

COLORADO GEOLOGICAL SURVEY

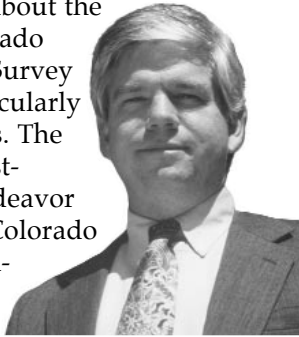
ROCKTALK

VOLUME THREE, NUMBER ONE JANUARY, 2000

WHO CARES ABOUT THE COLORADO GEOLOGICAL SURVEY?

BY GREG WALCHER,
DIRECTOR OF THE DEPARTMENT OF NATURAL RESOURCES

The citizens of Colorado should care about the Colorado Geological Survey (CGS), particularly as taxpayers. The CGS is a cost-effective endeavor within the Colorado state government. Let me explain.



Geologic hazards, such as landslides, rockfall, and avalanches, cheat all of us out of our tax dollars. Spending money trying to fix geologic hazards after the fact, to undo the damage they have caused is a prime example of wasteful government spending.

Geologic hazards cost Colorado citizens and taxpayers millions of dollars every year, yet ignoring them is the most costly thing we can do. Actually spending money on identifying hazards and dealing with them through mitigation and planning is the cheaper way out. If we wait until after the hazard has

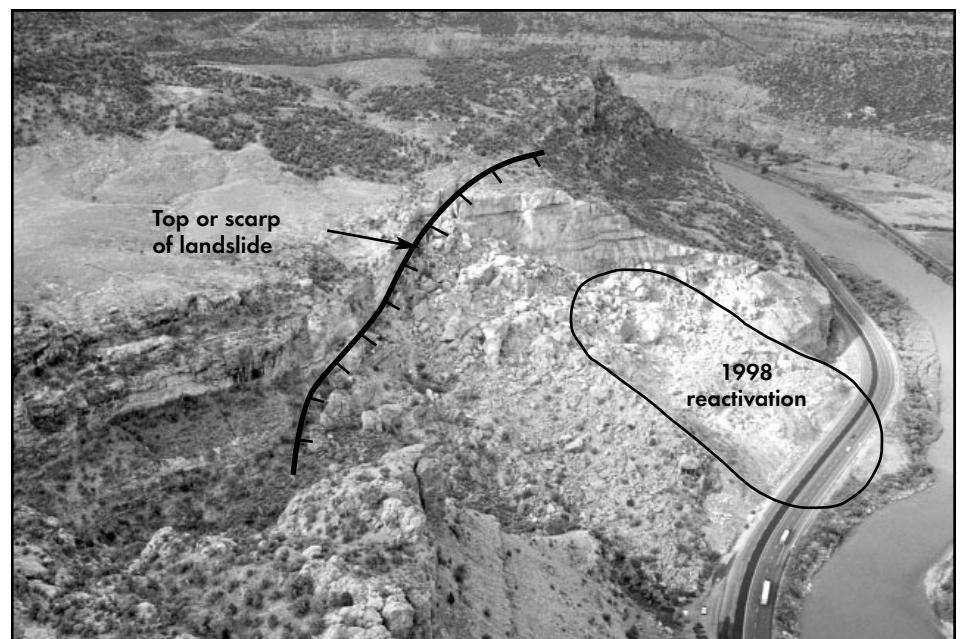
done its damage, we are spending our money on the wrong part of the problem.

CGS geologists are working to mitigate geologic hazards in a cost-effective manner in several areas around Colorado. As an example, let's consider the DeBeque Canyon Landslide Project. The DeBeque Canyon Landslide is such a large feature, that when you are driving along it on I-70, unless there is

recent debris near the road (which there usually is), you may not notice it from your drive-by perspective. However, from a bird's eye view, the DeBeque Canyon Landslide is huge. The crevices that have opened up on this landslide, and some of the rocks hanging above the canyon are larger than the semis speeding by below.

The DeBeque Canyon Landslide has been causing disruption to Colorado transportation since 1924, when it destroyed the railroad. The most recent serious movement began in 1998. A catastrophic failure of the landslide will disrupt Colorado's economy, and the economy of our entire region, because of the importance of the I-70 corridor. A \$1 million federal grant for studies, characterization and instrumentation is leading to cost effective engineered mitigation designs to avoid the catastrophic and uncontrolled loss of the Interstate and railway.

Other less-visible geologic hazards are swelling soils and heaving bedrock. These hazards strike on an individual-by-individual-home basis; the upfront cost of dealing with these quiet but certain hazards is cheap compared to the long-term cost of ignoring and continuing to build on the geologic hazard. The



Debeque Canyon Landslide with I-70 and the Colorado River near Palisade. Arrows outline scarp (line of cliffs formed by erosion) and landslide area reactivated in 1998

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Katie KellerLynn, editor

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cost benefit of efforts by CGS have been 425-to-1. Here's why. For 5 years beginning in 1990, CGS spent about \$20,000 each year on characterizing and understanding heaving bedrock and its damaging nature. Once the major stakeholders (homeowners, builders, engineers and county officials) were informed about the hazard, Jefferson County created a new process to deal with building in the areas subject to heaving bedrock. Geological research can predict a hazard like heaving bedrock, and building designs and methods were changed to take these hazards into account. In short, if we assume that, in the 17,000 undeveloped homesites in the affected area of Jeffco, only 10

percent would be spared the typical repair cost of \$25,000, we see that the cost of the upfront geologic characterization cost \$1 for every \$425 saved.

The CGS geologic mapping program is another way of putting state and federal funding to wise use. Geological maps provide basic information on the type and distribution of geological formations to a wide variety of users. Geological maps are critical in the location, assessment, and development of mineral and mineral fuel resources. These maps are also used to locate and define geological and other natural hazards to allow the safe location, design, and development of many types of public and private facilities. State and local governments specifically use geological maps in the development of land use and zoning ordinances.

Colorado's growing population has increased demands for water resources for domestic use, to support aquatic life, for recreational activities, and for industrial uses. CGS recognizes these needs and responds through its Water Quality Data Program (WQDP) by providing readily accessible water quality data and information resources for the public, institutions, and businesses of Colorado. Furthermore, the scientists in the WQDP investigate and report on water quality topics related to the geology and

hydrogeology of Colorado.

CGS also responds to the need to replace depleted natural resources by creating an environment that encourages private industry to find and develop new natural resources. CGS accomplishes this goal by providing basic geological information for the mineral and mineral fuel industries intended to stimulate new exploration. Mineral and mineral fuel exploration and development is a cyclic business. Long-range and stable programs of our state geological survey provide basic data on mineral and mineral fuel resources for the future, regardless of short-term economic conditions.

Each winter, on average, avalanches kill six people and cause economic losses totaling millions of dollars in Colorado. The probability of an avalanche disaster along a Colorado highway or at a developed site has been reduced due to the CGS avalanche forecast and education program. The Colorado Avalanche Information Center (CAIC) promotes safety by reducing the impact of avalanches on recreation, industry, and transportation in the Colorado through a program of forecasting and education; thereby, saving money and lives.

So I repeat my question, who cares? We all should, since geology affects our everyday lives—sometimes subtly, sometimes dramatically—in Colorado.

Bill Owens, **Governor, State of Colorado**
Greg E. Walcher, **Director, Department of Natural Resources**

CGS Staff

- Vicki Cowart, **State Geologist**
- James A. Cappa, **Mineral Resources and Mapping**
- David C. Noe, **Engineering Geology**
- Randal C. Phillips, **GIS and Technical Services**
- Vickie B. Pierce, **Administration and Outreach**
- Matt Sares, **Environmental Geology**
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Minerals

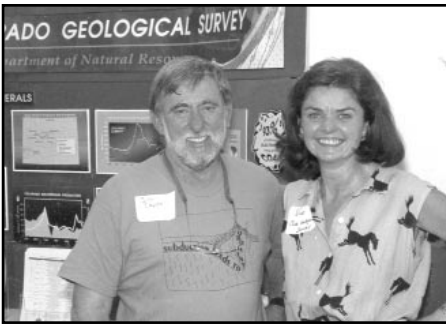
John Keller

WHO ARE WE?

We are the Colorado Geological Survey (CGS). Our mission is to serve, inform, and educate the citizens of Colorado about the important role of earth sciences in everyday life. The science, field studies, and research we perform are reflected in the decisions that we make, as well as the products and services we provide. Each of us is encouraged to participate in outreach events in order to transfer the information we have studied to a wide range of

audiences. The State Geologist and six section chiefs coordinate and lead our efforts.

VICKI COWART, the State Geologist and Director of the CGS, began working at CGS in 1993. Vicki received her BS degree in Physics from Worcester Polytechnic Institute, of Worcester, Massachusetts (1975) and her Master degree in Geophysics from the Colorado School of Mines (1977). Before becoming the State Geologist for Colorado, Vicki worked in the oil and gas industry



Jim Cappa and Vicki Cowart at the mining exhibit at the Taste of Colorado

for 16 years. She started as an exploration geophysicist working for Mobil Oil. Vicki has worked for other oil companies, including ARCO Oil & Gas and Schlumberger Well Services. Vicki first became a manager of a group of geologists and geophysicists during her employment at ARCO. Vicki was born in the small copper mining town of Miami, Arizona and grew up in Tucson.

JIM CAPPA is the Chief of the Mineral Resources and Mapping Section. Jim's "true loves" are mineral exploration and field work. Jim received his BA in Geology from the University of California, Santa Barbara (1967) and his MS in Geology from New Mexico Institute of Mining and Technology (1975). Jim has worked for the Houston Oil and Minerals Corporation and FMC Gold exploring for minerals in Zambia, Canada, Spain, Brazil, Chile, Mexico, Turkey, Australia, and throughout the United States. Jim has explored for uranium, molybdenum, tin, nickel, trona and other

industrial minerals, as well as managed tungsten and gold exploration programs. Jim has also worked for the U.S. Forest Service (doing Engineering Geology and Mapping) and as a petroleum geologist for Amoco. Jim joined CGS in 1991.

DAVE NOE became the Chief of the Engineering Geology Section on January 1, 1999. He succeeded W. Pat Rogers, who assumed the position in 1971 and retired in 1998. Dave has 17 years of experience in field, research, and applied geology. Dave is a PhD candidate in Geological Engineering at Colorado School of Mines. He received his BA degree in Geology from the University of Northern Colorado (1979) and his MA degree in Geology from the University of Texas at Austin (1984). His current interests include swelling soils, heaving bedrock, wetland functions, and the role of geology in public education and policy. A native Coloradan, Dave was born and raised in Greeley.

RANDY PHILLIPS is Chief of the GIS and Technical Services Section. Randy has 12 years experience in geologic database development and mapping systems design. He received his BS degree in Geology from Colorado State University (1985) and his Masters degree in Information Systems from the University of Denver (1990). For many years Randy has been interested in the physical sciences, anthropology, and technology. Some of his current projects include: developing a web-based mapping system, enhancing delivery of geologic information

using CD-ROM and internet technologies, and coordination of several GIS database development efforts.

VICKIE PIERCE, the Chief of the Administration and Outreach Section, received a BS in Business from the University of Phoenix. Vickie has 28 years of administrative and financial management experience in law, state and local government, and the transportation industry; the last six of those years have been at the Colorado Geological Survey.

MATT SARES, the Chief of the Environmental Geology Section, received a BS in Geology from the University of Toledo and a Professional Degree in Hydrogeology from the Colorado School of Mines. Matt has 16 years of geological experience, the last 9 years involved

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CONGRATULATIONS

SUSAN STEELE WEIR, a long-time advisor and mentor of the CGS, received the **Floyd T. Johnston Service Award** from the Association of Engineering Geologists (AEG). This award is given to a member of the Association who has provided active and faithful service to AEG for a period of at least nine years. AEG was developed to meet the professional needs of geologists who are applying their scientific training and experience to the broad field of civil and environmental engineering.



Clockwise from upper left: Randy Phillips, Dave Noe, Knox Williams, Vickie Pierce, Matt Sares, Vicki Cowart



Susan Steele Weir with Ron Cattany, DNR Deputy Director for Policy

specifically in environmental geology. He manages the CGS Water Quality Data Program aimed at providing water quality data to the public and investigating geologically related water quality issues. Matt also coaches YMCA basketball for 8-year-olds and is a Cub Scout Den Leader.

KNOX WILLIAMS has 29 years of experience as an avalanche researcher, forecaster, educator, and program director. Knox has been the Director

of the Colorado Avalanche Information Center (CAIC) since 1983. Prior to joining the CAIC, Knox was an Avalanche Scientist with the U.S. Forest Service Avalanche Research Project (1970–1983). Knox has been an instructor for the National Avalanche School since 1971, as well as the chair of its Steering Committee since 1986. Knox is the author/co-author of three books on avalanches, over 20 papers and articles, one safety brochure (NEW CGS publica-

tion SP 48), and one avalanche video script. Knox is a founding member of the American Association of Avalanche Professionals (1986), as well as a Governing Council Member (1986–1999); he has also served as the president (1994–98). Knox is a member of the American Meteorological Society. Knox received his BA in Mathematics from the University of Texas at Austin (1965) and a MS in Atmospheric Science from Colorado State University (1970.)

STAFF INVOLVEMENT AND SPECIAL ACCOMPLISHMENTS IN 1999

JIM CAPPA, Mineral Resources and Mapping Section, currently serves on the Society of Economic Geologists Organizational Committee for the 2002 annual meeting.

CHRIS CARROLL, Mineral Resources and Mapping Section, serves on the Dinosaur Ridge Advisory Board and the Colorado Mining Association Coal Team. Chris is also a volunteer for Channel 12 (PBS).

VICKI COWART, State Geologist, was elected as the American Association of State Geologists (AASG) Vice President (June 1999), and serves on AASG Executive and Liaison Committees. She was elected President of the Colorado School of Mines (CSM) Alumni Association (2000 term) and is an elected member of the American Institute of Professional Geologists Colorado Section Advisory Board (2000 term). She also received the CSM Distinguished Achievement Medal in May 1999. Vicki serves on the American Geological Institute's *Geotimes* Editorial Board and the Association for Women Geoscientists Foundation Advisory Board.

KATIE KELLERLYNN, Administration and Outreach Section, serves on the Geological Society of America's Education Committee. Katie is also the treasurer-elect for the Denver Section of the Association for Women Geoscientists. Katie spearheaded coordination of the first annual CGS Earth Science Week public field trips.

BOB KIRKHAM, Mineral Resources and Mapping Section, received the Colorado Scientific Society's Past President Award for Best Paper of 1999 and received the American Association of Petroleum Geologists, Rocky Mountain Section, Energy and Minerals Division award

for Best Paper presented at their 1997 meeting. He serves as Colorado's Geoscience representative to the Western States Seismic Policy Council and on their Basin and Range Province Committee. He is Co-chair of the Earthquake Subcommittee of the Colorado Natural Hazards Mitigation Council and is a member of the Technical Advisory Committee of the Willow Creek Reclamation Committee in Creede. Bob served as a judge at the San Luis Valley Regional Science Fair. Bob led field trips for the Glenwood Springs 1999 CGS Earth Science Week field trip and the Friends of the Pleistocene—Rocky Mountain Cell 1999 field trip. In addition to writing numerous CGS publications, Bob is co-editor of a book on evaporite tectonism in west-central Colorado that is being prepared for submittal to the Geological Society of America.

DAVE NOE, Engineering Geology Section, is the chair of the Colorado Natural Hazards Mitigation Council's Geologic Hazards Committee and a member of the Legislative and Regulatory Affairs Committee of the Association of Engineering Geologists, Rocky Mountain Section. In early 1999, Dave was a member of the Summit County Wetlands Technical Committee.

MONICA PAVLIK, Engineering Geology Section, was a member of the Summit County Wetlands Technical Committee in early 1999.

MATT SARES, Environmental Geology Section, received an U.S. Forest Service Leadership Award on November 19, 1999 for his abandoned mine land inventory work. Matt designed, implemented, and managed the recently completed abandoned mine land inventory for the U.S. Forest Service in Colorado. The inventory covers 25 percent



Matt Sares (center) receiving leadership award from Daryl Gusey (right) and Byron Shark (left) of the USFS

of Colorado and identifies and ranks environmental degradation and physical hazards at abandoned mine sites. Matt is on the Colorado Water Quality Monitoring Council and a member of its Methods Subcommittee. He has been a participant in the Animas River Stakeholders Group and the Water Quality Forum.

JIM SOULE, Engineering Geology Section, has served as a member of the State of Colorado 1999 Intera-gency Hazard Mitigation Team. The team was assembled to produce a report about 1999 hazard events and to address ongoing natural-hazard mitigation needs.

SCOTT TOEPFER, Colorado Avalanche Information Center, serves on the Board of Directors of the Summit Huts Association, a non-profit organization. He has been a volunteer for the last ten years at world Cup Races in Vail and Beaver Creek Ski Resorts. Scott helped the Newt Wheatly foundation in supplying backboards and toboggans at various ice climbs in Summit and Eagle Counties to expedite rescues of injured climbers. For the last ten years, Scott has volunteered time in teaching a free avalanche awareness class at the Vail Public Library.

KNOX WILLIAMS, Colorado Avalanche Informa-tion Center, has served as an instructor at every Nation-al Avalanche School held at Incline Village, Nevada, since its inception in 1971. It is an honor to be on this staff because only the top 20–25 instructors in the United States are considered. Knox served as chair of the Steer-

ing Committee of the National Avalanche School for the last seven schools and retired from this committee in 1999. Knox presented a paper at an international avalanche conference at Saint Vincent, Italy, in Decem-ber 1999 as the only American invited guest.

JON WHITE, Engineering Geology Section, was a field trip leader for the CGS Earth Science Week public field trips. Jon’s work in high altitude restoration on Independence Pass led in part to the Independence Pass Foundation (IPF) receiving the “Environmental Achievement Award of Distinction,” to be awarded at the International Erosion Control Association Annual Conference and Exposition in February 2000.

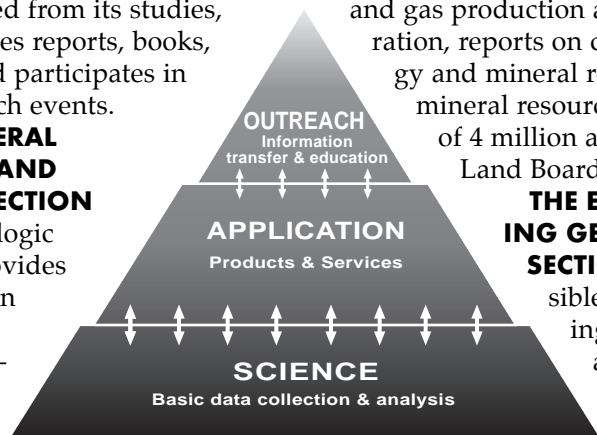
LAURA WRAY, Mineral Resources and Mapping Section, serves on the board for the Mineral Information Institute. She volunteers for the Rocky Mountain Associ-ation of Geologists *Outcrop* Editorial Committee. Laura is co-chair of the American Association of Professional Geologists Annual Convention 2001 Short Course and the Development Committee and Annual Campaign of St. Anne’s Episcopal School, Denver. Laura serves as the Regional Career Representative for Wellesley College. She coaches girls’ soccer (under age seven) for the Sky-line League, Pueblo, and is the co-convenor for K-2 Sun-day School teachers at Mountainview Friends Meeting, Denver. In addition, Laura led the Geological Society of America Annual Convention Science Day field trip for 60 students from Smiley Middle School in Denver.

WHAT DO WE DO?

Each CGS program performs basic data collection and anal-ysis (**science**) and from these studies develops products and ser-vices (**application**). As the science and application are completed, the CGS informs and educates the pub-lic about the results (**outreach**). The relationship among these endeavors is shown in the pyramid below. To reach the public with useful infor-mation derived from its studies, CGS distributes reports, books, and maps and participates in public outreach events.

THE MINERAL RESOURCES AND MAPPING SECTION

produces geologic maps and provides information on the develop-ment and pro-duction of mineral



and mineral fuel resources in Colo-rado. The program provides geologic mapping in areas of geologic haz-ards, mineral resources, and growing populations on 7.5-minute quadrangles at the scale of 1:24,000. Mineral Resources projects include: an annual report on the mineral and mineral fuel activity in Colorado, studies on coal quality and resources, technical bulletins, reports on oil and gas production and explo-ration, reports on county geolo-gy and mineral resources, and mineral resource inventories of 4 million acres of State Land Board Trust Land.

THE ENGINEERING GEOLOGY SECTION

is respon-sible for increas-ing awareness and under-standing of geologic

GEOHAZARD CONFERENCE

The CGS and Jefferson County are co-sponsoring this year’s geohaz-ard conference during Spring 2000. Planning is underway for the conference, which is called “Dipping Bedrock Revisited.” Its focus will be on the effective-ness of land-use regulations enact-ed by the county in 1995 to com-bat heaving bedrock hazards. A date and location will be announced soon. If you are interested in receiving registration information call Anissa Olguin at 303-866-3520.

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Dave Noe, Chief of the Engineering Geology Section, informing citizens about landslides during Earth Science Week

hazards within the state, and thereby lessening the impact of these hazards on citizens and property. This responsibility is undertaken through geological-suitability reviews of schools and subdivision sites for local governments; statewide research on a variety of geologic hazards; and assistance to state agencies, such as the Colorado Department of Transportation (CDOT), for geological issues including rockfall areas, road alignments, and construction planning and support.

THE ENVIRONMENTAL GEOLOGY SECTION identifies, investigates, and assists in solving environmental issues related to geology in Colorado. The Environmental Geology Section applies geology to environmental issues in Colorado such as water quality, abandoned mines, and radioactive mill tailings. It advises and serves other state and federal agencies to avoid or solve environmental geology problems and provides water quality information for the citizens of Colorado.

THE COLORADO AVALANCHE INFORMATION CENTER (CAIC) promotes safety by reducing the impact of avalanches on recreation, industry, and transportation in Colorado through a program of forecasting and education. The CAIC conducts avalanche awareness courses, provides information on their web site (www.caic.state.co.us), and prepares forecasts using data from over 35 field-observation sites for seven "hotlines" throughout Colorado. Forecasts are emailed to "Friends of

the Colorado Avalanche Information Center." (Log onto the CAIC web site to learn how to become a Friend.)

THE GIS AND TECHNICAL SERVICES (GTS) SECTION supports all CGS programs by providing digital services, database development assistance, and general computing and Web services. In addition, the GTS section coordinates compilation, editing and printing of CGS reports, maps, books, and CD-ROMs.

THE ADMINISTRATION & OUTREACH SECTION is responsible for publications sales and marketing, information distribution, educational materials development and distribution, outreach event coordination, budget preparation, accounting, contracts and grants management, and office management.

WHAT HAVE WE DONE IN 1999?

Science

As scientists, CGS staff members do research in the field, in the office, and in the library collecting and analyzing basic geologic data. Outcomes of this work are geologic maps, mineral resource evaluations, water quality information, geologic hazards assessment, and avalanche forecasts.

Geologic maps, for example, provide basic information on the type and distribution of geological

formations and structures to a wide variety of users. Geologic maps are used for mineral resource inventory, support and development of infrastructure and natural resources, evaluation and mitigation of natural hazards, and baseline data for the protection and remediation of the environment.

CGS has two mapping programs, each with a particular focus. The STATEMAP program is part of the National Cooperative Geologic Mapping Program (NCGMP) and is funded 50:50 by U.S. Geological Survey (USGS) and CGS general fund dollars. The STATEMAP program focuses mapping efforts in areas where increasing residential and commercial development are impacted by geologic hazards and mineral resources. The SEVTAX geologic mapping program is funded through the CGS severance tax fund, which is derived from the production of gas, oil, coal, and minerals in Colorado. SEVTAX mapping focuses in areas of potential mineral development.

Both mapping programs are important to Colorado because only about 25 percent of the state has been mapped at the scale most useful for planning purposes, 1:24,000 (1 in. = 2,000 feet). This is the scale of the typical USGS 7.5-minute topographic quadrangle map. There is a serious statewide need for complete geological information to address such issues as growth in Colorado's mountain communities, natural hazard identification and mitigation, natural resource identification, and environmental protection.

In addition to geologic maps, basic data collection is performed on mineral resources, including coal, oil, and gas. A team of CGS staff, interns, and contractors conduct Mineral Resource Inventories on State Land Board tracts. The geology of each tract of State Trust land is examined and an estimate of its mineral resource is made. The resource inventory is used by the State Land Board to evaluate the mineral estate on a particular tract. Private industry and citizens use the

inventory reports to evaluate the mineral resource potential of State Trust Lands. During 1999, CD-ROM reports were issued on State Trust Lands in the Stewardship Trust Nomination, and Phillips, Sedgwick, and Moffat Counties.

CGS also cooperates with the Colorado Oil and Gas Conservation Commission on the 3M Program of the San Juan Basin. The 3M program has three phases: mapping, modeling, and monitoring of the Fruitland Formation coal beds along the north rim of the San Juan Basin. The CGS has completed detailed geologic mapping along the 27 miles of outcrop.

Also completed are: an inventory of coal availability for the entire Somerset Coal Field, contour and isopach maps for the Piceance Basin, and a geology and mineral resource report for northwestern Park County. The objective of the Piceance Basin study is to promote the development of the Mesaverde gas resource over a larger portion of the basin that is currently being developed. The Park County Report will assist county commissioners in planning and decision-making.

CGS has worked with the U.S. Forest Service for over eight years completing a cooperative effort aimed at identifying all environmental and physical hazards associated with abandoned and inactive mines on Colorado's USFS lands (~25% of the state). A total of 11,307 mine openings and 6,829 waste rock or tailings piles were documented during the inventory. Currently CGS is working with the USFS to gain more detailed information on the mining history and environmental situation at the highest priority mine sites identified in the inventory.

CGS continues to collect baseline water quality data in areas of the state that have little information on ambient conditions, especially in headwaters areas.

CGS is involved with the Colorado Department of Transportation (CDOT) by providing planning and construction assistance along State Highway 82 between Basalt and Aspen. CGS is assisting in the com-



Nick Logan and Kathy Fraser of the CAIC collecting data for avalanche forecasts

pletion of the Shale Bluffs segment, just west of Aspen. In April work began on the final segment, Snowmass Canyon, a rugged, three-mile long alignment between Old Snowmass and Woody Creek. The project work includes construction of detailed geologic maps and cross-sections, drilling oversight, well logging, and computer modeling.

CGS continues investigating a major landslide in DeBeque Canyon near Palisade. This landslide, which has undergone periods of activity since 1924, caused damage and traffic delays on I-70 in 1998. The Federal Highways Administration (FHWA) has funded an emergency investigation program through CDOT. CGS is investigating the landslide along with the USGS, the Colorado School of Mines, and Golder Associates, a private consulting company. During July–September 1999 the project team designed an emergency response monitoring system, mapped the landslide and surrounding area, and drilled test holes. Remaining tasks include installing instrumentation, modeling and interpreting the landslide's driving mechanisms, and

presenting cost/benefit mitigation scenarios.

The Colorado Avalanche Information Center uses data from the Colorado observer network and the National Weather Service to assess current avalanche stability and to forecast mountain weather and avalanche hazard. Six CAIC avalanche forecasters are based in Silverton, Pagosa Springs, Carbondale, and the Eisenhower Tunnel. They prepare daily stability evaluations, provide recommendations for avalanche reduction and road closures, and maintain weather and avalanche records.

Application

Once the basic data is collected and analyzed, applications (i.e., products and services) are developed. In 1999, CGS produced 26 new publications. The table below shows the number of publications by subject area. A complete list of the new 1999 publications are found on p. 11–12.

Number	Subject Area
2	Avalanche
3	Coal
1	Earthquakes and Seismicity
3	Environmental Geology and Water Quality
1	Gas and Oil
1	Geologic Hazards
5	Geologic Maps
8	Mineral Resources
2	Swelling Soil and Heaving Bedrock

As an application of our science, as well as a statutory charge, CGS provides assistance to local governments, other state agencies, and the public with geologic hazards. In June 1999 CGS responded to a request by Colorado Office of Emergency Management (OEM) and the U.S. Federal Emergency Management Agency (FEMA) for assistance with landslide-damage evaluations in the Colorado Springs–Manitou

Springs area following the torrential rains of May 1999. In August 1999 CGS responded to a request from the Clear Creek County Emergency Manager for assistance following a series of debris flows that closed a number of roads (including Interstate 70). In response, CGS and the Colorado Water Conservation Board assembled a list of geologists, hydrologists, and meteorologists who investigated this event. The group will characterize the storm and its affects and offer advice for future mitigation to Clear Creek County.

CGS also applies expertise and knowledge during non-emergency events. Land use reviews are performed for county planning officials and municipalities such as Colorado Springs, Grand Junction, Lakewood, and Littleton. Water treatment plant and school site reviews are also performed. CGS has completed an average of 42.3 land-use reviews per month since January 1999. This program is undergoing a formal re-evaluation to improve customer service.

CGS provides technical expertise in removal, monitoring, and characterization of Underground Storage Tanks (UST) sites to state agencies. UST sites are a geological problem because contamination moves through soils, bedrock, and groundwater after the tanks rust and leak. CGS has assisted other state agencies by conducting investi-

gations for the removal and remediation of over 700 USTs.

Technical assistance to local governments and grassroots organizations is an important aspect of our work related to water quality issues. CGS assisted the Jefferson County Mountain Groundwater Study with

its quarterly sampling efforts.

The Animas River Stakeholders Group (Silverton area) and Willow Creek Reclamation Committee (Creede area) are addressing water quality impacts related to historic mining and natural sources. CGS is assisting with water sampling, database

compilation, and project scoping.

CGS geologic mapping program results in numerous products. The maps completed through the STATEMAP program this year are: the Durango West and Durango East (La Plata County) quadrangles, the Hunter Mesa (Garfield County) quadrangle, and the Mount Sopris quadrangle (Garfield and Pitkin Counties). This year's SEVTAX map is the Gribbles Park quadrangle (Park and Fremont Counties).

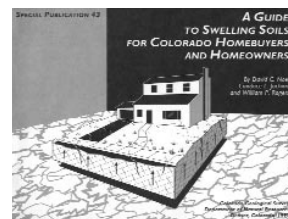
In 1998 and early 1999 CGS assisted the Summit County Wetlands Technical Committee in investigating landscape- and geology-based approaches to assessing wetland functions.

Outreach

To inform and educate the public, CGS distributes reports, books, and maps and participates in outreach events. CGS distributed over 2,900 publications per month during 1999. The 1999 "top-sellers" are listed below.

A particularly noteworthy publication is

Special Publication 43, *A Guide to Swelling Soils for Colorado Homebuyers and Homeowners*.



Not only is this an award-winning publication, but its usefulness to the citizens of Colorado is unsurpassed and is reflected in the number that have been distributed. CGS has distributed 67,482 copies of SP 43 (since 1997). SP 43 accounts for 84 percent of CGS publication distribution. Most SP 43s are purchased by homebuilders who inform potential homebuyers about swelling soils in accordance with the disclosure requirements of Colorado Senate Bill 13 (1984), C.R.S. 6-6.5-101.

Outreach events include participation or exhibits at conferences,

NEW TECHNOLOGY

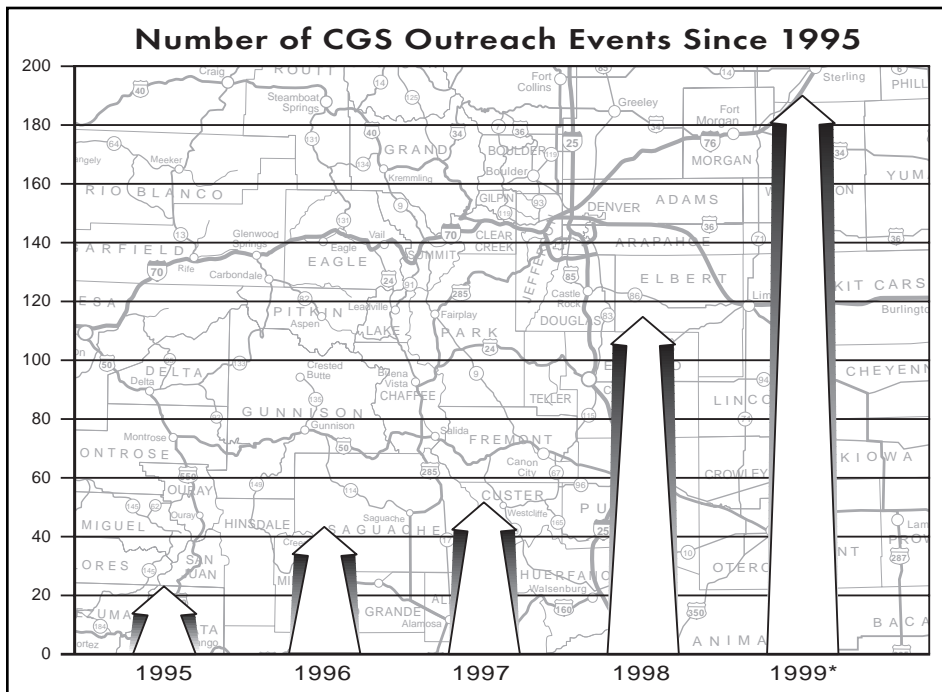
With this year's geologic maps, CGS stepped into a new realm of map publishing. The new products are the first CGS color geologic maps made using entirely digital techniques. These techniques include compilation of the author's original maps, using GIS software with final map production, and output using illustration programs. The result is a more efficient and cost-effective way to produce geologic maps.

NEW PUBLICATION LIST

Contact us with your name and mailing address for a new publication list.

Phone: (303) 866-2611,
Email: cgspubs@state.co.us

Pub No.	Title	No. Sold
SP 43	<i>A Guide to Swelling Soils for Colorado Homebuyers and Homeowners</i>	24,497
IS 33	<i>Gold Panning and Placering in Colorado: How and Where</i>	418
RS 28	<i>Gold Occurrences of Colorado</i>	274
SP 35	<i>Colorado's Dinosaurs</i>	228
SP 27	<i>Scenic Trips into Colorado Geology: Uncompahgre Plateau</i>	198
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B 51	<i>Guide to the Petroleum Geology and Laramide Orogeny, Denver Basin and Front Range, Colorado</i>	93
IS 45	<i>Active Permitted Mine Operations in Colorado, 1996-97</i>	90
IS 52	<i>Colorado Mineral and Mineral Fuel Activity, 1998</i>	84



* 249 with CAIC events

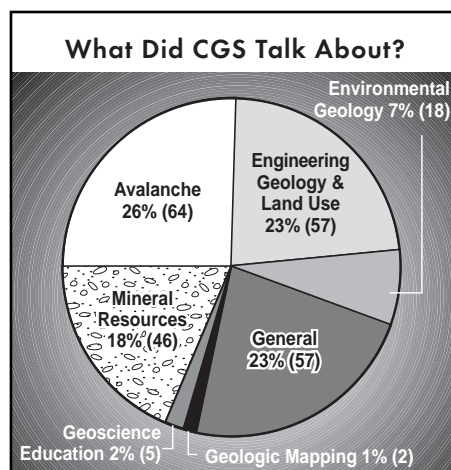
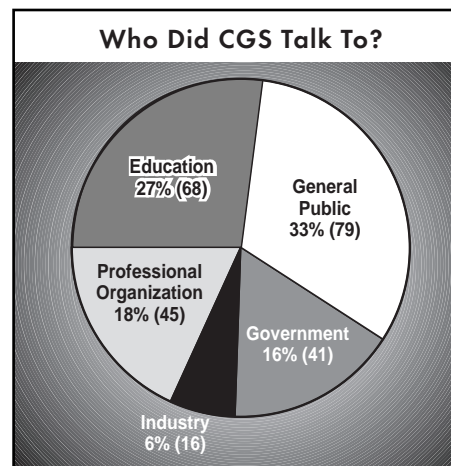
field trips, news releases, distribution of informational/educational materials, speaking engagements, and classroom presentations.

CGS outreach activity has increased eightfold since 1995. In 1999 CGS has participated in 249 events. Of these 249 events, 59 (24%) have been conducted by Colorado Avalanche Information Center due to the demand for avalanche awareness and safety training. The CAIC staff members participate in the largest number of outreach events of any section. CAIC reaches its constituents through public hotlines, email messages, radio broadcasts, news media, and their web page (www.caic.state.co.us).

It is instructive to look back and see “who we talked to” and “what we talked about” at outreach events, particularly with respect to our program objectives (outlined in the next section). We “talked” to a number of audiences: general public (33%), students and educators (27%), professional organizations (18%), government officials (16%), and industry (e.g., oil, gas, and ski) (6%). We “talked” about a number of subjects: avalanches (26%), engineering geology and land use (23%), general geology topics and issues (23%), mineral resources (18%), environmental

geology (7%), geoscience education (2%), and geologic mapping (1%).

Outreach efforts also give something back to CGS in terms of partnerships. For example, in January



1999, the CAIC trained 30 members of the Colorado Snowmobile Association to be avalanche observers. These volunteers have since been active in reporting snowpack information from locations other than our normal data sites. This has also heightened avalanche awareness within the Colorado snowmobile community and helped prevent accidents.



Bob Kirkham and Jon White discussing Storm King Mountain on Earth Science Week public field trip

A highlight of 1999 in terms of outreach events occurred during Earth Science Week. Governor Bill Owens proclaimed the second week of October as “Earth Science Week,” and 94 citizens of Colorado participated in free field trips led by CGS geologists. To sum up the trips, one participant said, “I wanted to tell you how great the entire thing went. The level of the presentations were right where everybody could understand them, yet we all still learned a lot.”

The two areas of Colorado that were highlighted during Earth Science Week were the Front Range Urban Corridor, from Boulder to South Jefferson County, and the Glenwood Springs area, including the Glenwood Canyon. Each trip was designed to acquaint participants with the geology, landscape, mineral resources, and geologic hazards of different parts of the state. Along the route participants were given time to explore a special area, talk with geologists, or simply admire the views.

A diverse audience participated in the field trips: teachers, retired geologists, a stock broker, a probation officer, housewives, sales repre-

sentatives, a registered nurse, a loan officer, and a CDOT worker. People of all ages and physical abilities participated. If you are interested in

receiving information about next year's trips, contact Katie Keller-Lynn at (303) 866-3330 or katie.kellerlynn@state.co.us.

WHERE ARE WE HEADED?

CGS is guided by its mission and the objectives set by the Department of Natural Resources (DNR). As an agency within DNR, the Colorado Geological Survey assists DNR in reaching its objectives. DNR and CGS program objectives show CGS where we are headed, and advisors such as the Minerals, Energy, and Geology Policy Advisory Board direct us along the way. The **science, application, and outreach** represented in the pyramid (p. 5) illustrates how CGS will continue to assist the citizens of Colorado in future growth and development.

Colorado's population growth and development are the major outside factors that influence CGS activities, specifically, geologic hazards coupled with the demand for development of subdivisions and roads, the need for geotechnical training and information, water quality, availability of land and materials to support population growth, and protection of lives and property from avalanche hazards.

Colorado's growth is resulting in record numbers of new subdivisions being proposed in all parts of the state. There is a statutory mandate for these proposed subdivisions (and their attendant roads and utilities) to be reviewed by CGS to ensure geological suitability of the site and the plans. Many of the newer, proposed subdivisions are located in areas of potential geologic hazards, since most of the flatter, "safer" areas have already been developed. Thus, despite recent advances in knowledge and mitigation techniques, the threat of geologic hazards is increasing statewide.

Colorado's growth is resulting in an increased demand for highway widening and reconstruction. An important part of the reconstruction process is the proper assessment of the engineering geology and the recognition of geologic hazards and constraints, both along and beside the new alignments. The Colorado Department of Transportation (CDOT) and CGS have a long-standing partnership in which CGS provides qualified engineering-geological assistance for highway project planning, reconstruction activities, routine maintenance, and emergency and safety issues with respect to rockfall, and landslides, and other geologic hazards. CGS cooperates with CDOT and

private consulting firms to meet this need.

Colorado's engineering geologists and geotechnical engineers—from government agencies, national companies, or small, locally-owned companies—are keenly interested in having access to training, as well as reports, maps, and presentations about recent, locally-performed research projects. CGS provides this training through its publications, as well as by presenting an annual geohazards conference. (See p. 5 for the early announcement of this year's geohazards conference.)

Water quality is an important issue in Colorado, and public concern about water quality influences CGS activities. With a growing population there is increasing demand for water resources for domestic use, to support aquatic life, for recreational activities, and for industrial uses. Consequently, there is an increasing need for water quality data and information related to these uses. CGS research links water quality issues with geology. The geology of an area adds its own water quality "signature" to the water moving through it. CGS studies many headwater areas of the state where ambient water quality data are lacking.

Land available (or deemed acceptable) for mineral development is becoming scarce as population pressures increase. Providing data for areas previously explored, lightly explored or unexplored is a public service that encourages a continuing extractive resources industry in Colorado, which in turn benefits citizens through employment and related taxes.

Costs of building our transportation infrastructure are heavily dependent upon available materials. At the present rate of consumption, we can estimate where the next five years worth of highway materials (sand, gravel, crushed stone, and cement) will be produced.

However, at a significantly increased pace of construction, we are likely to use these resources before we can locate, permit, and produce the remaining supply. In the next few years, we must locate the gravel and crushed stone quarries to meet consumption needs for the next 25 years. CGS maps and reports will help locate these resources.

Population growth in Colorado results in more people in the avalanche-prone areas of the state—for travel and/or recre-

COLORADO TEACHERS

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Colorado Geological Survey, 1313 Sherman Street, Room 715, Denver, Colorado 80203.

ation—thus resulting in more demand for CAIC service and avalanche safety training.

Science

Science is what we do at CGS. Science, that is, basic data collection and analysis, underscores all the decisions, applications, and outreach that CGS provides and will provide in the future. CGS will continue to conduct baseline scientific studies in order to do the following:

- help protect the state's water quality through geological and hydrogeological characterization,
- increase mineral production, employment and revenue in Colorado through identification, inventory, and evaluation of mineral resources,
- reduce avalanche-related deaths, injuries, and property damage in Colorado through data-collection and forecasting,
- identify, assess, and characterize geologic hazards throughout Colorado.

Application

Application, that is, products and services, are the outcome of the science we perform. We do the science in order to apply it to the needs of the citizens of Colorado. The products and services include all of the geological information, reports, GIS/digital products, and maps that we produce, as well as the compilation and maintenance of digital geologic data for more efficient use of information.

The application of science is where we meet the needs of state and local governments and citizens for geological advice, data and technical assistance to minimize hazards, construction and maintenance costs, and environmental impacts.

Furthermore, during geologic hazard emergencies, CGS applies the science we have performed and responds with expert advice and support to save lives and property, including expert advice for personal safety in times of high and extreme avalanche danger.

In summary, CGS applies the basic data collection and analysis through leadership, training, and technical assistance. The goal of our activities is the mitigation of geologic hazards and the development of mineral resources. Application of science is accomplished through partnerships, consortia, and advisory boards with private industry, government groups, and Colorado citizens.

Outreach

Outreach is the actual distribution of CGS products and services. Through requests for information and assistance, we determine who needs geoscience information, education, and training. Outreach consists of information transfer and education. CGS educates and distributes high-quality information to the people of Colorado, federal agencies, other state agencies, and local governments through newsletters, publications, workshops, office visits, phone calls, hotlines, field trips, educational aids, news media, web pages, and exhibits.

NEW PUBLICATIONS IN 1999

CGS has 26 exciting new publications available for purchase by phone (303-866-2611), fax (303-866-2461), and e-mail (cgspubs@state.co.us).

BULLETINS

Clastic Dikes Intruding Cretaceous Coals of Western Colorado

By J.K. Hardie
B 53, 48 p., \$10.00

INFORMATION SERIES

Colorado Water Quality Database from the Environmental Protection Agency's STORET Database

By J.M. Zook and M.A. Sares
IS 48, CD-ROM, \$20.00

Reconnaissance Field Investigation of Surface-Water Specific Conductance in the Snowmass-Glenwood Springs Area, West-Central Colorado

By R.M. Kirkham, J.M. Zook, and M.A. Sares
IS 49, 21 p., 1 color plate, \$15.00

Oil and Gas Fields of Colorado Statistical Summary through 1996

By A.D. Lawson and H.T. Hemborg
IS 50, 169 p., \$15.00

Colorado Mineral and Mineral Fuel Activity, 1998

By J.A. Cappa, C.J. Carroll, and H.T. Hemborg
IS 52, 28 p., \$6.00

Snow and Avalanche: Colorado Avalanche Information Center Annual Report 1998-99

By Colorado Geological Survey
IS 53, 40 p., \$5.00

MAP SERIES

Map of Areas Susceptible to Differential Heave in Expansive, Steeply Dipping Bedrock, City of Colorado Springs, Colo.

By J.W. Himmelreich and D.C. Noe
MS 32, 1 color plate, \$8.00

OPEN FILE REPORTS

Demonstrated Reserve Base for Coal in the Colorado Somerset Coal Field

By W. Eakins, C.M. Tremain Ambrose, R.C. Phillips, and M.L. Morgan
OF 98-05, 20 p., \$5.00

Preliminary Quaternary Fault and Fold Map and Database of Colorado

By B.L. Widmann, R.M. Kirkham, and W.P. Rogers
OF 98-08, 325 p., CD-ROM, 1 color plate, \$50.00

Evaluation of Mineral and Mineral Fuel Potential of Phillips County State Mineral Lands Administered by the Colorado State Land Board

By H.T. Hemborg, T.M. Lehart, A. Scarbrough, and H. TerBest
OF 99-01, CD-ROM, \$15.00

Geologic Map of the Gribbles Park Quadrangle, Park and Fremont Counties, Colorado

By C.A. Wallace, J.A. Cappa, and A.D. Lawson
OF 99-3, 21 p., 1 color plate, \$10.00

Geologic Map of the Durango West Quadrangle, La Plata County, Colorado

By R.M. Kirkham, M.L. Gillam, T.D. Loseke, J.C. Ruf, and C.J. Carroll
OF 99-4, 34 p., 1 color plate, \$10.00

Geologic Map of the Hunter Mesa Quadrangle, Garfield County, Colorado
By R.F. Madole
OF 99-5, 1 color plate, \$8.00

Geologic Map of the Durango East Quadrangle, La Plata County, Colorado
By C.J. Carroll, M.L. Gillam, J.C. Ruf, T.D. Loseke, and R.M. Kirkham
OF 99-6, 45 p., 1 color plate, \$10.00

Geologic Map of the Mt. Sopris Quadrangle, Garfield and Pitkin Counties, Colorado
By R.K. Streufert
OF 99-7, 21 p., 1 color plate, \$10.00

Evaluation of Mineral and Mineral Fuel Potential of Sedgwick County State Mineral Lands Administered by the Colorado State Land Board
By H.T. Hemborg, T.M. Lehart, A. Scarbrough, and H. TerBest
OF 99-8, CD-ROM, \$15.00

Directory of Colorado Water Quality Data
By G.R. Weber and M.A. Sares
OF 99-9, 151p., \$15.00

Correlation of Producing Fruitland Formation Coals and Coalbed Methane Leakage on the Southern Ute Reservation
By C.J. Carroll
OF 99-10, CD-ROM, \$15.00

Evaluation of the Mineral and Mineral Fuel Potential of Moffat County State Mineral Lands Administered by the Colorado State Land Board
By H.T. Hemborg, T.M. Lehart, A. Scarbrough, and H. TerBest
OF 99-11, CD-ROM, \$15.00

Evaluation of Mineral and Mineral Fuel Potential of SW Moffat County State Mineral Lands Administered by the

Colorado State Land Board
By H.T. Hemborg, T.M. Lehart, A. Scarbrough, and H. TerBest
OF 99-12, CD-ROM, \$15.00

Active Surficial-Geologic Processes and Related Geologic Hazards in Georgetown, Clear Creek County, Colorado
By J.M. Soule
OF 99-13, 7 p., 1 plate, \$7.00

Evaluation of Mineral and Mineral Fuel Potential of Park County State Mineral Lands Administered by the Colorado State Land Board
By H.T. Hemborg, T.M. Lehart, A. Scarbrough, and H. TerBest
OF 99-15, CD-ROM, \$15.00

Evaluation of Mineral and Mineral Fuel Potential of NE Moffat County State Mineral Lands Administered by the Colorado State Land Board
By M.J. Crane, H.T. Hemborg, T.M. Lehart, A. Scarbrough, and H. TerBest
OF 99-16, CD-ROM, \$15.00

Evaluation of Mineral and Mineral Fuel Potential of SE Moffat County State Mineral Lands Administered by the Colorado State Land Board
By M.J. Crane, H.T. Hemborg, T.M. Lehart, A. Scarbrough, and H. TerBest
OF 99-17, CD-ROM, \$15.00

SPECIAL PUBLICATIONS

Heaving Bedrock Hazards Associated with Expansive, Steeply Dipping Bedrock, Douglas County, Colorado
By D.C. Noe and M.D. Dodson
SP 42, 80 p., 2 color plates, \$25.00

A SPECIAL THANKS...

We would like to thank Bob Blakestad, Ed Church, John Curtis, Peter Dea, Doug Cain, John Kaufman, Jan Rousselot, Forrest Luke, Robert Santistevan, Marian Smith, Darrell Speer, and Susan Steele Weir for their support. These people have recently completed their service as members of the Colorado Geological Survey Advisory Committee.



Greg Schnacke, Executive Vice President of Colorado Oil and Gas Association, and Doug Peters, President of the American Institute of Professional Geologists—Colorado Section, congratulating John Kaufman on the completion of his year as chair of the CGSAC

Avalanche Wise: Your Guide to Avalanche Safety in Colorado
By K. Williams and D. Atkins
SP 48, 24 p., \$2.50



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