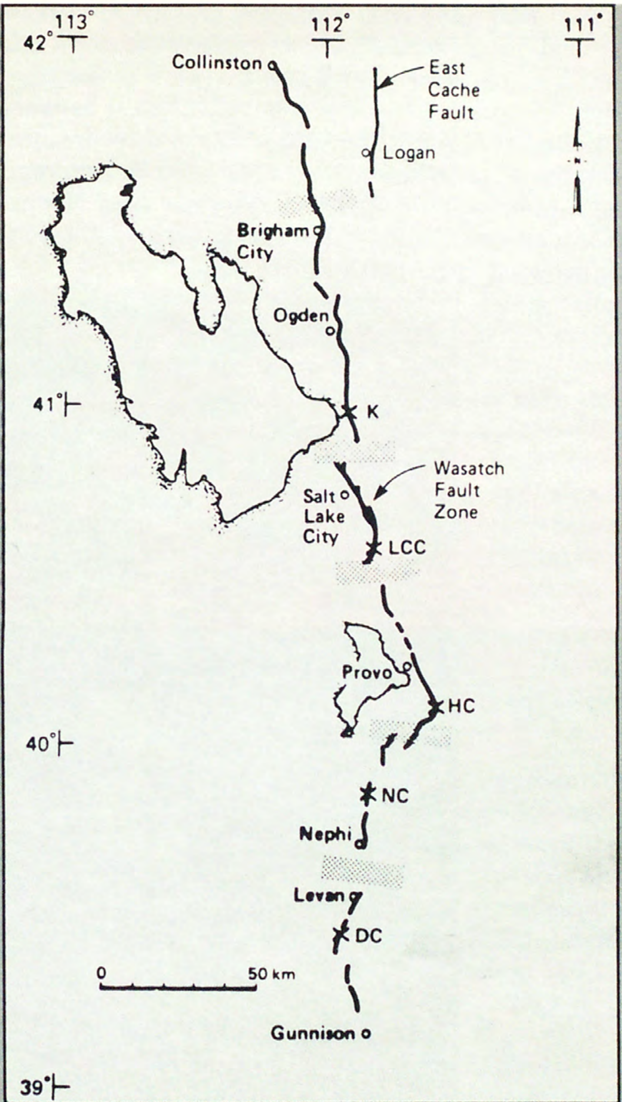
Earthquake Potential of the Wasatch Fault in Utah

The majority of Utah's population lives along the Wasatch fault, an active intraplate normal fault that extends for approximately 230 miles along the western front of the Wasatch Range. Investigations of earthquake recurrence on the Wasatch fault have revealed that segments of the fault have been the source of repeated large earthquakes, probably of magnitude 6-3/4 to 7-1/2.

Detailed geomorphic studies and trench excavations have uncovered critical information on the slip rate, recurrence intervals, displacement, and fault segmentation of the Wasatch fault. Topographic profiles of displaced geomorphic features suggest that the slip rate on the Wasatch fault between Nephi and Brigham City has averaged about 0.04 inches/year—about one to two orders of magnitude greater than slip rates for faults in other parts of the Basin and Range Province of the U.S. Late Pleistocene-Holocene rates of slip on the Wasatch fault zone locally range from essentially zero along the segment of the fault north of Brigham City to 0.05 inches/year along the Nephi segment.

Trench excavations clearly show that displacements have been consistently large, and that the displacements at the same locations along the fault have been essentially the same during successive events. The measured values range from 5.3 to 8.6 feet, with an average displacement per event of about 6.6 feet. Recurrence intervals vary along the length of the fault zone. Average intervals are shortest along the four central segments of the zone between Brigham City and Nephi, where they range from 1,700 to 3,000 years. In contrast, the ends are less active. A minimum interval of 5,000 years occurred along the southern segment of the zone prior to its most recent event, and the



The Wasatch fault is composed of six major segments: (north to south) Collinston, Ogden, Salt Lake City, Provo, Nephi, and Levan. The Collinston segment has had no identifiable surface faulting during the past 13,500 years. The Ogden segment has experienced multiple fault displacements, including two within the past approximate 1,580 years and with the most recent of these occurring within the past 500 years. The Salt Lake City and Provo segments have each had repeated Holocene offsets; the timing of the most recent event along the Salt Lake City segment is not known, and the youngest event on the Provo segments appears to have occurred more than 1,000 years ago. Along the Nephi segment one offset has occurred within the past 1,100 years and possibly as recently as 300 years ago; two earlier events occurred on this segment between about 4,580 and 3,640 years ago. The Levan segment has experienced only one event during the past 7,300 years and this event occurred less than about 1,750 years ago.

northern segment does not appear to have had a recognizable scarp-forming event during the past 13,500 years. Where radiocarbon dates constraining the actual interval between events, it is evident that the actual recurrence is not uniform and may vary from the average by a least a factor of two. At a site near Nephi, for example, there have been three surface faulting earthquakes during the past approximate 4,580 years; two of these occurred between about 4,580 and 3,640 years ago, and the most recent event is estimated to have occurred within the past 300 to 500 years. At this location, the interval between successive events was not uniform and varied from somewhat less than 1,000 years between the oldest and middle events to longer than 3,000 years between the middle and most recent events. This non-uniformity of earthquake recurrence is typical of faults in intraplate environments.

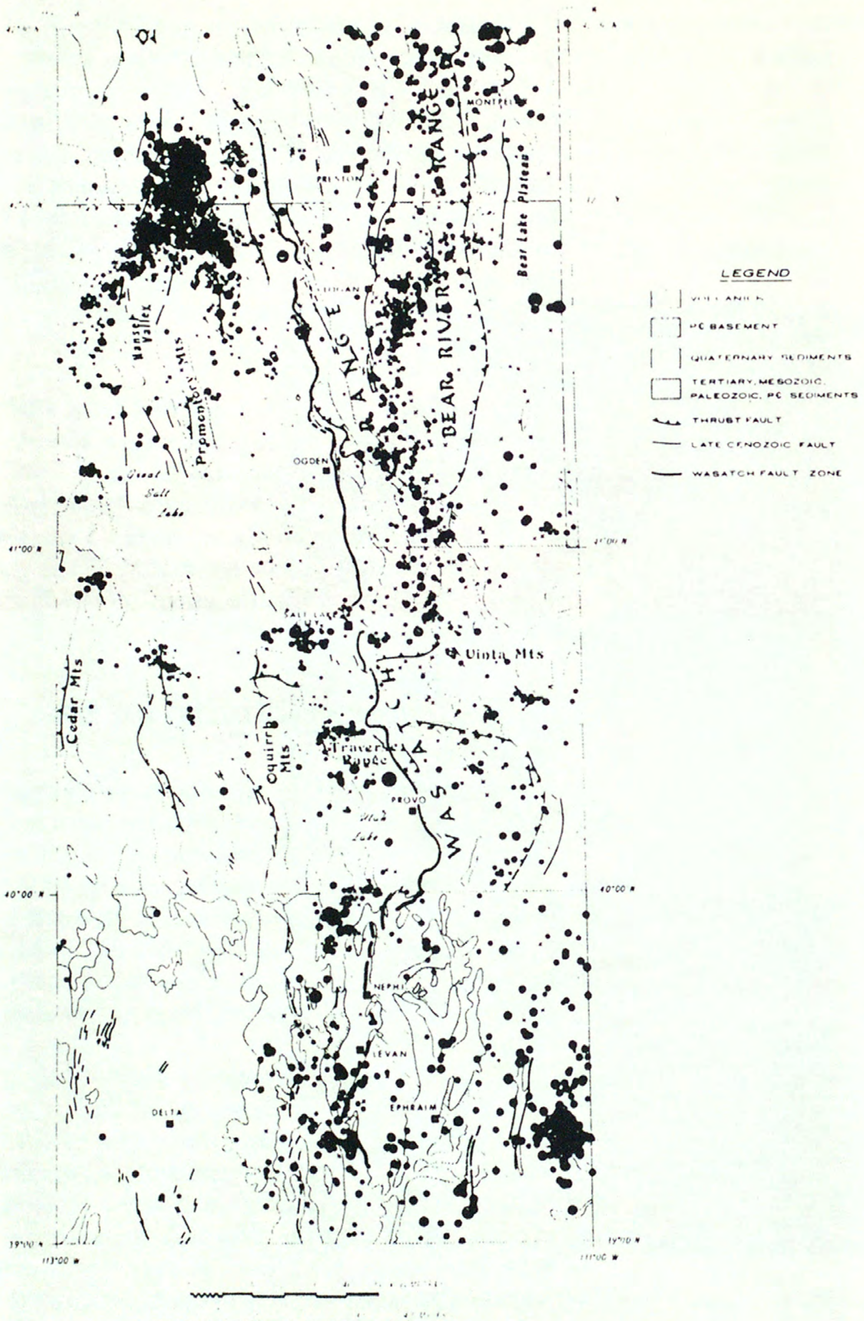
Prehistoric movement on the Wasatch fault has offset glacial moraines and lake and stream deposits at the mouth of Little Cottonwood Canyon, southeast of Salt Lake City, Utah. Geologic studies of the fault zone suggest that the average recurrence interval for large earthquakes in the fault zone is about 400 years. The Wasatch fault has not ruptured in any earthquake since Mormon pioneers arrived in 1847.

The average recurrence interval for a surface faulting earthquake along the entire Wasatch fault zone has been calculated to range from about 400 to 666 years, with a preferred value of 444 years. The estimate is based on the number of events observed or estimated in the geological record along each segment of the fault over the past 8,000 years.

Earthquake Activity on the Wasatch Fault

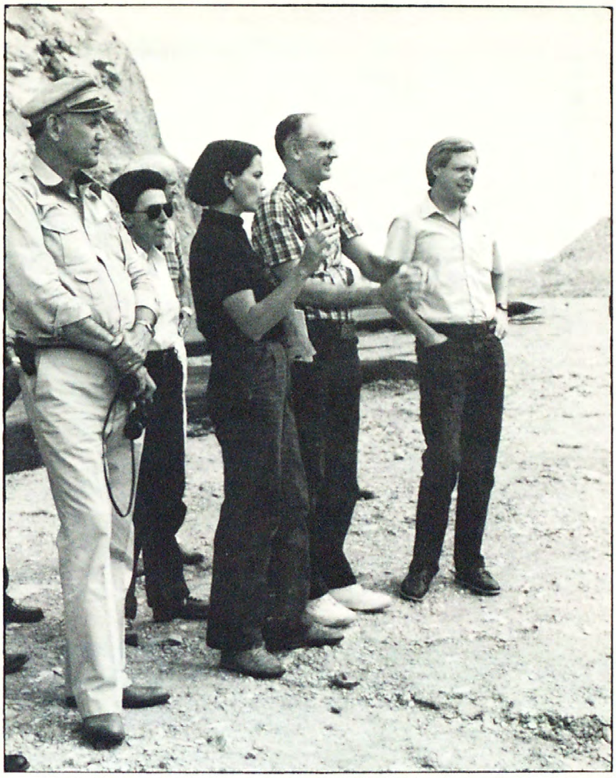
During historic time, approximately eight earthquakes of magnitude ≥6 have occurred in Utah. The largest of these were the magnitude (M_L) 6.6 Hansel Valley earthquake in 1934, (which may have been even larger in magnitude) and the magnitude (M_L) 6.5 Richfield earthquake in 1901. None of the large earthquakes have occurred actually on the Wasatch fault.

Detailed microearthquake studies of the Wasatch Front by seismologists at the University of Utah have revealed that much of the Wasatch fault is largely quiescent. Most earthquake activity (if *all* magnitudes are considered) is occurring east of the Wasatch fault, in the Wasatch Range. A diffuse but persistent zone of microearthquake activity extends southward beneath the Bear River Range, on the east side of Cache Valley terminating 13 miles east of Salt Lake City. Local concentrated zones of earthquake activity extend along an east-west zone across the Salt Lake City-Maga area, across the Transverse Range south of Salt Lake Valley,



Earthquake epicenters (1974-1982) and regional tectonic map of the Wasatch Front, Utah. The earthquakes were recorded by the University of Utah Intermountain Seismic Network, a modern, computer-recorded 76-station telemetered network that monitors the active fault zones of Utah and surrounding Rocky Mountain States. The network is supported by the U.S. Geological Survey.

Utah State Geologist Genevieve Atwood describes the 1983 Thistle, Utah landslide catastrophe to Secretary of the Interior Donald P. Hodel and other participants in a field trip describing earthquake and landslide hazards on the Wasatch Front. (Photograph by Wesley Dewsnup).



and at the southern end of Utah Lake. Activity continues south as a notable trend along the Juab Valley displaced west of the Wasatch fault.

Two elliptical zones of anomalously low seismicity occur along the Wasatch fault. One zone occurs along the Wasatch fault in the Ogden area, on the east side of the Salt Lake Valley; the other occurs south of Provo. The two areas of seismic quiesence have been interpreted as seismic gaps, where there may be a higher probability for future large earthquakes. Other possible explanations for the apparent low seismicity along the quiet zones of the Wasatch fault include: (a) release of strain energy by aseismic creep and/or by crustal rebound of ancient Lake Bonneville; and (b) the return rate for large earthquakes is sufficiently larger than the time window of the approximate 100 years of historic observation and is therefore too small to sample the long-term seismicity. Another important hypothesis to be tested suggests that earthquakes occurring along the west side of the Wasatch fault, for example, at Salt Lake City near

Magna and along the Santaquin-Nephi-Levan area may reflect earthquakes associated with the westward dipping faults in the Wasatch fault zone.

Workshops on "Earthquake and landslide hazards in Utah"

The U.S. Geological Survey, Federal Emergency Management Agency, Utah Geological and Mineral Survey (UGMS), Utah Division of Comprehensive Emergency Management (CEM), and the University of Utah continued in 1985 to jointly sponsor workshops on earthquake hazards and risk in Utah. Continuing a planning process begun at the first conference in 1984, two earthquake hazards workshops were convened in Salt Lake City during July-August 1985. The goal of the two workshops was to increase the capability of state and local governments, private industry, academic institutions, and engineers and architects to reduce losses from earthquake and landslide hazards.

The first workshop identified roles and responsibilities of the Utah State Geologist in earthquake hazards identification and reduction. These special roles and responsibilities include:

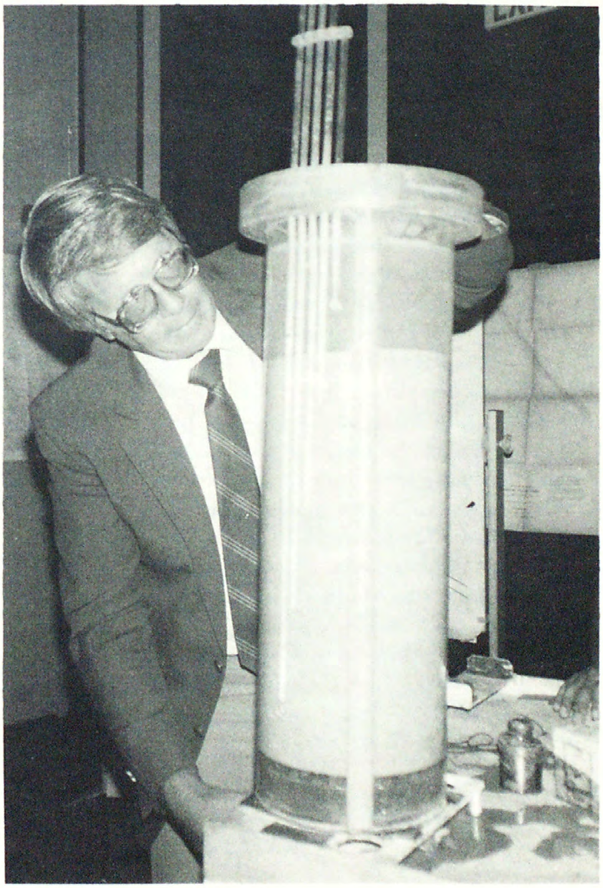
1. Collection, management, and distribution of information and maps.
2. Assistance and advice to local governments.
3. Review of site and development plans for local and state government at their request.
4. Evaluation of hazards.
5. Monitoring of hazards.
6. Advocate of seismic safety.

The workshop also concentrated on the role of the UGMS after an earthquake, during the response and recovery phases. The UGMS would be called upon to:

1. Provide technical advice to state and local agencies
2. Evaluate geologic hazards.
3. Document surface and subsurface effects and damage.
4. Coordinate with post-earthquake investigation teams, USGS, and CEM and other state and local agencies.

The workshop also discussed hazard monitoring and loss-estimation studies, and identified several agencies and groups that share these responsibilities. The workshop assigned UGMS the role of coordinator of hazard information and its collection, translation, and dissemination.

The second workshop focused on assisting the Utah Division of Comprehensive Emergency Management, and cities and counties in the state, to use hazard information and maps to reduce losses from earthquakes and landslides. The workshop was highlighted by a spirited interaction between geologists, seismologists, and social scientists, who collect and translate hazard information; and urban planners, emergency managers, and architects and engineers, who need to use the information in their communities and for their clients.



Professor Loren Anderson of Utah State University demonstrates the process of liquefaction to participants at a Workshop on "Earthquake and Landslide Hazards in the Wasatch Front Region of Utah."