COLORADO GEOLOGICAL SURVEY

ROCKTALK

OCTOBER, 2001 VOL. 4, NO. 4

Field Notes from the Director

When the Ground Lets You Down—Ground Subsidence and Settlement Hazards in Colorado

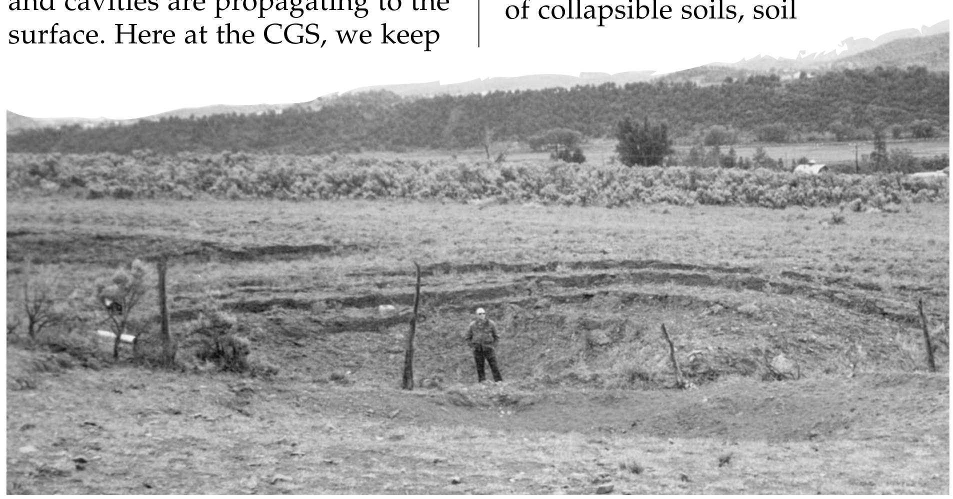
ON SOLID GROUND—that's how many of us think of good old, stable earth. So it's disconcerting when the ground moves out from under us in any way.

Because of our environment, history, and geology, Colorado has conditions where ground movements can costs millions of dollars in annual property damage from repair and remediation, litigation, required investigations, and mitigation. There has been recent attention to swelling clay soils and heaving claystone bedrock, and the media has helped publicize these problems, which are predominant along the Front Range. But that's only half the story. Geologic hazards in Colorado also include ground that sinks. Ground subsidence and soil settlement pose significant hazards in Colorado in many areas throughout the state. A variety of causes, some human-made and others inherent to the geology and geomorphology of Colorado, cause these sinking problems.

Coal and hard rock mining were important parts of the early development of Colorado and continue to play an important role in the state's economy. Besides mineral wealth, mining also left a legacy of undermined lands that are susceptible to ground subsidence because the old underground mine workings are caving and cavities are propagating to the surface. Here at the CGS, we keep a state coal mine subsidence library complete with maps of historic coal mines and subsidence risk investigations and assessments. Today's growth pressures are accelerating development in or near undermined areas. An important point to mention here is that normal homeowners' insurance does not cover ground movements at all, whether they are human caused or natural soil or bedrock hazards.

Ground subsidence hazards also occur where evaporitic bedrock (gypsum, anhydrite, and rock salt) dissolves. Subsidence sags and ground downwarping, caverns and open fissures, ground seepage and streams flowing from bedrock, and various types of sinkholes, are landforms collectively called karst morphology. The CGS is doing exciting and important scientific work in evaporitic bedrock areas of Colorado where these landforms exist. The research, which shows thousands of feet of regional collapse, salt neotectonics, diapiric piercement structures, and cubic miles of evaporite minerals dissolved and washed down the Colorado River over hundreds of thousands of years, illustrates how fascinating our state's geology is.

Collapsible soil is yet another different and difficult geologic phenomenon in Colorado. In areas of collapsible soils, soil



A sinkhole near Carbondale initiated by hydrodcompaction of surficial deposits and enlarged by piping into a void in the Eagle Valley Evaporite

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FOCUS ON: Coal Mine Subsidence, Evaporitic Bedrock, and Collapsible Soil

settlement sometimes occurs very rapidly. A wide variety of soil types, including hydrocompactive, piping, dispersive, and gypsiferous soils, can be a major concern where development and structures are founded on them. This problem exists mostly in western and southwestern Colorado. Unlike expansive soils that swell when water is added, these soils collapse and settle when they become wetted, usually from human activities, at a saturation level not naturally occurring in the semi-arid climate. The CGS continues to study the occurrences of collapsible soils and will soon publish both a definitive statewide study and a regional susceptibility map series.

If you are a geologist in Colorado, the variety and complexity of geologic conditions in our state will continuously fascinate you. If you are a homeowner, home-builder or community planner, the geology may seem more vexing than fascinating. Read on to see how the scientists of the CGS are tackling these problems and how we hope to help understand and solve some of the more expensive problems.

Subsidence above Inactive Coal Mines

Introduction

The earth's surface can subside because of underground mining when rock is removed at depth. Although subsidence can occur due to hard rock mining, this article only considers the effects of coal mining.

When coal is extracted underground, gravity and the weight of the overlying rock may cause the layers of rock to shift and sink downward into the void left by the removal of the coal. Ultimately, this process can affect the surface, causing the ground to sag and crack and holes to form. Merely an inch of differential subsidence beneath a residential structure can cause several thousand dollars worth of damage.

Subsidence can happen suddenly and without warning. Detailed investigations of an undermined area are needed before development occurs to resolve the magnitude of the subsidence hazard and to determine if safe construction is possible. While investigations after development can determine the extent of undermining and potential subsidence, often, existing buildings cannot be protected against subsidence hazards. The cost of remedial measures is often high.

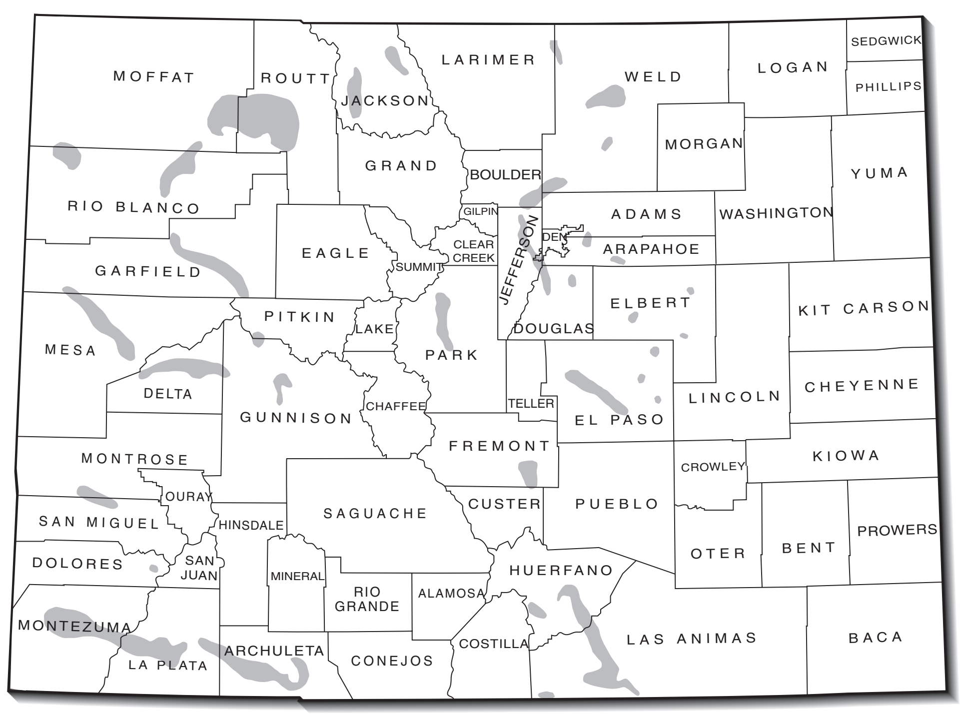
Inactive Coal Mines and Population Growth

Coal mining in Colorado started in the 1860s and is a continuing activity in many areas of the state. As of August 1977, Federal and State laws require that potential surface subsidence be taken into account in mining plans. Prior to that time, the effect of mining on the surface was not fully considered.

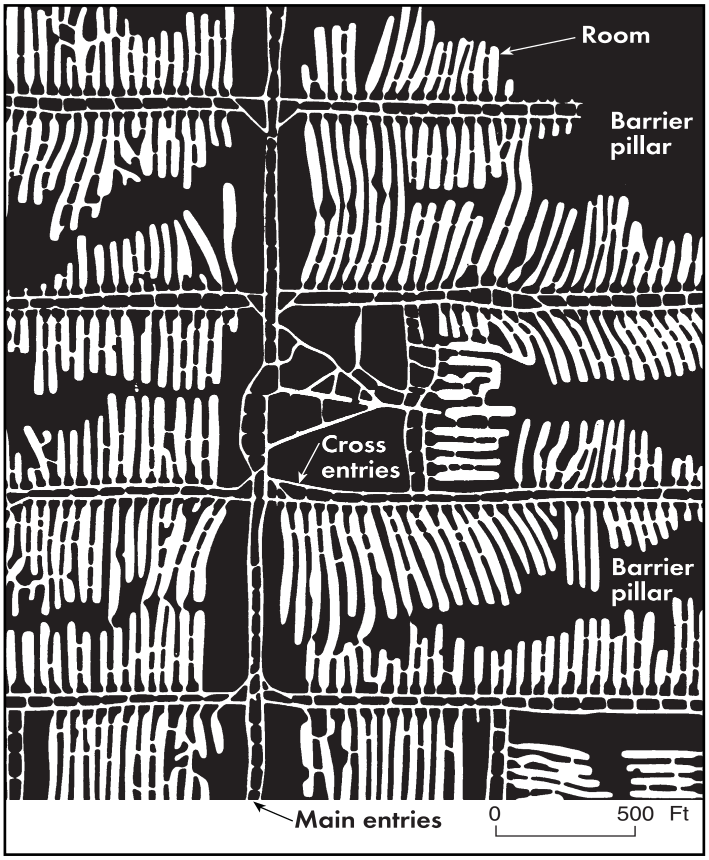
Many old mines are located near present urban areas. With Colorado's population growth in the last 25 years, not only have many homes been built over abandoned mines, but many homeowners are unaware of previous mining or the extent of mining in an area. A name such as Coal Mine Avenue may seem fanciful rather than significant. Subsidence over abandoned coal mines is a potential hazard for thousands of homes along the Front Range Urban Corridor, and these numbers will continue to grow as more people move into the state. The map below indicates general locations of inactive coal mines throughout the state.

Mining Methods

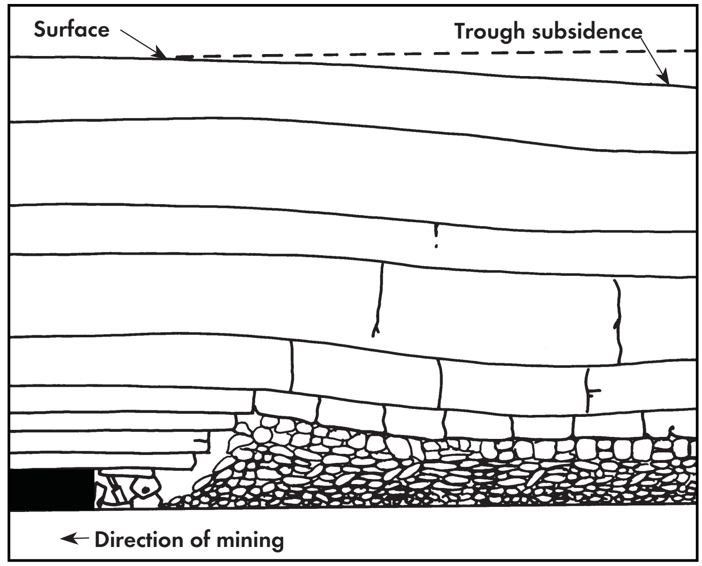
Room and pillar mining was the mining technique used almost exclusively in early Colorado mining and is still in use today (see



General locations of Inactive coal mines in Colorado.



The basic layout of a room and pillar mine plan showing nonuniform workings.—USED WITH PERMISSION, P.B. DUMONTELLE, 1981, MINE SUBSIDENCE IN ILLINOIS: FACTS FOR THE HOMEOWNER, *I.G.S., ENVIRON. NOTE 99.*



Cross-sectional view of a longwall mine.—USED WITH PERMISSION, S.S. PENG, ED., 1981, WORKSHOP ON SURFACE SUBSIDENCE DUE TO UNDERGROUND MINING

mine plan above). Approximately 50 to 80 percent of the coal was removed by this method. "Rooms" of coal were mined, and pillars of coal were left in place to support the roof of the mine.

Longwall mining is a newer mining technique where subsidence is expected and planned. In this high coal-extraction method, a panel of coal is removed in the form of a large continuous room, leaving the roof unsupported except along the face of coal being mined by machinery. As the working face advances, the roof sags into the mined void, as shown in cross section (above, right). This technique is more likely than room and pillar mining to produce an immediate effect at the surface.

When and How Much Subsidence Can Occur

Where longwall mining is active and subsidence is a well-documented and predictable action, surface response to ongoing mining can be accurately estimated. However, in the case of room and pillar mines, especially where they are inaccessible and record-keeping may be inaccurate, predictions of when subsidence will happen are not possible. Several factors contribute to the timing of caving at the mine level and subsidence appearing at the surface. Pillars and timber left in place can hold the roof of the mine up for long periods of time.

How much subsidence will occur and the features that will appear at the surface depend not only on the type of mining but on geology and several physical features of the voids left by mining. Some general rules of thumb are:

- the larger the mine opening height and width, the larger the subsidence feature at the surface;
- the shallower the mine below ground, the more noticeable the surface subsidence evidence; however, in Colorado pits have been found over mines as deep as 350 feet;
- the strength of the rock above the coal seam influences whether subsidence will reach the surface and the kind of features that can appear (see drawings of Subsidence Features on page 4).

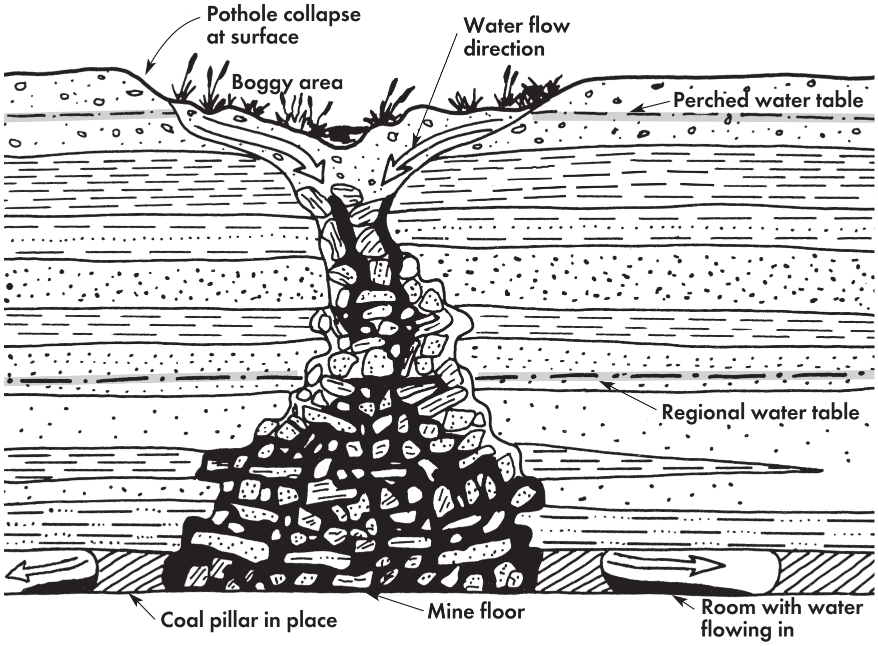
Subsidence Hazard Area Identification

A residence or other structure may be subject to subsidence if it is located over or close to an undermined area (see illustrations on page 4 and photo on page 5). Therefore, the first step in determining the subsidence potential at a specific location is to discover if the area is undermined. Several published sources of information are available for the locations of inactive mines. Maps showing the extent of inactive coal mines and actual maps of coal mines are available for viewing from the Colorado Geological Survey.

Some recent housing developments in the Front Range Urban Corridor, in response to Senate Bill 35 (1972), have had subsidence-hazard investigations completed prior to development. Individual site-specific investigations involve examining the available data and

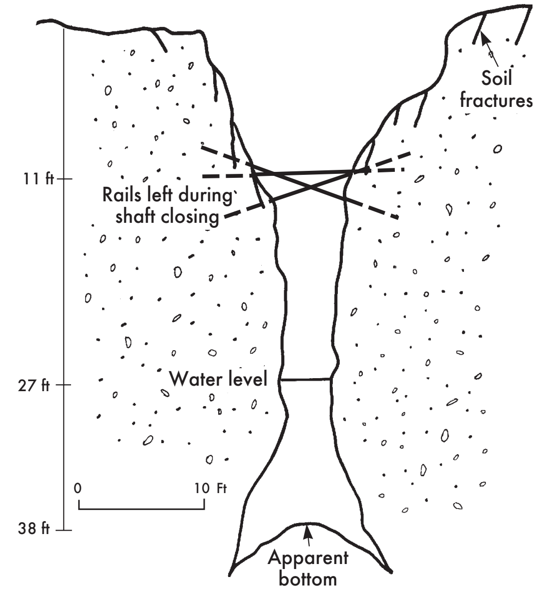
Subsidence Features

Holes



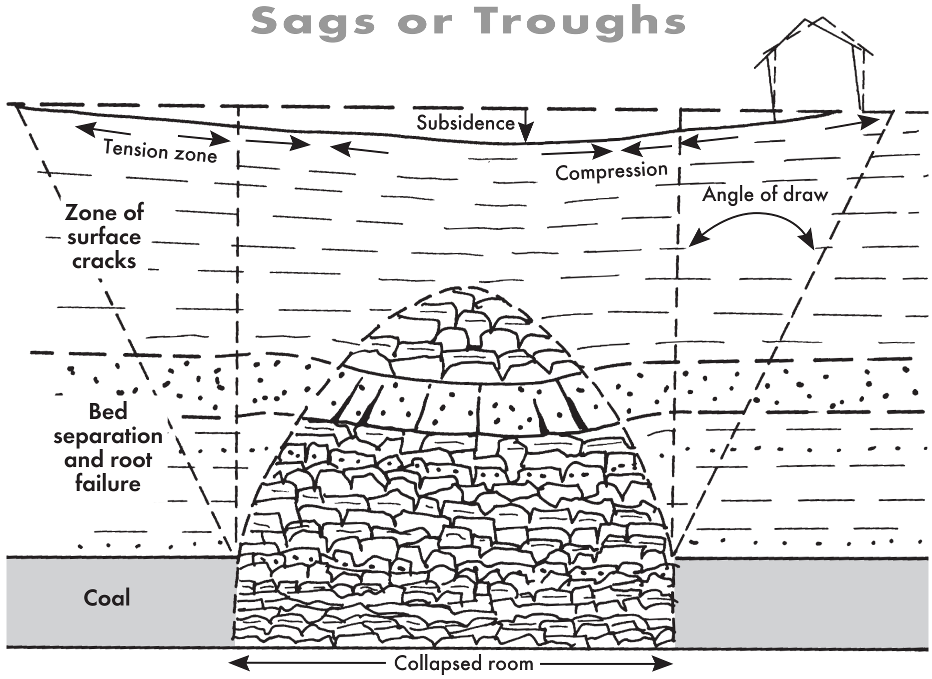
Cross-sectional view of a subsidence pit.—CGS SP 26

Mine Openings



Cross-sectional view of the Fremont air shaft.—MODIFIED FROM: AMUEDO AND IVEY, 1981AND CGS SP 26

Sags or Troughs



Cross-sectional view of roof caving, through subsidence Above a large collapsed room and the effects on overlying rock.—MODIFIED FROM: S.S. PENG, ED., 1981, WORKSHOP ON SURFACE SUBSIDENCE DUE TO UNDERGROUND MINING, CGS SP 26

drilling exploratory holes for information on the present condition of the mine. These investigations are completed to determine how the subsidence hazard can affect proposed development, if safe building areas exist, and what areas should be avoided.

These studies, when available, are often on file with the builder, city, or county. They also may be available for inspection from the files of the Colorado Geological Survey. To determine if one of these studies is available for a specific subdivision, the subdivision name (as platted) and location should be known.

Identifying Subsidence Damage

The different physical processes involved with subsidence will produce different types of damage. The vertical drop of pit subsidence can be damaging to buildings. However, a driveway or major structural member of a building can often bridge a hole for a short time.

Damage to structures or ground changes may suddenly appear or may be more gradual. Other ground hazards such as swelling soils, heaving bedrock, collapsible soils, or natural sinkholes can also cause cracking, shearing, other distortion-type

Federal and State Agencies That Have Inactive Mine Subsidence Information

U.S. Department of the Interior, Office of Surface Mining (OSM) Federal Reclamation Projects Branch (303) 844-1400	Handles emergency subsidence reclamation projects in Colorado and other western states
Colorado Dept. of Natural Resources Division of Minerals and Geology (303) 866-3401	The State's repository of operating mine maps. The agency has inventoried abandoned mines and administers the Mine Subsidence Protection Program.
Colorado Dept. of Natural Resources Colorado Geological Survey (303) 866-2611	Has subsidence hazard and abandoned mine maps for inspection. Provides information on subsidence hazards.

damage to structures, and ground changes such as spontaneous openings, sags, and fissures. When such damage occurs, the first course of action is to examine the references that were mentioned above.

Subsidence Insurance

For homes built before 1989, homeowners within an undermined area are eligible to participate in the Mine Subsidence Protection Program (MSPP), a federal program operated by the Mined Land Reclamation Board of the Division of Minerals and Geology. The annual premium is $35 per year. Call 1-800-44-MINES for more information.

Homes built after 1989 are not covered by the MSSP, which makes decisions about where to build especially important. Private subsidence insurance is available in Colorado.

What To Do in a Subsidence Emergency

If the ground sinks suddenly on or near your property and you have reason to believe the area is undermined, you should do the

Coal mine shaft collapse in a trailer park in Colorado

RockTalk
is published by the
Colorado Geological Survey
1313 Sherman Street,
Room 715, Denver, CO 80203
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Phone: (303) 866-2611
Fax: (303) 866-2461
E-mail: cgspubs@state.co.us
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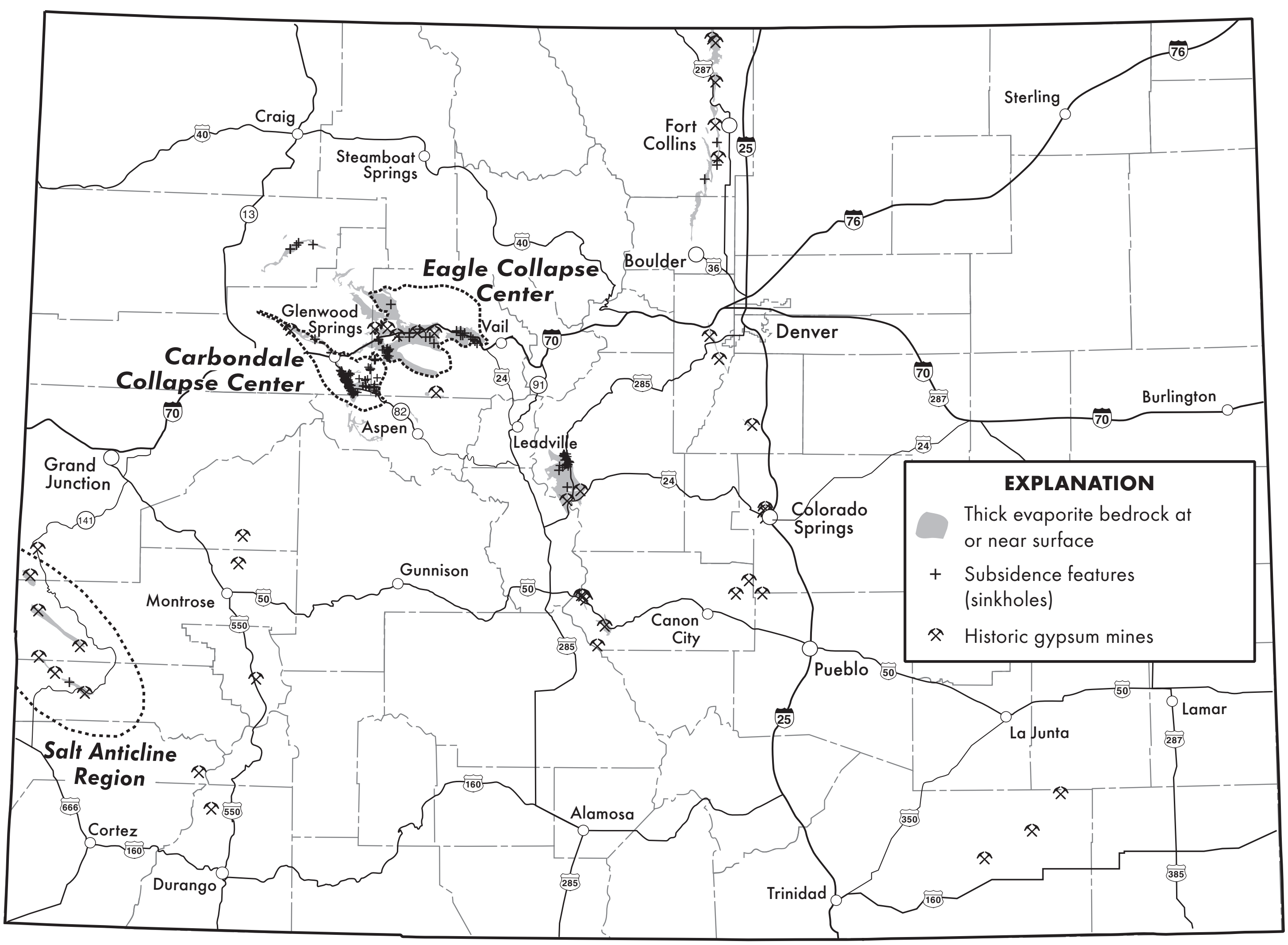
THIS ISSUE
Editors: Dave Noe, Vicki Cowart
Production: Cheryl Brchan, Larry Scott

following:

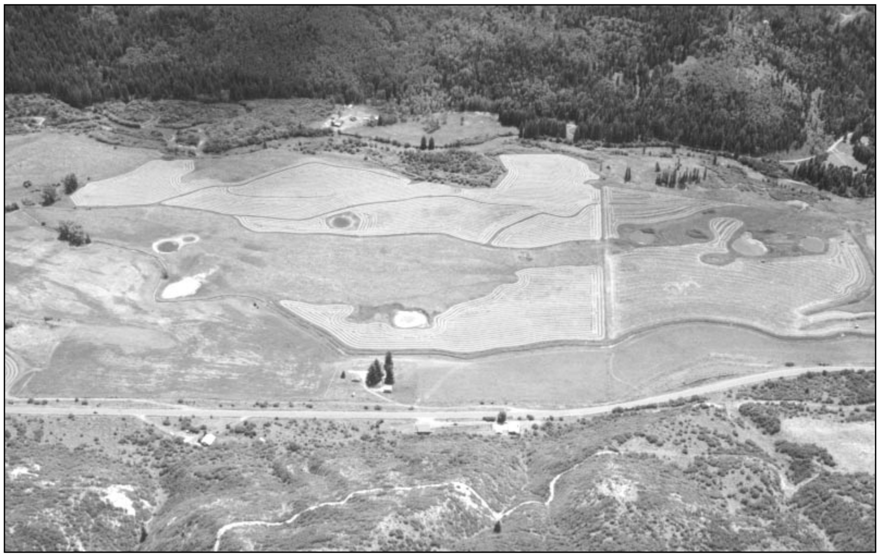
1) Determine if your building is served by natural gas. If so, contact the Public Service Company of Colorado or similar utility. If gas lines are cracked or broken, there is a potential for fire or explosion.
2) Contact your city or county safety department/fire department and the Office of Surface Mining (OSM), Federal Reclamation Projects Branch in Denver. OSM controls federal abandoned mine reclamation emergency funds. If the office representative determines the incident qualifies as a subsidence emergency, they will monitor the situation and repair the subsidence feature. They will not repair damage to a structure.
3) Contact your city water and sewer department so that these lines can be checked for damage.
4) Large windows should be taped to help prevent flying glass, should distorted windows shatter.
5) The homeowner should start a written log. This log will help investigators to determine if the damage is caused by subsidence.—THIS ARTICLE WAS EXERPTED BY CELIA GREENMAN FROM CGS SP 26, WHICH IS PLANNED FOR REISSUE

EVAPORITE KARST SUBSIDENCE

Many areas of Colorado are underlain by bedrock that is composed of evaporite minerals. Indicative of the word evaporite, these minerals were deposited during the cyclic evaporation of shallow seas that existed in central Colorado millions of years ago. As the water continued to evaporate, the remaining solution became hyperconcentrated with salts: minerals such as gypsum, anhydrite, and halite (rock salt). These minerals precipitate out of solution and accumulate in shallow nearshore basins on the bottom of the sea floor. Depending on the paleoevironment,



Evaporitic bedrock locations in Colorado—GYPSUM MINES FROM MINERAL RESOURCES OF COLORADO, 1968, P. 191; GEOLOGY MODIFIED FROM TWETO, 1979



Several sinkholes give the name to Pothole Valley, east of Buford on the North Fork of the White River

Exciting scientific work is ongoing in areas of evaporite karst in Colorado. The evaporite terrains of the Roaring Fork and Eagle River areas are centered in areas of Neogene deformation and regional subsidence, related to flowage, diapiric upwelling, and dissolution of evaporite minerals. Precise geologic mapping, river and hot springs water chemistry, and inconsistencies in superposition (elevations) of various volcanic flows compared to their determined ages has brought about new theories, and definable and defensible limits to the area of regional collapse. Highly contorted strata, collapse debris, structural sags, deformation of river terrace gravel, piercement structures, and river-centered anticlines are all geomorphic evidence of the subsidence and deformation.

thinly interbedded fine sandstone, mudstone, and black shales can also occur in the evaporite. Mostly Late Paleozoic and Mesozoic rock formations contain evaporite beds in Colorado. Some are thin and discontinuous—only minor beds within a rock formation. Others are massive, with evaporitic minerals many hundreds of feet thick.

Millions of years of burial, plastic deformation, mountain building, and erosion have forced the evaporite beds to the shallow subsurface and/or ground surface today. Evaporite minerals in Colorado are a valuable mining resource. Historic mining occurred throughout the state where thin gypsum beds were exposed. Active mining continues in the massive deposits near the town of Gypsum.

Two characteristics of evaporite bedrock are important. One is that evaporite minerals can flow, like a hot plastic, when certain pressures and temperatures are exceeded. The second, and most important to land use and development, is that evaporite minerals dissolve in the presence of fresh water. It is this dissolution of the rock that creates caverns, open fissures, streams outletting from bedrock, breccia pipes, subsidence sags and depressions, and sinkholes. These landforms are described collectively as karst morphology. Karst morphology originally referred to limestone areas known for characteristic closed depressions, sinkholes, caverns, and subterranean drainage. Evaporite karst comprises similar morphology where these features develop as a result of dissolution of the evaporite minerals.

While regional collapse related to evaporite flowage and dissolution is fascinating to geoscientists, it is the associated risk from localized and potentially spontaneous subsidence that can be destructive to facilities and potentially life threatening. Secondary considerations include seepage susceptibility and potential failure where reservoir dams are located, and water-quality concerns with dissolved-salt loading of rivers.

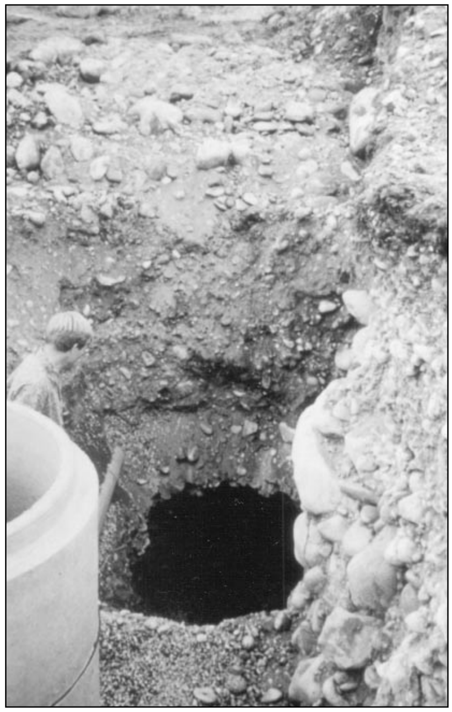
Most catalogued sinkholes of Colorado lie on surficial deposits such as flat-lying glacial outwash terraces, recent valleyside sediments, or older deposits on pediment slopes overlying the evaporite bedrock (see photo above). Some sinkholes, fissures, and caverns are exposed in the actual bedrock (see photo below). In surficial-soil mantles, subsurface borings in the

Large sinkhole (diameter approx. 200 feet) in Eagle Valley Evaporite near the Eagle County Airport outside of the town of Gypsum vicinity of sinkholes show wide irregularities of bedrock depths, as do exposures along road cuts. While the surface of the river terrace is relatively flat, the underlying bedrock surfaces is likely more indicative of karst topography. The highest densities of sinkholes that are manifested at the surface in Colorado occur in the Roaring Fork River-Carbondale area in Garfield County, the Eagle River around Gypsum and Edwards in Eagle County, the Buford-North Fork White River area in Rio Blanco County, and Park County south of Fairplay (see map on page 6).

Where evaporite bedrock is exposed at the surface or underlies thin surficial soils, there is some risk that subsidence could occur. The associated risk rises where the frequency of sinkholes increases. Dangerous and life-threatening, spontaneous collapse and opening of subsurface voids are rare, but do occur (see photo at right). More commonly, differential strains and settlement from localized ground subsidence or piping (removal of fine soils into subsurface voids) will damage facilities that are unknowingly constructed over a sinkhole or subsidence trough.

Where subsidence features are exposed at the surface and properly identified, they should be avoided if possible. Many older sinkholes have been covered with recent soil infilling and are completely concealed at the surface. While some concealed sinkhole locations can be seen in aerial photography by vegetation changes, only subsurface inspections, either by investigative trenching, a series of investigative borings, geophysical means, and/or observations made during overlot grading or utility installation, would ascertain whether sinkholes exist within a development area.

If such hidden sinkholes are located, an experienced geotechnical firm should be retained to evaluate the hazard and potential for future subsidence on the development. There are both ground-modification and structural solutions that can help mitigate the threat of subsidence if avoidance is not an option. Drainage issues and proper water management are as important as they are for collapsible soils. Additional increases of fresh water may accelerate dissolution, destabilize certain subsidence areas, re-open or establish new soil pipes to bedrock voids, and rejuvenate older sinkholes.—JON WHITE



Subsurface void encountered during construction in river terrace gravel overlying Eagle Valley Evaporite—
PHOTO COURTESY OF R. MOCK, HEPWORTH-PAWLAK GEOTECHNICAL

Collapsible Soils

At the end of the 19th and beginning of the 20th Century, some of the first settlers of the plateau region of western Colorado along the Colorado River, and the Uncompahgre and Paonia river basins, looked to fruit crops for their livelihood. The semi-arid but moderate climate was well suited for fruit orchards once irrigation canal systems could be constructed. But serious problems occurred when certain lands were first broken out for agriculture and wetted by irrigation. They sank, so much in places (up to 4 feet!) that irrigation-canal flow directions were reversed, ponding occurred, and whole orchards, newly planted with fruit trees imported by rail and wagon at considerable expense, were lost.

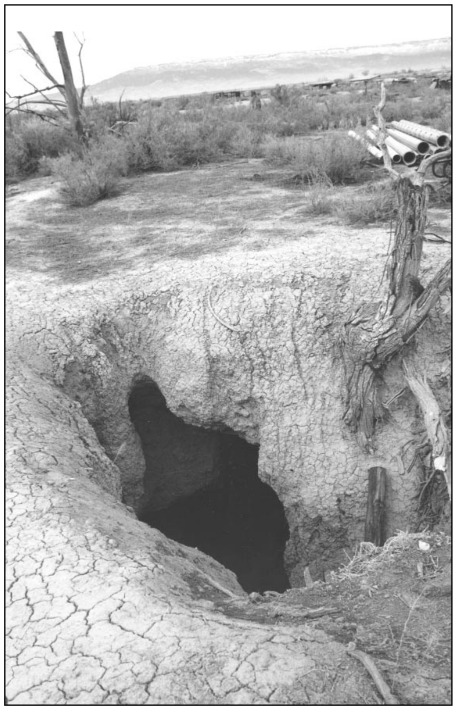
While not understood, fruit growers and agriculturists began to recognize the hazards of "sinking ground." Horticulturists with the Colorado Agricultural College and Experimental Station (the predecessor of Colorado State University) made one of the first references to collapsible soil in their 1910 publication, *Fruit-Growing in Arid Regions: An Account of Approved Fruit-Growing Practices in the Inter-Mountain Country of Western United States*. They warned about sinking ground and in their chapter, "Preparation of Land for Planting," made one of the first recommendations for mitigation of the hazard. They stated that when breaking out new land for fruit orchards, the fields should be flood irrigated for a suitable time to induce soil collapse, before final grading of the orchard field, irrigation channels excavation, and planting the fruit tree seedlings.

So, what are these soils? Why do they collapse? The reference cited above briefly stated that, "The tendency to settle appears to be due to the porous conditions of the subsoil." Such soil properties are diametrically opposite from the better-known swelling problems that are found in the "fat" plastic clay soils of the Front Range. Collapsible soils are generally dry, low density, silty soils with high void space or air gaps between the soil grains where the soil particle binding agents are highly sensitive to water. These micro-pores can sometimes be seen by the naked eye. When exposed to and weakened by water, the binding agents break, soften, or dissolve such that the soil grains shear against each other and re-orient in tighter, denser, configurations. This re-configuration causes a net volume decrease in the soil mass that, in turn, results in settlement of the ground surface. This condition can occur just by the weight of the soil itself, called the overburden, or the weight of a structure, such as a home foundation or dam abutment.

The binding agents of the collapsible soil structure can be very strong while the soil is in a dry state, and may possess high bearing capacities able to support heavy structures. When water is introduced, the soil fabric's skeletal structure quickly weakens and fails. Collapse rate is also dependent on saturation rate of the soil. Because the introduction of water causes this collapse, the terms hydrocompactive and hydrocompressible are also used to describe these soils.

There are other types of soil collapse. One is piping and formation of soil caverns in dispersive and erodible soils, caused by active suspension and removal of soil particles by flowing water (see photo above). Another is soil with a high evaporite-mineral or gypsum content, where actual dissolving of mineral grains and the cementation matrix (soil mass loss) can result in volume loss and settlement at the surface.

Structures and underground utilities founded on these types of soils can suffer from distress because of differential settlement.



Piping-void surface collapse near Loutsenhizer Arroyo east of Olathe

Because of the differential between two rates of settlement, strain can build until the structure bends, distorts, or breaks. The shifting and settling of the structure can be seen in a number of ways: 1) settlement, cracking, and tilting of concrete slabs and foundations; (see photo, next page) 2) displacement and cracking in door jams, window frames, and interior walls; and 3) offset cracking and separation in rigid walls such brick, cinderblock, and mortared rock (see photo, next page). The damage can be similar to that caused by expansive or swelling soil. In fact, where both types of soils occur, usually in complex interlaying, it becomes difficult to initially determine what soil property is the cause of damage.

So, why do these soils form and where are the locations? The soils are derived from a number of different types of sediment deposition, but the key is really geology, climate, and resultant geomorphology.

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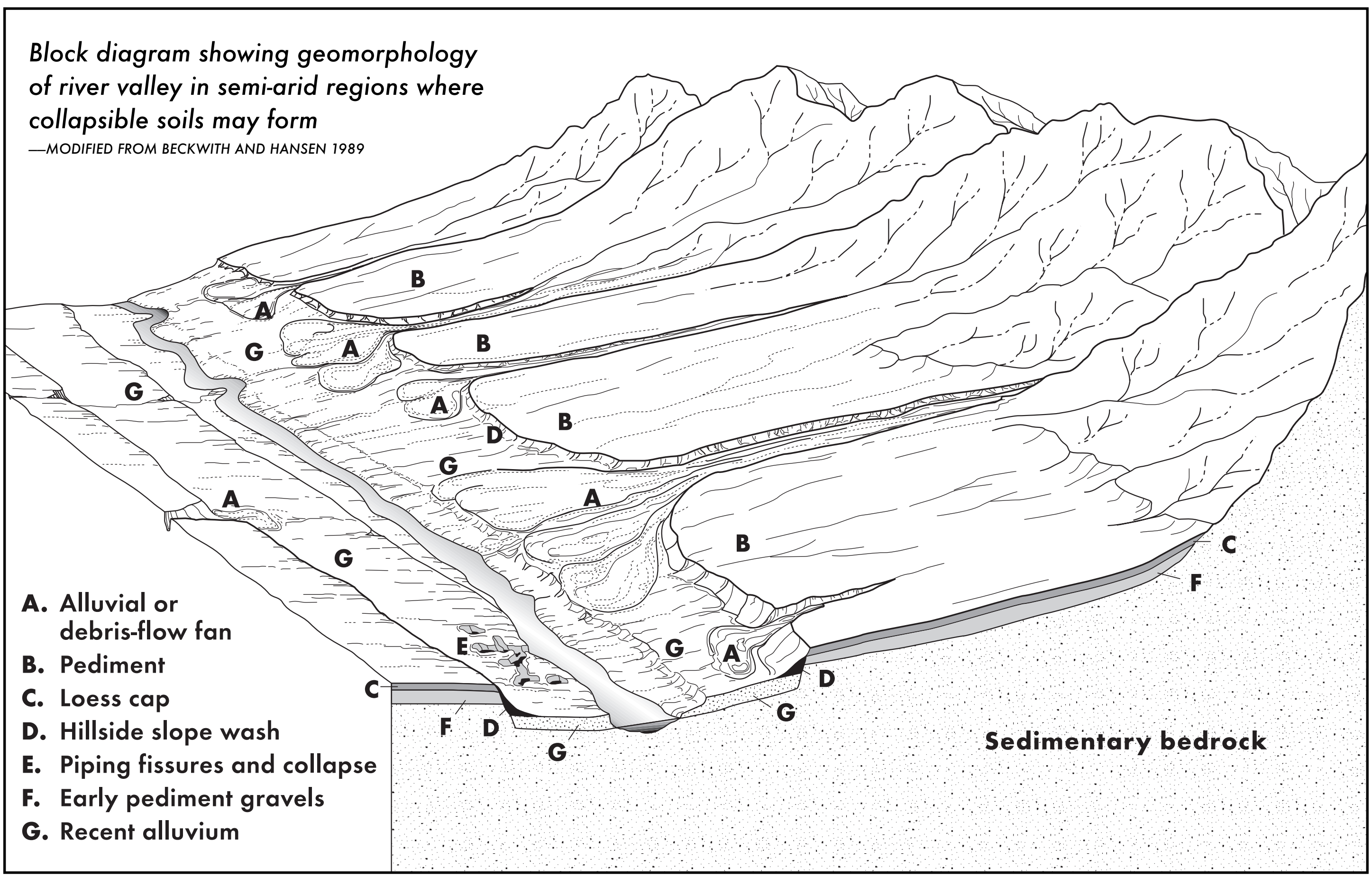
Continued settlement in collapsible soil dropped new townhome driveway to a level where vehicles are unable to enter garage. Note leveling slab of concrete on garage floor from previous repair.

Damage to foundation and mortored brick walls from settlement of collapsible soils. Building in Montrose was demolished shortly after photo was taken. PHOTO COURTESY OF BUCKHORN GEOTECH

Many regions of Colorado, outside of the crystalline rocks that form the major mountains, are underlain by poorly indurated (soft), clay and silt rich, sedimentary bedrock. The bedrock weathers easily and forms residual soils, susceptible to rapid erosion.

It has been shown that semi-arid areas are more prone to high sediment yields (expressed as tons of soil per acre lost by erosion, per year), which is to say that deposition of new sediments eroded from poorly vegetated hillsides is quick. Semi-arid regions have less vegetation and sufficient runoff of intense thunderstorms to transport large amounts of sediment. Sediment yields peak within the range of 12–20 inches in annual



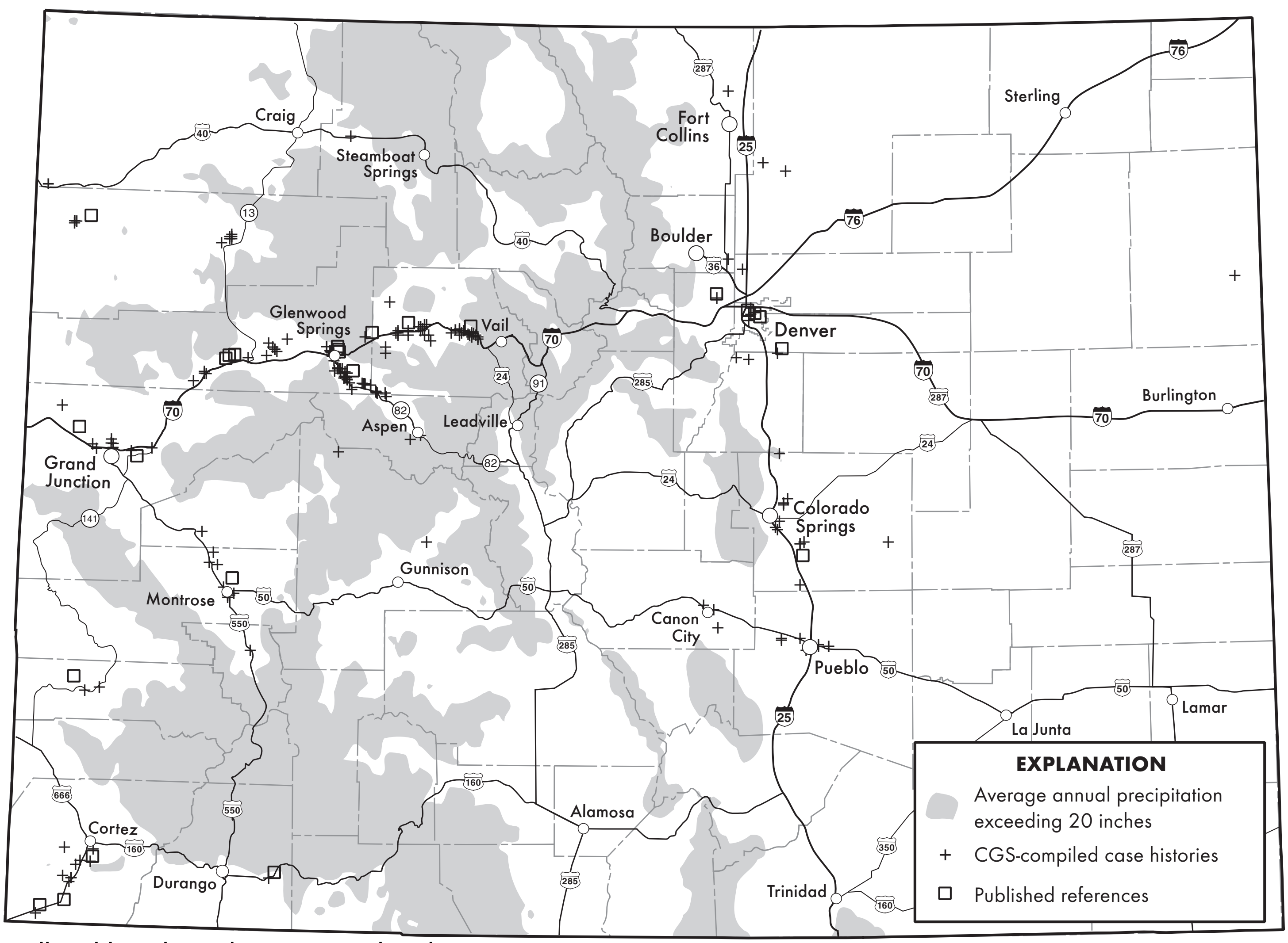
Block diagram showing geomorphology of river valley in semi-arid regions where collapsible soils may form
—MODIFIED FROM BECKWITH AND HANSEN 1989

precipitation that is typical for most of western Colorado, the intermontane valleys, and the high prairies next to the Front Range.

Numerous studies and case history compilations that include soil engineering properties (see map below) have shown that certain types of recent sediment deposits and soils can be susceptible to collapse. Those soils include windblown deposits of dust, silt, and fine sand called loess, hillside gravity deposits called colluvium, rapid deposition of unsorted water-borne material (mud and debris) in alluvial/debris flow alluvial fans and hillside slope wash, and recent overbank deposits called alluvium (silt and clay laid along tributary streams and gently sloped mud flats) (see block diagram, previous page). With few exceptions, soil collapse appears to occur in areas that have less than 20 inches of annual precipitation.

The common characteristic of these soils is recent and rapid deposition, depositional dynamics that result in an inherently unstable internal structure. The generally dry environmental conditions of the area cause these deposits to quickly desiccate (dry out) in their original condition, without the benefit of further re-working or packing of the sediment grains by water. Local ground-water levels generally never rise into these mantles of soil so they never become saturated. Only through human development and land use do local ground-water levels rise. The soils become introduced to moisture, through combinations of field irrigation, lawn and landscaping irrigation, capillary action under impervious slabs, leaking or broken water and sewer utilities, and altered drainage.

The most important thing to remember is that collapsible soils are dry in their natural state, and it is important that they remain so where structures have already been constructed without mitigation. Water and drainage management is always important for new-site development level but is even more so with maintenance of existing structures. Certain restrictions for lawn-irrigation systems are recommended. To reduce possible water



Collapsible soil case histories in Colorado—PRECIPITATION DATA FROM USDA-NRCS, NATIONAL CARTOGRAPHY AND GEOSPATIAL CENTER, FT. WORTH, TEXAS, 1999 introduction into the subsoil, xeriscape landscaping, requiring lower water usage, is suggested.

There are available engineering techniques to mitigate collapsible soils. They are grouped broadly into 1) ground modifications that mitigate the collapse potential of the soil, 2) structural reinforcement technique, and 3) deeper foundations to transfer building loads through the collapsible soil horizon to a competent soil or rock layer below.

The CGS has been studying collapsible soils in Colorado for a number of years and has compiled case histories in Colorado on sites studied by the CGS, cited in published references, or supplied by other government agencies and private consulting firms. The data have been analyzed with respect to local geology, geomorphology (landforms), soil formation, and climate. The CGS will be publishing both a regional susceptibility map and state-wide report on susceptibility of collapsible soils in Colorado in 2002. The regional study will be of the Roaring Fork River Corridor in Eagle, Garfield, and Pitkin Counties, and will be available as a map series late this winter. The more-comprehensive statewide report will be published later and is planned to be available in the summer of 2002.—JON WHITE

SWELLING SOIL PUBLICATION WINS ANOTHER NATIONAL AWARD

CGS Special Publication 43, *A Guide to Swelling Soils for Colorado Homebuyers and Homeowners*, by Dave Noe, William "Pat" Rogers, and Candace Jochim, is the winner of the 2001 Edward B. Burwell, Jr. Award by the Geological Society of America, Engineering Geology Division.

This prestigious award is made to the author(s) of a published paper of distinction that advances the principles or practices of Engineering Geology. Many of the previous award-winning publications have become hallmark references for the Engineering Geology and Geotechnical Engineering professions. Edward B. Burwell, Jr. was one of the founders of the GSA Engineering Geology Division, and was the first chief geologist of the U.S. Army Corps of Engineers.

The 76-page book is geared toward helping homebuyers and homeowners reduce damages from swelling soils and has become a favorite of the homebuilding industry. It is distributed to buyers of new homes for disclosure purposes. Over 100,000 copies have been sold since its publication in 1997.

The award will be presented at the Engineering Geology Division's Award Luncheon at the 2001 GSA Annual Meeting in Boston, Mass., on November 7, 2001.

The publication also received the John C. Frye Memorial Award in Environmental Geology from GSA in October 1998.

SP 43 is available for $7.00 plus shipping and handling fees (see "How to Order Publications" on p. 9).

Upcoming Events Involving CGS

November 8
Association of Enginnering Geologists Section Meeting, School of Mines Museum, Golden, 6:30pm (dinner), 7:30pm (talk), "Collapsible Soils in Colorado" by Jon White; contact Peggy Ganse at (303) 534-5789, ext. 3210

November 26–27
Colorado Counties Winter Conference, Colorado Springs; call Kristin Dunn at (303) 861-4076, ext. 241 or e-mail: kdunn@ccionline.org

ROCKTALK

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

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