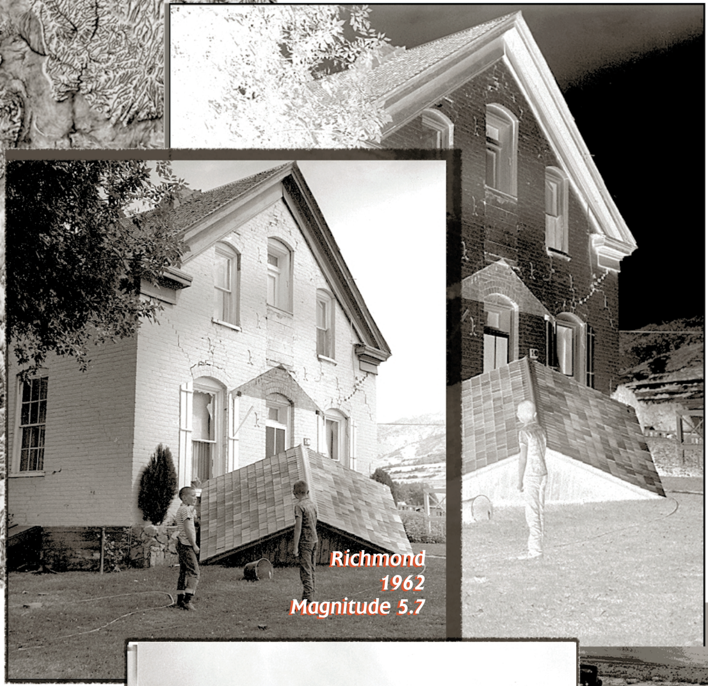
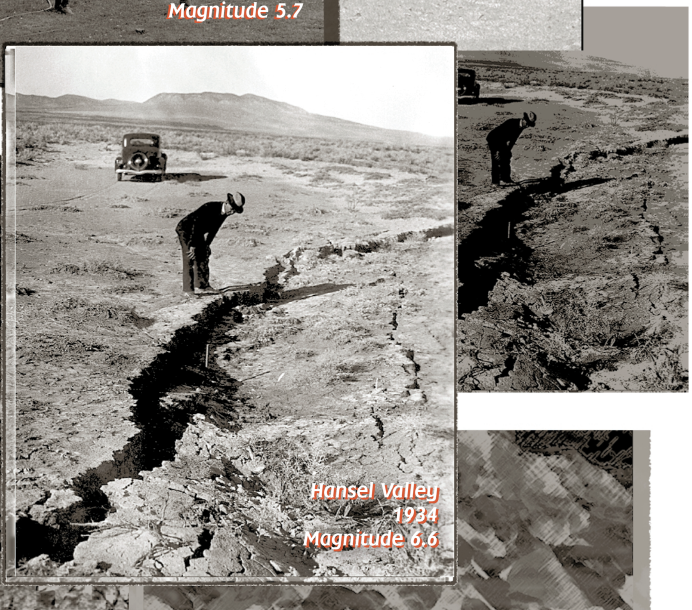
Earthquakes & Utah



Richmond
1962
Magnitude 5.7

Richfield
1901
Estimated
Magnitude 6.5

"The roads up [several] canyons have been rendered almost impassable by the rock rolled down from the cliffs, some . . . very large, and from 15 to 20 tons in weight."



Hansel Valley
1934
Magnitude 6.6

St. George
1992
Magnitude 5.8

This pamphlet is an introduction to Utah's earthquakes and answers the commonly asked questions of where, why, and how often earthquakes occur in Utah; how big they are and how they are measured; and what may happen during an earthquake.

HOW OFTEN DO EARTHQUAKES OCCUR?

Hundreds of small earthquakes are recorded each year in Utah. Moderate, potentially damaging earthquakes (magnitude 5.5 to 6.5) occur on average every 10 to 50 years. The largest earthquakes expected in Utah are in the magnitude 7.0-7.5 range, which take place about every 150 years.

Average number of earthquakes occurring in Utah

Magnitude	Frequency
≥ 3.0	6 per year
≥ 4.0	1 per year
≥ 5.0	1 every 4 yrs
≥ 5.5	1 every 10 yrs
≥ 6.0	1 every 20 yrs
≥ 6.5	1 every 50 yrs
≥ 7.0	1 every 150 yrs

≥ = greater than or equal to

(Source: University of Utah Seismograph Stations)

WHAT ARE SOME OF THE LARGEST EARTHQUAKES IN UTAH'S HISTORY?

Since pioneer settlement, the two largest earthquakes in Utah took place in Hansel Valley in 1934 and near Richfield in 1901 (magnitude 6.6 and estimated 6.5, respectively). The two most damaging earthquakes were in Richmond (Cache Valley) in 1962 and St. George in 1992 (magnitude 5.7 and 5.8, respectively). These four events illustrate that earthquakes of larger magnitude do not necessarily cause the most damage. The amount of damage also depends on the number and types of structures in the area, as well as local geologic conditions (soil or rock type, ground-water depth, and topography).

COVER PHOTOS

Hansel Valley: Utah's largest historical earthquake caused surface fault rupture (see cover photo and page 5), liquefaction (see page 4), the appearance of new springs, and waves in Great Salt Lake that overtopped both the pier at Saltair and the railroad trestle at Lucin. Eighty miles away in Salt Lake City, ground shaking was strong enough to cause two adjacent tall buildings to sway and make contact. *(Photo courtesy of Special Collections, University of Utah Libraries).*

Richfield: Many buildings in Beaver, Elsinore, and Central were damaged, and liquefaction as well as extensive rock slides and rock falls were reported from Utah's second-largest earthquake in historical time. *(Quote from Deseret News, 12/6/01).*

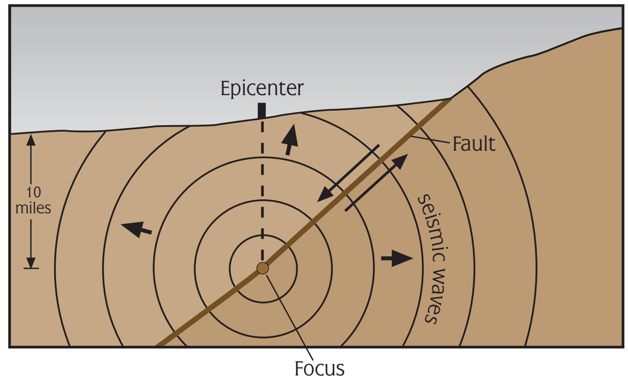
Richmond: Damage costs of $1 million in 1962 dollars make this the most costly earthquake in Utah. Three-fourths of the houses in Richmond were damaged. Mudslides and rock falls closed roads and blocked canals. *(Photo courtesy of Ogden Standard Examiner).*

St. George: The second most damaging earthquake in Utah cost about $1 million in 1992 dollars, mostly from a large landslide 28 miles away in Springdale that destroyed three houses. Other consequences were building and water-system damage in Hurricane and St. George, and numerous rock falls. *(Photo of Springdale landslide).*

Credits: Text by Sandra N. Eldredge. Design and graphics by Vicky Clarke. Maps by Jim Parker. Special thanks to T. Leslie Youd, Brigham Young University for photos; and to Sue Nava and Deedee O'Brien, University of Utah Seismograph Stations, and Gary Christenson, Utah Geological Survey, for contributions and reviews.

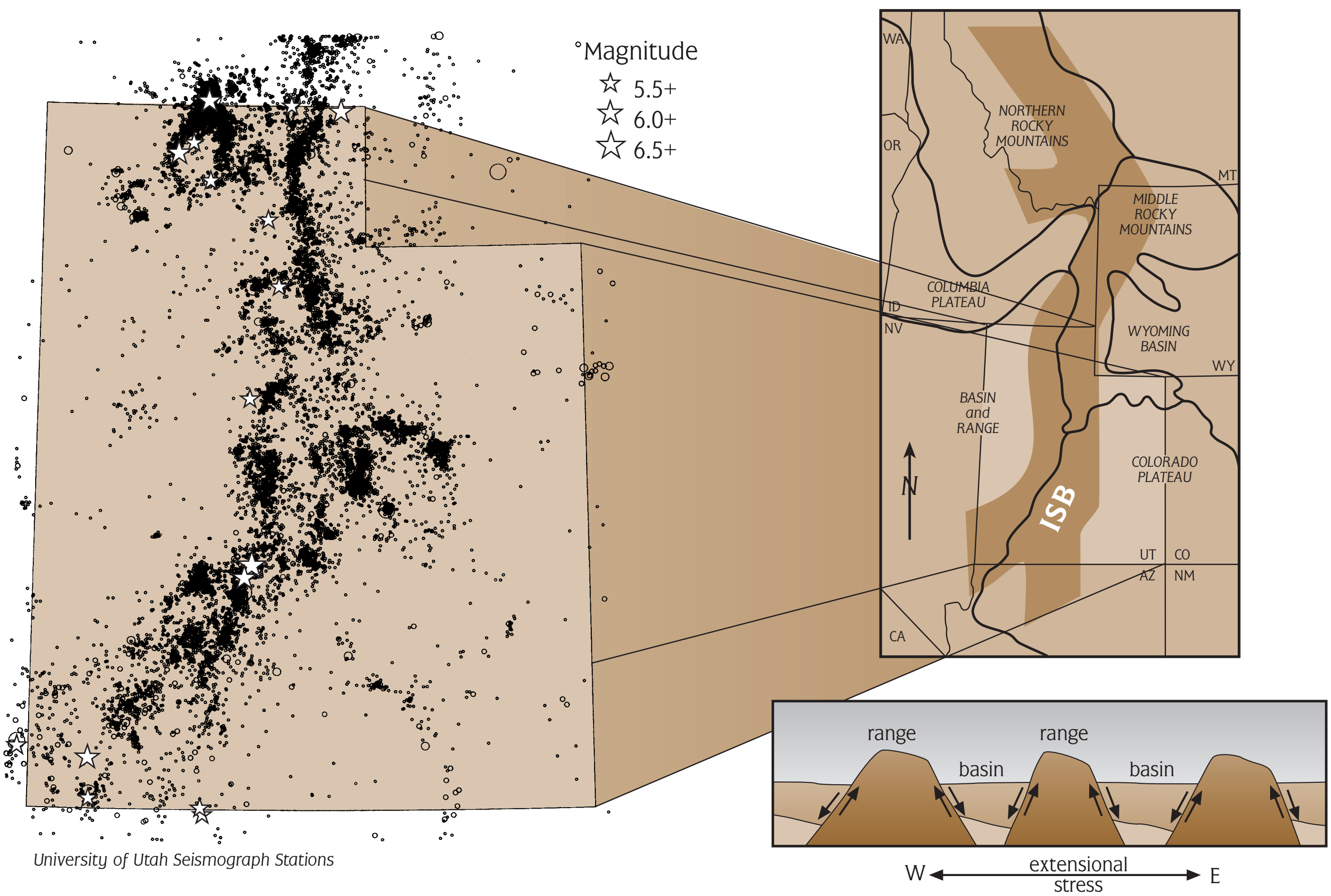
WHAT CAUSES EARTHQUAKES?

Earthquakes happen when stresses within the earth cause portions of the earth's crust to slip (rupture) along a fault. The focus is the site of initial slip on the fault and the epicenter is the point on the surface directly above the focus. The movement creates seismic waves that are transmitted outward and generate ground shaking.



WHERE DO EARTHQUAKES OCCUR?

Earthquakes occur virtually everywhere in Utah, but most, as well as all of the larger earthquakes, strike in the Intermountain seismic belt (ISB). The ISB is a zone of heightened earthquake activity extending from Montana south to northern Arizona. In Utah, the ISB coincides with the boundary between the Basin and Range physiographic province to the west and the Middle Rocky Mountains and the Colorado Plateau provinces to the east. The Basin and Range is slowly being stretched in an east-west direction between Utah's Wasatch Range and California's Sierra Nevada Range. Extension causes blocks of the earth's crust to move either up or down along faults, resulting in a mountain range - basin - mountain range topography sequence. Utah's most active stretching, and resulting stress, is along the eastern edge of the Basin and Range, where 16 earthquakes of magnitude 5.5 or greater (shown as starbursts) occurred between 1850 and 1995.



University of Utah Seismograph Stations

HOW ARE EARTHQUAKES MEASURED? *(Magnitude and Intensity)*

Magnitude is an instrumental measure of an earthquake's size based on the recording of earthquake waves made on a seismograph. Magnitudes range between less than 0 to the 9 range (although there is no upper limit to the scale, there are limits to how much strain can be stored in rocks). Typically, an earthquake needs to be at least magnitude 3.0 for people to feel it, and magnitude 5.0 for much damage to occur. The size of earthquakes in Utah is usually reported using the Richter magnitude scale, although other scales are used worldwide.

For each unit increase in an earthquake's magnitude, the energy released is roughly 30+ times greater. Thus, it would take at least 30 earthquakes of magnitude 6.0 to equal the same energy released from a single earthquake of magnitude 7.0.

Intensity, as expressed by the Modified Mercalli Intensity (MMI) scale, is based on people's observations of earthquake effects on humans and structures at a specific location. Intensity reflects local geologic conditions as well as magnitude. The Mercalli scale ranges from I to XII.

Approximately the same amount of energy is released from:

Number of earthquakes	Richter Magnitude
1	7.0
30+	6.0
900+	5.0

Relationships between Richter Magnitude, Modified Mercalli Intensity, and effects.

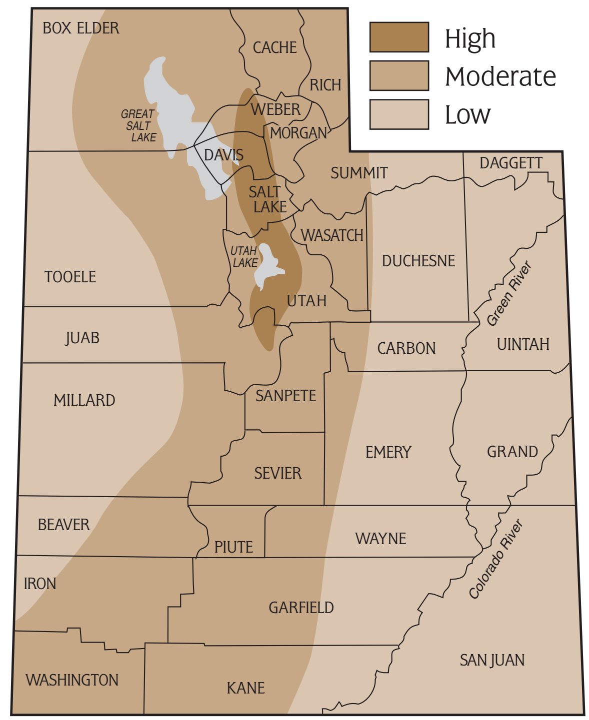
Modified Mercalli Intensity	*Richter Magnitude*	*Effects Noticed*	*Geologic Effects*
I-II	1-3	Felt by a very few people indoors, especially on upper floors.	
III	3-4	Felt by many people indoors. Similar to passing of light truck.	
IV	3-4	Felt by many indoors and a few outdoors.	Rock falls possible near epicenter.
V	4-5	Felt by almost everybody indoors and out doors. Small objects move; unstable objects overturned.	Liquefaction and landslides possible near epicenter. Rock falls likely.
VI	5	Felt by all: walking unsteady. Heavy furniture moves.	Same as V.
VII	5-6	Difficult to stand. Some chimneys broken. Some structures and underground pipes broken in liquefied areas.	Seiches (waves) in water bodies. Liquefaction and landslides likely.
VIII	6-7	Hard to steer car. Partially collapsed buildings. Damage moderate to major depending on construction.	Spring or well water may change flow rate. Surface fault rupture possible.
IX	7	Extensive loss of life possible. Major damage. Some buildings destroyed (total collapse).	Same as VIII.
X	7-8	Some well-built wooden structures destroyed. Most masonry structures destroyed.	Surface fault rupture likely. Landslides, some large, and rock falls are numerous and widespread.
XI	8-9	Few, if any (masonry) structures remain standing.	Same as X.
XII	8-9	Damage nearly total. Objects thrown into the air.	Same as XI.

WHAT AND WHERE ARE THE EARTHQUAKE HAZARDS?

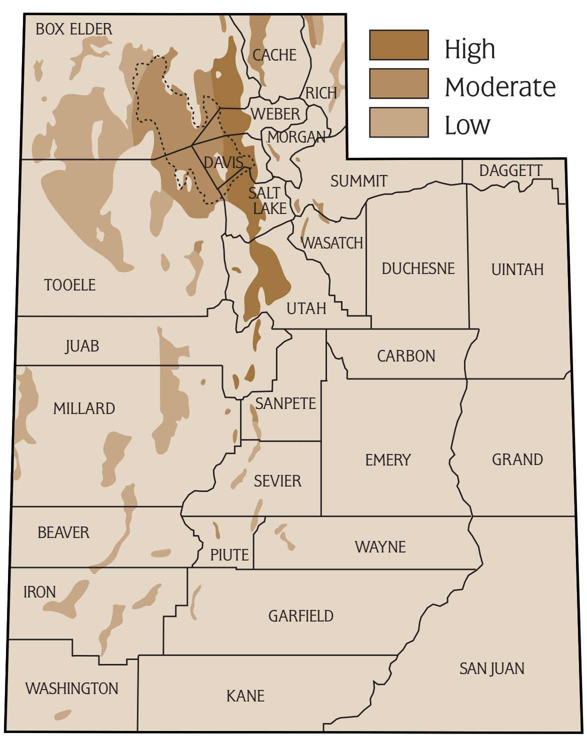
In addition to ground shaking, earthquakes may induce liquefaction, slope failures, surface fault rupture, and various types of flooding. The distribution and severity of the hazards vary across Utah and depend on variables including local geologic conditions such as topography, soil/rock type, and depth to ground water.

Ground shaking, caused by the vibrations of passing seismic waves, is the most widespread earthquake hazard. The intensity of ground shaking at a given site depends on the earthquake's location and magnitude, as well as local geologic conditions. Valleys containing deep sediments may experience amplified ground shaking.

Liquefaction can occur when water-saturated sandy soils are subjected to ground shaking from an earthquake of at least magnitude 5.0. The soils "liquefy," or act like a viscous fluid. Effects include the loss of bearing strength, so that buildings may settle or tip over; and soils may move on very gentle slopes.

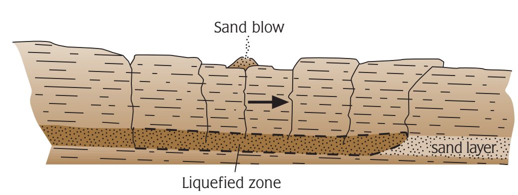


Relative likelihood of strong ground shaking



The likelihood of damaging liquefaction is greatest within the valleys of the ISB where the ground water is shallow, sandy soils are present, and moderate to large earthquakes are most common.

Barn pulled apart one foot at its base by a lateral spread. (Photo courtesy of T. Leslie Youd).



Lateral Spread

Lateral spreading, a consequence of liquefaction, can be triggered on very gentle slopes. As the subsurface layer liquefies and moves downslope, the surface layer also moves and cracks develop.

Slope failures, commonly in the form of landslides and rock falls, present a great risk to many Utahns. These failures could happen within several miles of the epicenter of a magnitude 4.0 earthquake. The distribution would increase with larger earthquakes - up to 175 miles away from the epicenter of a magnitude 7.5 event.

Home damaged in the Springdale landslide that was caused by the 1992 St. George earthquake.

Surface fault rupture occurs when movement along a fault is great enough to reach and rupture the ground surface (requires about magnitude 6.5 or greater). The surface may rupture fractions of inches to 20 feet in height, and several miles to about 40 miles in length. The faults most likely to be the source of future surface-rupturing earthquakes (most are within the ISB) are shown on the back cover map. The map's orange faults (the central portion of the Wasatch “WF”, the Bear River "BR", East Bear Lake “BL”, West Valley “WV” faults) are considered to have the greatest hazard for surface rupture based on activity in the past 10,000 years. The map's green faults are considered likely to rupture the ground surface and include the south end of the Wasatch (WF), East Cache (EC), Hansel Valley (HV), Oquirrh (OF), East Great Salt Lake (GSL), Utah Lake (UL), Hurricane (HF), Paragonah (PF), Sevier (SV), Strawberry (ST), Joes Valley (JV), and Gunnison (GF) faults. In this category, a grouping occurs southwest of Moab in the Needles area. The faults near Moab and in the Needles area are related to underground salt movement and probably not capable of producing large earthquakes. The map's narrow black faults are considered least likely to rupture the ground surface.

Ground cracking, tilting, and minor faulting usually accompany surface fault rupture. This zone of deformation occurs in the immediate vicinity of the surface fault, mostly on the downthrown (valley) side of the main fault trace. The deformation can extend hundreds of feet wide.

Regional tectonic subsidence, or the downdropping and tilting of the valley floor, may be another consequence of surface faulting. The greatest amount of subsidence will be where the fault breaks the ground surface, gradually diminishing out into the valley. Tectonic subsidence resulting from a Wasatch fault earthquake could cause flooding along the shores of Utah or Great Salt Lakes.

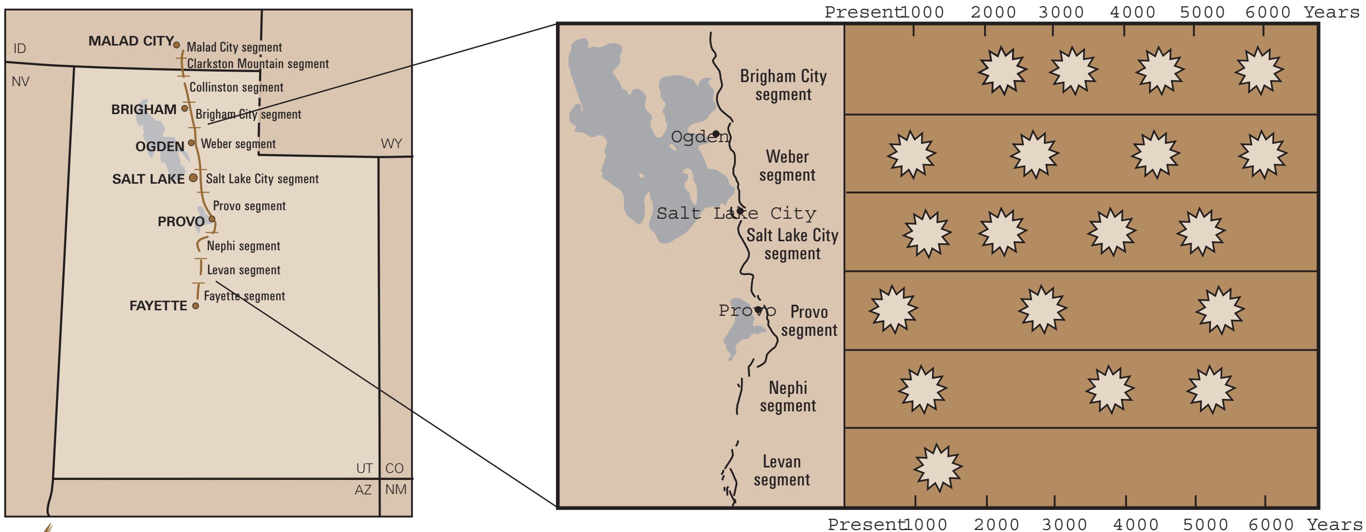
zone of deformation

Flooding is commonly a secondary effect of other earthquake hazards such as surface faulting, tectonic subsidence, liquefaction, and ground shaking. Some of the causes are dam failure, stream diversion, seiches (earthquake-induced waves in lakes), the ground dropped below the level of the water table, and water-line or canal breaks.

Surface fault rupture from the 1954, magnitude 6.8 Dixie Valley, Nevada earthquake. (photo courtesy of K.V. Steinbrugge)

WHY IS THE WASATCH FAULT OF SERIOUS CONCERN?

Utah's Wasatch fault presents the greatest earthquake hazard to the state's population because of its length and proximity to the majority of residents. The fault is approximately 240 miles long, extending from Malad City, Idaho to Fayette, Utah. Divided into 10 segments, the fault is likely to rupture only one segment at any given time.



HOW OFTEN DO LARGE EARTHQUAKES OCCUR ON THE WASATCH FAULT?

Over the past 6,000 years, at least 19 earthquakes (represented by starbursts in the figure above) large enough to rupture the ground surface have occurred on the Wasatch fault. These earthquakes took place on the fault's five central segments (Brigham City to Nephi), which are the most active segments, and one distal segment (Levan). Approximately every 350 years a large earthquake happens somewhere on the fault. For each individual segment, though, the interval is longer - from about 1,200 to 2,600 years on the central segments, and about 10,000 years or more on the distal segments. These intervals are approximations only.

HOW CAN WE BE PREPARED?

Earthquakes cannot be predicted and an economically devastating, destructive earthquake could happen today, next week, or hundreds of years from now. Therefore, earthquake preparedness is vital. Check with the Utah Division of Comprehensive Emergency Management (address below) and your local American Red Cross office for preparedness information. Also, some of the publications listed below include such information.

For additional Utah-specific earthquake information, see the following publications:

From the Utah Geological Survey
(1594 W. North Temple, Salt Lake City, UT 84116 801-537-3300)

Earthquake hazards & safety in Utah, 1990.

Earthquake fault maps of portions of Davis County, Salt Lake County, Utah County, and Weber County, 1990, 1991.

Earthquake ground shaking in Utah, 1994.

Homebuyers' guide to earthquake hazards in Utah, 1996.

Liquefaction-potential maps for parts of Davis County, Salt Lake County, Utah County, and Weber County, 1994.

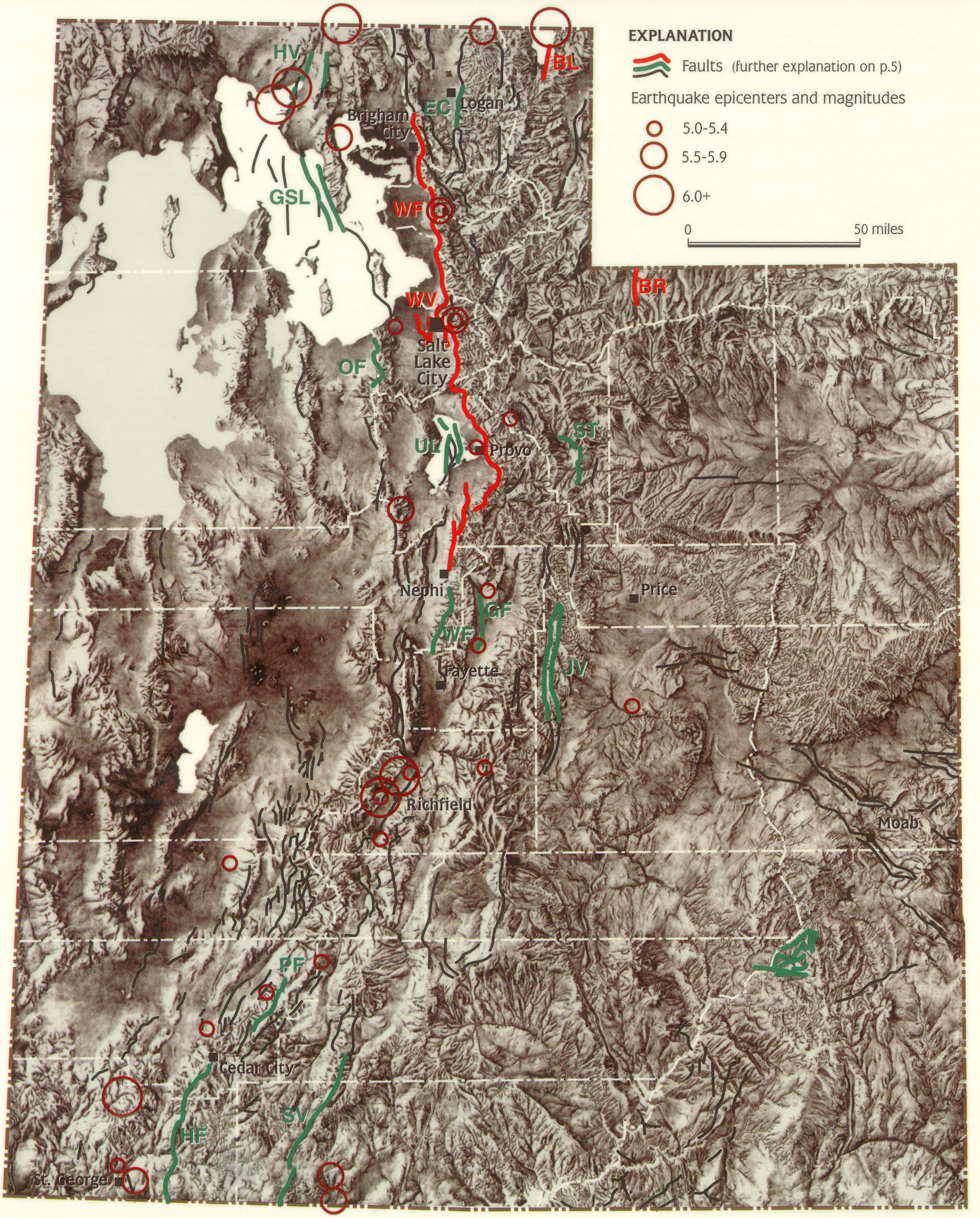
The Wasatch fault, 1996.

In addition, numerous technical publications are available.

From the Utah Division of Comprehensive Emergency Management
(1110 State Office Bldg., Salt Lake City, UT 84114 801-538-3400)

Earthquakes - What you should know when living in Utah.

Faults and ≥ 5.0 Magnitude Earthquakes



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