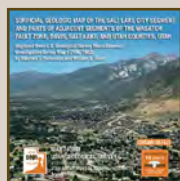
Cascade Falls is located in southern Utah, just south of State Highway 14. Highway 14 can be accessed from I-15 in Cedar City on the west or from U.S. Highway 89 at Long Valley Junction on the east. To get there from I-15 and Cedar City, head 27 miles east on Highway 14. After passing the Navajo Lake scenic pull-out with its

descriptive signs, turn right (south) on the road to the lake. After 0.4 mile, the road splits. The right fork goes on to the Navajo Lake boat docks and lodges, and the left fork goes approximately three miles (stay right at the "Y" junction to Duck Creek) to the Cascade Falls overlook and trail parking lot. The trail to the falls is approximately 1/2 mile one way.

NEW PUBLICATIONS



Geologic map of the Willow Springs quadrangle, Sevier and Emery Counties, Utah, by Hellmut D. Doelling, Paul A. Kuehne, and James I. Kirkland, CD (14 p., 2 pl., 1:24,000), M-237 \$14.95



Surficial geologic map of the Salt Lake City segment and part of adjacent segments of the Wasatch fault zone, Davis, Salt Lake, and Utah Counties (digitized from U.S. Geological Survey Miscellaneous Investigations Series Map I-2106, 1992), by Stephen F. Personius and William E. Scott, CD (2 pl., 1:24,000 [contains GIS files]), ISBN 1-55791-821-X, M-243DM \$24.95



Available coal resource for the Salina Canyon and southwestern part of the Wasatch Plateau coalfields, Sevier County, Utah, by David E. Tabet, Brigitte P. Hucka, Jeffrey C. Quick, and Sharon I. Wakefield, CD (17 p. + 14 p. appendix), ISBN 1-55791-817-1, SS-129 \$14.95



Paleoseismology of Utah, Volume 18: Paleoseismic investigation of the northern Weber segment of the Wasatch fault zone at the Rice Creek trench site, North Ogden, Utah, by Christopher B. DuRoss, Stephen F. Personius, Anthony J. Crone, Greg N. McDonald, and David J. Lidke, CD (27 p. + 9 p. appendices, 2 pl.), ISBN 1-55791-819-8, SS-130 19.95



Characterization and hazard zonation of the Meadow Creek landslide affecting State Route 9, part of the Coal Hill landslide complex, western Kane County, Utah, by Francis X. Ashland, Greg N. McDonald, Lucas M. Shaw, and James A. Bay, CD (29 p. + 1 p. appendix, 2 pl.), ISBN 1-55791-822-8, SS-131 \$19.95



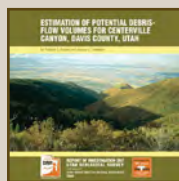
2008 Summary of mineral activity in Utah, by Roger L. Bon and Ken A. Krahulec, CD (14 p.), ISBN 1-55791-818-X, C-109 \$14.95



Ground-water sensitivity and vulnerability to pesticides, Curlew Valley, Box Elder County, Utah, by Mike Lowe, Janae Wallace, Stefan Kirby, Rich Emerson, Anne Johnson, and Rich Riding, CD (27 p., 2 pl.), RI-265 \$19.95



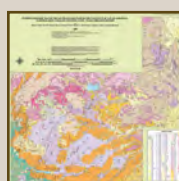
Ground-water sensitivity and vulnerability to pesticides, Beryl-Enterprise area, Iron, Washington, and Beaver Counties, Utah, by Mike Lowe, Janae Wallace, Rich Emerson, Anne Johnson, and Rich Riding, CD (28 p., 2 pl.), RI-266 \$19.95



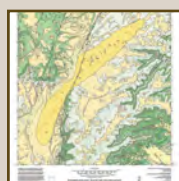
Estimation of potential debris-flow volumes for Centerville Canyon, Davis County, Utah, by Richard E. Giraud and Jessica J. Castleton, CD (14 p. + 19 p. appendix), RI-267 \$14.95



Snowmelt-induced ground-water fluctuations in selected northern Utah landslides—preliminary results from the 2007–08 landslide water year, by Francis X. Ashland, 19 p., OFR-550 \$8.95



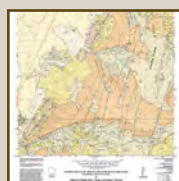
Interim geologic map of the south-central part of the Panguitch 30' x 60' quadrangle, Garfield, Iron, and Kane Counties, Utah—Year 1 progress report by Robert F. Biek, David W. Moore, John J. Anderson, Peter D. Rowley, L. David Nealey, Edward G. Sable, and Basia Matyjasik, 91 p., 1 pl., scale 1:100,000, OFR-553 \$14.95



Interim geologic map of the Yellowjacket Canyon quadrangle, Kane County, Utah, and Mohave County, Arizona, by Janice M. Hayden, 17 pg., 1 pl., scale 1:24,000, OFR-554 \$9.95



Progress report geologic map of the Rush Valley 30' x 60' quadrangle, Tooele, Utah, and Salt Lake Counties, Utah (year 1 of 3), by Donald L. Clark, Stefan M. Kirby, and Charles G. Oviatt, 57 p., 1 pl., scale 1:62,500, OFR-555 \$14.95



Interim geologic map of the Ephraim 7.5-minute quadrangle, Sanpete County, Utah, by Hellmut H. Doelling, Paul A. Kuehne, and Douglas A. Sprinkel, 35 p., 1 pl., scale 1:24,000, OFR-556 \$9.95



Sequence stratigraphic assessment of the Muley Canyon Sandstone and Masuk Formation, Henry Mountains syncline: Implications for understanding the Muley Canyon coal zone, by Lauren P. Birgenheier, Christopher R. Fielding, Matthew J. Corbett, Christopher Kesler, DVD (30 p. + 30 p. appendices, 7 pl. [contains GIS data]), OFR-557 \$24.95



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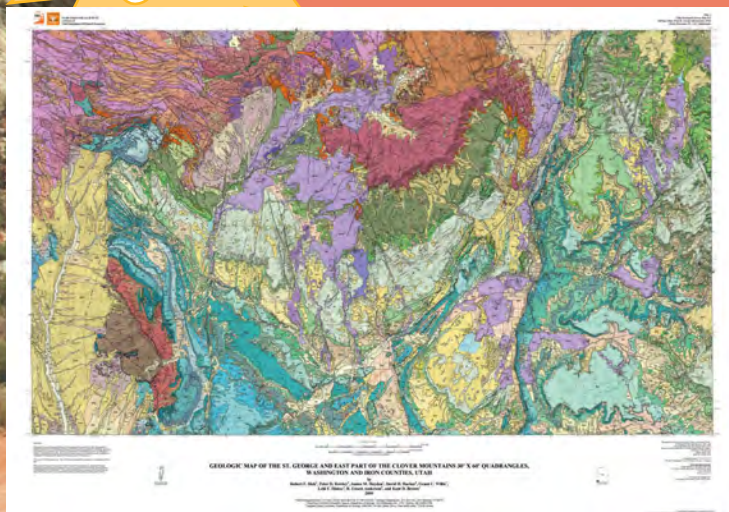
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NEW GEOLOGIC MAP OF SOUTHWESTERN UTAH



In early 2010, the Utah Geological Survey will release a geologic map of 2000 square miles in southwest Utah, comprising the St. George 30' x 60' quadrangle and the easternmost (Utah) part of the Clover Mountains 30' x 60' quadrangle. The map covers the area from the Beaver Dam and Bull Valley Mountains on the west, eastward through the St. George area to Zion National Park, and from the Arizona border north through the Pine Valley Mountains. The geologic map is one of many in our 1:100,000-scale series, where one inch on the map equals 1.6 miles on the ground.

Southwestern Utah is justly famous for its diversity of well-exposed rock formations, geologic structures and landforms, and geologic hazards and resources. Now, for the first time, this new full-color geologic map shows the regional geology in unprecedented detail. The map is accompanied by a 101-page booklet—with 68 annotated photographs and illustrations—that describes this geologically diverse and interesting region.

Utah Geological Survey Map 242

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