SURVEY NOTES

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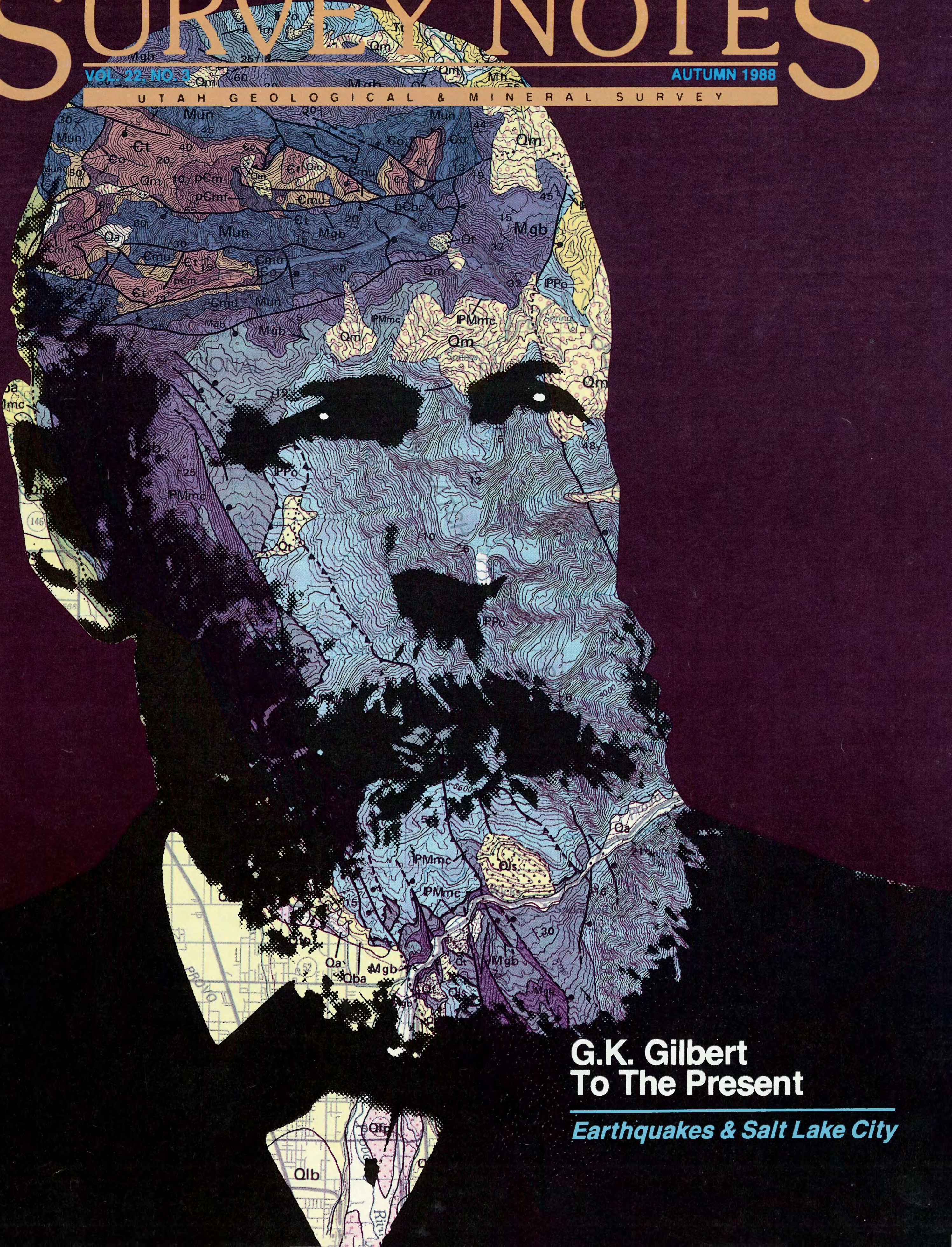

G.K. Gilbert To The Present

Earthquakes & Salt Lake City

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FROM THE DIRECTOR'S CORNER

In the lead article in this issue of Survey Notes William R. (Bill) Lund describes one facet of the Wasatch Front Earthquake Hazard Reduction Program and how he and other scientists are building on the pioneering work of G.K. Gilbert. One hundred five years ago Gilbert warned Salt Lake City residents of the earthquake hazard they faced and told them that the adobe houses in which many of them lived were particularly vulnerable to damage in an earthquake. Gilbert's conclusions on the earthquake threat to Salt Lake City were based on his understanding of the geology of the region and his observations of the effects of a major earthquake in a similar geologic setting at Lone Pine, California. Today, Bill and other scientists working on the earthquake hazard on the Wasatch Front still must rely on their own and their predecessor's geologic observations and extrapolate the effects of earthquakes in other areas to our conditions here.

Understanding of the earthquake hazard in Utah changed little in the years following Gilbert's warning. A major earthquake in Hansel Valley in 1934 did considerable damage along the Wasatch Front and increased public awareness, but it was not until the 1970s that major new studies were undertaken to better define the earthquake hazard. The work described by Bill is part of a highly successful cooperative program between the U.S. Geological Survey (USGS) and the Utah Geological and Mineral Survey (UGMS) that began in 1983. Under this program several millions of dollars, mostly from the National Earthquake Hazards Reduction Program (NEHRP), have supported research by scientists from the UGMS, USGS, the University of Utah, Utah State University, Brigham Young University, and several other universities and private firms.

The contrast between the work done by Gilbert in the last century and the work being done today is profound. Gilbert, working largely alone, covered most of northern Utah in a few months with little more than surveying instruments and camping gear, using horses and mules for transportation; he relied on his own observations of the geology exposed on the land surface and rarely spent more than a few hours at a location. Bill Lund's work involves the excavation of long trenches where he spends weeks mapping a few hundred square feet of trench wall. The work, although less costly than most other detailed exploration, is expensive compared to Gilbert's, requires the support of specialists in age dating, and must be interpreted in conjunction with results from other trench studies.

The work done by Bill is only one part of the dozens of kinds of research being conducted on the Wasatch Front earthquake hazard by hundreds of individuals. When Gilbert had completed his observations, he published a few conclusions in the Salt Lake Tribune. The readers of the Tribune then had, in one easily understood document, most of what was known about the earthquake hazard they faced.

Today the situation is much different. The knowledge of the earthquake hazard is contained in the work of many researchers, much of it in a form that cannot be understood and used by the general public and decision-makers who are expected to take action to reduce that hazard.

It is important that this information be made available in forms that can be understood and used. A document summarizing the major elements of the earthquake hazard is being drafted by a group initiated by Walter Hays, Deputy Chief of Research Applica-

continued page 2

UGMS Maps Released

Flood Hazard From Lakes and Failure of Dams in Utah, by Kimm M. Harty and Gary E. Christenson.

Flood hazard from lakes and failure of dams in Utah, compiled and written as a planning guide for local governments and regulatory agencies, outlines areas of the state that are likely to experience flooding hazards due to fluctuating lake levels and dam failures. The report discusses lake level fluctuations as determined from historical records and geologic and topographic features. Also discussed are Utah's dry lakes (Sevier and Rush), lowlands or basins, flooded marsh areas, salt flats and perennial lakes.

The map and report address 63 sites for which dam failure inundation studies have been completed and the agencies conducting those studies. Although more than 1000 water-retention structures are in use in Utah, only those for which inundation studies exist are on Map 111.

Ground-Water Resources of the Southern Wasatch Front Area, Utah by Don Price and Loretta S. Conroy.

Utah Geological and Mineral Survey Map 55-C is one of a series of maps describing the geology, natural resources and hazards along the Wasatch front. This non-technical report outlines the occurrence, availability and quality of ground water in the southern Wasatch front area. Examination of ground water storage in consolidated rocks of the mountains and in unconsolidated basin fill involves characteristics of basin fill that enable water storage, general conditions of ground water occurrence and dynamics of recharge and discharge of water in the ground systems. Also mentioned, is ground water quality (dissolved solids concentrations in) and temperatures.

The map is presented in three plates. Plate 1 shows ranges of transmissivity (rate at which water moves through a unit width of an aquifer under a unit hydraulic gradient) in basin fill along the front. Plate 2 traces changes in the altitude of the potentiometric surface (level at which water stands in a well that taps one or more water bearing strata. Where none of the water-bearing strata are confined, this surface is also called the water table) over a ten year period. Plate 3, water quality, shows dissolved solids concentrations of water in basin fill and locations of thermal ground water.

Mineral Resources of the Southern Wasatch Front, compiled by Fitzhugh D. Davis with a section on petroleum by Floyd C. Moulton and Raymond L. Kerns, Jr.

UGMS map 55-D shows local rock types grouped into metamorphics, igneous extrusives, igneous intrusives, carbonates, coarse and fine grained clastics and unconsolidated sediments. Evaluation of the area's metallic mineral potential includes discussion of five mining district's, their histories, type of deposits and brief production reports. Non-metallic mineral occurrences, their distribution and uses are also outlined. Construction materials, briefly mentioned, include cement, granite, sandstone, limestone, sand and gravel.

The study area, located on the eastern edge of the Basin and Range province, partially overlaps the north-south trending Hingeline. A discussion by Moulton and Kerns traces the role that the Hingeline plays in petroleum potential of the study area. Suggested petroleum targets include deep Paleozoic and Mesozoic overthrust type occurrences and shallower Tertiary sediment accumulations in valleys bounded by listric "basin and range" faults. The authors mention the potential of undiscovered, new targets created by the unique geologic setting of the region.

FROM THE DIRECTOR'S CORNER ...
continued from page 1

tions, USGS, one of the champions of earthquake hazard reduction in Utah. This document will be presented in a January 1989 workshop to about 200 earth scientists, engineers, social scientists, planners and emergency response officials representing the many groups that have worked on the hazard or are concerned with actions to reduce the hazard. The product of this workshop will be a "consensus" document of what we know about the Wasatch Front earthquake hazard and, finally, a document which can be used by professionals.

Wasatch Front earthquake hazard researchers generally agree that our knowledge is now sufficient to begin actions which would reduce the hazard. We have essential agreement on where earthquakes will happen, how often they happen, and what the effects will be. We know that ground shaking will cause extensive damage to communities near and far from a major earthquake. We have a better understanding of surface rupture, ground failure, and hydrologic changes that will be associated with a major earthquake.

In addition, the USGS has awarded a grant to the University of Utah for Walter Arabasz, Director, U. of U. Seismograph Stations and Don Mabey, retired USGS/UGMS to prepare a book for non-earth scientists describing the Wasatch Front earthquake hazard (the "consensus" document) in non-technical terms.

This process of developing a consensus on the scientific nature of the hazard is the culmination of several years of intensive study. Continuing research will refine our knowledge of the Wasatch Front earthquake hazards, particularly the mechanism of fault rupture, distribution of ground responses, and consequences to the built environment. Earthquake hazards associated with Utah's other faults still need definition. But for the next few years the emphasis will be to significantly reduce losses from the first major earthquake to strike the Wasatch Front in historic time.

The Wasatch Fault Zone, Earthquakes and Salt Lake City: G.K. Gilbert to the Present

by William R. Lund
Utah Geological and Mineral Survey, Salt Lake City, Utah

GILBERT'S THEORY OF EARTHQUAKES IN THE GREAT BASIN

G.K. Gilbert (1843-1918) was one of the most perceptive geologists ever to work in the American West. His regional investigations of Basin and Range geology with the Wheeler Survey (1871-1874), Powell Survey (1875-1879), and U.S. Geological Survey (1879-1883) resulted in a number of scientific firsts and benchmark studies that are classics of American geologic thought. Many of his theories have withstood the test of time, notably his contributions to the understanding of mountain-building processes and earthquakes in the Basin and Range province. He was the first to recognize that faulting and not folding is the primary mechanism responsible for mountain building in the interior basins of Utah and Nevada (Gilbert, 1872, 1875). He was also the first to identify "piedmont" scarps as evidence that the mountains were the result of incremental movements along range-bounding faults during earthquakes (Gilbert, 1875, 1890, 1928; Wallace, 1980).

The Wasatch fault zone, particularly near Salt Lake City, played a major role in the formulation of Gilbert's theories about mountain building and earthquakes. Although prefaced by his disclaimer, *"that the fault scarps were at no time a leading subject of investigation,"* U.S. Geological Survey Monograph 1 has his classic description of young faulting exposed along the Wasatch fault zone, and states, *"It was at the base of the Wasatch Range that the fault scarp was first discriminated as a distinct topographic feature..."* (Gilbert, 1890, p. 342). The fault scarps at the mouth of Little Cottonwood Canyon (figures 1 and 2) occupy a prominent place in Gilbert's field notes (Hunt, 1982), and undoubtedly were the source of many of his ideas about Basin and Range faulting. He visited Little Cottonwood Canyon twice, first in 1877 to make notes on the geology and surface-water resources of the area, and again in 1880 to spend several days mapping the geology. The importance Gilbert attached to the faults at this location is evidenced by his detailed description and geologic map of the area (figure 1) in Monograph 1.

In 1883, confident that his theories about mountain building and earthquakes were correct, Gilbert issued an earthquake hazard warning to the residents of Salt Lake City. In an article in the Salt Lake City Tribune (Sept. 20, 1883) reprinted in the American Journal of Science (1884, v. 27), he summarized his ideas and emphasized their practical application in Utah. He stated that the mountains in the Basin and Range province are uplifted in small increments along faults following the release of strain that has accumulated slowly over long periods of time, and that *"the instant of yielding is so swift and abruptly terminated as to constitute a shock"* (Gilbert, 1884, p. 50). Wallace (1980, p. 38) points out that, given the current understanding of how earthquakes are generated, Gilbert's reasoning relating mountain building to earthquakes is *"so modern that, in 1980, it is difficult to understand why, once stated, the concept would not have been generally accepted and become a firm part of the working base of geologists and seismologists."* However, several decades were to pass before Gilbert's ideas gained general acceptance.

Gilbert's earthquake warning was remarkable for its recognition that earthquakes in the Basin and Range province are unevenly distributed in time and space. He concluded that once an earthquake occurs at a particular location on a fault, it is unlikely that another will take place there until sufficient time has elapsed for the necessary strain to reaccumulate. He interpreted the absence of young fault scarps along some portions of active fault zones as evidence of long quiescence and strain accumulation, marking the subdued section of the fault as a prime candidate for a future earthquake. It was for that reason that Gilbert issued his warning to Salt Lake City. He had identified young scarps extending northward from Warm Springs at the north edge of Salt Lake City and southward from Emigration Canyon, but found scarps to be *"conspicuously absent"* (Gilbert, 1884, p. 52) along the mountain front adjacent to the city between those two points. He concluded that, *"the rational explanation of their absence is that a very long time has elapsed since their last renewal. In this period the earth strain has been slowly increasing, and some day it will overcome the friction, lift the mountains a few feet, and re-enact on a more fearful scale the catastrophe of Owens Valley"* (Gilbert, 1884, p.

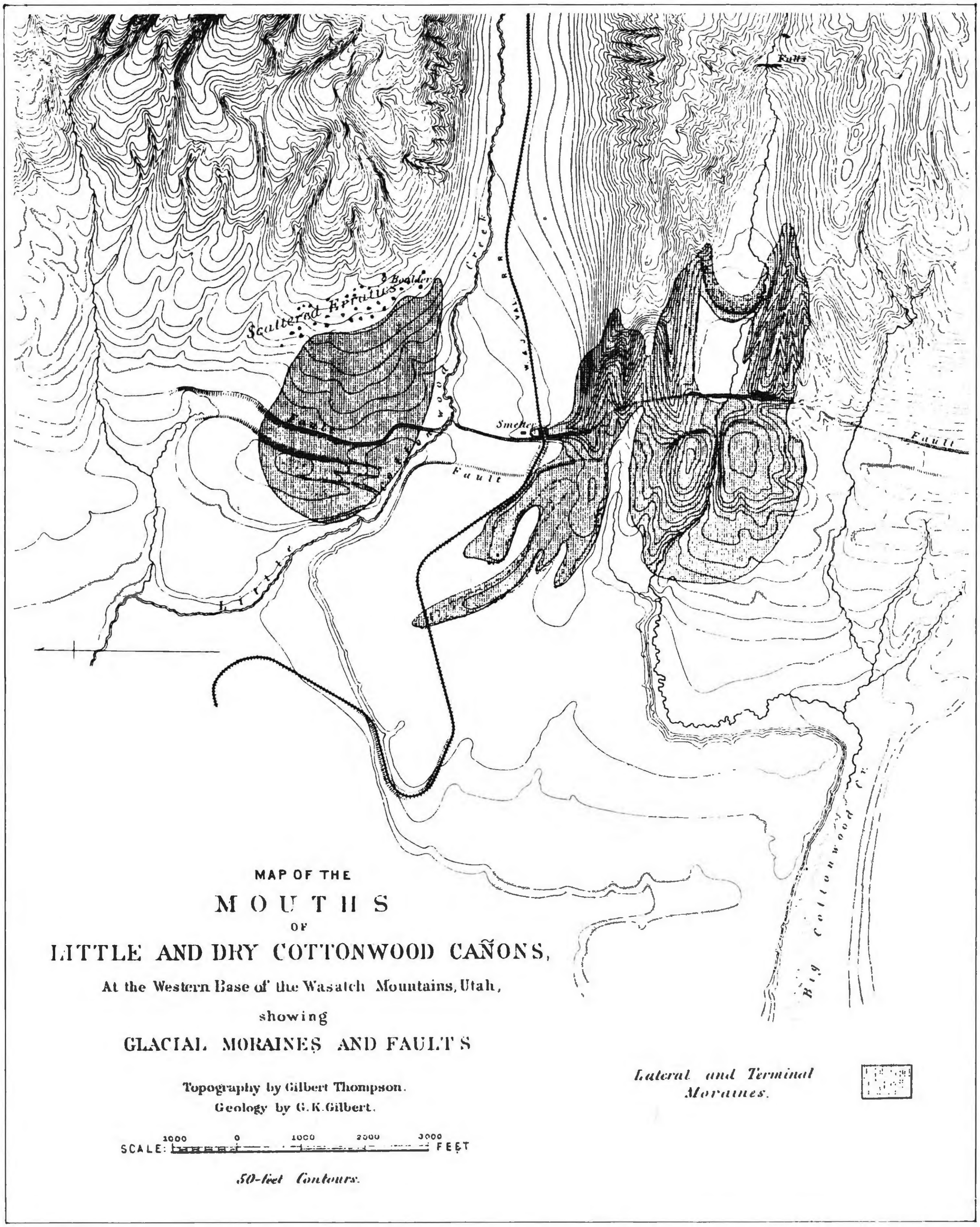


Figure 1. Gilbert's (1890), plate XLII, mapping of moraines and fault scarps at Little Cottonwood Canyon, Wasatch fault zone.

52). Gilbert considered the great 1872 Owens Valley, California earthquake (M 7.8) to be the result of the same type of forces acting on the Wasatch fault zone and, therefore, to be a model for the earthquake that would someday affect Salt Lake City.

Gilbert was perceptive about human nature and also one of the first thinkers in the field of relative risk assessment. He predicted that following the next large earthquake, *"Salt Lake City will have been shaken down, and its surviving citizens will have sorrowfully rebuilt of wood,"* a material he considered more resistant to earthquake forces based on observation of the damage to buildings in Lone Pine, California resulting from the Owens Valley earthquake (Gilbert, 1884, p. 52). Asking what the citizens of Salt Lake City were going to do about his warning, he answered, *"probably nothing."* He considered it unlikely that the city's inhabitants would *"abandon brick and stone and adobe, and build all new houses of wood."* He further concluded that even if they did rebuild the city with wood, it would only increase the danger of fire which, *"in the long run destroys more property than earthquakes"* (Gilbert, 1884, p. 53). Time has proven Gilbert's forecast of public response to his warning correct. The many unreinforced brick and stone structures (including many schools and hospitals) built in the Salt Lake City area until relatively recently are evidence that little was done through land-use planning and building codes to mitigate earthquake hazards. On the other hand, Salt Lake City never experienced a major destructive fire similar to those which occurred in many American cities before the turn of the century.

GILBERT'S EARTHQUAKE HAZARD EVALUATION OF THE WASATCH FAULT ZONE

Gilbert (1884, 1890) showed an extraordinary understanding of the geologic processes and principles critical to earthquake hazard evaluation. Geologists and seismologists studying the Wasatch fault zone today are, for the most part, either expanding on his work, pursuing ideas he germinated, or trying to answer questions he raised. Recurrence intervals, elapsed time since the most recent surface-faulting event, fault segmentation, seismic gaps, ground deformation, fault geometry, and characteristic earthquake models are all current research topics whose origins can be found in one form or another in Gilbert's work. Even his instinct for identifying the best locations to study the fault zone has proven reliable. Swan and others (1981) excavated trenches for one of the first detailed paleoseismic investigations on the Wasatch fault zone across scarps first identified and described by Gilbert (Hunt, 1982) at the mouth of Little Cottonwood Canyon. More recently, Lund and Schwartz (1987) excavated trenches at Dry Creek Canyon about 2 km south of Little Cottonwood Canyon (figure 2) on scarps examined by Gilbert in 1877 and 1880 (Hunt, 1982). The purpose of trenching is to obtain information on the size and timing of past earthquakes. Information that Gilbert, in his warning to Salt Lake City, recognized as necessary before effective earthquake hazard mitigation could take place.

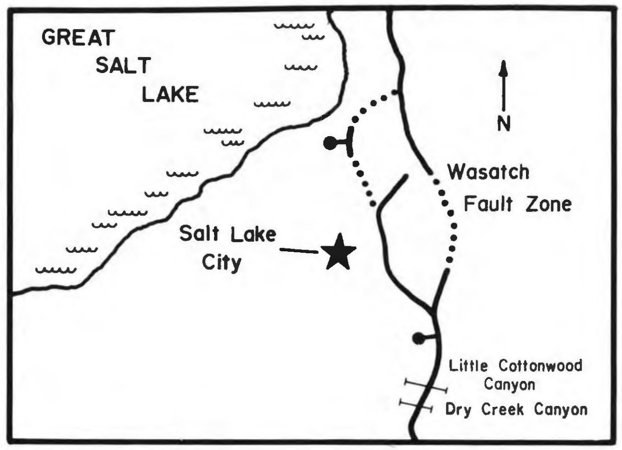


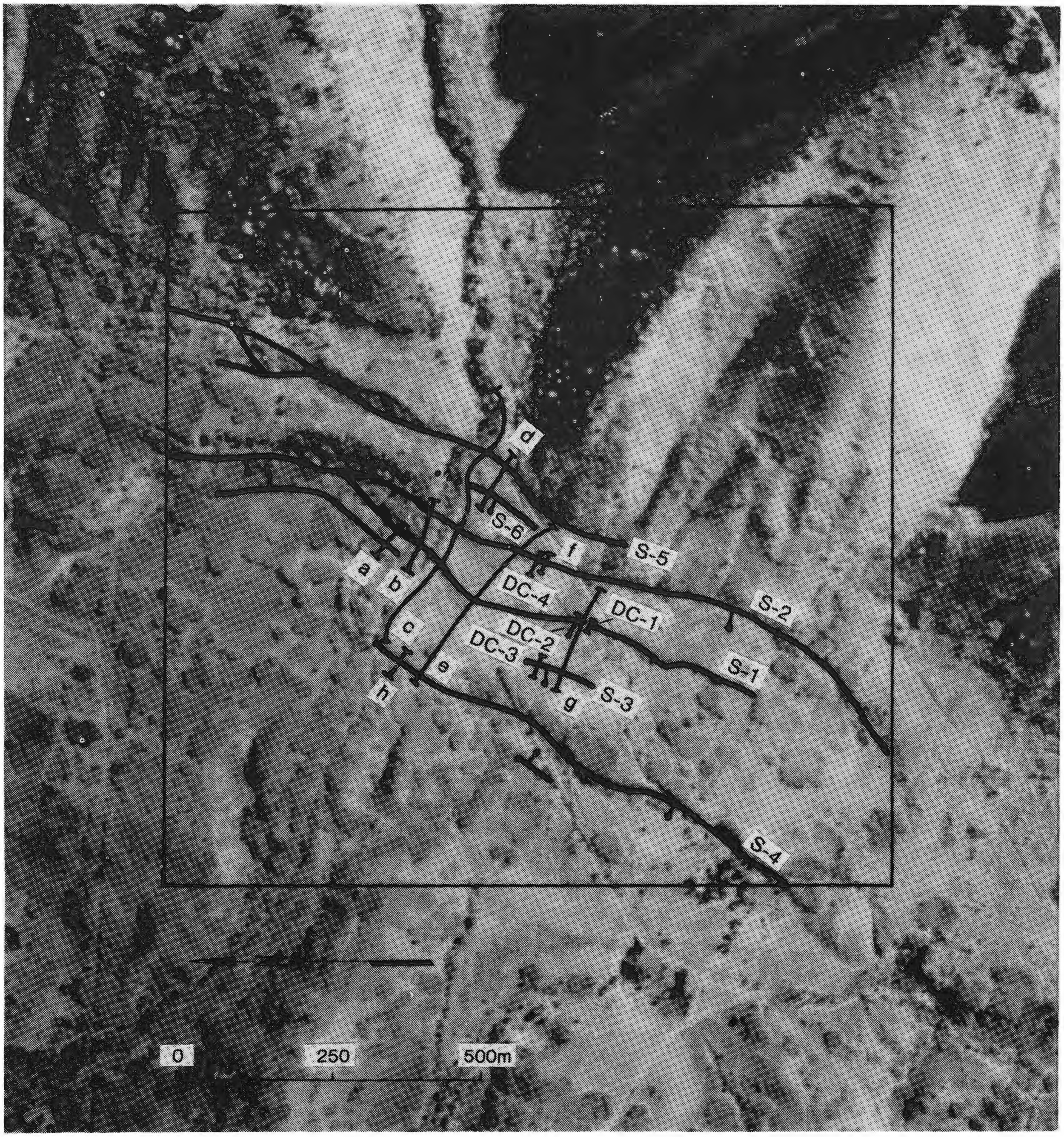
Figure 2. *Map showing location of Little Cottonwood Canyon and Dry Creek Canyon trench sites.*

RESULTS OF RECENT PALEOSEISMIC INVESTIGATIONS

The Wasatch fault zone crosses Little Cottonwood Creek (figure 3) as a major graben in Lake Bonneville lacustrine sediments and alluvial deposits. The zone of most recent faulting is conspicuous where it crosses lateral and terminal moraines at the mouths of Bells and Little Cottonwood Canyons. Immediately north of Little Cottonwood Canyon, the fault zone is defined by a steep, curvilinear, west-facing scarp and a zone of antithetic faulting 200 m (meters) wide. The heights of the antithetic scarps vary from less than 10 m to about 20 m. The main scarp is 20 to 45 m high and splays to the north into three west-facing scarps having heights of 4.5, 2.0, and 3.5 m (Hanson and Schwartz, 1982). Trenches were excavated into the westernmost of the three main fault scarps, across the graben, and into the main antithetic fault (figure 3). The trenches exposed Bonneville lacustrine sediments, post-Bonneville alluvial-fan and graben-fill deposits, Bells Canyon till, and scarp-derived colluvium. Details of the investigation are presented in Swan and others (1981) and Schwartz and Coppersmith (1984).

In summary, the trenches showed evidence for two surface-faulting earthquakes during the past 8000-9000 years. The older event occurred shortly before 8000-9000 years ago; timing of the most recent event could not be constrained. A maximum average recurrence interval of 4000-4600 years between surface-faulting events was obtained based on information from the trenches. However, estimates of earthquake recurrence at Little Cottonwood Canyon are complicated by multiple fault traces and a wide, complex zone of deformation. No subsurface data are available for the other two splays of the main fault at the trench site. Both Swan and others (1981) and Schwartz

Figure 3. *Low-sun-angle photograph showing the complexity and width of the Wasatch fault zone at the mouths of Little Cottonwood and Bells Canyons (from Swan and others, 1981).*



EXPLANATION

DC-1	Trench
a	Profile
S-3	Scarp; bar and ball on downthrown side.

Figure 4. *Location of fault scarps, exploration trenches, and topographic profiles at the Dry Creek Canyon site.*

and Coppersmith (1984) are uncertain to what extent the parallel scarps represent additional events that could decrease the interval between surface-faulting earthquakes. An alternative recurrence interval of 2400-3000 years was calculated using a net tectonic displacement of 14.5 m measured across the Bells Canyon moraine (profile A-A', figure 3), an age for the moraine of 19,000 ± 2000 years (Madsen and Currey, 1979), and a displacement per event of 2 m determined from the depth to Bonneville lacustrine deposits displaced in the graben. Using the same value of net tectonic displacement, a slip rate of 0.76 (+0.6; −0.2) millimeters per year was calculated for the Wasatch fault zone at Little Cottonwood Canyon for the past 19,000 ± 2000 years (Schwartz and Lund, 1988). That slip rate is similar to late Pleistocene-Holocene rates determined elsewhere along the Wasatch fault zone.

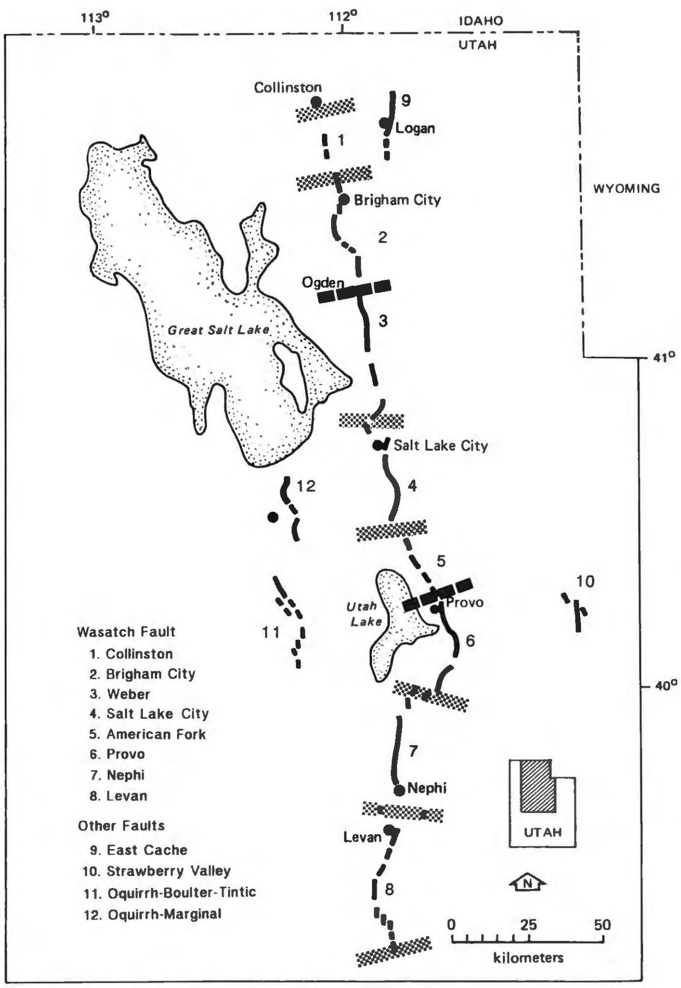


Figure 5. Segmentation model for the Wasatch fault zone, Utah. Stippled bands define segment boundaries identified by Schwartz and Coppersmith (1984); dashed bands are additional boundaries interpreted by Machette and others (1987).

The investigation at Dry Creek Canyon (Lund and Schwartz, 1987; Schwartz and others, 1988) demonstrated the occurrence of two middle to late Holocene surface-faulting earthquakes. Mean-residence-time radiocarbon dates of soil A horizons buried by scarp-derived colluvium show that the older event occurred shortly after 5545-5975 yr B.P. (years before the present). The timing of the most recent event is less well defined, occurring after 1130-1890 yr B.P. The Wasatch fault zone at Dry Creek Canyon consists of five parallel to *en echelon* scarps in a zone up to 300 m wide (figure 4). Displacement occurred on each scarp during the past two surface-faulting earthquakes. Topographic profiling of a debris-flow levee displaced only by the most recent event and alluvial-fan deposits displaced by both events, combined with measurements of displaced marker horizons in the trenches, indicate a net tectonic slip of 4.5-5.0 m per event for the past two surface-faulting earthquakes (Schwartz and Lund, 1988). This is the largest displacement value measured for a single event along the Wasatch fault zone.

Given the short distance (2 km) between the two trench sites, it is reasonable that the earthquakes at Dry Creek Canyon also occurred at Little Cottonwood Canyon. The inability to clearly recognize two post-middle Holocene events at Little Cottonwood Canyon is additional evidence of the uncertainty regarding the activity of individual fault scarps at that location during individual surface-faulting earthquakes. However, the similarity in style of faulting at Dry Creek and Little Cottonwood Canyons and their proximity to one another strongly suggest that the parallel scarps at Little Cottonwood Canyon slipped simultaneously during past surface-faulting earthquakes (Schwartz and Lund, 1988). The resulting larger slip per event would be more consistent with the broad fault zone and high scarps found at Little Cottonwood Canyon than the previous estimate of 2 m per event.

Combining observations from Little Cottonwood and Dry Creek Canyons indicates that at least three large-magnitude, surface-faulting earthquakes have occurred on the Wasatch fault zone near Salt Lake City in the past 8000-9000 years. One event occurred shortly before 8000-9000 years ago, one shortly after 5500-6000 years ago, and the most recent event shortly after 1100 to 1800 years ago. Considering the uncertainties in the timing of the events, an average recurrence interval of 4000 ± 1000 years appears appropriate for the Wasatch fault zone near Salt Lake City (Schwartz and Lund, 1988). However, the actual intervals separating the events may range from 2000 to 4900 years. The difference between the actual and average recurrence intervals is in part due to uncertainties in dating, but it also reflects the temporal variations that occur between earthquakes at a given location on the fault. Such variations demonstrate the need to establish the earthquake history of the Wasatch fault zone over the longest time period possible and to show that "average" recurrence intervals must be used with caution when evaluating earthquake hazards.

STATUS OF EARTHQUAKE HAZARD EVALUATION ON THE WASATCH FAULT ZONE

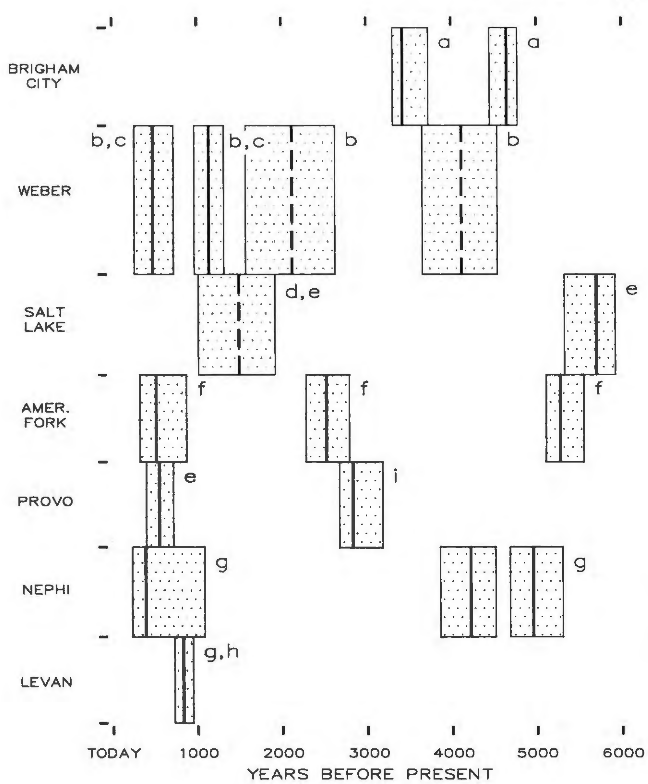
Although current earthquake hazard research on the Wasatch fault zone can trace its origins to Gilbert's pioneering efforts, systematic study of the earthquake history of the fault zone did not begin until 1977, when the first detailed paleoseismic investigation was conducted near Kaysville (Swan and others, 1980). Since then, 20 other sites have been investigated along the fault zone (Machette and others, 1987), many as part of a joint Utah Geological and Mineral Survey/U.S. Geological Survey program to investigate earthquake hazards along the Wasatch Front (Atwood and Mabey, 1987).

A reasonably accurate picture of the earthquake history of the Wasatch fault zone for the past 5000-6000 years now exists, and it is recognized that the Wasatch fault zone consists of several segments (figure 5), each essentially seismically independent of the others (Schwartz and Coppersmith, 1984; Machette and others, 1987).

Since the middle Holocene, earthquakes on the Wasatch fault zone appear to occur in clusters, short intervals of time (hundreds rather than thousands of years) during which all or most of the active fault segments experience a surface-faulting earthquake (Machette and others, 1988; Schwartz and others, 1988; figure 6). Longer periods of relative quiescence appear to follow these "bursts" of intense earthquake activity, although there is some variability, such as that which occurs along the Weber segment (figure 6). During the most recent cluster, beginning about 1200 years ago, all the fault segments recognized as active during the Holocene (with one and possibly two exceptions) have experienced a surface-faulting earthquake (figure 6). The two exceptions are the Brigham City segment where a surface-faulting earthquake has not occurred for more than 3000 years, and the Salt Lake City segment where 1100-1800 years have gone by since the last large earthquake. Studies at American Fork Canyon (Machette and Lund, 1987), Kaysville (Swan and others, 1981), and East Ogden (Nelson and others, 1987) show that more time has elapsed on the Salt Lake City segment (figure 6) since the last surface-faulting event than on adjacent segments. Although we are still far from being able to make a prediction of the time and place of the next surface-faulting earthquake on the Wasatch fault zone, it is possible to indicate a relative hazard for individual fault segments based on the timing of their most recent surface-faulting earthquake. The principle employed is the same as that stated by Gilbert in 1884: fault segments that have experienced recent surface-faulting are the least likely to generate the next earthquake. Using that criterion, the segments with the greatest elapsed time since the last surface-faulting earthquake are the most likely to experience the next event. Therefore, the Brigham City and Salt Lake City segments are the most probable candidates for the next large-magnitude, surface-faulting earthquake on the Wasatch fault zone. In the case of Salt Lake City, this confirms what Gilbert predicted 105 years ago.

Readers interested in Wasatch Front neotectonics should find the field trip guidebook (no. 12) for the annual Geological Society of America meeting of great interest (see review in this issue of "In the Footsteps of G.K. Gilbert ...").

WASATCH FAULT ZONE RECURRENCE



Sources of data:
a. S. Personius in Machette et al., 1988.
b. A. Nelson in Machette et al., in prep.
c. Swan et al. (1980)
d. Lund and Schwartz (1987)
e. Schwartz et al. (1988)
f. Machette et al. (1987)
g. Schwartz and Coppersmith (1984)
h. M. Jackson, M.A. Thesis, U. Colorado, 1988.
i. W. Lund (written communication)

Figure 6. *Space-time plot of large-magnitude earthquakes along the Wasatch fault zone during the past 6000 years. Heavy solid line indicates best estimate of timing; heavy dashed line is approximation. Stippled boxes reflect uncertainties to timing based on age dates and stratigraphic relationships (Compiled by David Schwartz, U.S. Geological Survey).*

STATE OF UTAH
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Utah Geological & Mineral Survey

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Please circulate this form among your staff for the required information, and return the information as soon as possible. On the map on the reverse side of this page, indicate the quadrangles covered (or to be covered). More copies are available on request.

If you know of any other universities or organizations who are doing geological work in Utah, please send us their names.

To assist those doing geological work in Utah, the Utah Geological and Mineral Survey has compiled a bibliography of the Geology of Utah on computer. Special searches can be made by quadrangle, formation, commodity, type of study, etc. Please write for more information.

Many thanks for filling out this form. A copy can be obtained by request at no charge.

Genevieve Atwood

Genevieve Atwood, *Director*
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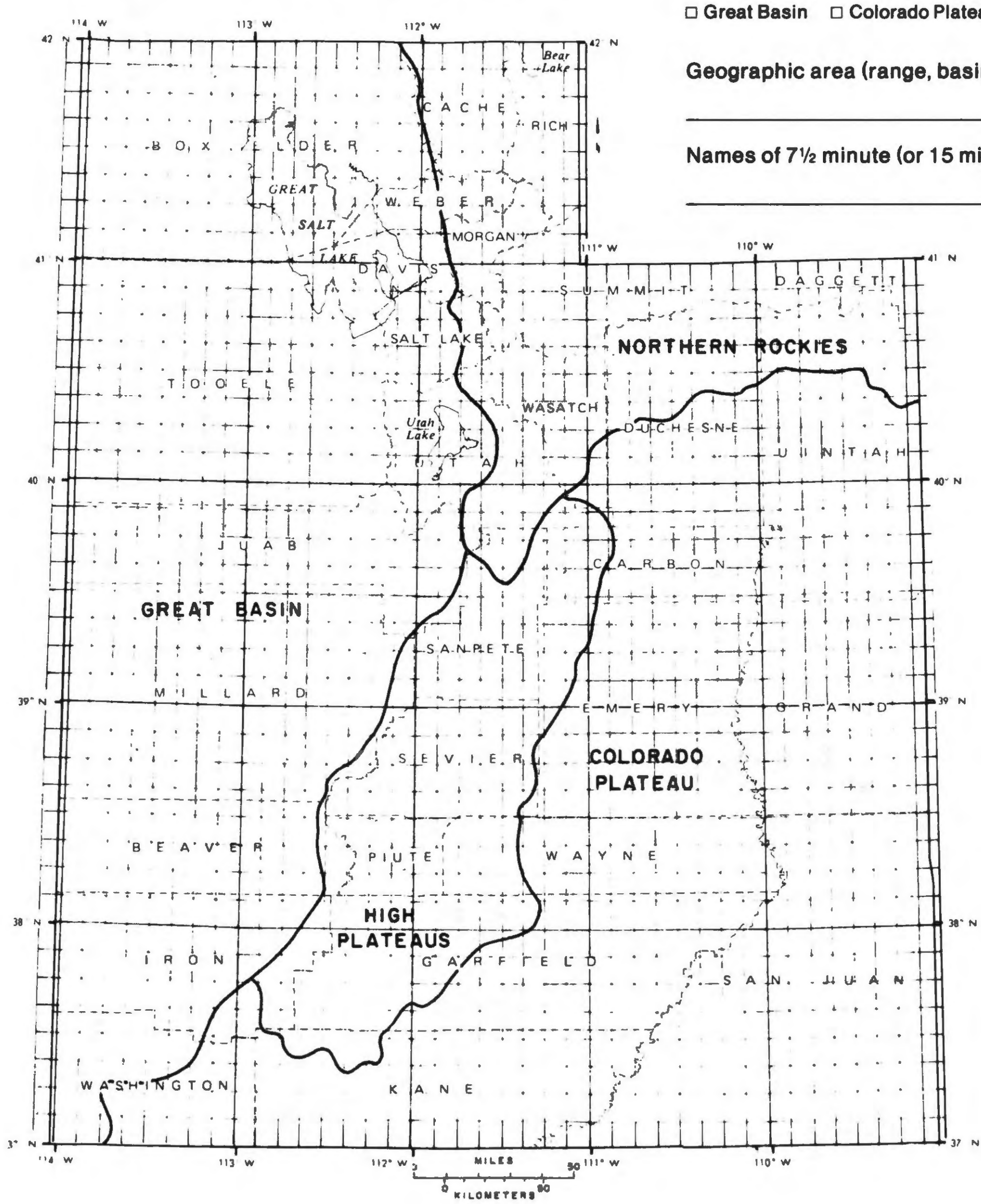

Which Counties are covered by this study?
(please circle)

All Counties
Beaver
Box Elder
Cache
Carbon
Davis
Daggett
Duchesne
Emery
Garfield
Grand
Iron
Juab
Kane
Millard
Morgan
Piute
Rich
Salt Lake
San Juan
Sanpete
Sevier
Summit
Tooele
Uintah
Utah
Wasatch
Washington
Wayne
Weber

If possible, please fill in location of study area on this map of Utah. Each small square equals one 7½ minute quad.

Acknowledgements

I thank Gary Christenson, Kimm Harty, and Suzanne Hecker of the Utah Geological and Mineral Survey, and David Schwartz of the U.S. Geological Survey for their timely review of this article. Their comments and suggestions were of great assistance and improved both the accuracy and readability of the final product.

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Mineral resources of the Parunuweap Canyon Wilderness Study Area, Kane County, Utah, by R.E. Van Loenen, E.G. Sable, H.R. Blank, Jr., H.N. Barton, K.L. Cook, and J.E. Zelten, 18 p., 1 pl., 1988, U.S. Geological Survey B 1746-B.

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Mineral resources of the Mt. Hillers Wilderness Study Area, Garfield County, Utah, by R.F. Dubiel and others, 14 p., 1 pl., 1988, U.S. Geological Survey B 1751-C.

Interim geologic maps and explanation pamphlet for parts of the Stockton and Lowe Peak 7½-minute quadrangles, Utah, by E.W. Tooker, and R.J. Roberts, 20 p., 2 pl., 1988, U.S. Geological Survey OF 88-0280.

Maps of fault scarps formed on unconsolidated sediments, Tooele 1° x 2° quadrangle, northwestern Utah, by T.P. Barnhard, and R.L. Dodge, 1 pl., 1988, U.S. Geological Survey MF 1990.

Geologic map showing a late Cenozoic basaltic intrusive complex, Emery, Sevier, and Wayne Counties, Utah, by A.E. Gartner, and P.T. Delaney, 1 pl., 1988, U.S. Geological Survey MF 2052.

Diagenesis and burial history of nonmarine Upper Cretaceous rocks in the central Uinta Basin, Utah, by J.K. Pitman, K.J. Franczyk, and D.E. Anders, 24 p., 1988, U.S. Geological Survey B 1787-D.

Land use and land cover and associated maps for Salina, Utah, U.S. Geological Survey OF 85-0316.

Land use and land cover and associated maps for Huntington, Utah, U.S. Geological Survey OF 85-0325.

Geology of Antelope Island, Davis County, Utah, by Hellmut H. Doelling and others. Utah Geological and Mineral Survey OF 144, 1988, 99 p., 2 pl., scale 1:24,000.

Antelope Island is a small fault block mountain range in the Basin and Range physiographic province of Utah. It is the largest and most prominent of several islands in the Great Salt Lake and is located in the lake's southeastern corner. The island contains Precambrian high-grade metamorphic rocks, Late Precambrian and Cambrian metasedimentary rocks, Tertiary conglomerates, mudstones, dolomites, tufaceous sandstones, and volcanic air fall tuffs, and Quaternary Lake Bonneville and Great Salt Lake sediments.

The report is divided into five different sections: rock units; structural geology including metamorphic structures, faults, shear zones, and folding and tilting; geologic history; economic geology with mineral resources grouped into metallic deposits (copper and iron) and non-metallic or construction materials; and geologic hazards such as landslides, debris flows, rock falls, lake flooding and erosion, and earthquake ground shaking.

Quaternary Geology — Tule Valley, West-Central Utah, by Dorothy Sack. Utah Geological and Mineral Survey OF 143, 1988, 60 p., 1 pl., scale 1:100,000.

Tule Valley is located about 130 miles southwest of Salt Lake City and 45 miles west of Delta, Utah in Juab and Millard Counties and occupies a structural basin of interior drainage in the Basin and Range physiographic province. It is bordered by the House Range on the east, the Confusion Range on the west, and by portions of the Fish Springs Range, Middle Range, and Honeycomb Hills on the north. Quaternary deposits include alluvial, eolian, lacustrine, mass movement, playa, spring, and bedrock. Also discussed is the valley's late Quaternary history, economic geology, springs, and geologic hazards.

Geologic History of Utah, by Lehi F. Hintze. Brigham Young University Geology Studies Special Publication 7, 1988, 102 p. Lehi F. Hintze, professor emeritus of geology at Brigham Young University, has completed a revised edition of his popular 1973 book on the geology of Utah. This new publication, primarily for beginning students of geology, employs new information about local and regional geology of Utah. Professor Hintze begins his book with a general overview of Utah's topography and geology and discusses the imprint that each geologic period left on our state. This publication is complemented by numerous photographs and schematic drawings as well as an extensive bibliography and 102 stratigraphic sections from strategic locations throughout the state.

Geologic Consequences of the 1983 Wet Year in Utah, by Bruce N. Kaliser and James E. Slosson, PhD. Utah Geologic and Mineral Survey Miscellaneous Publication 88-3, 1988, 109 p. The hydrologic and climatologic settings in Utah during the 1982, 1983 and 1984 wet cycle produced saturated and supersaturated soils that ultimately resulted in extensive debris flows. This paper briefly examines meteorological conditions and their impact on geologic events during Utah's "wet years." The area studied includes 24 of Utah's 29 counties (eliminating five counties in the southeastern quarter of the state). Types of slope movement monitored or observed during the time frame includes translational and rotational debris slides. The study analyzes specific debris flows that occurred during this historic period.

In the Footsteps of G.K. Gilbert—Lake Bonneville and Neotectonics of the Eastern Basin and Range Province, edited by Michael N. Machette. Utah Geological and Mineral Survey Miscellaneous Publication 88-1, 1988, edited as a guidebook for the October 1988 GSA meeting, 120 p.

This publication contains road logs for three one-day field trips. The field trip focuses on both the Wasatch fault zone and geomorphic features of Lake Bonneville. Papers include discussions of G.K. Gilbert's classic stratigraphic and geomorphic localities in this portion of Utah. Data from new sites is introduced along with a close examination of Gilbert's interpretations in light of modern theories and a regional tectonic framework. Gilbert's three primary interests that are examined include: geomorphology of Lake Bonneville deposits, the stratigraphy of the lacustrine cycles of Lake Bonneville, and neotectonics of the eastern Basin and Range province.

Salt Deformation in the Paradox Region, by H.H. Doelling, C.G. Oviatt, and P.W. Huntoon. Utah Geological and Mineral Survey Bulletin 122, 1988, 93 p.

UGMS Bulletin 122 is a compilation of three research projects conducted on thick salt sequences in the Paradox Basin area of southeastern Utah. The first article, "The geology of Salt Valley anticline and Arches National Park, Grand County, Utah," by Hellmut H. Doelling studies one of the salt anticlinal structures in the Paradox Basin. The article discusses local stratigraphy, structure and examples of how salt has helped shape the landscape. This study is a companion to previously published UGMS Map 74, "The geologic map of Arches National Park and vicinity, Grand County, Utah."

The second article in this bulletin is "Evidence for Quaternary salt deformation in the Salt Valley anticline, southeastern Utah." The author, Charles G. Oviatt, discusses local stratigraphic and geomorphic evidence of folding, faulting and other forms of deformation. Volcanic ash beds lend dates to deformation, thus giving credence to theories that active dissolution and diapirism still exist in the area.

Peter W. Huntoon's article "Late Cenozoic gravity tectonic deformation related to the Paradox salts in the Canyonlands area of Utah" relates deformation of rocks overlying the salt to three active mechanisms. Huntoon points out that salt dissolution, salt flowage and gliding of the rocks above the salt are events that occurred due to the erosion of the Colorado River and its tributaries. The article presents evidence that these processes continue to be active and are destabilizing the salt.

Devonian, Carboniferous, and Permian stratigraphy of the Burbank Hills in western Millard County, Utah by Lehi F. Hintze. Published in the New Mexico Bureau of Mines and Mineral Resources memoir 44, 1988.

Doctor Hintze's paper is a diagnostic summary of the present concept of stratigraphy for this area in west-central Utah in order to provide a basis for future work. The excellent discussion also includes a thorough reference list useful to future mappers, paleontologists, and stratigraphers.

Old Utah Trails by William B. Smart. This is the fifth of the Utah Geographic Series (Utah Canyon Country, Utah Ski Country, Utah Wildlands, Utah's Wasatch Front), good looking, well done, and informative mini-coffee-table publications. This 1988 book details 8 of the famous expeditions/tracks through Utah with a good array of text, maps, and photographs. Personal rather than scholarly, it is not only readable but accurate in combining current advice on travel with primary source excerpts to depict the trials and trails through Utah's geologic milieu.

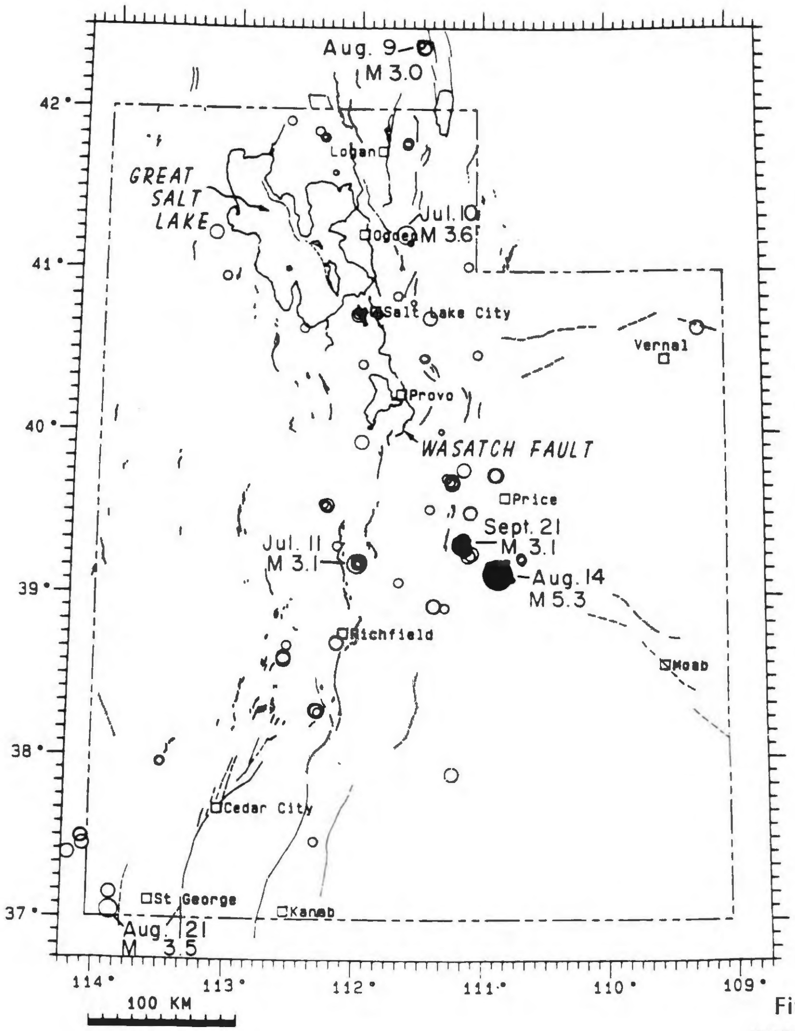
Stone House Lands: The San Rafael Reef by Joseph M. Baumon, Jr. Like Old Utah Trails, this is personalized natural history of a particular part of Utah. The chapter titled "The Environment, Then and Now" is a good layman summation of geologic and environmental history. A University of Utah Press publication.

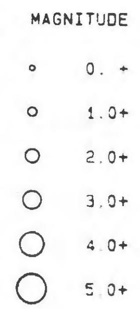
UTAH EARTHQUAKE ACTIVITY

by Susan J. Nava

UNIVERSITY OF UTAH SEISMOGRAPH STATIONS, DEPARTMENT OF GEOLOGY AND GEOPHYSICS

Utah Earthquakes July through September, 1988





During the three-month period July 1 through September 30, 1988, the University of Utah Seismograph Stations located 260 earthquakes within the Utah region (see accompanying epicenter map). Of these earthquakes, 86 had a local magnitude (M_L) or coda magnitude (M_C) of 2.0 or greater, nine had a magnitude of 3.0 or greater, and eight were reported felt.

The largest earthquake during the report period was a shock of M_L 5.3 on August 14 at 2:03 PM MDT on the northwest edge of the San Rafael Swell in central Emery County, 20 km southeast of Castle Dale, Utah. This was the largest earthquake to occur in the Utah region since the 1975 M_L 6.0 Pocatello Valley earthquake. The Emery County earthquake was felt strongly throughout central Utah (Modified Mercalli Intensity V to VI), where it caused some minor damage, and was reported felt as far away as Golden, Colorado and Albuquerque, New Mexico. Six foreshocks of M_L1.8 to 3.8 occurred during the 65 minutes prior to the main shock. The two largest foreshocks, of M_L2.9 at 12:58 PM MDT and of M_L3.8 at 1:07 PM MDT, and the largest aftershock of M_L4.4 on August 18 at 6:44 AM MDT, were felt in nearby small towns. The second largest aftershock, of M_L3.0, occurred on August 15 at 8:50 AM MDT. During the report period, 147 earthquakes associated with the San Rafael Swell sequence have been located. The aftershocks form an epicentral zone, 3 x 4 km adjacent to the main shock epicenter and elongated slightly in a north-northeast direction and a hypo-central zone extending from 8 to 15 km in depth and dipping 60°-70° east-southeast, with a length along strike of 4 km and a downdip extent of 8 km. (A preliminary seismological summary of "The Magnitude 5.3 San Rafael Swell, Utah, earthquake of 14 August 1988" by S.J. Nava, J.C. Pechmann, and W.J. Arabasz appeared in the last issue of Survey Notes.

Five other earthquakes of magnitude 3.0 and greater occurred in the Utah region during the report period: M_L 3.6 on July 10 at 2:45 PM MDT, located 30 km east of Ogden, Utah; M_L 3.1 on July 11 at 5:46 AM MDT, felt at Fayette, Utah; M_C 3.0 on August 9 at 5:07 PM MDT, located 25 km southeast of Soda Springs, Idaho; M_L 3.5 on August 21 at 5:21 PM MDT, located 30 km southwest of St. George, Utah; and M_C 3.1 on September 21 at 11:58 AM MDT, located 20 km west of Huntington, Utah. Additional earthquakes reported felt in Utah during the report period included shocks of: M_L 1.6 on August 23 at 11:13 PM MDT, felt in Salt Lake City; M_L 2.7 on September 8 at 3:42 PM MDT, felt at Goshen; and M_L 2.4 September 23 at 7:40 PM MDT, felt in West Valley City and Magna.

Additional information on earthquakes within Utah is available from the University of Utah Seismograph Stations.

Geo-Calendar

Meeting information is as accurate as we can make it. Listings may be sent to Survey Notes Editor, *but we're picky.*

A UTAH CHAPTER OF THE SOCIETY FOR INDUSTRIAL ARCHAEOLOGY was formed October 14 in Salt Lake City. Their first newsletter divulges diverse details concerning purpose, style and goals of the SIA. Contact Gary Daynes for information on the newsletter and to submit articles: 342 South 1200 East, #2, Salt Lake City, Utah 84102.

Feb. 8-10 MINING-INVESTMENT IN THE FUTURE, conference and exhibit. Denver, CO. Contact Colorado Mining Association, 1500 Grant Street, No. 330., Denver, CO 80203. (303) 894-0536.

Feb. 13-14 GEOPHYSICS OF THE ROCKY MOUNTAINS, MEETING in Golden, CO. Contact Front Range AGU Service Center, Box 18-P, Denver, CO 80218. (303) 831-6338.

Feb. 27-Mar. 2 SOCIETY OF MINING ENGINEERS 1989 ANNUAL MEETING AND TMS ANNUAL MEETING will be in Las Vegas, Nevada at the Las Vegas Convention Center. Contact Meetings Dept., SME, P.O. Box 625002, Littleton, CO 80162, (303) 973-9550.

Mar. 6-8 ROCKY MOUNTAIN SECTION, SOCIETY OF PETROLEUM ENGINEERS MEETING, Denver, CO. Contact Front Range AGU Service Center, Box 18-P, Denver, CO. 80218. (303) 831-6338.

Mar. 12-14 GSA SOUTH-CENTRAL SECTION MEETING in Arlington. Contact William L. Balsam, Dept. of Geology, Box 19049, Univ. of Texas, Arlington, TX 76019, (817) 273-2987.

Mar. 13-16 APPLICATION OF GEOPHYSICS TO ENGINEERING & ENVIRONMENTAL PROBLEMS, MEETING, Golden, CO. Contact Ron Bell, BellWest Geoservices, Box 10845, Edgemont Branch, Golden, CO 80401. (303) 237-5697.

Mar. 19-21 SOUTHWEST SECTION, AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS MEETING, San Angelo, TX. Contact AAPG, Box 979, 1444 S. Boulder, Tulsa, OK 74101. (918) 584-2555.

Mar. 20-23 ENGINEERING GEOLOGY AND GEOTECHNICAL ENGINEERING MEETING, Reno, NV. Contact Eng. Symp., Division of Continuing Education, Univ. of NV, Reno, NV 89557-0024 (702) 784-4046.

Mar. 23-25 GSA NORTHEASTERN SECTION MEETING in New Brunswick. Contact Richard K. Olsson, Dept. of Geological Sciences, Rutgers-The State University, New Brunswick, NJ 08903, (201) 932-2044.

Apr. 6-7 GSA SOUTHEASTERN SECTION MEETING in Atlanta. Contact J.A. Whitney, Dept. of Geology, University of Georgia, Atlanta, GA 30602, (404) 542-2652.

Apr. 5-7 SOCIETY OF PETROLEUM ENGINEERS REGIONAL MEETING, Bakersfield, CA. Contact SPE, Box 833836, Richardson, TX 75083-3836. (214) 669-3377.

Apr. 20-21 GSA NORTH-CENTRAL SECTION meeting in Notre Dame. Contact Michael J. Murphy, Dept. of Earth Sciences, Univ. of Notre Dame, Notre Dame, IN 46556, (219) 239-6686.

Apr. 23-26 AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS 74TH ANNUAL CONVENTION, San Antonio, TX. Contact AAPG, Box 979, 1444 S. Boulder, Tulsa, OK 74101. (918) 584-2555.

May 3-5 WESTERN SURFACE COAL MINING MEETING, Gillette, Wyoming. Contact Meetings Dept., SME, P.O. Box 625002, Littleton, CO.

May 7-10 ROCKY MOUNTAIN AND CORDILLERAN SECTIONS, GSA JOINT MEETING held in Spokane, WA. Contact Sandra Rush, GSA Communications Dept., P.O. Box 9140, 3300 Penrose Place, Boulder CO 80301; (303) 443-8489.

May 20-24 FOURTH U.S. NATIONAL CONFERENCE ON EARTHQUAKE ENGINEERING, in Palm Springs, CA. Contact Dee Czaja, 4NCEE, Civil Engineering Dept., Univ. of California, Irvine, CA 92717, (714) 856-8693.

July 9-19 28TH INTERNATIONAL GEOLOGICAL CONGRESS, Washington, D.C. For information contact Bruce B. Hanshaw, Box 1001, Herndon, VA 22070-1001, (703) 648-6053.

July 30-Aug. 2 SOIL AND WATER CONSERVATION SOCIETY 44TH ANNUAL MEETING in Edmonton, Alberta, Canada. Contact Alfred Birch, 7515 N.E. Ankeny Road, Ankeny, IA 50021.

Aug. 13-23 FRIENDS OF THE PLEISTOCENE, ROCKY MOUNTAIN CELL, 1989 FALL FIELD TRIP. Contact Pete Birkeland, Dept. Geological Sciences, Campus Box 250, Univ. of Colorado, Boulder, CO 80309.

Sept. 10-14 EDITING INTO THE NINETIES. Joint meeting at the Westin Hotel in Ottawa, Canada of Council of Biology Editors, European Assn. of Science Editors, Assn. of Earth Science Editors, and National Research Council of Canada. Contact Ken Charbonneau, Executive secretary, National research Council of Canada, Ottawa, Canada K1A OR 6, (613) 993-9009.

Sept. 10-14 WYOMING GEOLOGICAL ASSOCIATION 40TH FIELD CONFERENCE. Contact Lynette George, 2220 Volcaro Rd., Casper WY 82604 (307) 265-0775 or Stephen Hollis, PO Box 1068, Casper WY 82602 (307) 577-7460.

Oct. 1-6 ASSOCIATION OF ENGINEERING GEOLOGISTS ANNUAL MEETING, Vail, CO. Contact Denver Section, AEG, P.O. Box 15124, Denver CO 80215.

Oct. 23-26 FOURTH INTERNATIONAL CONFERENCE ON SOIL DYNAMICS AND EARTHQUAKE ENGINEERING, in Mexico City, Mexico. Contact A.S. Cakmak, Dept. of Civil Engineering, Princeton University, Princeton, NJ 08544, (609) 452-4601.

Nov. 6-9 GSA ANNUAL MEETING in St. Louis. Contact Sandra Rush, GSA Communications Dept., 3300 Penrose Place, Box 9140, Boulder, CO 80301, (303) 447-8850.

New Publications from the UGMS

Effective January 1, 1989. The UGMS is continually striving to improve our service to geoscientsts in industry, government, and higher education, and to policy-makers and the general public. One way is to make UGMS information more available and easier to obtain. To this end, we now accept mail and telephone requests for publications without requiring prepayment. There is no further charge (postage is now paid by us) except for the Utah sales tax for Utah residents.

Report of Investigation 218 Technical reports of the Wasatch Front County Geologists June 1985-June 1988, compiled by B.D. Black and G.E. Christenson, 154 p., 1988 .... $7.50

Open-File Report 140 Geology of Calico Peak quadrangle, Kane County, Utah, by H.H. Doelling and F.D. Davis, 40 p., 1 pl., 1:24,000, 1988 .... $5.50

Open-File Report 141 Geology of Lampo Junction quadrangle, Box Elder County, Utah, by D.M. Miller, M.D. Crittenden, Jr., and T.E. Jordan, 49 p., 2 pl., 1:24,000, 1988 .... $8.00

Open-File Report 142 Geology of the Cannonville quadrangle, Kane and Garfield Counties, Utah, by R. Hereford, 25 p., 1 pl., ... $4.00

Open-File Report 143 Quaternary geology — Tule Valley, west-central Utah, by D. Sack, 60 p., 1 pl., 1988 .... $8.00

Circular 80 Annual production and distribution of coal in Utah, by A.D. Smith and F.R. Jahanbani, 8 p., 1988 .... $2.50

Bulletin 122 Salt deformation in the Paradox region, by H.H. Doelling, C.G. Oviatt, and P.W. Huntoon, 93 p., 1988 .... $9.50

Miscellaneous Publication 88-3 Geologic consequences of the 1983 wet year in Utah by B.N. Kaliser and J.E. Slossen, 109 p., 1988 .... $13.50

Open-File Report 135 Thematic mapping applied to hazards reduction, Davis County, Utah, by B.N. Kaliser, 18 p., 1988 ..... $2.00

Open-File Report 138 Geology of the Crater Island quadrangle, Box Elder Co., Utah by D.M. Miller, T.E. Jordan, and R.W. Allmendinger, *available for public inspection at the UGMS Library.*

Open-File Report 139 Geology of the Lucin 4SW quadrangle, Box Elder Co., Utah, by D.M. Miller, T.E. Jordan, and R.W. Allmendinger, *available for public inspection at the UGMS Library.*

Open-File Report 82-DF Significant drill hole data of the Wasatch Front valleys, including Cache Valley and Tooele Valley, Utah by W.F. Case and C.D. Burt, 27 p., 1 5¼" diskette $5.00

Miscellaneous Publication 80-1 In the footsteps of G.K. Gilbert — Lake Bonneville and neotectonics of the eastern Basin and Range Province, guidebook for field trip twelve, Geological Society of America annual meeting, 120 p., 1988 .... $8.50

Open-File Report 144 Geology of Antelope Island, Davis County, Utah, by H.H. Doelling and others, 99 p., 2 pl., 1988, *available for public inspection at the UGMS Library.*

Map 107 Geologic map of the Howell quadrangle, Box Elder County, Utah, by T.E. Jordan, R.W. Allmendinger, and M.D. Crittenden, Jr., 10 p., 2 pl., 1:24,000, 1988 .... $5.00

Map 109 Geologic map of the Thatcher Mountain quadrangle, Box Elder County, Utah, by T.E. Jordan, M.D. Crittenden, Jr., R.W. Allmendinger, and D.M. Miller, 10 p., 2 pl., 1:24,000, 1988 .... $5.00

Map 54-C Ground-water resources of the central Wasatch Front area, Utah, by Don Price, 5 p., 3 pl., 1:100,000, 1988 .... $6.00

The latest publications catalog is available upon request!

Call For Papers

Those wishing to present papers at the *World Gold '89—Gold Forum Technology & Practices* meeting to be held October 22-25, 1989 are invited to submit a 200-word abstract. Held at Bally's Hotel, Reno, Nevada, the meeting is sponsored by Society of Mining Engineers and The Australasian Institute of Mining and Metallurgy. Submit abstracts to:

Meetings Department—World Gold '89
Society of Mining Engineers
P.O. Box 625002
Littleton, CO 80162
(303) 973-9550

A call for papers has been issued for the 1990 Society of Mining Engineers Annual Meeting, February 26-March 1, Salt Lake City, Utah. The deadline for receipt of preliminary abstracts is February 1, 1989.

To receive details of the proposed session topics, contact:

Meetings Department
Society of Mining Engineers
P.O. Box 625002
Littleton, CO 80162
(303) 973-9550, Telex: 881988, Fax: 303-973-3845.

Utah Geological Association requests papers for a 1989 conference/field trip focusing on geology and hydrology of hazardous-waste, mining-waste, wastewater or brine-disposal, and waste-repository sites in Utah. Tentatively scheduled for October 6-7 in Salt Lake City, the meeting will have papers printed in The Proceedings Guidebook and given orally. Brief descriptions are due December 1 and drafts by April 1, 1989. Contact:

Joseph S. Gates
U.S. Geological Survey, WRD,
1745 W. 1700 S., Salt Lake City, UT 84104.
(801) 524-4073 or (801) 524-4244.

Geological Society of America annual meeting in St. Louis, Missouri. Abstracts are due July 19. Abstracts Coordinator GSA, 3300 Penrose Place, P.O. Box 9140, Boulder, CO 80301, (303) 447-8850.

UGMS Projects

Readers of the last issue of Survey Notes will remember Director's Corner and the lead article by Genevieve Atwood on the "Sunset legislation" and its impact on the UGMS. Every year UGMS defines goals and how to achieve them. Goals and schedules are adjusted within the framework of the legislative mandate which defines the UGMS, and within the constraints of personnel and funding. The review process generates lists of projects, and the following is a very simplified version of that listing showing much of our current effort.

Newcastle geothermal project: a cooperative study with the U.S. Department of Energy to characterize the geology and geohydrology of a hydrothermal system near this town. Includes ground-based gravity and magnetic surveys, geologic mapping of bedrock and surficial deposits, shallow temperature gradient monitoring, soil-mercury geochemical sampling, water chemistry and O/H isotopic study.

Mineral evaluation of selected wilderness study areas in Kane County. The Department of Community and Economic Development for the state of Utah has elicited the help of UGMS to become better informed with regard to mineral potential of proposed Wilderness Study Areas in this county.

Land exchange study. The Division of State Lands and Forestry has requested that UGMS assist in determining mineral resource potential of certain tracts of state land within military reservations, and national parks and monuments. These tracts will then be compared to the mineral potential of land that the state wishes to exchange with the Bureau of Land Management.

Mineral occurrence map series. UGMS is preparing a series of maps showing mineral occurrences for Utah. The Tooele 1° x 2° sheet (1:250,000 with district maps at 1:48,000) is in review. The Delta and Cedar City 1° x 2° sheets are in progress.

Quaternary deposits in Millard County. This is one of the COGEOMAP projects (see Survey Notes v. 21, no. 2-3 for an explanation of this cooperative program) for geologic mapping in western Utah; scale 1:100,000.

Earthquake hazards map of Utah. A map at 1:750,000 scale and text depicting surface fault rupture, ground shaking, liquefaction, and other hazards in the state. The map is designed for use by planners in assessing hazards at a regional scale.

Quaternary faults, folds and selected volcanic features of the Cedar City 1° x 2° quadrangle, south-western Utah. A map at 1:250,000 and text for use in evaluating the potential for large earthquakes in southwest Utah, and for documenting Quaternary structural features and tectonics. Cooperative with U.S. Geological Survey.

Brochures on the economic geology of Utah's 29 counties for non-geologists in cooperation with DCED. The first one will be Box Elder.

Great Salt Lake research: ongoing collection, study, and interpretation of brine chemistry.

West Desert pumping-resource monitoring. A multi-agency effort to monitor the salt resource and the pumping effects.

Salines of Utah. In-depth study of oil-well brines, lake brines, geothermal brines, bedded salts.

Quadrangle mapping. UGMS, USGS, other professionals, and students map the geology of 7.5-minute quadrangle under UGMS auspices for publication at 1:24,000. The Spring issue will have a detailed summary of this program.

Sewer inflow-infiltration during the wet years 1982 to 1984.

Quaternary geology of the Newcastle 7.5-minute quadrangle, Iron County, Utah. Geologic mapping deposits in conjunction with USGS at 1:24,000.

Problem soils map of Utah. Compilation map at 1:750,000 scale of expansive and collapsible soils, karst, piping and erosion areas for regional planning purposes.

Wastewater disposal study. Map soil cover and bedrock to examine waste disposal problems in Duchesne County.

Geologic mapping of the Keg Pass 7.5-minute quadrangle. Mapping at 1:24,000 plus 1:48,000 mapping of the surrounding area as part of the U.S. Geological Survey Delta CUSMAP (see Survey Notes, v. 20, no.4).

Coal sample bank. Cooperative project with Fuels Department of University of Utah to characterize the producing coal seams of Utah. Samples from 24 active coal mines representing 15 seams are examined for macerals and ranked by reflectance.

Landslide inventory map of Utah. Compilation of data (at 1:100,000) to create a computer database and produce a regional map at 500,000.

National Coal Resource Data System. Cooperative agreement with USGS to compile and interpret coal data of Utah.

UGMS Projects, continued

Wasatch Fault trenching studies. Trenching and detailed analysis of faults along the valley margin to determine age, recurrence time, etc.

Regional assessment of geologic conditions for landfills. County-wide study of Sevier Co. at 1:100,000 to define areas geologically suitable for landfills.

High-calcium limestone resources of Utah. UGMS is preparing a sampling program of limestone units capable of yielding material for coal mine dusting, flux in steel and copper smelting, flue gas desulfurization, cement, and lime manufacturing.

Methane research. An examination of Methane resources of Utah; joint study with University of Utah; funded by DOE.

Henry Mountains and Alton Coal Field studies. Cross sections and isopachs of known coal resources.

Quaternary fault map of Utah. Compilation of potentially active faults, their distribution, timing, and size of recent surface faulting. Data will be used to make a 1:500,000 map with text.

Utah Zeolites. Compilation of existing data on zeolite deposits in Utah. Mapping, sampling, deposit characterization of large occurrences.

Earthquake hazards: Wasatch Front. Compilation of available data on earthquake hazards along the Wasatch Front.

Rockfall hazards: Wasatch Front and Cache County. Compilation and mapping at 1:24,000 of rockfall-prone areas.

Cleats in Utah coals. Cleat and joint measurements, interpretation; regional trend maps; evaluation of existing mine designs in relation to known cleat orientation.

County geologic mapping. Complete mapping and evaluation at 1:100,000 and publication.

Antelope Island geologic mapping. A complete, detailed geologic study of Antelope Island; to be published as a map and bulletin.

Petroleum geology of Grand County. As part of a county study, detail the activity and potential as well as subsurface geology.

Hingeline Study. A USGS cooperative study on the evolution of sedimentary basins and the Wasatch Front, Wasatch Plateau, and the Colorado Plateau.

Hazards bibliographic compilation. Earthquake, rockfall, landslide, problem soils, shallow ground water, flooding, etc. information is collected, verified, and entered in a computerized database for quick reference.

Utah Conference on the Potential Indoor Radon Hazard

Wednesday, June 21, 1989
8 a.m. to 5 p.m.
State Office Building Auditorium

Sponsored by the Utah Geological and Mineral Survey, the Utah Bureau of Radiation Control, and the University of Utah Research Institute.

Objective

This conference will provide a forum for public education by presenting a non-technical overview of current radon research. Topics will emphasize factors affecting Utah and the Rocky Mountain region. Major topics to be considered will include a definition of the basis for current concern, and will trace the course of public and professional involvement from detection of the potential hazard through prevention or mitigation.

Scope

A 1-day symposium will be held in Salt Lake City in mid-June, 1989. The audience will be drawn primarily from the non-technical public of the Wasatch Front region who desire to obtain more information on this recently publicized potential health hazard. Admission will be free, but a modest charge will be made for a volume of symposium talks.

GSA Fact Sheets

The GSA sends out information flyers of a geoscience nature which they call "Fact Sheets." The latest one, titled *Hydrology* is a good example of the genre: a basic, layman level, thorough explanation of the hydrologic cycle, its possible contamination, the means by which various parts of it are measured and explored, and a simplified set of illustrations. They are well written, informative, useful tools for teachers, science writers, and interested people in general.

Contact:
Geological Society of America
Communications Department
P.O. Box 9140
3300 Penrose Place
Boulder, CO 80301

UGMS Staff Changes

Cynthia Brandt, petroleum geologist and Sample Library Manager, has changed course to become Management Systems Analyst at University Hospital. The job combines her interests in computer systems and accounting to make cost accounting at the hospital a bit easier — our best wishes.

The Mapping Section has two new geotechs on a temporary basis, but *Michael Wright* and *Vajdieh Marxen* are already in full swing.

Jean Muller swapped her position as secretary for Economic/Mapping to stand behind a terminal for Eastern Airlines.

Our new monetary manipulator is *Werner Haidenthaller,* recently from the Legislative Auditor General's office. He is still trying to see over the stack of accumulated paperwork on the Accounting Officer's desk — good luck!

Michael Laine, late of Applied Section, has gone over to Oil, Gas and Mining for full-time work.

Venturing a little too near the Yawning Chasm, Grand Canyon, Arizona, U.S.A. Photo from the UGMS archives.

CORRECTION:

The full names of the following people were inadvertently omitted in the Acknowledgements section of *Geologic effects of the 14 and 18 August, 1988 earthquakes in Emery County, Utah,* SURVEY NOTES, Spring/Summer 1988, p. 13:

Sharon A. Jacobsen, of Emery, Guy Seeley, who resides in Clawson, and Darrell V. Leamaster, Castle Valley Special Service District.

This omission does not mean that their contribution to the report is less appreciated; Sharon provided significant rockfall distribution evidence, Guy noted a rockfall produced by an 18 August aftershock, and Darrell provided photographs and spring data which were essential to the report.

GREAT SALT LAKE LEVEL

Date (1988-9)	Boat Harbor South Arm (in feet)	Saline North Arm (in feet)
Aug 01	4208.05	4207.25
Aug 15	4207.60	4206.90
Sept 01	4207.40	4206.55
Sept 15	4207.05	4206.20
Oct 01	4206.85	4206.00
Oct 15	4206.70	4205.90
Nov 01	4206.60	4205.65
Nov 15	4206.50	4205.60
Dec 01	4206.50	4205.60
Dec 15	4206.45	4205.60

Source: USGS provisional records.

UTAH DEPARTMENT OF NATURAL RESOURCES
Utah Geological and Mineral Survey
606 Black Hawk Way
Salt Lake City, Utah 84108-1280

Address correction requested

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