

Colorado Geological Survey—2007 Summary

Director's Message—Dedication



This issue is dedicated to the memory of Alyssa Heberton-Morimoto, a summer field assistant in our STATEMAP program, who was murdered in late June in the Pike National Forest while working with Dr. Karen Houck, a CGS contract mapper. Alyssa and her husband were graduate students at the University of Colorado-Denver (UCD) where she took her first geology course from Dr. Houck. Alyssa and Karen had worked together during a previous field season, conducting a paleontological survey for the US Forest Service in the same general area. Alyssa was a vibrant, intelligent individual whose life was unnecessarily cut short. Although her own death was not preventable, part of her legacy will be to save other lives because of the renewed emphasis on general safety for field workers throughout the country.

This senseless act by a individual who had served nineteen years in prison for a previous murder caused widespread concern among organizations who conduct work in the out-of-doors. Although it is highly unlikely that anyone could have stopped a person such as this, the incident has caused state and federal agencies at all levels to re-examine their field-safety procedures. Both the Association for Women Geologists (AWG) and the Geological Society of America (GSA) sponsored field safety sessions in Alyssa's honor at their annual meetings last Fall.

This tragedy deeply affected those of us at CGS. We grieve for her and her family.

—Vince Matthews

2007 Highlights

Projects

Denver Basin Cross-Sections

As part of a long-term project mapping the surface and subsurface geology along the Front Range urban corridor, CGS hydrogeologists are creating a series of cross-sections throughout the Denver Basin hydrologic province using existing geophysical logs provided by the Division of Water Resources and other sources. Taking into consideration new interpretations of the stratigraphic architecture of sediments found in the basin, this study incorporates results of recent surface geologic mapping efforts with new subsurface data in order to gain a better understanding of the three-dimensional relationships of the vital bedrock aquifers which supply water to hundreds of thousands of citizens along the Front Range Corridor. The product will help water resource managers, planners, and individual landowners understand where groundwater is located and how it moves through the complex sedimentary framework beneath the region.

Statewide collapsible soil publication

Collapsible soils, present in many parts of Colorado, can cause significant damage. For example, a recent lawsuit over collapsible soil damage to a large structure was settled for \$11 million. A booklet on collapsible soils is scheduled for release in FY2008. This comprehensive report describes collapsible soils, their engineering properties, their occurrences in Colorado, what mitigative construction and remedial techniques are available, what level of geological and geotechnical investigations are needed, and what the home and property owner can, and should, do if their home is suspected to rest on collapse-prone soil.

Regional collapsible soil susceptibility maps

A companion project of the Statewide Collapsible Soil Program is the development of regional collapsible soil susceptibility maps at 1:50,000-scale. The first map was of the Roaring Fork River corridor. In 2007 the second map was completed and is scheduled for release in early 2008. This map is of the Colorado River corridor centered at the town of Rifle.

Land Board Resource Assessment

CGS accomplished a resource-evaluation program on a section of State land administered by the State Land Board in the spring of 2007. The project involved evaluation of gypsum resources on the parcel by field mapping and drilling. A report was produced to enable evaluation of the property (located south of Colorado Springs adjacent to Fort Carson) by resource companies. The effort culminated in an auction for lease of the property in February 2008, enabling the Land Board to realize a fair value for the lease.

New Resource for Researching the Lower Arkansas River Alluvial Aquifer

CGS completed a landmark groundwater product in 2007: a map-based, digital bibliography for the Lower Arkansas River Alluvial Aquifer. Using this GIS-based bibliography, an end-user can point to an area of interest on the map on their computer screen and access references to studies, investigations, and reports by location, size and content. The content options include aquifer configuration, aquifer properties, water levels, or water quality. The database also has a "find and query" functionality. The references are hot-linked, if available digitally, to allow the user to access the publication directly from the internet. A project library has been established at CGS to archive hardcopies of

each reference also. This project will be extended to include the upper reaches of the Arkansas River and also include bedrock aquifers as a precursor to development of a decision support system for the Arkansas River Basin.

Oil Shale Support Analysis

Rising crude oil prices combined with a national priority placed on energy independence re-awakened interest in developing the vast oil shale resources found in the tertiary sedimentary basins in Western Colorado, Eastern Utah, and Southwestern Wyoming. CGS participates in multi-agency reviews of specific oil shale pilot study permit applications, as well as the U.S. Bureau of Land Management Draft Programmatic Environmental Impact Statement on the development of oil shale and tar sands in Colorado, Utah, and Wyoming. CGS personnel also participate in monthly BLM Oil Shale Research and Development Program Multi-Regulatory Agency meetings. These meetings are a forum convened to coordinate regulatory efforts by the many state and federal agencies that will have jurisdiction over various aspects of oil shale permitting and to keep all parties informed about current developments in the industry.

Paleoseismologic Trenches

CGS completed investigations of a 95-mile long, 100-foot high escarpment near Anton, as part of a program to identify potentially active faults in Colorado. A total of four trenches have been dug at the Anton site since 2004, exposing a 2500-foot transect from the top to the base of the escarpment. Two benched trenches, excavated in late 2007, completed an examination of the subsurface geology. One 400-foot long trench was dug beneath a 15-foot deep filled gully in the main escarpment face. The second, a 600-foot long trench, was dug beneath a modern playa and a 15-foot high escarpment at the playa margin.





Steve Holen, Denver Museum of Nature and Science, regales field-trip attendees with the Geological Society of America with a summary of archaeological findings from the Anton trench. Photo by Dave Noe

The trenches revealed unbroken Pleistocene to Pliocene strata with no evidence of fault rupture. CGS is now assessing evidence that this feature formed during the past 20,000 years as a result of simultaneous wind erosion and adjacent loess deposition.

The results of this study indicate that there is no reason to elevate the earthquake hazard in this part of Colorado—the kind of result we like to see. A smaller escarpment near La Junta was excavated by the federal geological survey with much different results. This particular escarpment occurred on the Cheraw faults and is now included in the National Earthquake Hazard Map as being capable of generating a magnitude 7.0 earthquake.

Piceance and Raton Basin Groundwater

In a cooperative effort with the Division of Water Resources and the Oil and Gas Conservation Commission, CGS recently completed studies of surface water depletions caused by the production of coalbed methane (CBM) in the Piceance and Raton Basins. Production of CBM often involves the pumping of large volumes of groundwater from coal seams in order to release methane gas

bound in the coal structure. Pumping this groundwater has the potential to deplete surface water, thereby injuring, existing surface water rights and these studies evaluated the magnitude of these potential depletive effects given current and anticipated future CBM production levels. The results of the studies provide the regulating community a background for better managing these basic resource activities. CGS hydrogeologists developed the geological framework used in evaluating the depletive effects while the analytical modeling was performed by a private consulting firm specializing in groundwater modeling.

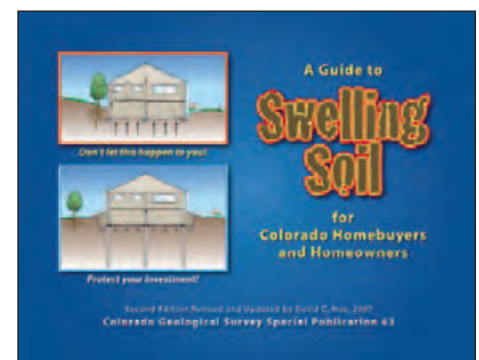
Upper Black Squirrel Creek Basin Project

In 2007 the CGS Groundwater Group, through funding from the El Paso County Water Authority, initiated a major project in the Upper Black Squirrel Creek Basin of El Paso County to determine how much groundwater could be stored in the alluvial aquifer of that basin. The Upper Black Squirrel alluvial aquifer, which supplies water to local irrigators, residents, and communities is also a major water source for the newer developments east of Colorado Springs. Historic over-development of the

groundwater resources has resulted in over 65,000 acre-feet of depletion. The removal of this water from storage in the aquifer now provides an opportunity to implement managed aquifer recharge and storage projects. The project involves study of the aquifer configuration, depth to water, and aquifer properties with the intent to locate a suitable site(s) for a pilot project implementation. This is the first in depth study conducted by the state to advance the recommendations of the Senate Bill 06-193 study.

New Edition of Swelling Soil Guide

CGS announced the release of a new publication, *A Guide to Swelling Soil for Colorado Homebuyers and Homeowners, Second Edition*. This colorful, easily understandable booklet offers steps that Colorado homeowners can take to help protect themselves against this costly hazard. Homebuyers can learn how homes can be designed and built to withstand swelling soil movements, how to recognize swelling soil damage, and how to landscape a property to manage water use and reduce soil movements and damage. Over 280,000 copies of the award-winning first edition have been distributed. The new second edition was updated and revised based on extensive interviews with homeowners, homebuilders, and civil and structural engineers. The old, two-toned drawings and photos are replaced by colored illustrations to aid the reader.



The Guide to Swelling Soils is CGS's most popular publication. The new edition has been improved and illustrated in color to help homeowners and homebuyers understand the problem of swelling soils.

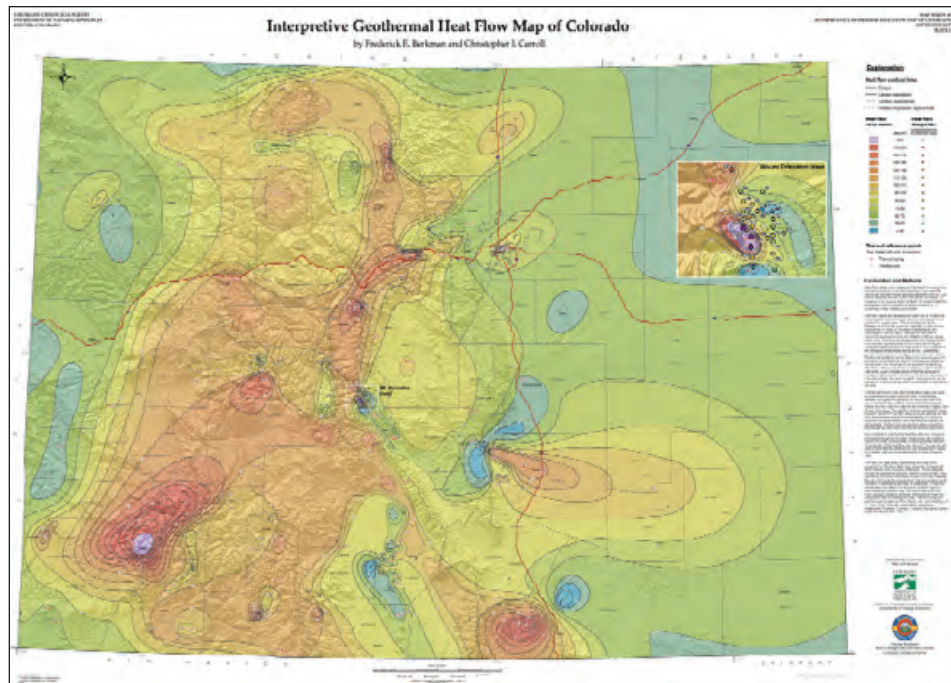
CGS Renews Geothermal Resource Investigations

Development of renewable energy sources such as wind, biomass, solar and geothermal, for electrical power production is growing throughout the western U.S. Among these, geothermal power plants are attractive because they can provide a consistent, or “baseload,” power supply that is not dependent on the wind, sunny skies or biomass availability. Currently, geothermal resources in Colorado are used directly for recreation (pools and spas), greenhouse agriculture, aquaculture, space heating and district-wide heating—but not for electrical power.

Therefore, after a 25-year hiatus the Colorado Geological Survey (CGS) has renewed its investigations of the state’s geothermal resources to help identify areas that are prospective for power generation as well as to increase direct use of geothermal waters. CGS is working with the Governor’s Energy Office to develop two statewide maps indicative of geothermal potential. One map characterizes “geothermal heat flow,” which is the amount of heat moving through the Earth’s crust. The other is “geothermal gradient,” which is the rate of temperature increase as a function of depth in the Earth.

Several lines of evidence indicate that the geothermal potential for Colorado may be underestimated in regard to electrical generation:

- High heat flow—Colorado has the second largest heat flow anomaly in the U.S.
- Quaternary volcanism (occurring within the last two million years)—Colorado has five such volcanoes
- Quaternary faulting (younger faults have more potential)—Colorado has over 90 such faults
- Rift zone tectonics in the San Luis Valley and upper Arkansas River basin
- A low-velocity seismic P-wave anomaly in central Colorado, The Aspen Anomaly, indicates a significant area of less dense, warmer upper mantle. This could contribute to higher geothermal gradients in the area.



The interpretive heat flow map of Colorado. The warmer colors indicate higher heat flow, with red to purple areas being the highest. The highest heat flow trends in Colorado are associated with the Rio Grande Rift feature in the San Luis Valley extending north into the upper Arkansas River valley and from the western San Juan Mountains extending northeast to Clear Creek County. Notable areas of high heat flow include the Mount Princeton, Rico, and Trinidad areas.



Drilling to evaluate the geothermal potential at Poncha Springs, Chaffee County. Potential is recognized by measurement of high heat flow on the surface and drilling is carried out to test the temperature of waters at depth. Photo by Jim Cappa.

In addition, two sedimentary basins in Colorado indicate potential for geothermal resources at depths in the range of existing oil and gas wells. Oil and gas fields in the Denver Basin have recorded bottom-hole temperatures that range between 200–250°F at

roughly 10,000–11,000 feet. Similarly, bottom-hole temperatures in the San Juan Basin south of Durango have recorded temperatures ranging from 150–250°F at depths of between 6,500–9,000 feet. Twenty of these wells have temperatures of 250°F or more.

Newer geothermal power plant technology allows electrical power generation with lower temperature water than was possible 25 years ago. Previously, one needed steam at the surface or superheated water above 300°F for power production. Now, electricity can be generated with water temperatures of 200°F or more and, in one case, electricity is being generated with temperatures as low as 165°F.

The geologic characteristics of Colorado, along with newer geothermal power plant technology suggest the time is right to pursue exploration and greater use of our geothermal resources. New data and studies being done by CGS will contribute to that end.

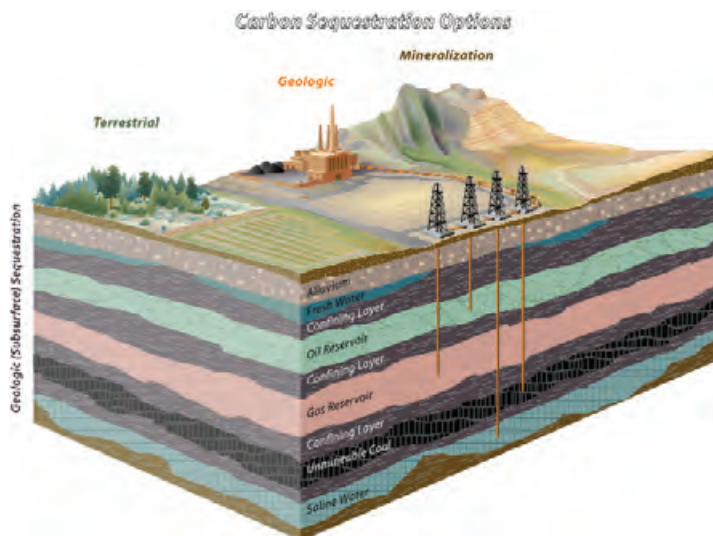
CO₂ Sequestration Potential of Colorado

The CGS is a participant in the Southwest Regional Partnership on Carbon Sequestration project whose primary goal is to determine an optimum strategy for minimizing greenhouse gas intensity in the southwestern United States. The Southwest Partnership is led by the New Mexico Institute of Mining and Technology and comprises a large, diverse group of expert organizations and individuals specializing in carbon sequestration science and engineering, as well as public policy and outreach. The project is sponsored by the Department of Energy's National Energy Technology Laboratory.

In 2000, CO₂ emissions were more than 92 million short tons in Colorado and are projected to increase by 2.4 percent per year through 2025. Nearly 76 percent of these emissions result from activities in the utility and transportation sectors. Power generation in the state relies primarily on coal and as a result, 42 million short tons of CO₂ or 46 percent of the total emissions in Colorado are emitted from power plants in the utility sector. These stationary point sources afford the possibility of capture and separation of CO₂ for transport to and storage at nearby "sinks."

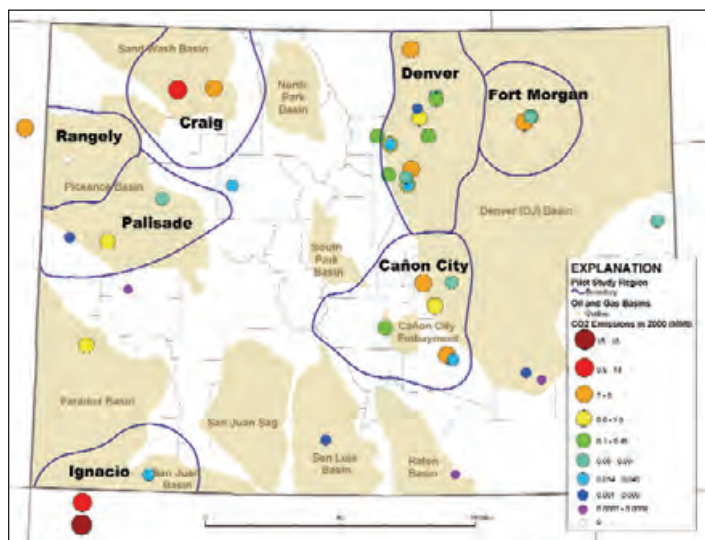
Geologic storage options (or "sinks") for CO₂ in Colorado include deep saline aquifers, depleted and marginal oil fields, natural gas and CO₂ fields, deep unmineable coal beds and advanced mineralization engineering. Although all of these options are widely distributed across the state, characterization efforts conducted by the CGS have thus far focused on seven primary Pilot Study Regions. These regions were defined based on maximum diversity in potential sequestration options within 30 to 40 miles of one or more power plants. Subsurface storage options were further screened for depths sufficient to maintain injected CO₂ as a supercritical fluid instead of a gas.

Utilizing both geologic and mineralization options, carbon storage capacity within these regions is an estimated 720 billion short tons. With the availability of suitable technology, the pilot areas have the potential of providing a long-term storage solution based on 2000 CO₂ emission levels. The highest CO₂ sequestration capacity potential for Colorado lies within the oil, gas, coalbed, and saline aquifer reservoirs of the Denver, Cañon City Embayment, Piceance, and Sand Wash basins.



Geologic storage options for CO₂ include depleted oil and gas reservoirs, unmineable coals and deep saline aquifers. Terrestrial and advanced mineralization methods are also options.

Further site-specific investigations are required to determine both the technical and economic feasibility of implementing any one of these options. In these analyses, it is as important to consider the short-term costs as it is to consider the long-term benefits. To this end, the Colorado Geological Survey is currently participating in three ongoing geologic sequestration test pilots at: (1) Aneth Field in the Paradox Basin, (2) Pump Canyon Fruitland ECBM pilot in the San Juan Basin, and (3) SACROC/Claytonville in the Permian Basin. In addition to these smaller tests, the Survey will be active in characterizing geologic storage sites in the region with the potential to accommodate 1 MT of CO₂ per year.



Characterization efforts in Colorado have concentrated thus far on seven pilot study regions. These regions are centered around power plants with high volumes of CO₂ emissions.

Programs

Abandoned Mines Site Characterization

An excellent, but little known, set of resources on a number of Colorado mining districts is found in CGS's studies on abandoned mine lands. During the 1990s the CGS conducted a statewide inventory of abandoned mines on U.S. Forest Service property. After reviewing the inventory, the Forest Service requested more detailed investigations at a number of mines. Completed in 2007, these detailed investigations included a historical review of mining activity and the geology of the site, as well as the current environmental conditions present. Particular emphasis was given to the water quality conditions at

the sites as well as any potential impacts to human users and wildlife. Several of these reports have been published by the CGS as Open-File Reports and the remainder is in the process of being published. In all, 25 mines were investigated in this project.

Colorado Earthquake and Fault Map

Colorado's Earthquake and Fault Map provides general information about earthquake hazards in Colorado. It was created to increase public awareness of earthquakes. The map contains the locations of over 300 earthquakes of magnitude 3 or greater and traces of Colorado's known or suspected geologically young faults. Information on Colorado's earthquake history, potentially hazardous faults, emergency preparedness and sources of additional informa-

tion is included in the publication. This free publication will be released later in 2008 by CGS, Colorado Division of Emergency Management and the Colorado Earthquake Hazard Mitigation Council.

Mine Subsidence Information Center (MSIC)

The CGS staffs and operates the Mine Subsidence Information Center (MSIC) out of its main office at 1313 Sherman Street, Room 715, in Denver. The MSIC is a resource and reference library that contains historic coal mine maps, mine subsidence research studies and maps, technical reports and investigations, reference books, and a work space.

The operation of the MSIC primarily involves responding to requests for general subsidence information from the public. This includes assisting home



CGS field scientist samples a mountain stream to analyze for acidity and metals content. Note the red-orange color of the streambed due to the presence of iron oxide minerals—an indication of low pH and high dissolved metal concentrations. This stream may be impaired due to either naturally occurring conditions or acid mine drainage resulting from human activities. Photo by Bob Wood.





Shannon Townley, CGS mapping intern, takes a strike and dip reading on a bedding plane in the Dakota Sandstone near Delta. Photo by Dave Noe.

owners, consultants, other agency groups, local governments and many other people who are interested in subsidence associated with historic coal mining in Colorado, and we can help arrange for and provide copies of selected maps to requestors (who are charged for the cost of production). Many of the historic coal mine maps and subsidence investigation maps are now available in digital format. The CGS staff also manages the reference library, adds reference material, organizes materials for efficient retrieval, and maintains access and usage control of reference materials. Official professional opinions on the type and risk of subsidence related to underground coal mines rendered for or on behalf of real estate development, sale, or transfer are beyond the scope of the grant.

The MSIC is funded by a federal grant from the Office of Surface Mining

(OSM), passed through the Colorado Division of Reclamation Mining and Safety (DRMS) as part of its annual Abandoned Mine Land Grant.

STATEMAP Program

The CGS continues to play a prominent role in the STATEMAP program, supported by the National Cooperative Mapping Program. In 2007, the CGS mapped 8½ 1:24000-scale quadrangles in the state—Delta, Hoovers Corner, Olathe NW, Bayfield, Marmot Peak, Antero Reservoir, Climax, Dakan Mountain and a portion of the Larkspur quadrangle. The program is accomplished using in-house CGS staff, consultants and interns. Permanent staff involved in the program include Dave Noe, Matt Morgan, Jonathan White, Chris Carroll, Karen Morgan, Nick Watterson and Larry Scott. Consultants during the 2007 season were Bob Kirkham, Karen Houck,

Jonathan Funk, Jim McCalpin, Jay Temple, Alan Busacca, David Gonzales, Felicie Williams, the San Luis Valley GIS/GPS Authority and Digital Services, Inc. Interns and volunteers included Shannon Townley, David Mendel, Karri Sicard and Alyssa Heberton-Morimoto.

Statewide Landslide Inventory

In FY 2008, CGS initiated the Statewide Landslide Program. In 2007, all landslides in the 1:24,000 scale USGS and CGS geologic maps were scanned and digitized into a GIS framework. Other larger-scale geologic maps will be digitized in 2008. This landslide inventory will ultimately be available to the public and used in the second phase of the statewide landslide program to develop a statewide, landslide-susceptibility map.

Colorado Avalanche Information Center Activities

The Colorado Avalanche Information Center promotes safety by reducing the impact of avalanches on recreation, industry and transportation in the State through a program of forecasting and education.

The CAIC head office is at the National Weather Service in Boulder. The Summit County Avalanche Office is in Breckenridge. CAIC staff is composed of 5 forecasters and 1 outreach coordinator at the main office in Boulder, 2 forecasters and one intern in Silverton, 1 forecaster in Pagosa Springs, 1 forecaster in Marble, 2 forecasters at the Eisenhower Tunnel, 2 forecasters at the Summit County, and 1 forecaster in the Ophir office.

The November to March snowfall was near average across the state in 2006–07. There was great variability from month to month and location to location. February was the snowiest month state wide, while March was quite dry. There were 2,386 avalanches reported to the Center, slightly above the five-year average of 2,255 reported avalanches.

The CAIC introduced a new web page in late December. The most popular online forecasts received about 20,000



The staff of the Colorado Avalanche Information Center provide an indispensable service to the people of Colorado.

views a month. Each day, the CAIC emailed about 2,500 forecasts to friends, observers and the ski industry. Email replaced the majority of faxes, and we reduced the number of daily faxes to 5, saving time and money. Additionally, 11 radio stations broadcast our hotline messages daily. As Colorado's spokes-

agency for avalanche matters, we received 123 contacts from broadcast and print media. Further, CAIC staff 92 avalanche seminars to 3,984 people.

Our web site generated around 6.5 million visits for avalanche information.

We published our newsletter, *The Beacon*, three times for Friends of the CAIC.

2007 Land Use Fun Facts

Did you know that for over two decades, the Colorado Geological Survey (CGS) has assisted local governments with geologic hazard problems and other geologic concerns related to proposed development? In 2007, the small but versatile CGS land-use staff accomplished the following:

- Examined over 480 development proposals for 60 cities, counties and school districts throughout Colorado.
- Assessed the potential for geologic and soil-related hazards on over 43,000 acres of land and 28,000 residential, commercial and industrial lots.
- Of the over 300 development proposal examined, CGS developed plans and recommendations for mitigation of the following hazards:

Geologic Hazard	Number of Development Sites
Major or Localized Flooding	80
Swelling Soil or Bedrock	48
Unstable Slopes	46
Landslides	25
Rockfall	17
Subsidence from Historic Mining	10
Avalanche	4



2007 CGS Publications

- Colorado Mineral and Energy Industry Activities, 2006*, by Cappa, J.A.; Young, G.B.; Burnell, J.R.; Carroll, C.J.; and Widmann, B.; Information Series 75.
- Geologic Map of the Olathe Quadrangle* by Morgan, M.L.; Noe, D. C.; and Keller, S. M.; Open File Report 07-01.
- Geologic Map of the Fairplay West Quadrangle, Park County, Colorado* by Widmann, B. L.; Kirkham, R.M.; Houck, K.J. and Lindsay, N.R.; Open File Report 06-07.
- Geologic Map of the Signal Peak Quadrangle, Gunnison County, Colorado*, by Stark, A.; Coogan, J. C.; Fillmore, R.; Brunkal, H.; Nicolette, J.; and Payton, A.; Open File Report 07-03.
- Geology and Mineral Resources of Lake County, Colorado* by Cappa, J.A. and Bartos, P.J.; Resource Series 42.
- Geology and Mineral Resources of Saguache County, Colorado* by Cappa, J.A. and Wallace, C.A.; Resource Series 43.
- CO₂ Sequestration Potential of Colorado* by Young, G.B.; Lintz, V.A.; Widmann, B. L.; Bird, D.A.; and Cappa, J.A.; Resource Series 45.
- Field Trip Guidebooks, 1st North American Landslide Conference, Vail, Colorado, June 3–10, 2007*, by Noe, D.C. and Coe, J.A.; Special Publication 56.
- A Guide to Swelling Soil for Colorado Homebuyers and Homeowners* by Noe, David C., Jochim, Candace L., and Rogers, William P., second edition revised and updated by David C. Noe; Special Publication 43.
- ### Outside publications
- Berry, Karen, *The Phoenix Guide: A Handbook for Watershed and Community Wildland Fire Recovery*. National Association of Conservation Districts and the USDA Forest Service.
- Burnell, James, 2007, *What's happening in the Colorado mining and coal industry, 2007 and beyond*; (abst), Northwest Mining Association Annual Meeting.
- Burnell, J., Carroll, C., and Widmann, B., 2007, *Colorado state summary in Annual Mining Review 2006*; *Mining Engineering*, Vol. 59, May 2007, pp. 76–81.
- Jeffrey A. Coe, Jonathan W. Godt, T.C. Wait, and Jason W. Kean, *Field Reconnaissance of Debris Flows Triggered by a July 21, 2007, Thunderstorm in Alpine, Colorado, and Vicinity*, USGS Open File Report 2007-1237.
- Matthews, Vincent, *The Colorado Geological Survey and Science Policy in Colorado* (abst); Geological Society of American Annual Meeting.
- Morgan, Matthew L., *Development of the Loutsenhizer drainage basin and associated collapsible soils, Montrose and Delta Counties, western Colorado*; (abst) Geological Society of America Annual Meeting.
- Morgan, Matthew and Matthews, Vincent III; *Mud Lake: No evidence of meteorite impact near Nederland Colorado*; (abst) Geological Society of America annual meeting.
- Noe, David C., *Evolution of upland gravel deposits adjacent to the Uncompahgre River Valley near Montrose, Colorado*; (abst) Geological Society of America Annual Meeting.
- Noe, D. C.; Higgins, J. D.; and Olsen, H. W., 2007a, *Steeply dipping heaving bedrock, Colorado: Part 1, heave features and physical geologic framework: Environmental and Engineering Geoscience*, v. XII, no. 4, p. 289–308.
- Noe, D. C.; Higgins, J. D.; and Olsen, H. W., 2007b, *Steeply dipping heaving bedrock, Colorado: Part 2, framework mineralogical and engineering properties: Environmental and Engineering Geoscience*, v. XII, no. 4, p. 309–324.
- Noe, D. C.; Higgins, J. D.; and Olsen, H. W., 2007c, *Steeply dipping heaving bedrock, Colorado: Part 3, environmental controls and heave processes: Environmental and Engineering Geoscience*, v. XII, no. 4, p. 325–344.
- Noe, D.C., White, J.L., and Zabel, G., 2007, "Drive-by Guidebook: Geology and Geologic Hazards along the I-70 Corridor, Glenwood Springs to Grand Junction, Colorado," in Noe, D.C. and Coe, J.A., eds., *Field Trip Guidebooks, 1st North American Landslide Conference: Association of Environmental & Engineering Geologists Special Publication 21 and Colorado Geological Survey Special Publication 56*.
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- Oerter, E.J., Brimhall, G.H., Redmond, J., Walker, B., 2007, *A method for quantitative pyrite abundance in mine rock piles by powder X-ray diffraction and Rietveld refinement*, *Applied Geochemistry*, v. 22, p. 2907–2925.
- Topper, Ralf, *Citizen's Guide to Denver Basin Groundwater*, Colorado Foundation for Water Education.
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- Young, G.B.C., Gorucu, F.B., and Reeves, S.R., 2007, *San Juan Basin Enhanced Coalbed Methane (ECBM)—Carbon Storage Pilot: Role of Pre-Injection Site Characterization in Project Design* [abs.]: American Association of Petroleum Geologists 2007 Annual Convention & Exhibition, Long Beach, CA, April 1–4, Abstracts Volume, p. 156.

Meetings Hosted

Industrial Minerals Conference

The CGS served as the official host for the 43rd Forum on the Geology of Industrial Minerals, held in Boulder in May 2007. Jim Cappa, Beth Widmann, Chris Carroll and Jim Burnell served on the Board and played key roles in the organization and operation of this highly successful international meeting. The meeting hosted 120 attendees from around North America. Six technical sessions covered topics from across the realm of industrial minerals, from aggregates and cement to bentonite and gemstones, and included state reports summarizing industrial mineral activity around the U.S. and Canada. Five field trips covered a range of industrial minerals sites in Colorado from the Yule Marble quarry to brick mining and manufacturing in the Denver metro area. Guest field trips showcased a range of attractions along the Front Range, culminating in a dinner at the Red Rocks facility.



Ralf Topper awarded Fellow Status at the annual meeting of the Geological Society of America.

Honors and Awards

Ralf Topper was named a Fellow of the Geological Society of America. This is a level of membership reserved for members who have made significant contributions to the science of geology.

Peter Barkmann received the Service to Geology Award from the American Institute of Professional Geologists to recognize dedicated service to the Colorado section and to the profession of geology.

Vince Matthews was awarded the Arthur Lakes Legacy Award from the Friends of Dinosaur Ridge for outstanding service to the field of geology.

Peter Barkmann (left) and Vince Matthews (right)



Sessions Chaired

Karen Berry chaired the session on “Urban, Coastal, and Community Resources” at the Annual Meeting of the National Association of Conservation Districts.

Matt Morgan co-chaired a session entitled “Landscape Evolution and Land Use Practices in Western Colorado at the annual Geological Society of America meeting in October; At that same meeting, Ralf Topper co-chaired the session “Groundwater Mining and Population Growth.”

At the 43rd Forum on the Geology of Industrial Minerals, three CGS personnel chaired sessions—Jim Cappa for “Geology of Industrial Minerals in Colorado and other Western States;” Beth Widmann for the “Potpourri” session, and Jim Burnell, “Industrial Minerals: Then, Now, and Future.”

Chris Carroll chaired the session “Mining in Colorado” at the 109th Annual National Western Mining Conference, held in Denver in February.



Jim Burnell



Chris Carroll



Field Trips Led

At the 43rd Forum on the Geology of Industrial Minerals in May 2007, three field trips were led by CGS staff—Jim Cappa led the 2-day trip “Stone, Yule Marble and Gypsum in Colorado,” Beth Widmann led a trip to “Northern Front Range Stone Producers,” and Jim Burnell led a trip entitled “Clay Resources and Products of the Golden Area” (see photographs on the following page).

Field trips at the annual Geological Society of America meeting in October were led by Matt Morgan and Matt Sares—“Buttes to Bowls: Repeated Inversions in the Landscape of the Colorado Piedmont,” Jon White and Vince Matthews—“The Beautiful Vail Valley: A Classroom in Geologic Hazards and Mitigation,” David Noe—“A GeoMystery Field Trip to the Anton Escarpment,” and Chris Carroll and others, “Old and New Geologic Studies along the Front Range between Golden and Morrison, Including Structural, Volcanic and Economic Geology and Paleontology.”

CGS personnel were actively involved in the field trips for the First North American Landslide Conference in Vail in June. David Noe was co-chair for the field trips committee and assisted those trips. Jon White led a trip “The DeBeque Landslide at I-70, Mesa County,” and co-authored field trip guidebooks for “Geology and Geologic Hazards Along the I-70 Corridor, Vail to Glenwood Springs” and “... Glenwood Springs to Grand Junction.”

Vince Matthews led a field trip covering Front Range geology for the Central Cluster meeting of the American Association of State Geologists and the U.S. Geological Survey.

Peter Barkmann led a field trip for the annual teachers’ institute of the American Ground Water Trust in July, to look at regional aquifer exposures along the hogback near Golden, finishing at Coors water treatment plant.



David Noe



Vince Matthews discusses the Meadow Mountain landslide that could potentially dam the Eagle River and flood the town of Minturn. This location is also a rockfall hazard area. Note the large boulders that litter the slope behind him. Vince and his co-leader Jon White led this field trip to examine geologic hazards in the Vail Valley area for the Geological Society of America national conference last October.



Above: At the Lyons Flagstone Quarry, participants carry off a sample donated for the silent auction at the 43rd Forum on the Geology of Industrial Minerals. Photo by Jim Burnell.

Left: Field trip participants at Robinson Brick's Gunflint Mine outside Golden during the Clay sites field trip of the 43rd Forum on the Geology of Industrial Minerals. Photo by Jim Burnell.



Outreach

CGS Booth

CGS provided a booth for outreach at twelve different events in 2007. Included were Oil and Gas Prospect Fair, National Meeting of the Geological Society of America, the Denver Gem and Mineral Show, the 43rd Annual Forum on the Geology of Industrial Minerals, the American Ground Water Trust Forum on Colorado Ground Water Management Policy, Colorado Oil and Gas Association, Association of Engineering Geologists Vail Conference, 5th Annual Energy Expo, 109th Annual National Western Mining Conference, and the Colorado State Fair.

CGS Booth provided information and publications at numerous venues in 2007. Photo by Jim Burnell.



2007 Colorado State Fair Exhibit

CGS set up and staffed our colorful and informative “Mineral Room” exhibit at the State Fair in 2007. The CGS Mineral Room is located in the Department of Natural Resources building on the fairgrounds, and was open to the public from August 24th through September 3rd, 2007. Exhibits included samples and descriptions of Colorado’s state rock (Yule Marble), mineral (rhodochrosite), gem (aquamarine), and dinosaur (stegosaurus), dinosaur models, fossils and tracks, mining tools and mineral samples, Colorado’s groundwater resources, and descriptions and photos of geologic hazards that impact Colorado citizens and visitors. Our big improvement to the room this year was a stenciled quote around the wall, just below the ceiling, “On all the broad extent of these United States, certainly no region can be found which presents more facts of interest, more opportunities for investigation, and greater possibilities of new discoveries, than the state of Colorado.” (S.F. Emmons, 1883, United States Geological Survey). The exhibit received many compliments from Department of Natural Resources colleagues and visitors.

Landslide Conference

The CGS was a sponsor and key participant in the *1st North American Landslide Conference* held in Vail in June, 2007. David Noe and Jon White assisted in the planning of the Conference by serving on the Organizing Committee and organizing and leading field trips. Over 400 people attended 8 field trips that were offered on a single day during the conference. Destinations included Glenwood Canyon, DeBeque Canyon, the Grand Valley, Grand Mesa, Marble, Aspen, Leadville and Vail. In addition, there was a pre-meeting trip from DIA to Vail and a post-meeting trip to the world-famous Slumgullion landslide.



*The CGS display at the State Fair was a popular venue for adults and Children alike.
Photo by Jill Carlson*

Speakers

Vince Matthews gave the luncheon address to the Energy Minerals Division of the annual meeting of the American Association of Petroleum Geologists in Long Beach, California. He also gave an invited talk on Global Natural Resources to the World Petroleum Conference in Houston, Texas.

Matt Sares spoke on geothermal energy to the State Working Group, Lakewood, the Colorado Public Utilities Commission, the Geothermal Investors Forum at the Renewable Energy Symposium in Montrose, the Keiretsu Forum for Renewable Energy Investment in Denver and the Clean Energy Action monthly meeting in Boulder.

Ethan Greene spoke on “Snow, Weather, and Avalanche Observations to Support Operational Forecasting Programs” at the National Avalanche School in Snowbird, Utah.

Ethan also spoke on “Understanding Snow and Avalanches” to the Cooperative Program for Operational Meteorology and Education and Training Service of Canada in Boulder and delivered a talk on “Snow and Avalanches” at the Natural hazards Seminar, Department

of Forest, Rangeland and Watershed Stewardship of the Colorado State University in Fort Collins.

Spencer Logan of the CAIC produced an educational brochure entitled “First Tracks.”

CGS personnel delivered numerous other talks to groups around the state in 2007. Some of the recipients include American Ground Water Trust, American Water Resources Association, National Ground Water Association, Colorado Ground-Water Association, Peak to Prairie Landscape Symposium, Conifer Area Council, Division of Water Resources Staff, World Petroleum Conference, Garfield Energy Advisory Board, Grand Junction Energy Expo, BLM NW Regional Advisory Committee, Colorado State Parks Board, Colorado Public Radio, the Rocky Mountain Association of Geologists, the American Institute of Professional Geologists, the Colorado Mining Association, the Petroleum Pioneers, the Institute of Professional Independent Geologists, the Colorado Scientific Society, the Denver Mining Club, Friends of Dinosaur Ridge, National Coal Resource Data System Cooperative States program, various colleges and universities, civic clubs and mineral clubs.

Service to the Profession and the Community

Offices Held

Ralf Topper was President of the Colorado Ground-Water Association.

Peter Barkmann served his third term as Editor for the Colorado Section of the American Institute of Professional Geologists.

Karen Berry served as President of the Coalition for the Upper South Platte and the Upper South Platte Watershed Association, on the Board of Directors of the Jefferson Conservation District, on the Resource Policy Committee and was the Urban Committee Chair of the National Association of Conservation Districts.

Karen Berry also served on the Policy committee of the Front Range Fuels Treatment Partnership and also served on the Board of Directors of the Denver Regional Council of Governments and the Policy Committee of the Colorado Municipal League.

Matt Sares served on the 27th Oil Shale Symposium Organizing Committee and the Colorado Inactive Mine Land Reclamation Program Advisory Committee.



Matt Sares

Mark Mueller served as Executive Director and Brad Sawtell served as co-chair of the Education Committee of the American Avalanche Association.

Ethan Greene was the U.S. representative to the North American Avalanche Danger Communication Working Group and the Worldwide Practitioner Representative on the Working Group on Snow Classification.

Matt Morgan served as Councilor of the Colorado Scientific Society and Secretary of the Colorado Earthquake Hazards and Mitigation Council.



Matt Morgan

Chris Carroll took on the job of Board President, Friends of Dinosaur Ridge.

Vince Matthews was the Treasurer and member of the Executive Committee of the Association of American State Geologists and served on the Executive Committee of the Western States Seismic Policy Council.

Jill Carlson served as the Treasurer and Website Administrator of the Rocky Mountain Section of the Association of Environmental and Engineering Geologists.

The Rocky Mountain Association of Geologists (RMAG) benefited from the presence of **Genevieve Young** on the Continuing Education and Awards Committees. Genevieve also was selected to serve as the Rocky Mountain Councilor for the American Association of Petroleum Geologists (AAPG).



Genevieve Young


Support

One of the first faces you see when you walk into the front door of CGS's main office is that of **Rachael Nickless**. And that face usually has a big smile on it as she happily greets visitors to the office and answers the phone




calls. Rachael joined CGS March 2005. She has an undergraduate degree in Environmental Science, which has helped her immensely in her current position of Publications Retail Manager. Have a question about a publication? About one of our fleet vehicles? About anything to do with CGS? Rachael will most likely have the answer for you. And if she doesn't have the answer, she will find the person who does.

Mosey on past Rachael's desk with an accounting question, and you will find **Dori Vigil**.



Dori has been with CGS since December 1999, and there isn't anything about CGS's accounting transactions that she doesn't know. Dori is the person that consultants and contractors deal with and depend on and interface with for CGS business. Her diligent efforts keep the agency's procurement and accounting running seamlessly.

But you came here with questions about computer systems or you have a land use review question? You need to see **Brenda Hannu**. Brenda sits outside the State Geologist's office




(keeping him in line while she's at it) and works in the Land Use Review program, the Subsidence Information Center program, as first-line IT support and as Director's Assistant. Most times, you will find her carrying around an armload of files while trying to chase down the Land Use Review Program Manager. She also assists staff with specifications for new laptops and desktops, along with first-line IT support. She has a master of science degree in Tropical Forest Ecology, and while that area of expertise isn't something you'd typically need in Colorado, she has become a valuable asset to CGS.

These three Administrative Section staff are located at the west end of the office. If you go down to the east end, you'll find two other Administrative Section staff, the "artistic" ones—Nick Watterson and Larry Scott.

Nothing quickens the pulse of a geologist faster than a map. **Nick Watterson** is the person behind the maps produced and used by the CGS. Nick joined CGS August 2006 in the Environmental Geology section as a six-month temp, and successfully landed the position as the agency's GIS specialist. Nick has a master of science degree in geography and is our ARC GIS wizard. With Nick's extensive background in geology and geography, plus his years of experience AND his GIS capabilities, his help is valuable to everyone in CGS.



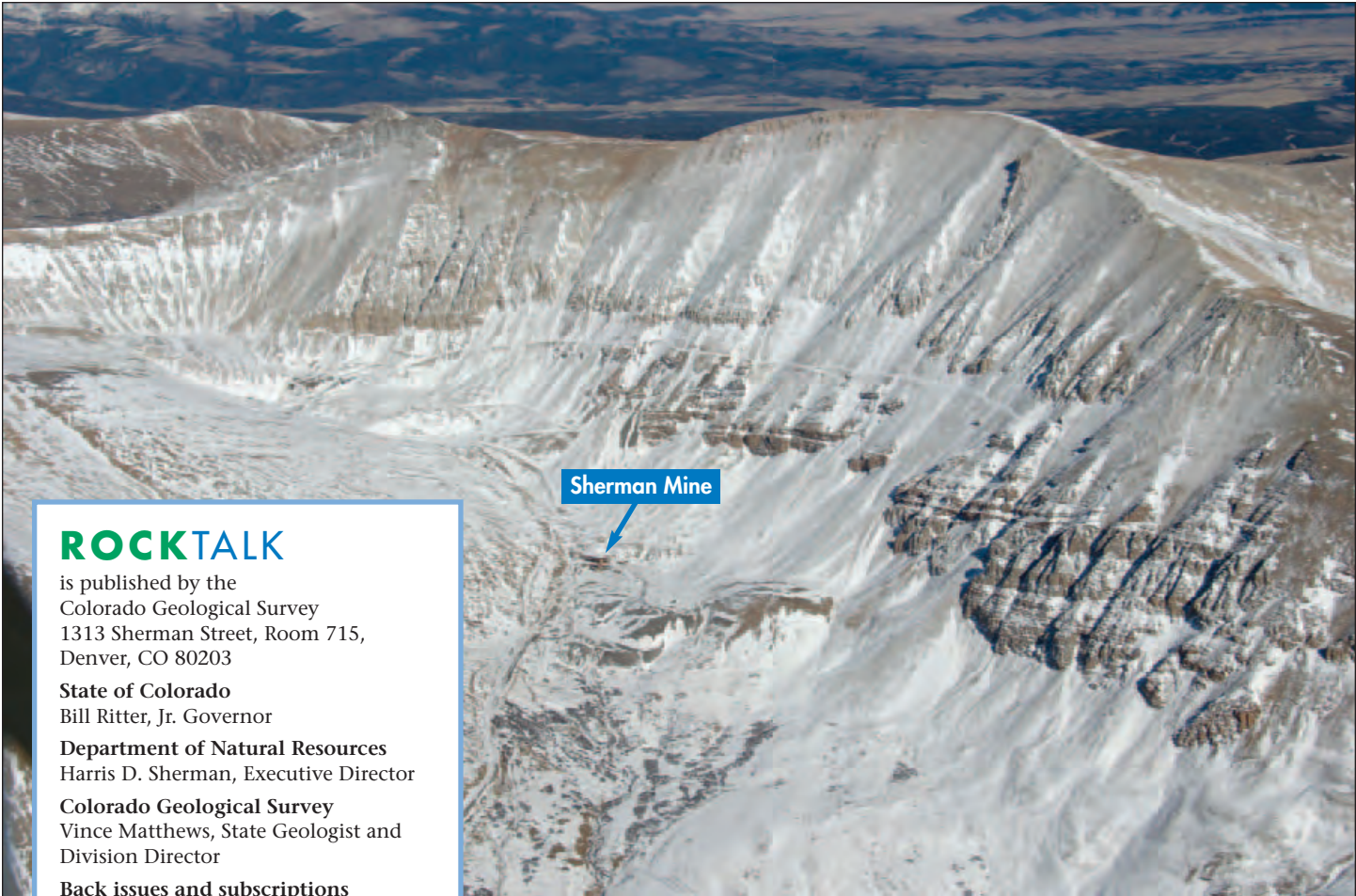
If you've seen an illustrated poster at a CGS booth or display or an instructive figure in a CGS publication, you have probably



seen the work of **Larry Scott**. Larry has a B.A. degree in illustration and painting and has been with CGS since 1991. There is nothing that Larry can't do when it comes to incredible poster work and illustrations. Being the master of design that he is, he creates original works of art that showcase CGS's science and research and his skills are visible on or in every publication that CGS releases. Without him, we'd probably be doing our posters with an Etch-A-Sketch!

When CGS staff have a question about reallocations, or cost reports, or agency finances, or the legislative budget process, they need to see **Pat Schindler**, the supervisor of the Administrative Section. Pat has been with CGS since 2000. With her degree in accounting and her years of experience in government finance and accounting, she has been able to help the Director and Deputy Director keep the agency functioning like a well-tuned machine. CGS's funding is one of the most complicated within the Department of Natural Resources, and Pat has done an excellent job of creating a structure that ensures that the agency's financial status is monitored and there are no surprises at fiscal year end.





Sherman Mine

ROCKTALK

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Vince Matthews, State Geologist and
Division Director

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Web site: <http://geosurvey.state.co.us>

THIS ISSUE

Editor: J. Burnell

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Mount Sherman is located between Fairplay and Leadville, along the boundary of Park and Lake Counties. The peak, at 14,040 feet, is considered one of the easiest of Colorado's Fourteeners to climb. This view up Iowa Gulch shows the Sherman Mine, at 12,200 feet, in the Iowa Amphitheatre. The Sherman Mine contained silver-zinc-lead deposits in a grand geologic setting, with sulfide ore occurring in an old cave system (paleokarst) in the Leadville Limestone. The sedimentary sequence that includes the Leadville Limestone forms the horizontal layers on the wall of the amphitheatre, with large sills of igneous rock, intruded between the sedimentary layers, enhancing the horizontal layering. The Sherman mine was open as late as 1982, producing 10 million ounces of silver in its history. The mine was particularly known for its beautiful golden barite crystals.
Photo by Harry Ranney.



ROCKTALK

Colorado Geological Survey
1313 Sherman Street, Room 715
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