COLORADO EARTHQUAKE HAZARDS

by Colorado Earthquake Hazards Mitigation Council
2013

The towering Sangre de Cristo Mountains in south-central Colorado were uplifted along the Sangre de Cristo fault, one of the most active faults in Colorado. The Sangre de Cristo fault (approximate location shown by white dotted line) lies at the base of the mountains. Geologic evidence indicates the fault caused numerous prehistoric strong earthquakes and will cause large earthquakes in the future. Photo by V. Matthews.

Overview

This publication provides general information about earthquake hazards in Colorado. It was created to increase public awareness of earthquakes. Information on Colorado's earthquake history, potentially hazardous faults, emergency preparedness, and sources of additional information is included in the publication.

The historical record of earthquakes provides important clues to scientists about earthquake hazards. Future earthquakes may occur in the same general locations as past earthquakes. Past earthquakes also provide an indication of the size of future earthquakes. The locations (or epicenters) of Colorado's historical earthquakes are shown on the accompanying map.

Earthquakes generate seismic waves that can be detected by sensitive instruments called seismographs. Records of seismic waves (called seismograms) are used by seismologists to locate and measure the size of earthquakes. Although Father Armand W. Forstall installed the first seismograph in Colorado at Regis College in 1906, it was not used primarily to detect and record earthquakes in Colorado; but rather to detect large earthquakes worldwide. In the 1960s, modern seismographs began to be used to locate and measure the magnitude of earthquakes in Colorado. At that time the epicenters of recorded earthquakes typically were accurate to only 10 or 20 miles. Recently, new seismographs have been installed in Colorado as part of the Advanced National Seismic System (see map for locations of the four currently operating permanent seismographs). With the installation of new seismographs, earthquake epicenters can be more accurately located and smaller earthquakes can be detected.

Locations of Colorado's earthquakes that pre-date the 1960s are estimated using "felt" reports that describe the effects of the earthquake at various locations. Each felt report can be assigned a Modified Mercalli Intensity value (see table in third column). The epicenter is arbitrarily placed in the area with the highest intensity. Earthquake locations based on felt reports are considerably less accurate than the epicenters of instrumentally recorded earthquakes. The epicenters of Colorado's earthquakes that were determined using seismographs are shown on the accompanying map by the colored circles. Locations of earthquakes that rely upon the felt reports are shown by the colored squares. The size of the circle or square indicates the magnitude or maximum Modified Mercalli intensity of the earthquake.

Geological evidence of prehistoric earthquakes also provides important clues about earthquake hazards. Earthquakes result from the sudden movement or rupture of rocks along faults in the earth's crust. The energy released as the rocks slip along the fault during an earthquake causes the ground to shake.

For earthquakes larger than about magnitude 6 ¼ to 6 ½, the fault rupture often extends to and breaks the earth's surface. To determine which faults have caused large prehistoric earthquakes, geologists look for evidence of fault rupture at the earth's surface. By studying relationships between faults and young geological deposits along the faults, the timing and magnitude of the prehistoric earthquakes that caused the surface ruptures can be estimated.

Using information from a variety of sources, the Colorado Geological Survey compiled information on nearly 100 potentially hazardous faults in Colorado that ruptured the earth's surface during the past 2 million years. These faults are shown as lines on the accompanying map.

The past 2 million years of geologic time is called the Quaternary Period, a time of recurring glacial ice ages. Quaternary-age geologic deposits are used to evaluate the activity of faults during the recent geologic past. For example, if a fault offsets or deforms a deposit, the most recent movement of the fault happened since that deposit formed. If a deposit covers a fault and is not offset or deformed by it, then the last movement of the fault pre-dates the deposit. Faults with evidence of movement during the past 130,000 years are often considered active faults. These faults are shown in red on the accompanying map. Faults that last moved between 130,000 and 2 million years ago may be considered potentially active. Locations of these faults are depicted on the map by the dark red-brown lines. Thousands of other faults exist in Colorado, but few have been studied in sufficient detail to determine their activity during the recent geologic past. Some of these faults also may be hazardous.

Earthquakes can also occur on faults that do not rupture the ground surface or on faults that are not yet recognized as being hazardous. These so called "random" earthquakes are considered in most hazard analyses to help account for faults that are not apparent at the earth's surface.

Primary earthquake hazards include strong ground shaking, which can affect large areas, and rupture of the ground surface, which happens along the fault trace. Secondary earthquake hazards such as landslides, rockfall, liquefaction, and tsunamis can have severe impacts on life, infrastructure, and property. Much of Colorado's steep terrain is prone to slope-failure hazards that could be triggered by earthquakes. Fortunately for landlocked Colorado, tsunamis only occur in oceans. However, potentially damaging large waves called seiches can form in lakes during earthquakes. The threat of large, damaging earthquakes reinforces the need for emergency preparedness and hazard mitigation in the state.

Colorado's Largest Historic Earthquakes

Date	Location	Magnitude	Intensity
1870, Dec. 4	Pueblo/Ft. Reynolds	—	VI
1871, Oct.	Lily Park, Moffat Co	—	VI
1880, Sep. 17	Aspen	—	VI
1882, Nov. 7	North-Central CO	6.6*	VII
1891, Dec.	Maybell	—	VI
1901, Nov. 15	Buena Vista	—	VI
1913, Nov. 11	Ridgeway area	—	VI
1944, Sep. 9	Montrose/Basalt	—	VI
1955, Aug. 3	Lake City	—	VI
1960, Oct. 11	Montrose/Ridgway	5.5	V
1966, Jan. 4	N. E. of Denver	5.0	V
1966, Jan. 23	CO-NM border near Dulce, NM	5.5	VII
1967, Aug. 9	N. E. of Denver	5.3	VII
1967, Nov. 27	N. E. of Denver	5.2	VI
2011, Aug. 22	Trinidad	5.3	VII

** Magnitude for this older earthquake is estimated from historic felt reports (Spence and others, 1996). Other magnitudes are body-wave magnitudes reported by Stover and others (1988), Kirkham and Rogers (2000), and US. Geological Survey on-line earthquake catalog (http://earthquake.usgs.gov/earthquakes/).*

Magnitude and Intensity

Magnitude is a measurement of the size of an earthquake or the energy released by it. Several different magnitude scales exist. In 1935, Charles Richter developed one of the earliest and most well-known ways to quantify magnitude, which is often referred to in the media as the "Richter Scale". In Richter's method the magnitude is determined from the ground movement during an earthquake as measured by a specialized instrument called a seismograph. Magnitude scales are logarithmic, therefore, the maximum seismic-wave amplitude recorded on a seismograph for a magnitude 6.0 earthquake is ten times greater than the seismic-wave amplitude of a magnitude 5.0 earthquake. Seismologists currently favor the Moment Magnitude Scale to describe the size of large earthquakes.

The amount of energy released by a magnitude 6.0 earthquake is over 30 times greater than the energy released by a magnitude 5.0 earthquake. The energy released in a magnitude 6.0 earthquake is about the same as the energy released by the atomic bombs used in World War II.

Intensity describes the observed damage and first-hand reports of shaking of an earthquake at a specific location. Intensity values are usually assigned according to the Modified Mercalli intensity scale (see below for a simplified version). An earthquake will have only one magnitude; however, intensity or shaking varies from place to place. Therefore, an earthquake can have many intensities. Intensity depends on several factors, including the magnitude of the earthquake, distance from the fault, depth of the earthquake, and the geology and soil at a particular location. Intensity values are useful for the study of old earthquakes that were not measured by seismographs. For example, the maximum reported intensities during an old earthquake can be used to estimate the location or epicenter of the earthquake. The size of the area over which an old earthquake was felt provides clues to the earthquake's magnitude.

Modified Mercalli Intensity Scale of 1931

Adapted from Sieberg's Mercalli-Cancani scale. Modified and condensed (Woodand Nuemann, 1931)

I	Not felt or only rarely felt under especially favorable circumstances.
II	Felt indoors by few, especially on upper floors. Sometimes hanging objects may swing, occasionally trees, structures, liquids, bodies of water, may sway, doors may swing.
III	Felt noticeably indoors, motion usually rapid vibration like that due to passing of light, or light-loaded trucks, or heavy trucks some distance away. Hanging objects may swing slightly. Movements may be appreciable on upper levels of tall structures.
IV	Felt indoors by many. Vibration like that due to passing of heavy or heavily loaded trucks. Sensation like heavy body striking building or falling of heavy objects inside. Rattling of dishes, windows, and doors. Hanging objects swing.
V	Felt indoors by all. Buildings tremble throughout. Broke dishes, glassware to some extent. Hanging objects, doors, swing considerably. Cracked plaster in a few places.
VI	Felt by all, many ran outdoors. Damage slight in poorly constructed buildings. Plaster cracks and falls; cracks chimneys in some instances. Broke dishes, glassware, in considerable quantity, also some windows. Fall of knick-knacks, books, pictures.
VII	Frightened all, ran outdoors. Rang large church bells. Damage negligible in buildings of good design and construction, slight in poorly built or badly designed buildings. Cracked chimneys to considerable extent, walls to some extent. Fall of plaster considerable. Shook down loosened brickwork and tiles. Broke weak chimneys. Dislodged bricks and stones.
VIII	Damage slight in brick structures built especially to withstand earthquakes. Considerable in ordinary buildings; partial collapse. Cracked, broke, solid stone walls seriously. Fall of chimneys, columns, and towers.
IX	Damage considerable in structures built especially to withstand earthquakes; great in substantial buildings, some collapse in large part. Underground pipes sometimes broken. Damage serious to reservoirs, dams, dikes, and embankments. Severe to well-built wooden structures and bridges, some destroyed. Cracked ground.
X	Damage severe or total to well-built wood-frame and masonry structures. Damage great to dams, dikes, and embankments often for long distances. Badly cracked ground. Landslides.
XI	Most building collapse, few remain standing. Bridges destroyed. Buried pipelines destroyed.
XII	Damage total.

Map Development

The map is a composite overlay of eight digital layers of information produced with the computer mapping capabilities of Geographic Information Systems. Each map feature represents digital data collected from different agencies at varying scales.

For More Information On Colorado Earthquakes

More detailed information on Colorado earthquakes, faults, and geology can be found at the Colorado Geological Survey (http://geosurvey.state.co.us) and U.S. Geological Survey (http://earthquake.usgs.gov). The Federal Emergency Management Agency (http://www.fema.gov/earthquake) and Colorado Office of Emergency Management http://www.coemergency.com/) have information on preparedness and hazard mitigation. The Colorado Geological Survey maintains a reference collection on Colorado seismicity. A listing of the reports in the reference collection can be viewed at the Colorado Geological Survey web site. An interactive earthquake and fault map is available on-line from the Colorado Geological Survey web site (http://geosurvey.state.co.us). Users can browse information on each earthquake and fault, including intensity maps and paleoseismic investigations. Site-specific engineering decisions should not be based on this publication.

Selected References

Coffman, J.L., Von Hake, C.A., and Stover, C.W., 1982, *Earthquake history of the United States*: U.S. National Oceanic and Atmospheric Administration and U.S. Geological Survey, Publication No. 41-1 (through 1980), 258 p.

Hadsell, F.A., 1968, History of earthquake activity in Colorado: in Geophysical and geological studies of the relationship between the Denver earthquakes and the Rocky Mountain Arsenal well, *Colorado School of Mines Quarterly*, v. 63, no. 1, p. 57-72.

Kirkham, R.M., and Rogers, W.P., 1981, *Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43*, 171 p.

Kirkham, R.M., and Rogers, W.P., 1985, *Colorado earthquake data and interpretation 1867-1985: Colorado Geological Survey Bulletin 46*, 111 p.

Kirkham, R.M., and Rogers, W.P., 2000, *Colorado Earthquakes, 1867 through 1996: Colorado Geological Survey Bulletin 52*, CD-Rom.

Kirkham, R.M., Rogers, W.P., Powell, L., Morgan, M.L., Matthews, V., and Pattyn, G.R., 2004, *Colorado Earthquake Map Server: Colorado Geological Survey Bulletin 52b*, http://geosurvey.state.co.us/.

Major, M.W., and Simon, R.B., 1968, A seismic study of the Denver (Derby) earthquakes: in Geophysical and geological studies of the relationship between earthquakes and the Rocky Mountain Arsenal well, *Colorado School of Mines Quarterly, v. 63*, no. 1, p.9-55.

Meremonte, M.E., Lahr, J.C., Frankel, A.D., Dewey, J.W., Crone, A.J., Overturf, D.E., Carver, D.L., and Bice, W.T., 2002, Investigation of an earthquake swarm near Trinidad, Colorado, August-October 2001: *U.S. Geological Survey Open-File Report 02-0073*.

Oaks, S.D., and Kirkham, R.M., 1986, Results of a search for felt reports for selected Colorado earthquakes: *Colorado Geological Survey Information Series #23*, 89 p.

Richter, C.E., 1958, *Elementary Seismology*: W.H. Freeman and Co., San Francisco, CA, 768 p.

Spence, W., Langer, C.J., and Choy, G.L., 1996, *Rare, large earthquakes at the Laramide deformation front-Colorado (1882) and Wyoming (1984)*: Seismological Society of America Bulletin, v. 86, no. 6, p. 1804–1819.

Stover, C.W., Reagor, B.G., and Algermissen, S.T., 1984, *Seismicity map of the State of Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-1694*, scale 1:1,000,000.

Stover, C.W., Reagor, B.G., and Algermissen, S.T., 1988, *Seismicity Map of the State of Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-2036*, scale 1:1,000,000.

Widmann, B.L., Kirkham, R.M., Morgan, M.L., and Rogers, W.P., with contributions by Crone, A.J., Personius, S.F., and Kelson, K.I., and GIS and Web design by Morgan, K.S., Pattyn, G.R., and Phillips, R.C., 2002, *Colorado Late Cenozoic fault and fold database and internet map server:* Colorado *Geological Survey Information Series 60a.*

Widmann, B.L., Kirkham, R.M., and Rogers, W.P., 1998, *Preliminary Quaternary fault and fold map and database of Colorado: Colorado Geological Survey Open-File Report 98-8*, 331 p.

Wood, H.O., and Neumann, F., 1931, *Modified Mercalli intensity scale of 1931: Seismological Society of America Bulletin, v. 21, no. 4*, p. 277-283.

Acknowledgments

The following agencies provided data for this project: Colorado Office of Emergency Management (Municipal Boundaries, County Boundaries, Cities); Colorado Department of Transportation (Highways); Colorado Geological Survey (Faults, Earthquake Epicenters), and the U.S. Geological Survey (Seismic Stations, Earthquake Epicenters, 30-meter Digital Elevation Model of Colorado). This project is a joint effort between the Colorado Geological Survey, Colorado Office of Emergency Management, and the Colorado Earthquake Hazards Mitigation Council.

ABOUT CEHMC: The Colorado Earthquake Hazard Mitigation Council is a multi-disciplinary organization that is interested in developing a better understanding of earthquake hazards in Colorado. The council's members include civil engineers, emergency managers, geologists, geophysicists, geotechnical engineers, mechanical engineers, risk managers, seismologists, and structural engineers in the private sector, academia, and state and federal government. The group has been in existence in various forms for more than three decades.

Colorado Earthquake Information

Modified from the earthquake fact sheet developed by the Earthquake Subcommittee of the Colorado Natural Hazards Mitigation Council

Nearly 100 potentially hazardous faults have been identified in Colorado. Generally, these are faults thought to have had movement within about the past 2 million years. There are other faults in the state that may have potential for producing future earthquakes. Because the occurrence of earthquakes is relatively infrequent in Colorado and the historical earthquake record is relatively short (only about 130 years), it is not possible to accurately estimate the timing or location of future dangerous earthquakes in Colorado. Nevertheless, the available seismic hazard information can provide a basis for a reasoned and prudent approach to seismic safety.

Faulting

Sudden movement on long faults is responsible for large earthquakes. By studying the geologic characteristics of faults, geoscientists can often determine when the fault last moved and estimate the magnitude of the earthquake that produced the last movement. In some cases it is possible to evaluate how frequently large earthquakes occurred on a specific fault during the recent geologic past.

Geological studies in Colorado have discovered about 100 faults that moved during the Quaternary Period (past 2 million years) and could be considered potentially active. The Sangre de Cristo fault, which lies at the base of the Sangre de Cristo Mountains along the eastern edge of the San Luis Valley, and the Sawatch fault, which runs along the eastern margin of the Sawatch Range, are two of the most prominent potentially active faults in Colorado. However, not all of Colorado's potentially active faults are in the mountains. For example, the Cheraw fault, which is in the Great Plains Physiographic Province in southeast Colorado, appears to have had multiple movements during the recent geologic past. Some potentially active faults cannot be seen at the earth's surface. The Derby fault near Commerce City lies thousands of feet below the earth's surface. It has not been recognized at ground level, and for that reason it is not shown on the accompanying map.

Several potentially active faults in Colorado are thought to be capable of causing earthquakes as large as magnitude 7¼ based on recent detailed studies. In comparison, California has hundreds of hazardous faults, one or two of which can cause earthquakes of magnitude 8 or larger. The time interval between large earthquakes on faults in Colorado is generally much longer than on faults in California.

Past and Possible Future Earthquakes

About 400 earthquake tremors of magnitude 2.5 or higher have been reported in Colorado since 1867. More earthquakes of magnitude 2.5 to 3.0 probably occurred during that time, but were not recorded because of the sparse distribution of population and limited instrumental coverage in much of the state. The largest known historical earthquake in Colorado occurred on November 7, 1882 and had an estimated magnitude of 6.6. The location of this earthquake probably was in the northern Front Range.

Although many of Colorado's earthquakes occurred in mountainous regions of the state, some have been located in the western valley and plateau region or east of the mountains. The best known Colorado earthquakes were a series of events in the 1960s that were later shown to be triggered by the injection of liquid waste into a deep borehole at the Rocky Mountain Arsenal. Twelve of the "Rocky Mountain Arsenal" earthquakes caused damage, including a magnitude 5.3 earthquake on August 9, 1967 that resulted in more than a million dollars in damage in Denver and the northern suburbs. This series of earthquakes continued for about ten years and was followed by about six years of quiescence. Earthquake activity resumed in the northeast Denver area in 1978, including a magnitude 4.3 event on April 2, 1981.

Colorado's earthquake hazard is similar to other states in the intermountain west region. It is less than in states like California, Nevada, Washington, and Oregon, but greater than many states in the central and eastern United States. It is prudent to expect future earthquakes as large as magnitude 6.6, the largest historical event in Colorado.

Conclusions and Recommendations

Based on Colorado's historical earthquake record and geologic studies, an event as large as magnitude 6 ½ to 7¼ could occur somewhere in the state. Scientists are unable to accurately predict when the next major earthquake will take place in Colorado; only that one will occur. The major factors that prevent the prediction of the timing and location of future damaging earthquakes are the limited knowledge of potentially active faults and short historical record of earthquakes. Given Colorado's continuing economic growth and the accompanying expansion of population and infrastructure, it is prudent to continue the study and analysis of earthquake hazards. Existing knowledge should be used to incorporate appropriate levels of seismic safety into building codes and practices. Seismic safety of critical facilities and vulnerable structures is especially important. Emergency response and recovery planning should consider earthquake hazards and risk. Concurrently, we should expand earthquake monitoring, geological and geophysical research, and mitigation planning and activities.

What To Do Before, During, and After an Earthquake

The following information is from the Federal Emergency Management Agency's web site at http://www.fema.gov/earthquake/index.shtm

Earthquakes strike suddenly, violently and without warning. Identifying potential hazards ahead of time and advance planning can reduce the dangers of serious injury or loss of life from an earthquake. Repairing deep plaster cracks in ceilings and foundations, anchoring overhead lighting fixtures to the ceiling, and following local seismic building standards, will help reduce the impact of earthquakes.

Six Ways to Plan Ahead

1. Check for Hazards in the Home
- Fasten shelves securely to walls.
- Place large or heavy objects on lower shelves.
- Store breakable items such as bottled foods, glass, and china in low, closed cabinets with latches.
- Hang heavy items such as pictures and mirrors away from beds, couches, and anywhere people sit.
- Brace overhead light fixtures.
- Repair defective electrical wiring and leaky gas connections. These are potential fire risks.
- Secure a water heater by strapping it to the wall studs and bolting it to the floor.
- Repair any deep cracks in ceilings or foundations. Get expert advice if there are signs of structural defects.
- Store weed killers, pesticides, and flammable products securely in closed cabinets with latches and on bottom shelves.

2. Identify Safe Places Indoors and Outdoors
- Under sturdy furniture such as a heavy desk or table.
- Against an inside wall.
- Away from where glass could shatter around windows, mirrors, pictures, or where heavy bookcases or other heavy furniture could fall over.
- In the open, away from buildings, trees, telephone and electrical lines, overpasses, or elevated expressways.

3. Educate Yourself and Family Members
- Contact your local emergency management office or American Red Cross chapter for more information on earthquakes. Also read the "How-To Series" for information on how to protect your property from earthquakes.
- Teach children how and when to call 9-1-1, police, or fire department and which radio station to tune to for emergency information.
- Teach all family members how and when to turn off gas, electricity, and water.

4. Have Disaster Supplies on Hand
- Flashlight and extra batteries.
- Portable battery-operated radio and extra batteries.
- First aid kit and manual.
- Emergency food and water.
- Nonelectric can opener.
- Essential medicines.
- Cash and credit cards.
- Sturdy shoes.

5. Develop an Emergency Communications Plan
- In case family members are separated from one another during an earthquake (a real possibility during the day when adults are at work and children are at school), develop a plan for reuniting after the disaster.
- Ask an out-of-state relative or friend to serve as the "family contact." After a disaster, it's often easier to call long distance. Make sure everyone in the family knows the name, address, and phone number of the contact person.

6. Help Your Community Get Ready
- Publish a special section in your local newspaper with emergency information on earthquakes. Localize the information by printing the phone numbers of local emergency services offices, the American Red Cross, and hospitals.
- Conduct a week-long series on locating hazards in the home.
- Work with local emergency services and American Red Cross officials to prepare special reports for people with mobility impairments on what to do during an earthquake.
- Provide tips on conducting earthquake drills in the home.
- Interview representatives of the gas, electric, and water companies about shutting off utilities.
- Work together in your community to apply your knowledge to building codes, retrofitting programs, hazard hunts, and neighborhood and family emergency plans.

What To Do During an Earthquake

Stay as safe as possible during an earthquake. Be aware that some earthquakes are actually foreshocks and a larger earthquake might occur. Minimize your movements to a few steps to a nearby safe place and stay indoors until the shaking has stopped and you are sure exiting is safe.

If indoors
- DROP to the ground; take COVER by getting under a sturdy table or other piece of furniture; and HOLD ON until the shaking stops. If there isn't a table or desk near you, cover your face and head with your arms and crouch in an inside corner of the building.
- Stay away from glass, windows, outside doors and walls, and anything that could fall, such as lighting fixtures or furniture.
- Stay in bed if you are there when the earthquake strikes. Hold on and protect your head with a pillow, unless you are under a heavy light fixture that could fall. In that case, move to the nearest safe place.
- Use a doorway for shelter only if it is in close proximity to you and if you know it is a strongly supported, loadbearing doorway.
- Stay inside until shaking stops and it is safe to go outside. Research has shown that most injuries occur when people inside buildings attempt to move to a different location inside the building or try to leave.
- Be aware that the electricity may go out or the sprinkler systems or fire alarms may turn on.
- DO NOT use the elevators.

If outdoors
- Stay there.
- Move away from buildings, streetlights, and utility wires.
- Once in the open, stay there until the shaking stops. The greatest danger exists directly outside buildings, at exits, and alongside exterior walls. Many of the 120 fatalities from the 1933 Long Beach, California earthquake occurred when people ran outside of buildings only to be killed by falling debris from collapsing walls. Ground movement during an earthquake is seldom the direct cause of death or injury. Most earthquake-related casualties result from collapsing walls, flying glass, and falling objects.

If in a moving vehicle
- Stop as quickly as safety permits and stay in the vehicle. Avoid stopping near or under buildings, trees, overpasses, and utility wires.
- Proceed cautiously once the earthquake has stopped. Avoid roads, bridges, or ramps that might have been damaged by the earthquake

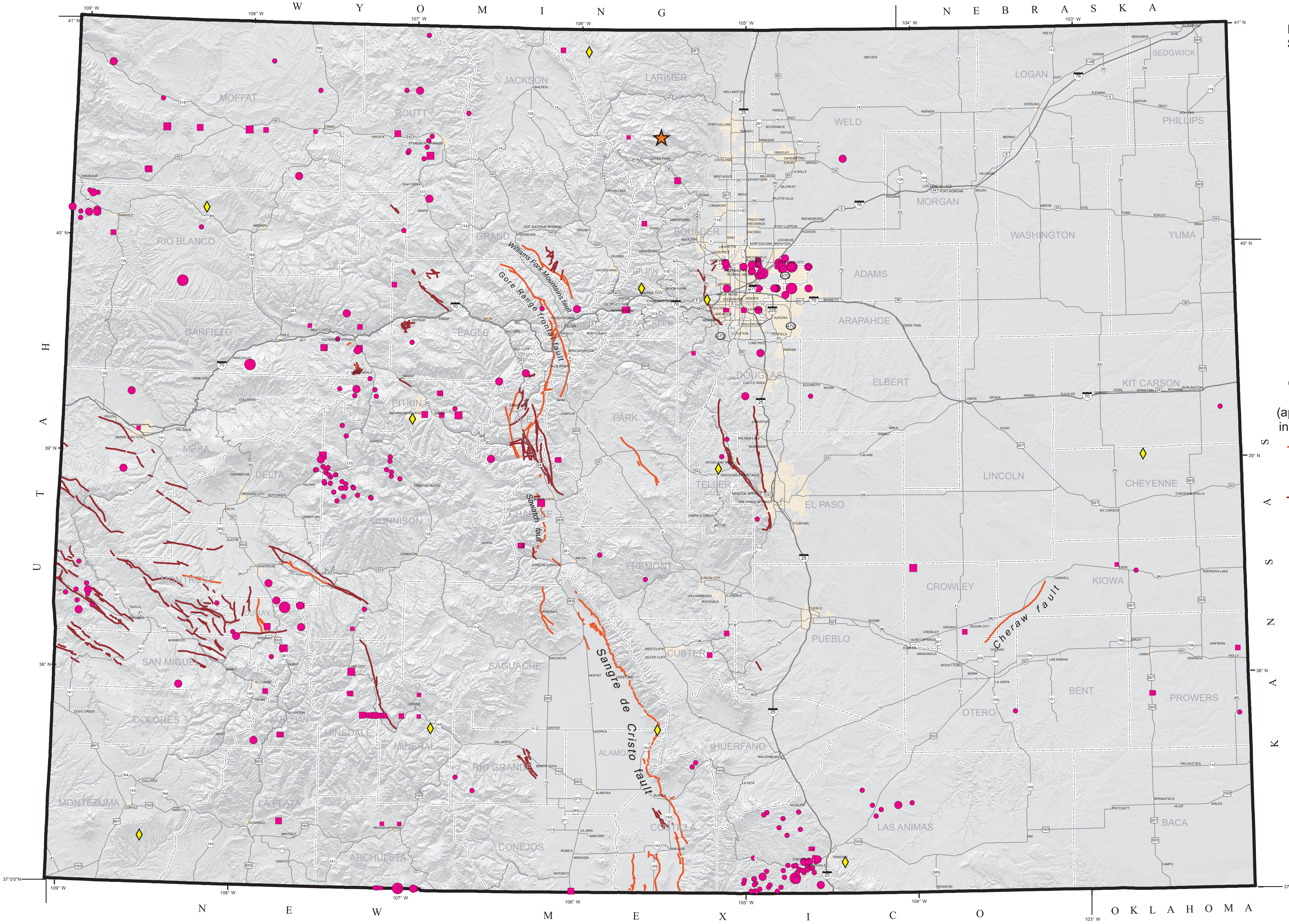
If trapped under debris
- Do not light a match.
- Do not move about or kick up dust.
- Cover your mouth with a handkerchief or clothing.
- Tap on a pipe or wall so rescuers can locate you. Use a whistle if one is available. Shout only as a last resort. Shouting can cause you to inhale dangerous amounts of dust.

What To Do After an Earthquake

- Expect aftershocks. These secondary shockwaves are usually less violent than the main quake but can be strong enough to do additional damage to weakened structures and can occur in the first hours, days, weeks, or even months after the quake.
- Listen to a battery-operated radio or television. Listen for the latest emergency information.
- Use the telephone only for emergency calls.
- Open cabinets cautiously. Beware of objects that can fall off shelves.
- Stay away from damaged areas. Stay away unless your assistance has been specifically requested by police, fire, or relief organizations. Return home only when authorities say it is safe.
- Be aware of possible tsunamis if you live in coastal areas. These are also known as seismic sea waves (mistakenly called "tidal waves"). When local authorities issue a tsunami warning, assume that a series of dangerous waves is on the way. Stay away from the beach.
- Help injured or trapped persons. Remember to help your neighbors who may require special assistance such as infants, the elderly, and people with disabilities. Give first aid where appropriate. Do not move seriously injured persons unless they are in immediate danger of further injury. Call for help.
- Clean up spilled medicines, bleaches, gasoline or other flammable liquids immediately. Leave the area if you smell gas or fumes from other chemicals.
- Inspect the entire length of chimneys for damage. Unnoticed damage could lead to a fire.
- Inspect utilities.
- Check for gas leaks. If you smell gas or hear blowing or hissing noise, open a window and quickly leave the building. Turn off the gas at the outside main valve if you can and call the gas company from a neighbor's home. If you turn off the gas for any reason, it must be turned back on by a professional.
- Look for electrical system damage. If you see sparks or broken or frayed wires, or if you smell hot insulation, turn off the electricity at the main fuse box or circuit breaker. If you have to step in water to get to the fuse box or circuit breaker, call an electrician first for advice.
- Check for sewage and water lines damage. If you suspect sewage lines are damaged, avoid using the toilets and call a plumber. If water pipes are damaged, contact the water company and avoid using water from the tap. You can obtain safe water by melting ice cubes.

COLORADO'S EARTHQUAKE and FAULT MAP

Showing Locations of Historical Earthquakes and Known or Suspected Geologically Young Faults



EARTHQUAKE EPICENTERS

Instrumentally located epicenters (~1962 to 2007)
Size of dot indicates magnitude.

- 5-5.5
- 4-4.9
- 3-3.9

Approximate location of pre-instrumental earthquake epicenters (~1867 to 1961). Square size indicates the maximum Modified Mercalli intensity for the earthquake (see back of map for intensity scale).

- VII
- VI
- V
- IV
- I-III

1882 Earthquake; magnitude estimated at 6.6 +/- 0.6 (Spence and others, 1996)

QUATERNARY FAULTS

Geologically young faults that displace sediments or rocks deposited during the Quaternary Period (approximately past 2 million years). Named faults are included in the USGS National Seismic Hazard Maps.

- Known or suspected fault displacement of late Quaternary deposits (approximately past 130,000 years)
- Known or suspected fault displacement of middle to early Quaternary deposits (approximately past 130,000 to 2 million years old)

Permanent Seismic Stations - Includes eleven seismographs as part of the Advanced National Seismic System and USArray.

Cities and Towns

DATA SOURCES
Earthquake epicenters:
U.S. Geological Survey; Colorado Geological Survey; Kirkham and others, 2004; Kirkham and Rogers, 2000
Faults: *Colorado Geological Survey; Widmann and others, 1998*
Seismic Stations:
U.S. Geological Survey

This map does not meet U.S. National Map Accuracy Standards and is intended for general reference only.

Scale 1:1,150,000

0 10 20 30 40 50
Miles

0 20 40 60 80
Kilometers

Map Compilation by Matthew L. Morgan, Colorado Geological Survey, 2006-2013