

Centennial Anniversary of the Colorado Geological Survey

This year marks the one-hundredth anniversary of the founding of the Colorado Geological Survey in 1907 and the fortieth anniversary of its recreation in 1967. According to the 1908 first annual report, "The Sixteenth General Assembly of Colorado enacted a law creating a State Geological Survey, and appropriating \$5,000 per annum for carrying on the work outlined in the act."

Although the mining community strongly supported the establishment of a Colorado Geological Survey, some were less than pleased with the details of the final bill, as evidenced by the following quote from the *Mining Reporter* of April 1907:

Criticism is made of the proposed advisory board, particularly of the placing thereon of the presidents of the State University and the State Agricultural College; also, having the survey located at Boulder instead of Denver; of the naming as state geologist, the professor of geology of the State University, who may be a good teacher, but who, like the majority, may or may not be an effective executive; and lastly, of the paltry appropriation of \$5,000 annually for this important work in a state productive of \$50,000,000 and more yearly. Exception is also taken to the naming of state institution teachers as assistants to the State Geologist, who ought to have the assistance of men less academic and having a knowledge of the exploitation of ore deposits and of the search for them.

The First Annual Report continues as follows:

The Advisory Board of the Survey met in May, 1907, and instructed the State Geologist (Russell D. George) to begin work. Unfortunately the survey appropriation was placed in the fifth class, and, as a result, the funds were not available until April, 1908. However, a field party was formed, an outfit secured, and work was begun early in June, 1907. The State Geologist paid the bills and expense accounts to the amount of \$1200, and became personally responsible for \$1300 more. These adverse conditions, and the necessary reduction of the field force, made it impossible to complete any of the field work undertaken, and consequently impossible to prepare the reports and maps. During the season of 1908 the field work outlined below was completed, and the reports are contained in the present volume.



Seal from the First Annual Report of the
 Colorado Geological Survey 1908

Those reports included the results of geologic mapping around Hahns Peak, the Boulder County tungsten field, the Montezuma area in Summit County, and the geologic formations along the northeastern flank of the Front Range. Work in progress included the preparation of topographic and geologic maps of the State, a map of metalliferous deposits in the State, a map of the location of coalfields, a bibliography of the geological literature of Colorado, and establishment of a Colorado Geological Survey library containing more than 600 volumes at a cost not exceeding \$10.00. The survey

used the services of professors of geology at the "State University" and the School of Mines at an average cost of \$5.00 per day and expenses.

Prior to the establishment of the Colorado Geological Survey, the Territorial Legislature established the position of State Geologist in 1872. Seven geologists occupied the position prior to the establishment of the survey in 1907. The Colorado Geological Survey flourished until the mid 1920s when it mysteriously faded out of existence. It was re-created on June 9, 1967, and the new Director and State Geologist (John Rold) was hired in February 1969. For a more complete history of the Survey, visit "About Us" on our Web site at <http://geosurvey.state.co.us>.

CGS Becomes Full-Fledged Division in DNR

In 1992, CGS was placed under the Division of Minerals and Geology in the Department of Natural Resources (DNR). In 2005, Governor Bill Owens signed legislation into law reestablishing CGS on the same level as the other eight divisions in DNR. The legislation was cosponsored by Senators Taylor, Entz, Isgar, and Teck and by Representatives White, Boyd, Coleman, Hoppe, Liston, and Massey. The bill was an outgrowth of a 2004 cooperative study to determine whether CGS should move to the Colorado School of Mines.

Funding difficulties for the very first Colorado Geological Survey are described at the beginning of this issue. The twenty-first-century Colorado Geological Survey is also experiencing funding challenges. CGS has taken steps over the past three years to increase efficiency, to streamline our organization, and to make better use of existing State resources. Our committed and talented staff has been able to get the job done despite a ten percent reduction of authorized full-time employees and, in addition, has taken on increasing responsibilities at the request of the Department of Natural Resources.



The good work of your CGS often goes on quietly behind the scenes. Consequently, many people may be unaware of the significant contributions made to a wide variety of matters. For that reason, I would like to take this opportunity, on the one-hundredth anniversary of the Colorado Geological Survey, to outline some selected examples of how our work influences decision making around the State. The examples are grouped by sector such as Federal agencies, State agencies, and the business community.

Business and Industry

- Preliminary copies of the CGS report *Carbon Sequestration Potential in Colorado* are currently being used by Shell in their planning for a major oil shale facility in the Piceance Basin and by Xcel in their planning for a major Integrated Gasification Combined Cycle (IGCC) power plant in the Denver Basin.
- As a direct result of CGS studies, a Rural Electrical Association and a private company have begun discussions on the possibility of building Colorado's first geothermal power plant.
- Homebuilders and developers in Colorado used CGS expertise to develop a new standard-of-practice for building in areas with the geologic hazard of heaving bedrock.
- CGS annual reports on the activity of the Colorado mineral and energy industries are the only reliable source that decision makers in Colorado have at their disposal. The annual report covers all aspects of the mineral and energy industries including oil and gas, coal, precious and base metals, uranium, industrial minerals, construction materials, and renewable energy sources. Each report is an integral part of the annual Colorado Business Economic Outlook of the Leeds School of Business. Colorado media commonly refer to the statistics and information in the report.
- Because of our expertise in both minerals and geologic hazards, CGS was the first agency called on to help when the Trapper Mine in Moffat County recently suffered a major landslide in their coal mining operations.

- Shell is currently using CGS expertise and studies to evaluate the earthquake hazard in the vicinity of their new oil shale facility.

Legislative and Judiciary Branches

- Within two months of publication, the CGS *Groundwater Atlas of Colorado* was cited in a Colorado Supreme Court decision.
- The Legislature's Water Resource Review Committee directed the Colorado Water Conservation Board (CWCB) to use information from the CGS study on underground storage of water in the board's Statewide Water Supply Initiative.
- The CGS report on the potential for aquifer recharge and underground water storage was the foundation for SB 06-193, which directs that a thorough study be made of the potential for underground storage of water in the South Platte and Arkansas Basins.

Executive Branch

- CGS provided assistance in one form or another to nineteen different State agencies during the twenty-first century.
- CGS groundwater studies of the Rocky Mountain Arsenal gave the Attorney General the ability to increase Colorado's natural resource damage claim.
- CWCB used information from CGS's *Groundwater Atlas of Colorado* in compiling the Statewide Water Supply Initiative report and the South Platte Decision Support System database.
- CGS geologic maps were used by the Colorado Oil and Gas Conservation Commission in their 3M Project to promulgate rules for the rapidly expanding development of coalbed methane in the San Juan Basin.
- CGS computer evaluations of the consequences of the next strong earthquake in Colorado are used by the Division of Emergency Management for scenarios of how to plan for the event.
- CGS supplied the Governor's office with a brief on energy resources in order to aid in recommendations to the Federal Government on roadless areas in Colorado.
- CGS geologic characterizations of strata producing coalbed methane are being used by the Colorado Oil and Gas Conservation Commission and Division of Water Resources to determine whether pumping water from coalbed methane wells affects stream flow and/or tributary groundwater.
- Colorado Department of Transportation (CDOT) used a CGS landslide study to mitigate movement of a major landslide that disrupts I-70 on the western slope.
- CGS conducts emergency response and follow-up investigation for CDOT after highway rockfall events.

City and County Governments

- As a result of CGS's report on the potential for underground storage of water, the El Paso County Water Authority is studying the potential for a large underground storage project and is actively seeking and using technical advice from CGS.
- Montrose County requested CGS to prepare geologic maps to be used for the geologic hazard and mineral resource aspects of their development planning.
- For new developments, the CGS land use review group provides expert advice to counties concerning geologic hazards and their mitigation, as mandated by State statute. Because the credibility of this group has continually grown over the decades, eleven municipalities also now request CGS's assistance in this area, although they are not mandated by statute to do so.
- The Colorado Springs Planning Department staff uses CGS landslide susceptibility maps in their approval process for subdivision applications.
- Gunnison Water Conservation District officials consulted with our geologic mapping team about the location of a proposed reservoir. Upon discovering that a landslide was mapped at that location, they are reconsidering the proposed site.
- Garfield County and the town of Basalt use CGS maps in their land use planning and subdivision review/approval decisions to avoid sinkhole and collapsible soil hazards.
- Estes Park, Evergreen, and Colorado Springs use CGS rock-fall susceptibility maps to make informed planning and land use decisions.
- CGS helped to produce timely maps of postwildfire mudslide hazards following the High Meadows, Bobcat, and Missionary Ridge wildfires. The maps were used by local and county governments for emergency preparedness in the event of large rainstorms in the burned areas.
- For planning purposes, Jefferson County uses CGS maps of sensitive and erodible soils in the county.

Task Forces

- CGS groundwater geologists provide ongoing technical assistance to the Interbasin Compact Commission and the nine basin roundtables, particularly in identifying how aquifers and groundwater in each particular basin can help address water supply and storage needs.
- CGS supplied information and maps for the Roadless Area Task Force that helped enable it to reach a consensus recommendation to the Governor on National Forest lands in Colorado.
- CGS played a key role in the DNR Interagency Task Force on the twenty-year management plan for the Roan Plateau.

Federal Government

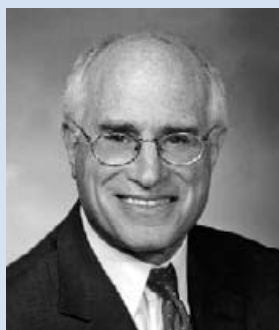
- CGS expertise in mineral and energy resources is regularly sought by the U.S. Bureau of Land Management (BLM) in their planning for oil shale and conventional energy development.
- CGS studies on earthquake hazards in Colorado are used by the U.S. Geological Survey in updating the national earthquake hazard maps. These hazard maps are what determine the requirements in the International Building Code used throughout the United States.
- CGS solely represented the State of Colorado on the Evaluation Panel for the Oil Shale RD&D (research, demonstration, and development) proposals, partly because it was determined that a representative from a regulatory agency might have a conflict of interest.
- The U.S. Geological Survey extracts parts of the CGS Annual Report that deal with the energy and mineral industries for their Minerals Yearbook.

Citizens

- A quarter million homeowners in Colorado received a CGS publication illustrating how they can protect their homes from swelling soil hazards.
- The CGS publication *Messages in Stone: Colorado's Colorful Geology* is used as a text in at least 12 institutions of higher education around the State.
- Classrooms in secondary and middle schools use a set of seven posters created by CGS on topics such as geologic hazards, mineral and energy resources, avalanche safety, water, and the geology of Colorado.
- Thousands of visitors to the Colorado State Fair visit CGS's mineral and geology room each August.
- Citizen inquiries from the simple to the complex are promptly answered each day. Our geology Web site averages about 20,000 hits per day during the week, and our Avalanche Information Center Web site receives about 80,000 hits per day.
- Our Colorado Avalanche Information Center has provided safety training to more than 40,000 citizens and has reduced the avalanche deaths-per-hundred-thousand-citizens markedly over the past decade.

Governor Bill Ritter's inaugural address outlined his vision for the "Colorado Promise." Our work over the past several years on carbon sequestration and geothermal energy positions us well to play key roles in Colorado's New Energy Economy. Our work on the geology of State Parks and groundwater integrates well with the Governor's economic development plans. We at CGS look forward to this exciting new era and meeting the geologic information needs of Colorado for the next 100 years.

—Vince Matthews



Harris D. Sherman Named Executive Director of DNR

In January 2007, Harris D. Sherman was appointed by Governor Bill Ritter, Jr., as Executive Director of the Colorado Department of Natural Resources. The job is not new to Harris, as he was appointed to head the Department by Governor Richard Lamm in 1974, serving in that capacity until 1980. During Harris's first term, John Rold, an honorary member of the American Association of State Geologists, served as State Geologist and Director of the Colorado Geological Survey.

Prior to joining State Government, Harris was a senior partner specializing in environmental law in the firm of Arnold & Porter and also served as a commissioner on the Denver Water Board. Harris currently serves as a trustee of the Boettcher Foundation, chair of the Colorado chapter of the Trust for Public Land, and member of the Colorado Forum. He had earlier served as chairman of the Colorado Water Quality Control Commission, chairman of the Denver Regional Air Quality Council, chairman of the Colorado Mined Land Reclamation Board, Colorado Commissioner of Mines, Colorado's representative to the Western States Water Council and National Governors Association, and trustee of Colorado College. He has an LL.B. from Columbia Law School and a B.A. from Colorado College.

CGS Hosts or Cohosts National and International Meetings

The CGS is hosting the 43rd Forum on the Geology of Industrial Minerals to be held in May 2007 at the Millennium Harvest House hotel in Boulder. Industrial minerals currently being produced in Colorado include sand, gravel, crushed stone, silica sand, dimension and decorative stones, cement, clay, gypsum, and peat. The Forum is a six-day international gathering of geologists, industry leaders, consultants, mine operators, mining equipment representatives, and students. Presentations and field trips focus on the geology of industrial minerals, end uses, mining and processing, transportation, marketing, mining trends, and policy. A committee of local geologists and industry leaders is helping CGS plan for the 2007 Forum.

From September 25 to 29, 2006, CGS cohosted the 57th Highway Geology Symposium that was jointly held with the 32nd Northwest Geotechnical Workshop at Breckenridge. This week-long national conference was attended by more than 300 engineering geologists, geotechnical engineers, and their guests. Vince Matthews was the featured banquet speaker and impressed the attendees with his presentation on Colorado's colorful geology. A major anticipation of this conference is always the day-long field trip to examine the local geology of the host State with an emphasis on highways. Our field trip covered Colorado's colorful geologic terrain from Breckenridge up to the top of Vail Pass



and then back over Loveland Pass to Georgetown. Discussions and field-trip stops covered the geology of the central Colorado Mountains, the difficulty and evolution of highway construction in the transportation corridors of I-70 and Highway 6, our mining history, geologic hazards, water resources, and avalanches. Jon White was on the local steering committee, which was chaired by Frank Harrison of Golder Associates. Jon also authored the field-trip guidebook with Mark Vessely of the Colorado Department of Transportation. Jill Carlson, Beth Widmann, Dave Noe, Sean Gaffney, and Rachael Nickless also participated as either field-trip leaders or with the CGS exhibit at the conference. The proceedings and field-trip guidebook of this conference will soon be published by the CGS on CD-ROM.

Dave Noe is serving as field-trip committee chair for the first North American Landslide Conference, which will be held in Vail later this year. Fortunately for this conference, but unfortunately for our citizens, Colorado has spectacular examples of landslides.



New Faces

As some folks have left us, new folks have joined us in the past two years.

Nick Watterson began his career at CGS as a temporary physical scientist in the GIS (geographic information systems) lab, working with several other key staff members on a hydrogeology mapping project. His knowledge of GIS led to a permanent position with our team. Holding a master's degree in geography with a geology undergraduate degree in fluvial geomorphology (human/land interaction with a focus on surface water and land use impacts on rivers and streams), Nick is very excited to be with us. Also an athlete, he played competitive soccer in college for a German soccer team and currently is considered a professional elite cyclist here in Colorado. His first child, a son named Everett, was born in September.

Jim Burnell is a welcome transplant from the Colorado Division of Reclamation, Mining and Safety. Our newest Minerals Geologist, Jim also loves to fish, travel abroad with his wife, and cook. He considers himself a "foodie"—some of his specialties include curry and Cajun cooking—and he dabbles in a love of wines. Other interests include genealogy and numismatics. Before coming to work for the State, Jim taught various classes in geology at Auburn University and was a geologic specialist for CERT (Council of Energy Resource Tribes), a Native American council having a focus on natural resources development on Indian lands. Jim with his impressive resume makes a wonderful addition to our staff.

Joining us in the Administrative and Business section is Rachael Farnsworth, who happily became Mrs. **Rachael Nickless** at the end of May. She brought a strong organizational background to help streamline the day-to-day operations of the Sur-



Left to right: Jim Burnell, Rachael Nickless, and Nick Watterson

vey, especially those concerning the online bookstore, archival library, and inventory. She has a bachelor's degree in environmental sciences, and she plans to return to school to obtain a master's degree in engineering geology. Since her arrival, she has become an integral part of CGS.

Sean Gaffney joined the CGS staff in 2000 as an engineering geologist. He decided to move to Pennsylvania to pursue consulting in the engineering geology/environmental field. Sean returned to his old position at CGS in 2006. He is part of the Land Use Review Team and works mainly on the western slope. He also surveys and monitors landslides. Sean has a

bachelor's degree in geosciences from Penn State. He enjoys being back in Colorado with his friends at CGS and is also excited to ski again!

Erik Oerter transferred to the CGS from the Colorado Department of Transportation in February 2007. He has a bachelor's degree in geology from the University of Colorado–Boulder as well as a master's degree in earth and planetary science from the University of California–Berkeley. He is thus an excellent addition to the Environmental Geology Section of the CGS. Erik was a raft guide for seven years and still enjoys guiding raft trips whenever possible.



Left to right: Erik Oerter and Sean Gaffney

People Profile—Jim Cappa

by Christian Lyons

If you were to walk down the street where you live, stop the first person you see, and ask questions about his or her life, you might be surprised at the answers you get in return. As part of this edition of *RockTalk*, we approached the Chief of Mineral Resources here at the Colorado Geological Survey and did that very thing ... asked questions.

Jim Cappa has been with CGS since 1991. Did he always want to play with rocks? No. In fact, Jim's first passion was to become a jazz trombonist.

"That way I could hang out in smoky bars with fast women," he said, a mischievous twinkle in his eye. Though he majored in music at his San Francisco high school, life intervened on that particular dream.

He had always been mechanically inclined and harbored a fondness for machines, and so it was no surprise to his family when he enlisted in the Navy and became part of the Naval Air Squadron as mechanic and crew member. He loved working on aircraft engines. His unit was stationed in his home State of California, where he was on regular patrol of the west coast and Hawaii.

After a two-and-a-half-year stint with the military, Jim enrolled at the University of California—Santa Barbara in aeronautical engineering. It didn't take him long to figure out that it wasn't the right field for him.

"I said to myself, 'No way did I want to spend my career sitting at a table drafting engine parts.'"

He recalled one of his high school earth science instructors, John Schaeffer, who was a very dynamic and passionate teacher and who instilled in his students a similar excitement for geology. It was during one of several field trips and after viewing photos of various geologic formations that Jim knew which direction he wanted to head next. This decision was strengthened when he realized he had a real wanderlust, a desire he pushed aside in order to pursue a degree. He graduated from the University of California—Santa Barbara with a bachelor's degree in geology.

During his first job with the U.S. Forest Service in Santa Barbara, his wanderlust began to really make him antsy to be traveling. Europe was his first goal, but his ultimate destination was Africa. And so he left the Forest Service, packed his backpack, and hit the road.



Jim Cappa arm-waving about the old Bonanza Mining District in the southern Sawatch Range. In 1915, CGS published Bulletin 9 describing the geology of the Bonanza District.

In London, he learned of a company called Anglo-American Corporation, whose home base was in South Africa. He strode into their European office and applied, figuring he could work and travel at the same time. He was hired on the spot. For the next couple of years, he explored mines in Zambia and hiked the African countryside scouting for copper. Finally, he decided it was time to go home. He bought a 1969 Honda CB 450 motorcycle—one of the largest machines on the market at the time—and began his trek back to the United States, a journey that traversed several continents and is a story unto itself.

Once back on home soil, he chose to continue his education, enrolling in the master's program at the New Mexico School of Mines. When he graduated in 1975, it was during the worst energy crisis the United States had ever seen. He scouted around for work and accepted a position with AMOCO in Denver, even though it was the lowest salary of all the companies he looked at. He wanted to live in Colorado. He discovered that being a desk jockey in a major corporation was nothing like the autonomy he'd had while working in Africa. "I sat staring out the window of my Denver office thinking that I would just do anything to be outside," Jim said.

He made a move to Houston Oil and Minerals, based in Denver, for whom he did uranium exploration. That led him to FMC Gold Company, another Colorado organization, with whom he spent the next ten years doing international exploration and satisfying his wanderlust at the same time. The Denver FMC office closed in 1991, and Jim was once again forced to decide what his next path would be. He started his own private gold consultation

business, which took him to Yugoslavia during a time when the Yugoslavian Federation was breaking into civil war.

Later in 1991, he applied to the Colorado Geological Survey. Then-Director John Rold indicated to Jim that he was one of three top contenders for the position offered. Jim was the recipient, and the rest, as they say, is history.

Most recently, Jim saw his two sons married, one week apart, which sounds like a planning nightmare. But he didn't seem to mind at all. "I gained two wonderful daughters," he said with obvious pride.

Outside of his work with CGS, Jim keeps very busy. He has been a pilot for over twenty-five years, holding both commercial and instrument ratings. He co-owns three aircraft: a Piper Saratoga, a Piper Archer, which is used mostly for his own flight training, and a Beechcraft Bonanza. He has flown cross-country more times than he can recall and has used his aircraft on State business numerous times.

There are rumors of his pending retirement from CGS after fifteen years. We asked about his plans. "I will continue to travel and work on my collector vehicles, a '72 MG, which has won several prizes from the annual British Motor Car Conclave and which I restored myself, and a '67 Buick GS 400 convertible, which still needs work."

He intends to do some hiking locally and will still work in geology, though part-time. He would like to do some consulting on precious metals and industrial minerals. In the meantime, he heads the planning committee for the 43rd Forum on the Geology of Industrial Minerals to be held in Boulder, May 20–25, 2007.

Jim feels that his time with CGS has been very satisfying and varied, "a tremendous career." He has certainly earned bragging rights for his accomplishments, which include increased focus on Colorado mineral and energy resources. But his greatest achievement to date was starting, with former CGS geologist Bob Kirkham, the geologic mapping program, initiated in 1993. Beginning with a mere half-quad in Glenwood Springs, the CGS mapping program "has grown into something quite remarkable," Jim said. CGS now maps six to seven quads a year.

Whatever happened to the motorcycle he bought in Zambia? He still owns it and plans on taking a road trip with it sometime this year. Apparently, he never really got over that wanderlust.

Ethan Greene Assumes Helm of CAIC

Ethan Greene, a native of Colorado, became Director of the Colorado Avalanche Information Center (CAIC) in September 2005. Ethan has a strong background in meteorology and snow physics, as well as experience with operational avalanche forecasting in Utah and Montana. At Colorado State University in December, he successfully defended his Ph.D. dissertation on thermophysical and microstructural properties of seasonal snow covers. Ethan was lead editor and author of a recent publication entitled



Snow Weather and Avalanches: Observational Guidelines for Avalanche Programs in the United States. Ethan's broad experience is a welcome addition to our management team at CGS.

CAIC Director Ethan Greene examines weak snow layers at scene of fatal avalanche accident



The folks in the CAIC continue to reduce the average number of deaths from avalanches in Colorado through their forecasting of conditions and safety education. Upper Row (left to right): Scott Toepfer (Boulder—forecaster), Matt Dayer (Silverton—intern), Susan Hale (Silverton—forecaster), Spencer Logan (Boulder—forecaster), Ethan Greene (Boulder—director), Nick Logan (Breckenridge—forecaster), Rob Hunker (Marble—forecaster). Lower Row (left to right): Ben Pritchett (Boulder—educator), Brad Sawtell (Breckenridge—forecaster), Stu Schaefer (Eisenhower Tunnel—forecaster), John Snook (Boulder—forecaster), Mark Mueller (Pagosa Springs—forecaster), Lee Metzger (Eisenhower Tunnel—forecaster).

Service to the Geologic Profession

Many CGS geologists contribute to the science community through participating in outside organizations and societies.

- **Celia Greenman** is the newsletter editor for the Colorado Scientific Society and also serves as a member of that organization's Council.
- **Chris Carroll** served the science in several roles with the Geological Society of America: the Joint Technical Program Committee member for the Coal Division in 2005, cochair of the general Coal Division session, organizer of the Coal Division Business Meeting, 2006 Coal Division chairman, and chairman of the Cady Award Committee. He is president of the Board of Directors of Friends of Dinosaur Ridge and is chairing the Mining in Colorado Session at the 109th National Western Mining Conference in 2007.
- **Genevieve Young** chaired the Rocky Mountain Association of Geologists Rockbusters' Ball Committee in 2005.
- **Jill Carlson** is the webmaster for the Association of Engineering and Environmental Geologists—Rocky Mountain Section.
- **Jim Cappa** serves as vice president of the Colorado Section of the American Institute of Professional Geologists.
- **Karen Berry** is a board member of the Jefferson Conservation District, president of the Upper South Platte Watershed Association, vice-chair of the Coalition for the Upper

South Platte, member of the Urban, Community and Coastal Resources Committee of the National Association of Conservation Districts, and on the Steering Committee of the Jefferson County Mountain Ground Water Task Force.

- **Matt Morgan** is chair of the Colorado Scientific Society's Best Paper Committee and is president elect of the society. He is also secretary of the Colorado Earthquake Hazard Mitigation Council.
- **Peter Barkmann** is the editor and a member of the Executive Board of the Colorado Section of the American Institute of Professional Geologists.
- **Ralf Topper** organized and moderated the Ground Water Recharge and Storage topical session at the 2006 National Ground Water Association Expo. He is also the vice president of the Colorado Ground Water Association.
- **Vince Matthews** served as president and past president of the Colorado Scientific Society. Vince also served on the Geological Society of America Research Awards Committee. He is a member of the Executive Committee of the Western States Seismic Policy Council and nominee for an office in the Association of American State Geologists.

See Service on page 8

Field Trips

CGS is dedicated to providing education to the public as well as professional organizations through geology-related field trips. CGS geologists Vince Matthews, Chris Carroll, Jon White, Beth Widmann, Matt Morgan, Jim Cappa, and Dave Noe guided a number of field trips in the past two years. The field-trip topics included the Anton trench, highway geology, talus flatirons, sackungen (ridge-top troughs), Bonanza and Orient mining districts, underground coal mines, a “drive through time,” and geologic hazards.

New CGS Publications

The following is a list of CGS publications issued during 2005 and 2006. These may be purchased through our online bookstore at <http://dnr.state.co.us/geostore> or by calling (303) 866-2611.

- Coal Resource Maps of Colorado*: C. Carroll
- Colorado Coal Directory, 2005*: C. Carroll
- Colorado Mineral and Energy Industry Activities, 2005*: J. Cappa, G. Young, J. Keller, C. Carroll, and B. Widmann
- Critical Landslides of Colorado*: W.P. Rogers
- Geologic Map of Dawson Butte Quadrangle, Douglas County, Colorado*: M. Morgan, J. Temple, M. Grizzell, and P. Barkmann
- Geologic Map of La Valley 7.5-Minute Quadrangle, Costilla County*: R. Kirkham, J. Lufkin, N. Lindsay, and K. Dickens
- Geologic Map of Manitou Springs 7.5-Minute Quadrangle, El Paso and Teller Counties, Colorado*: J. Keller, C. Siddoway, and M. Morgan
- Geologic Map of the 7.5-Minute Breckenridge Quadrangle, Summit and Park Counties, Colorado*: C. Wallace, J. Keller, J. McCalpin, P. Bartos, E. Route, N. Jones, F. Gutierrez, C. Williams, and M. Morgan
- Geologic Map of the 7.5-Minute Vallecito Reservoir Quadrangle, La Plata County, Colorado, CD-ROM*: J. Frechette, D. Stahr, T. Osmera, N. Morse, and K. Graham
- Geologic Map of the Almont Quadrangle, Gunnison County, Colorado*: J. Coogan, A. Stork, and R. Fillmore
- Geologic Map of the Buena Vista West Quadrangle, Chaffee County, Colorado*: J.P. McCalpin and J.R. Shannon
- Geologic Map of the Castle Rock North Quadrangle, Douglas County, Colorado*: J. Thorson
- Geologic Map of the Como Quadrangle, Park County, Colorado*: B. Widmann, R. Kirkham, J. Keller, J. Poppert, and J. Price
- Geologic Map of the East Half of the Larkspur Quadrangle, Douglas and El Paso Counties, Colorado*: J.P. Thorson
- Geologic Map of the Gunnison Quadrangle, Gunnison County, Colorado*: A. Stork, J.C. Coogan, A. Csar, and R. Wentz
- Geologic Map of the Mount Pittsburg Quadrangle, El Paso, Pueblo, and Fremont Counties, Colorado*: M. Morgan, J. Temple, and D. Martin
- Geologic Map of the Russellville Gulch Quadrangle, Douglas and Elbert Counties, Colorado*: J.P. Thorson
- Geologic Map of the Sedalia Quadrangle, Douglas County, Colorado*: M. Morgan, J. McHarge, and P. Barkmann

- Geologic Map of the Southern Half of the Culebra Peak Quadrangle, Costilla and Las Animas Counties, Colorado*: R. Kirkham, J. Keller, J. Price, and N. Lindsay
- History, Geology, and Environmental Setting of the Akron Mine, Gunnison National Forest*: R.H. Wood II and D.A. Bird
- Mine Site History and Watershed Characterization of the Cinnamon Gulch Area, Dillon Ranger District, White River National Forest, Summit County, Colorado*: R. Wood, D. Bird, and M. Sares
- Minerals and Mineral Fuel Activity Report, 2004*: J. Cappa, G. Young, J. Keller, C. Carroll, and B. Widmann
- Oil and Gas Well Map of Colorado*: J. Milne, C. Brchan, and G. Young
- Poster—Avalanches in Colorado*: L. Scott and J. Wilson
- Poster—Geologic Hazards of Colorado*: L. Scott and J. Wilson
- Poster—Geologic Mapping Colorado*: L. Scott and J. Wilson
- Poster—Geology of Colorado*: L. Scott
- Poster—Mineral Resources of Colorado*: L. Scott and J. Wilson
- Poster—Symbols of Colorado: Mineral, Gem, Rock and Fossil*
- Poster—Water and Contamination in Colorado*: L. Scott and J. Wilson
- Rockfall Hazards Susceptibility in Colorado Springs, El Paso County, Colorado*: T.C. Wait and J. White
- Rockfall Hazards Susceptibility in the Estes Valley Development Code Area, Estes Park, Larimer County, Colorado*: T.C. Wait and K. Berry
- Rockfall Hazards Susceptibility in the Evergreen Area, Jefferson County, Colorado*: T.C. Wait and K. Berry
- Shapefiles for the 2002 Oil and Gas Fields Map of Colorado*: L.L. Wray, A.D. Apeland, H.T. Hemborg, C.A. Brchan, M.L. Morgan, and G.B.C. Young

Outside Publications in Journals

- **Dave Noe** submitted three papers forming a series representing a major part of his Colorado School of Mines thesis research to *Environmental and Engineering Geoscience* (published by the Association of Engineering Geologists). He also published a technical paper titled “Geologic Controls of Subdivision Damage near Denver, Colorado” in 2005 in the American Society of Civil Engineers (ASCE) *Journal of Geotechnical and Geoenvironmental Engineering*.
- **Jon White** published “Characteristics and Susceptibility of Collapsible Soils in Colorado: Results of a Statewide Study,” and Dave Noe coauthored “Spectral Reflectance as a Rapid Technique for Field Determination of Soil Engineering Properties” in the ASCE Colorado Section geotechnical seminar GEO-volution: The Evolution of Colorado’s Geological and Geotechnical Engineering Practice.
- **Nick Watterson** and Julia A. Jones published “Flood and Debris Flow Interactions with Roads Promote the Invasion of Exotic Plants along Steep Mountain Streams, Western Oregon” in *Geomorphology* volume 78.
- **Matt Sares** was coauthor on several papers: “Impacts on Water Quality and Biota from Natural Acid Rock Drainage in Colorado’s Lake Creek Watershed,” “Hyperspectral Sens-

ing of Acid Mine Drainage—Two Colorado Case Studies,” “Naturally Occurring Acid Rock Drainage in Colorado’s Lake Creek Watershed,” and “Hyperspectral Remote Sensing—An Effective Tool for Mapping Acid Rock Drainage and Mine Tailings in Colorado.”

Presentations and Outreach

All CGS geologists have public outreach as one of their performance objectives, and all do an excellent job of presenting the results of our work to a wide variety of audiences from international professional meetings, to local professional societies to service clubs, geology departments at universities, educational groups, and virtually anyone who is willing to listen. What we are no longer able to do is make presentations to school groups. The demand would be too great, and we do not have the resources of time and funding to visit schools. Instead, we are trying to produce things such as posters, bookmarks, postcards, and so forth that will reach this large audience. We also believe that by spending the little time that we have in educating teachers, we can have a farther reach. We will soon have much more information available for students on our Web site. Through this medium, we will be able to reach far more people for the time spent.

State Fair Geology and Mineral Room

CGS set up and staffed a colorful and informative exhibit at the State Fair in 2005 and 2006. The “Mineral Room” is located in the Department of Natural Resources building on the fairgrounds and was open to the public for two weeks in both years. Exhibits included samples and descriptions of Colorado’s State Rock (Yule Marble), State Mineral (rhodochrosite), State Gemstone (aquamarine), and State Dinosaur (*Stegosaurus*). We also displayed dinosaur models, fossils and tracks, mining tools and mineral samples, maps of Colorado’s groundwater resources, and descriptions and photos of the

Views of the CGS Mineral Room at the State Fair. Jill Carlson supervised the beautiful displays for us. Larry Scott prepared many of the graphic posters, and many folks loaned specimens.



State’s geologic hazards. New exhibits featured avalanche safety and a Colorado Points of Geologic Interest (POGI) poster to showcase the POGI *RockTalk*. The exhibit received many compliments from visitors, and more than 60,000 people visited the DNR building where the exhibit is held.

Technical Advisors

CGS personnel commonly provide technical expertise to various groups in a variety of ways. The following are recent examples:

■ Roadless Area Task Force

The Federal Government asked the States for recommendations on what to do with roadless areas in national forests in their States. Colorado formed a task force with members appointed from across the State who had diverse backgrounds and points of view. It was hoped that they might reach a consensus recommendation to the Governor.

CGS collected all available data on the mineral and energy resources in the roadless areas, entered them into a GIS database, and prepared uniform maps for each national forest under consideration. Each booklet contained a set of maps showing locations of Federal oil and gas leases and Federal units, areas with approved oil and gas spacing orders, existing and permitted oil and gas wells, existing oil and gas fields, areas of undiscovered oil and gas resources, mine permits and prospecting permits, known mineral deposits and occurrences, areas favorable for selected metallic and nonmetallic minerals, and potentially mineable coal resources and historic coal mines. Presentations were also given about the global energy and mineral resource situation and its impact on Colorado.

The task force did submit a consensus recommendation to Governor Bill Owens in the fall of 2006.

■ Roan Plateau

When Congress turned over management of the Naval Oil Shale located atop the Roan Plateau to the BLM, they mandated that it be leased for oil and gas development. DNR was one of the collaborating agencies in BLM’s development of a twenty-year management plan for the Roan Plateau. DNR’s team was composed of representatives from the Division of Wildlife, State Parks, Colorado Oil and Gas Conservation Commission, DNR’s Executive Office, and CGS.

Given that the BLM was mandated to lease the 34,000 acres atop the plateau, DNR used its multidisciplinary talents to draw upon ideas in the five draft Alternatives to craft a plan that it was hoped would have the least environmental impact on the recreational, wildlife, riparian, water, and other resources in the area. The plan included limiting the number of well pads to reduce surface impact, positioning well pads for the least visual impact, reducing the need for redundant facilities and pipelines, restricting drilling to ridge tops in order to protect riparian areas and water resources, allowing development on only one ridge top at a time to minimize impact on deer and elk migration, and restricting drilling

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during calving season. Most of DNR's ideas were incorporated into the final plan, which designated 45 percent of the area atop the plateau for "no surface occupancy or disturbance" and an additional 43 percent for "Controlled Surface Use." It is estimated that multiple, directionally drilled wells from single well pads will recover in excess of 90 percent of the natural gas reserves under the plateau, while keeping the impact on the other natural resources as low as possible.

Aerial view southward over the heart of oil shale country in the Piceance Basin. Snowy area is the Roan Plateau part of the basin. Battlement Mesa is the snowy area in the distance.



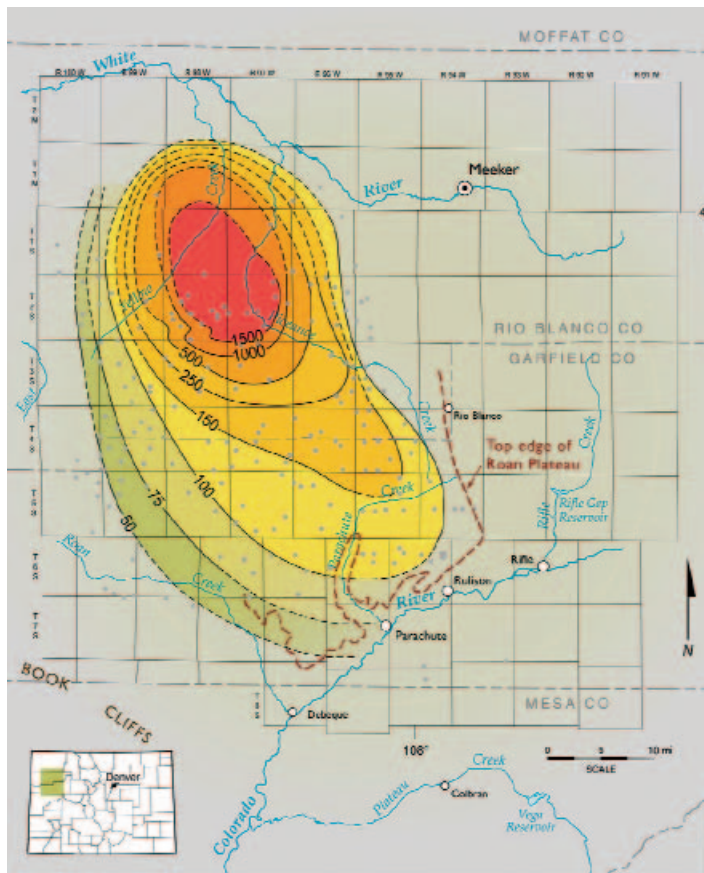
■ Oil Shale

Colorado has the richest and thickest deposits of oil shale in the world. CGS published a bulletin titled *Oil Shales of Colorado* in 1921. CGS was active in the oil shale boom of the late 1970s and early 1980s. We have also been quite involved in the recently emerging oil shale activity in Colorado.

CGS represented the State of Colorado on the evaluation panel for the BLM's research, demonstration, and development (RD&D) projects. We worked with the BLM in the preparation of the reasonable and foreseeable development (RFD) scenario for the programmatic environmental impact statement (EIS) that the BLM is preparing for commercial oil shale leasing. We prepared maps illustrating various aspects and potential impacts of RD&D tracts for State policymakers. And we are a member of the State's multidisciplinary oil shale task force. CGS also helped the Colorado Energy Research Institute (CERI) at Colorado School of Mines plan for a renewal of their oil shale conferences that were sponsored in past decades.

■ Water Roundtables

CGS hydrogeologists Peter Barkmann and Ralf Topper are assisting the newly created "basin roundtables" in discussions about groundwater. The "Colorado Water for the 21st Century Act" (HB 05-1177) created these water basin roundtables "to facilitate discussions within and between basins on water management issues." In our liaison function, CGS is providing important expertise, data, and resources for discussions related to groundwater supply. Two recent CGS publications, *Groundwater Atlas of Colorado* and *Artificial Recharge of Groundwater—A Statewide Assessment*, are serving as basic information sources for roundtable members. From these



Map of the Piceance Basin, Colorado, showing thickness (in feet) of oil shale that contains more than 25 gallons of oil per ton. The innermost red area is greater than 1500 feet thick.

publications, the members have the necessary information to help define how groundwater resources in their basin can help meet their future needs. As the members grapple with difficult water issues, especially trying to find additional water supply and water storage, part of the answer may lie underground.

■ CGS Rockfall Project

CGS has historically provided technical assistance to the Colorado Department of Transportation (CDOT) Geotechnical Section with various geologic and geotechnical support. Most of our work has focused on rockfall and landslide investigations. In August 2005, a new three-year task order was signed to provide continued assistance in both these areas. CGS will be providing initial response and geologic characterization to rockfall incidents on State highways and will continue our monitoring of the DeBeque Canyon landslide on I-70 east of Grand Junction in Mesa County.

In 2005, CGS assisted CDOT Soils and Rockfall staff with rockfall risk assessments and initial response of rockfall incidents at several locations on Colorado highways. One of the largest events, which was heavily covered by media, was the rockslide that forced the closure of U.S. Highway 6 in Clear Creek Canyon during the summer of 2005. CGS was one of the first responders and through the summer was part of the technical review team planning the best course of action for mitigation of the potentially dangerous rock overhangs that remained after the rockslide. This project involved the blast-

ing and excavation of 40,000 cubic yards of rock and the installation of more than 100 rock bolts.

In addition, CGS assisted CDOT with rockfall work on the Georgetown Incline, along I-70 in Clear Creek County. This is one of Colorado's most dangerous highway rockfall sites. The work included assisting with the production of a CDOT film about rock-scaling operations to remove dangerously weathered or otherwise loose rock and the construction of a new rockfall fence system. CGS also created high-resolution, 3D draped images and animations of the site through the use of GIS programs. The CGS personnel involved were Jon White, Sean Gaffney, and Dave Noe.

■ Land Use Review

The past two years saw a marked increase in requests to our Land Use Review program. The focus of this program is to provide expert technical reviews of development plans for counties, cities, and school districts. The reviews are intended to determine geologic suitability of various development projects. Overall, 2005 and 2006 were the two busiest years in the past decade for staff working in the Land Use Review program; in fact, CGS averaged 542 reviews per year. Each submittal is reviewed on the ground, and a report is provided to the county within 21 days of receipt of the request. January, March, and August of 2006 set month-specific records.

Celia Greenman, manager of the Land Use Review program, notes that the significant increase in review requests came from Montrose, La Plata, and Grand counties, partly

because of increased development near ski areas. Although municipalities are not required by statute to submit subdivision proposals to CGS, there are now 11 municipalities that regularly ask CGS to review their geologic reports. Requests from municipalities in 2005 constituted 28 percent of total land use reviews. The CGS Web site (<http://geosurvey.state.co.us>) provides more information about the program.



One of two trucks involved in the rockfall along U.S. Highway 6. Fortunately, no one was seriously injured. The glide plane was a granite pegmatite that cut across the metamorphic foliation.

Notable Projects

Geothermal Energy Project

According to a January 2006 report by the Western Governor's Association, Colorado has the geothermal resource potential to produce up to 20 megawatts of electrical power within ten years. To help meet and, it is hoped, exceed that goal, CGS is working with the Governor's Office of Energy Management and Conservation (OEMC) to update our knowledge of Colorado's geothermal resources. Among alternative renewable resources, geothermal electrical generation plants are unique in that they can satisfy base-load demand because they are operative approximately 95 percent of the time. A base-load power plant is one that provides a steady flow of power regardless of total power demand by the grid. Geothermal plants run at all times through the year except in the case of repairs or scheduled maintenance. According to the World Energy Congress, the yearly production of energy from geothermal plants is five or six times greater than that from wind plants with similar rating capacities.

We compiled a Colorado-specific geothermal database from national geothermal data sources and newly released data, such as AMAX Corporation's geothermal exploration work in the Buena Vista–Mt. Princeton area. The data are being used to create a new **statewide heat-flow map**. Heat flow is a measurement of the rate that heat moves through the Earth.

In addition, bottom-hole temperature and drill-stem test data from oil and gas wells are being used to create a **statewide geothermal-gradient map**. The geothermal gradient at a specific location quantifies the rate of increase in temperature with depth in the Earth at that location, so is useful in identifying prospective areas for geothermal energy exploitation.

In January 2007, CGS participated in the first Geothermal State Working Group meeting and presented preliminary versions of our new geothermal mapping. The group was convened by OEMC to help foster awareness and increased use of geothermal resources in Colorado, including heat pumps (for home or building heating and cooling), direct use (recreational pools, greenhouses, aquaculture), and electrical generation. CGS is on track to deliver timely information to meet the needs of industry and citizens interested in developing Colorado's geothermal resources.

CO₂ Sequestration Project

For the past several years, CGS has been an active participant in the Southwest Regional Partnership (SWP) on CO₂ Sequestration. We just completed our Phase I report on Carbon Sequestration Potential of Colorado and are well into the Phase II Pilot Program. We are also actively planning for the Phase II deployment to begin in 2009. Summarized below are key findings in the report on Phase I.

■ Sources

In 1999, Colorado's CO₂ emissions totaled more than 86 million tons. Power generation in the State primarily relies on coal, and as a result, 36 million tons of CO₂ or 42 percent of the total emissions for Colorado are emitted from power plants in the utility sector.



Area covered by the Southwest Regional Partnership (SWP) on CO₂ Sequestration, showing pipelines that could transport CO₂ and locations of Phase II pilot tests.

■ Sinks

Geologic storage options 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. CO₂ sequestration capacity for deep saline aquifers is conservatively estimated to range from 167 billion tons to more than 668 billion tons; these capacities are based on a 1 to 4 percent efficiency factor in the storage process, respectively. This range represents a three- to twelve-fold increase over the *combined* storage estimates for oil, gas, coal, and mineralization options. Further, deep saline aquifers may provide several centuries' worth of carbon storage potential if the process is only 1 percent efficient. The storage potential is widely distributed throughout the State: eastern Colorado is predicted to provide 44 percent; north-western Colorado, 42 percent; and southwestern Colorado, the remaining 14 percent. Synergistic opportunities may exist for carbon sequestration demonstrations via enhanced recovery projects (oil, gas, and coalbed methane), particularly where economic sources of anthropogenic CO₂ are available. Such projects may serve as the required catalyst to promote longer-term carbon storage programs partly because of the potential for offsetting costs with revenue-generating capability as well as revitalizing some of the State's oil-producing provinces.

■ Costs

The combustion of fossil fuel produces a contaminated flue gas that is approximately 80 percent N₂ and only 20 percent CO₂ by volume. Purification of flue gas via carbon capture and storage (CCS) can be accomplished with either Integrated Gasification Combined Cycle (IGCC) or Pulverized Coal (PC)

power-generation technology. CCS costs add approximately 40 to 50 percent to the cost of electricity for IGCC and 70 to 90 percent for PC with bituminous coals. Although cost data vary considerably with location and type of coal, the average cost of CCS is approximately \$55 per metric ton of avoided CO₂ for both technologies.

■ Pilot Projects

The Colorado Geological Survey is a participating member of the Southwest Regional Partnership on CO₂ Sequestration, one of seven created by the U.S. Department of Energy (DOE) in 2003. The SWP is currently conducting three geologic pilots, one each in the San Juan Basin Fruitland coal, in the Greater Aneth field in the Paradox Basin, and at SACROC field in the Permian Basin. CGS is taking a key role in the design, implementation, and analysis of the San Juan Basin pilot because of our particular expertise in coalbed methane development. In addition, as CO₂ Project Manager, Genevieve Young is the co-lead for the Site Characterization technical team for all three pilot projects, as well as the point-of-contact for the Site Characterization, Reservoir Modeling, and Data Archiving technical teams.

■ Larger-Scale Deployment

The U.S. DOE plans to establish multiple CCS demonstrations on the scale of one million metric tons of CO₂ sequestered per year. When the smaller-scale pilot projects conclude in late 2009, larger-scale deployment projects will be initiated by each of the regional partnerships to run until late 2019. The SWP has placed two Colorado options at the top of the list for consideration as larger-scale demonstrations—Shell's oil shale development project in the Piceance Basin and Xcel Energy's commitment to building an IGCC power plant in Colorado. Both options offer advantages; however, recent State legislation establishes Colorado as the most economically attractive State for IGCC development nationwide.

Paleoseismic Trenches

In order to understand the earthquake history of Colorado, it is necessary to study the faults that have created strong earthquakes in the past. The best way to conduct these studies is to dig trenches across the faults. We have studied two of the most dangerous faults with trenches. The U.S. Geological Survey and the U.S. Bureau of Reclamation also each trenched across faults in Colorado during the past two years. CGS conducted a two-week trenching investigation along the Williams Fork Mountain Fault, approximately 8 miles to the southeast of Kremmling. The trench, which was dug in the scarp of a splay fault, was about 60 feet long and as deep as 13 feet about midway down the scarp slope. It uncovered the Miocene Troublesome Formation and younger (Quaternary?) sands and gravels. No direct evidence of faulting was found. However, the clay-rich Troublesome strata appear to have been folded, and the younger sediments onlap onto the scarp toe. This small feature may be a late Cenozoic or Quaternary monoclinial fold. We are waiting on age-dating results for the younger sediments. Bob Kirkham (CGS emer-

Trench excavated by CGS through the Williams Fork Mountain Fault in Grand County



itus) was the lead scientist. Dave Noe, Lauren Heerschap, Andy Gleason, and Matt Morgan were on the trenching and interpretation team.

CGS spent most of the summer and fall of 2006 excavating and logging a very large trench on the Eastern Plains of Colorado, near the town of Anton. The purpose of this project is to investigate the genesis of the 95-mi-long, 100-ft-high Anton scarp, particularly to find out whether it formed as a result of faulting and might represent an earthquake hazard. The trench, which was nearly 600 ft long and as deep as 18 ft, was dug near the base of the scarp, next to a large, shallow depression. It uncovered a variety of eolian and playa deposits, ice-wedge casts, organic and calcareous paleosols, and a buried unconformity. No direct evidence of faulting was found in the trench, although future trenching and tracing of the unconformity may give us clues about the scarp's origin. As a side benefit, this trench yielded interesting fossils and archeological materials. Dave Noe was the lead scientist. Other CGS personnel included Lauren Heerschap, Vince Matthews, Matt Morgan, Jeremy McCreary, Celia Greenman, John Datz, Andy Gleason, Peter Barkmann, and Jake Baker. A National Earthquake Hazards Reduction Program grant will help fund completion of the trenching program in 2007.



Anton trench excavated by CGS in Washington County

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Montrose County Geologic Hazards

In 2005, CGS agreed to conduct a comprehensive geologic hazards program for fast-growing Montrose County that includes geologic hazard identification (mapping), hazard risk assessment, and assistance with designing a mitigation strategy for the county. Montrose County, CGS, and the Colorado Division of Emergency Management will cooperatively fund the work. This three-year project commenced in March 2006 and focuses on high-growth areas adjacent to the town of Montrose and along the Uncompahgre River valley. Two geologic maps were completed in 2006 in preparation for this work.

Collapsible Soils

In 2005, CGS wrapped up its statewide project on the study of occurrences of collapsible soils in Colorado and completed the draft manuscript and maps. This major engineering geology publication went through internal CGS review in 2005 and external peer review in 2006. This publication will include more than 80 figures and illustrations and six map plates.

A part of this project was sharing and comparing the results of the Colorado work with other major researchers on collapsible soils in the semiarid to arid western United States. Jon White, the principal researcher at CGS, co-organized a topical session on the formation and mitigation of collapsible soils for the Geological Society of America national meeting in Salt Lake City. In that session, Jon presented the major findings of CGS's work in Colorado.

Collapsible soils are a major geologic hazard for land development in many locations of Colorado. The hazard manifests itself as ground settlement, which can be damaging to overlying structures if the soil problems are not mitigated or the structure is not engineered properly. Although not of the severity of damage related to swelling soils and heaving claystone bedrock, ground settlement has resulted in hundreds of millions of dollars in damage. As growth pressure increases in western Colorado, more areas susceptible to soil collapse will be considered for development. The best illustration of this geologic hazard's potential liability was the case of townhomes damaged by collapsing soils in a Glenwood Springs development built in the early 2000s. The court case resulted in a \$12 million payment by the developer and his engineering consultants to townhome owners.

Sinkholes

Sinkholes in evaporite karst terrain continue to be investigated by CGS in several parts of Colorado. The sinkholes develop because of dissolution of evaporite rocks. This geologic hazard is most serious in areas having evaporite rocks and undergoing rapid population growth, such as Eagle, Garfield, and Pitkin counties. In January 2005, a dangerous sinkhole opened in a new golf course and residential development in the Roaring Fork River valley between Glenwood

Springs and Carbondale. This sinkhole opened on the side of a storage tent, and two golf carts were lost. Sinkholes can occur throughout the lower Roaring Fork River and Eagle River valleys, both evaporite rock-bearing areas where development pressures are high. In 2005, the CGS completed a draft map showing areas having evaporite rocks either at the surface or shallowly underlying unconsolidated sediments or soils. All known sinkhole locations have been digitized for inclusion in the map, except for locations in southwestern Colorado. This map will be published in 2007. The southwestern Colorado area, in the Paradox Salt Anticline region, is the focus of another mapping effort slated for future publication.



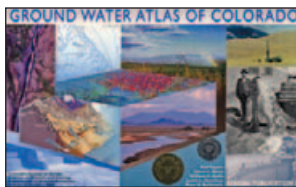
A sinkhole suddenly opened in the middle of the soccer field at Colorado Mountain College in Glenwood Springs.

Central Colorado Mineral Cooperative

CGS personnel cooperated on the U.S. Geological Survey's Central Colorado Assessment Project. CGS has updated the Colorado part of the Mineral Resource Data System (MRDS) database, which is the major digital source of mineral resource information for Colorado and the rest of the United States. The database was originally designed in the 1970s, and various scientists have entered new data into the database periodically since that time. CGS staff worked cooperatively with U.S. Geological Survey scientists to upgrade and update the Colorado part of the database with new or more complete information. The locations given by many of the older MRDS records are often too generalized, and sometimes they are altogether wrong. By using GIS software and more careful literature research, the locations and other information for mineral deposits can be markedly improved. CGS added information derived from a large set of mineral exploration paper files from the Sunshine Mining Company. These files were donated to CGS by the Idaho Geological Survey, who received them from the company.

Awards

Since its publication, CGS's *Ground Water Atlas of Colorado* has been well received and has garnered remarkable recognition by the professional community. The Geological Society of America bestowed its E. B. Burwell, Jr., Award to the atlas in 2005. This award is made to the author or authors of a published paper of distinction that advances knowledge concerning the principles or practice of engineering geology or of related fields of applied soil or rock mechanics where the role of geology is emphasized. It was the second national award for this publication; the American Library Association previously named it a 2004 Notable Government Document. The atlas was also awarded the 2006 John C. Frye Environmental Geology award. The Geological Society of America and the Association of American State Geologists jointly present this award for the best environmental geology paper published each year.



CGS developed a Web site that features a synopsis of the atlas. The Web site version contains three to four pages of condensed text and selected graphic materials for each chapter of the publication. In addition, the Web site contains the complete glossary and high-resolution downloads of selected images and figures. The public, without obtaining permission, may reproduce these figures for educational purposes. The site can be viewed at <http://geosurvey.state.co.us/wateratlas/>.

New Deputy Named

Chief of Environmental and Engineering Geology Matthew Sares was named Deputy Director of CGS this past year, a position just recently created for our agency. He will retain his duties with the Environmental Geology section while performing other much-needed functions for CGS. In a year full of positive changes, this is perhaps one of the most exciting! Join us in congratulating Matt in his new endeavor.



Matthew Sares, Chief of Environmental and Engineering Geology, is the new Deputy Director of CGS.

New Academic Degrees



*Vince Matthews, State Geologist, congratulates Dave Noe (left) and Matt Morgan (right) upon their graduation at the Colorado School of Mines in December. **Matt Morgan** received a Master of Science degree with the following thesis title: "Carbonate Accretionary Lapilli in the Late Devonian Alamo Breccia: Impact History, Genesis and Interpretations Related to the Origin of the Alamo Breccia." **Dave Noe** received a Ph.D. degree in geological engineering with the following thesis title: "Engineering Geology of Steeply Dipping, Heaving Bedrock, Front Range Piedmont, Colorado."*

CGS Director Gives Keynote Addresses

Director Vince Matthews gave the keynote opening address to Grand Junction's Energy Expo in February 2007 and will repeat the presentation in the Keynote Address to the Energy Minerals Division of the American Association of Petroleum Geologists in Long Beach, California, in April. The talk, "China's and India's Ravenous Appetite for Natural Resources and Its Impact on Colorado," has been presented to approximately 10,000 Coloradans over the past two and a half years.

Geologic Mapping



Beth Widmann, supervisor for the CGS geologic mapping program, and contract mapper J. Temple get up close and personal with a basement-involved thrust fault in the Woodland Park quadrangle. CGS completed its 72nd geologic quadrangle (1:24,000) map in 2006.

ROCKTALK

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Vince Matthews, State Geologist and
Division Director

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Fax: (303) 866-2461

E-mail: pubscgs@state.co.us

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

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Production: R. Ciminelli



ROCKTALK

Colorado Geological Survey
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Denver, CO 80203

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