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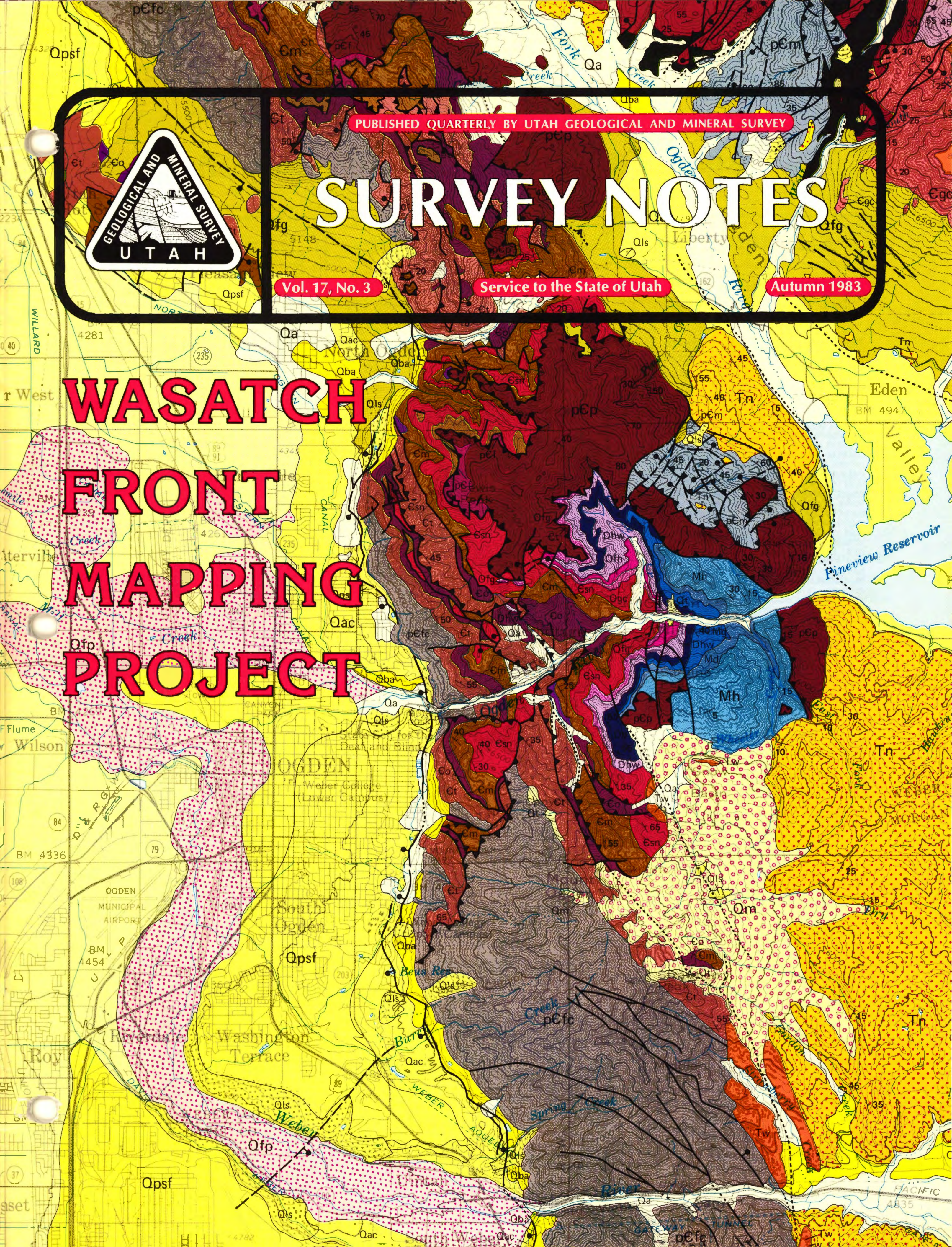
WASATCH FRONT MAPPING PROJECT



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The Salt Lake Daily Tribune.

WEEKLY TRIBUNE

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EARTHQUAKES.

A Prophetic Discourse by G. K. Gilbert, United States Geologist.

The Matter Brought Home to the People of Salt Lake.

There are many geologists who are very wise, but even they do not understand the forces which produce mountains. And yet it must be admitted, not only that mountains have been made, but that some mountains are still rising. The mysterious forces appear to act in different ways in different places, and it is possible that their nature is not universally the same. Suffice it to say that in the Great Basin the movements they cause are vertical. It is as though something beneath each mountain was slowly, steadily, and irresistibly rising, carrying the mountain with it.

In yielding to this all-compelling upward thrust, the earth's crust sometimes bends and stretches, but more often it breaks; and when it breaks, the fracture occurs in a peculiar place. It does not run along the medial axis of the mountain, but along one margin. On one side of the fracture the crust is lifted and tilted; on the other side it either sinks or remains undisturbed. The uplifted part of the crust is the mountain, and the storms carve out its canyons; the unlifted part remains a lowland or valley, and receives the debris washed out from the canyons.

A mountain is not thrown up all at once by a great convulsive effort, but rises little by little. The subterranean upthrust is continuous and slow, and would produce a continuous upward movement of the mountain if the mountain's weight were the only resisting factor. But there is also a great friction to overcome, the friction along the surface of fracture, between the rising and stationary parts of the crust; and friction gives to slow motion an interrupted or rhythmic character.

The disagreeable jarring of a railway car started while the brake is set is due to the interruption of motion by friction, the wheels alternately sliding and stopping. The musical vibration of a violin strings is due to the alternate cohesion and sliding of the bow upon it, and fails when the friction of the bow is insufficient. Attach a rope to a heavy box and drag it slowly, by means of a windlass, across a floor. As the crank is turned the tension of the rope gradually increases until it suffices to overcome the starting friction, as it is called. Once started, the box moves easily, because sliding friction is less than starting friction. The rope shortens or sags until its tension is only sufficient for the sliding friction, and it would continue in that state but that the box, having acquired momentum, is carried a little too far. This slacks the rope still more, and the box stops, to be started only when the tension again equals the starting friction. In this way the box receives an uneven, jerky motion.

Something of this sort happens with the mountain. The upthrust produces a local strain in the crust, involving a certain amount of compression and distortion, and this strain increases until it is sufficient to overcome the starting friction along the fractured surface. Suddenly, and almost instantaneously, there is an amount of motion sufficient to relieve the strain, and this is followed by a long period of quiet, during which the strain is gradually reimposed. The motion at the instant of yielding is so swift and so abruptly terminated as to constitute a shock, and this shock vibrates through the crust with diminishing force in all directions. Movable objects are displaced, and the soil, which is moveable as compared with solid rock, is cracked. In consequence of earth-cracks subterranean waters find new channels, leading to the stoppage of some springs and the starting of others. In fine, all the phenomena of an earthquake are produced.

This is not a universal theory of earthquakes—some of them are doubtless to be accounted for in a different way; but it affords a sufficient, and I do not doubt that it affords the true, explanation of the earthquakes of the Great Basin. In this region a majority of the mountain ranges have been upraised by the aid of a fracture at one side or the other, and in numerous instances there is evidence that the last increase of height was somewhat recent.

Let us look a moment at this evidence. The material eroded from a mountain by the elements is washed out through the canyons and deposited in the adjacent valleys. The coarser part of it lodges at the mountain base, and is built into a sloping mass called the foot-slope, or colloquially the "bench." When an earthquake occurs a part of the foot-slope goes up with the mountain, and another part goes down (relatively) with the valley. It is thus divided, and a little cliff marks the line of division. A man ascending the foot-slope encounters here an abrupt hill, and finds the original grade resumed beyond. This little cliff is, in geologic parlance, a "fault-scarp;" and the earth fracture which has permitted the mountain to be uplifted is a "fault." In the course of time the same slow process of erosion and deposition which originally formed the foot-slope restores its shape and obliterates the fault-scarp. When a mountain ceases to grow its fault-scarp soon disappears; and conversely, when we find a fault scarp at the base of a mountain we are assured that the uplifting force has not ceased to act. Fault scarps have now been found at the bases of so many ranges of the Great Basin that it is safe to say that the subterranean forces are generally active in this region, and this is especially true of all the large mountain masses. The Wasatch is a conspicuous example, and residents of this city need not go far for ocular demonstration. A fault scarp, thirty or forty feet high, divides the powder houses north of the Hot Spring, so that some of them stand above and some below it, and considerable grading was necessary to lead the road to the upper magazines. With one exception, all the lime kilns between the powder houses and the Warm Springs are built in the face of the fault scarp, the lime rock being conveniently delivered to the kilns from the upper level, and the lime as conveniently drawn out at the lower level. At the mouth of Little Cottonwood Canyon a smelter has been built on the edge of the upper bench for the convenience of dumping its slag over the fault scarp. At the mouth of Spanish Fork Canyon the D. & R. G. railroad encounters the scarp, and the engineers have started an embankment a long way back to climb it. Similar features may be seen, with rare intervals, all along the mountain base from Nephi to Willard.

The fault scarps of the Wasatch follow the western base. Those of the Sierra Nevada follow the eastern base; and it happens that one of them has been formed since the settlement of the country. It occurred in 1872, and produced one of the most notable earthquakes ever recorded in the United States. The height of the scarp varies from five to twenty feet, and its length is forty miles. Various tracts of land were sunken a number of feet below their previous positions, and one tract, several thousand acres in extent, was not only lowered, but carried bodily about fifteen feet northward. The ground was cracked in various directions, and several springs permanently disappeared. All houses of adobe or stone in the immediate vicinity were thrown down, and about thirty persons lost their lives. In the little town of Lone Pine, numbering some three hundred inhabitants, twenty-one were killed by falling walls

There was only one violent shock, and the damage was all done in a few seconds, but for two months there were occasional tremors. Theoretically, the main strain of the earth's crust was relieved at once, but a complete equilibrium was brought about more slowly.

The surviving inhabitants of Lone Pine observed that the only houses which remained standing were of wood, and in rebuilding they employed that material exclusively. Such a course was natural, but I conceive that their precaution was unnecessary. They may indeed feel feeble shocks propagated from earthquakes centering elsewhere, but in their own locality the accumulated earthquake force is for the present spent, and many generations will probably pass before it again manifests itself. The old maxim "Lightning never strikes the same spot twice," is unsound in theory and false in fact; but something similar might truly be said about earthquakes. The spot which is the focus of an earthquake (of the type here discussed) is thereby exempted for a long time. And conversely, any locality, on the fault line of a large mountain range, which has been exempt from earthquake for a long time is by so much nearer to the date of recurrence—and just here is the application of what I have written. Continuous as are the fault scarps at the base of the Wasatch, there is one place where they are conspicuously absent, and that place is close to this city. From the Warm Springs to Emigration Canyon fault scarps have not been found, and 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.

It is useless to ask when this disaster will occur. Our occupation of the country has been too brief for us to learn how fast the Wasatch grows; and, indeed, it is only by such disasters that we can learn. By the time experience has taught us this, Salt Lake City will have been shaken down and its surviving citizens will have sorrowfully rebuilt it of wood: to use a homely figure, the horse will have escaped, and the barn-door, all too late, will have been closed behind him.

When the earthquake comes, the severest shock is likely to occur along the line of the great fault at the foot of the mountain. This line follows the upper edge of the upper bench from Big Cottonwood canyon to the rifle targets back of Fort Douglas, cutting across each creek just where it issues from between walls of bed-rock, and passing only a short distance back of the Fort. At a point not far north of the targets the fault divides; one branch continuing northward, across the spur, toward Farmington; the other turning westward, running just back of that hopeless artesian boring, and following the upper edge of the gravel bench to the vicinity of the Warm Springs. Should the earthquake follow the former of these branches, the city will not fare so badly as the Fort; should it follow the latter, or follow both, city and fort will alike suffer severely.

What are the citizens going to do about it? Probably, nothing. They are not likely to abandon brick and stone and adobe, and build all new houses of wood. If they did, they would put themselves at the mercy of fire, and fire, in the long run, unquestionably destroys more property than earthquakes. It is the loss of life that renders earthquakes so terrible. Possibly some combination of building materials will afford security against both dangers.

G. K. GILBERT.

FROM PAGE 4, COLUMNS 4 & 5

G.K. Gilbert's Warning of Salt Lake City's Earthquake Hazard — One Hundred Years Later

By JAMES F. PETERSEN

A century ago, on September 16, 1883, the *Salt Lake Daily Tribune* published an article by Grove Karl Gilbert that warned of serious earthquake hazards to Salt Lake City. Gilbert presented evidence of geologically recent faulting along the Wasatch Front, and made reference to recurrence intervals, seismic gaps, earthquake mechanisms, the relationship between building construction types and earthquake casualties, and the human reaction to natural hazards. The article is notable as an early discussion of these topics of current interest.

Gilbert felt that, as a responsible scientist, his discoveries should be reported to the citizens of Salt Lake City and he wrote a letter to the *Tribune* to alert the people of this potential danger. The same message was communicated to the scientific community in the *American Journal of Science*, January 1884 (p. 49-53).

Gilbert stated that the Wasatch fault zone should be considered active and that the mountains would continue to rise. He admitted that scientific knowledge concerning seismicity and earthquake hazard was incomplete and inadequate, but warned that a major earthquake could occur at any time. To sum up these points Gilbert wrote:

> "It is useless to ask when this disaster will occur. Our occupation of the country has been too brief for us to learn how fast the Wasatch grows; and indeed, it is only by such disasters that we can learn. By the time experience has taught us this, Salt Lake City will have been shaken down . . ." (Gilbert, 1883; 1884, p. 52).

Gilbert's article is fairly well-known among those who are concerned with earthquake studies in Utah. However, it is not common knowledge that on Wednesday, September 19, 1883, the *Salt Lake Tribune* ran an editorial reply to Gilbert's warning. The rebuttal, entitled "Zion and Earthquakes," begins with a somewhat facetious condemnation of the religious reverence for Salt Lake City, but continues with a passage that reveals some important insights into the attitudes of the people at that time. The author is unknown, but many of the arguments he employed are repeated today, implying that not much progress has been made in educating the public about seismic hazards. The latter part of the reply to Gilbert is reprinted below (verbatim, but in four sections with commentary):

> "There have been shocks plainly felt here at different times; we are on the earthquake belt; there are plenty of signs of seismic action up and down the valley; Mr. Gilbert found in leveling the high bench mark of Lake Bonneville that it had changed its relative altitude at different points by three hundred feet or more; and yet the internal forces of the earth have given no signs of activity about here in recent years that probably need depreciate the price of city lots."

Here, the writer reveals a knowledge of Gilbert's work on isostatic deformation of Lake Bonneville shorelines, but apparently confuses that issue with tectonic uplift of the Wasatch. The comment on real estate values is particularly significant, as it suggests that there may have been little change in public attitudes on this issue in the last one hundred years.

> "It seems that the rising of the mountains and the descending of the hills (valleys) can go on and does without causing any faults that shake down towns. Mr. Gilbert instances the case at Lone Pine of a fault fifteen feet, vertical, and forty miles in length. It seems to have been enough to throw down the houses on the people, but it was not much to the old fault made when the Wasatch was upheaved, which Clarence King said was eight miles vertical."

This section refers to Gilbert's comparison of the Wasatch piedmont fault scarps to those which formed at the base of the Sierra Nevada during the Lone Pine, California earthquake of 1872. Gilbert noted that the Wasatch scarps looked remarkably similar to those near Lone Pine (which were 11 years old at the time). However, the rebuttal suggests that the Wasatch Range has resulted not from many small increments of faulting, but from an ancient and massive upheaval. The writer misses some of Gilbert's points, particularly that 1) mountains may be built by small surface offsets separated by times of inactivity, and 2) over millions of years of geologic time, the cumulative uplift from these small offsets may produce thousands of feet of relief.

> Evidently that kind of faulting was finished and done a long time ago, and it may be safely trusted that the valley, even under the city, rests on a solid foundation. It won't do for us all to load a car load on a wheelbarrow, if the scientific men do. However, Mr. Gilbert's one wheel may carry the weight, and the inclined plane under the city may be dropped down at the heel.

(see page 10)

Dr. James F. Petersen, assistant professor, Southwest Texas University.

IN THIS ISSUE

WASATCH FRONT MAPPING PROJECT

By FITZHUGH D. DAVIS

The Wasatch Front Map series project was conceived for the purpose of presenting geologic and hydrologic information to a potentially broad spectrum of users and the first group of these maps is now available. The Wasatch Front maps are a cooperative venture of the Utah Geological and Mineral Survey and the Water Resources Division of the U.S. Geological Survey. Presently, the UGMS is committed to publish 12 maps - a geologic map, a surface-water map, a ground-water resources map, and a mineral resources and petroleum potential map for each of three areas along the Wasatch Front. The maps are at a scale of 1:100,000 and cover the northern, central, and southern Wasatch Front (Figure 1). Short texts accompany the maps. The USGS is contributing the surface-water and ground-water resources maps and the UGMS is contributing the geologic and mineral resources maps. Features common to all the maps are 100-foot contour intervals, numerous bench marks, towns, highways, trails, waterworks, and other cultural symbols.

The geologic maps show information that can be used by city, county, and state planners; engineers; landowners; students; hikers; scouts; outdoor people; and geologists. For example, landowners and engineers can pinpoint very closely the location of mapped faults and landslides. Also, students, hikers and scouts, by using the map and explanation, can identify the various rock types and their ages as they hike along roads or trails. The surface-water and ground-water resource maps are intended for use by landowners, planners, hydrologists, and engineers. The mineral resources and petroleum potential maps should be of interest to landowners, planners, people in the mining and petroleum industries, engineers, and geologists.

Thus far, the geologic maps of the central Wasatch Front and the southern Wasatch Front have been published (UGMS Maps 54-A and 55-A). Also, the three surface-water resources maps have been published (UGMS Maps 53-B, 54-B, and 55-B). The geologic map of the northern Wasatch Front (UGMS 53-A) is ready for publication and will appear soon. The ground-water resources maps and texts for the northern and central Wasatch Front have been completed by the USGS and cartographic work is in progress. All 12 maps should be published by summer 1984 and will be sold individually and also as an atlas.

As viewed from the west the Wasatch Mountains are an imposing escarpment, the base of which separates the Basin and Range physiographic province from the Middle Rocky Mountains physiographic province. The Wasatch Front has a great diversity of rock types that range in age from Precambrian X to Holocene. These rocks have been deformed into complex structures and are involved with igneous intrusions, unconformities, normal faults, and thrust faults. Important precious and base metal mining districts are associated with some of the igneous intrusions. The Bingham mining district alone has yielded over $5 billion in metal values since 1863. Water from the mountains and ground-water in the valleys supply the domestic, industrial, and agricultural needs of three-fourths of the state's population along the Wasatch Front.

The Geologic Maps (A-series)

The geologic maps are a compilation of the best available sources which were GQ maps of the U.S. Geological Survey, geological society publications, university theses, Utah Geological and Mineral Survey publications, Brigham Young University Geology Studies, and other U.S. Geological Survey publications and open-file reports. In areas where information was missing, or inadequate, mapping of a reconnaissance nature was done. The geologic sources are shown on an index map on the explanation sheet that accompanies each map. None of the source maps were originally at the scale of 1:100,000. Extreme care was exercised to accurately reduce and join source maps.

The Wasatch Front is a segment of the geologically old Wasatch line which was the hingeline of the Cordilleran miogeocline from at least early Precambrian Z time (800 million years B.P.) until the end of the Paleozoic Era (225 million years B.P.). West of the hingeline great thicknesses of marine basinal and shallow-water sediments accumulated during this time. East of the hingeline a markedly thinner shelf sequence of sediments was deposited adjacent the craton. During Triassic and Jurassic time sedimentation diminished (or ceased) west of the hingeline and increased east of it.

From latest Jurassic time to early Cenozoic time the Sevier Orogenic belt formed in eastern Nevada and western Utah. East-west compressional forces produced large folds and thrust faults that transported thick sections of basinal strata eastward across the Wasatch line. Along the Wasatch Front, from north to south, the major thrust faults are the Willard and the Charleston which are probably connected in the strata of the downdropped grabens along the front. Erosion and eastward drainage from the thrust sheets resulted in the deposition of thick clastic units.

The Laramide anticlinal uplift of the Uinta Mountain arch in Late Cretaceous and Paleocene time produced a synclinorium in the central Wasatch Front (Emigration syncline, Spring Canyon anticline, and Parley's syncline). The east-west axis of the Uinta arch crosses the Wasatch Front just north of Little Cottonwood Canyon. To the south, between Dry Creek Canyon and American Fork Canyon, the Uinta uplift produced an eastward-plunging anticlinorium.

In Eocene and Oligocene time, igneous rocks, including the Alta, Little Cottonwood, and Bingham stocks, were emplaced along the Uinta arch axis.

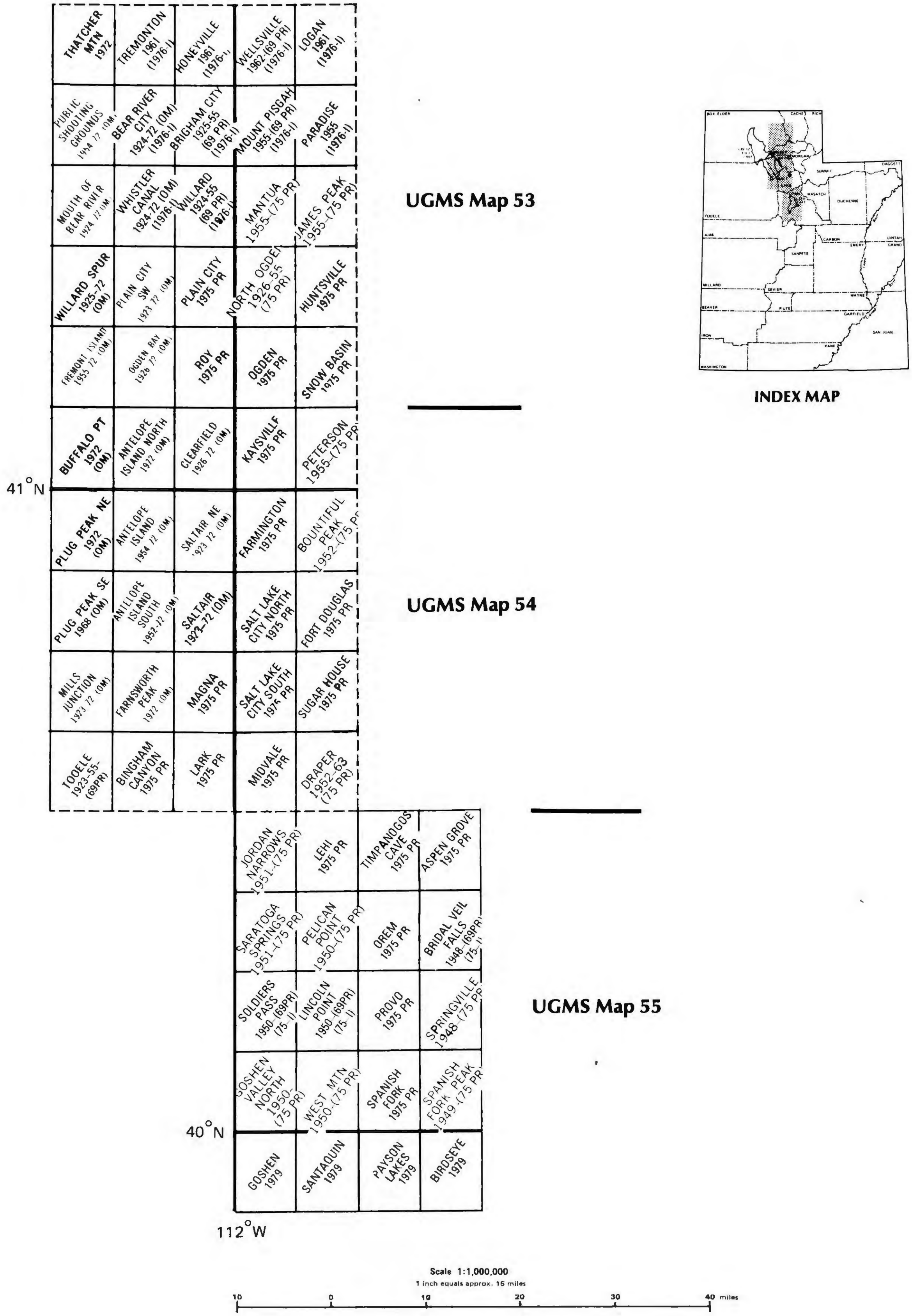


Figure 1. Index of topographic quadrangles covered by the UGMS Wasatch Front map series.

A view to the northwest of the Warm Springs fault scarp adjacent to Beck's Street in North Salt Lake. This is an active Quaternary fault (photo H. H. Doelling).

Basin and Range normal faulting commenced during Oligocene or Miocene time. Differential uplift and subsidence occurred along large-scale, north trending faults that displaced prior thrust planes and produced horsts and grabens that outline the present mountains and valleys. A reversal of drainage (to the west) also took place. Basin and Range faulting is still proceeding as witness the seismically active Wasatch fault zone adjacent the western base of the Wasatch Mountains as well as the east Cache fault zone at the western base of the Bear River Range.

During Pleistocene time, lakes inundated the Wasatch Front valleys, Cache Valley and Ogden Valley. Glaciation was extensive in the higher parts of the Wasatch Range.

Precambrian, Paleozoic, and Cenozoic rocks are present on all the maps. Mesozoic rocks are not exposed on the northern Wasatch Front map, but are present on the others. Tertiary igneous rocks, both intrusive and extrusive, are present in the central and southern areas. The northern Wasatch Front map has 45 bedrock stratigraphic units and 12 Quaternary units; the central map shows 43 bedrock stratigraphic units, four igneous rock units, and 13 Quaternary units; the southern map portrays 40 bedrock stratigraphic units, two igneous rock units, plus 13 Quaternary units. In a number of cases the same stratigraphic unit was present on two, or all three, of the maps; for examples, the Precambrian X Farmington Canyon Complex and the Pennsylvanian-Permian Oquirrh Formation. Most of the Quaternary units were used on all three maps.

The Surface-Water Resources Maps (B-Series)

The purpose of the three surface-water resources maps is to show in a general way the quantity and dissolved-solids concentration of surface-water along the Wasatch Front. The U.S. Geological Survey monitors 80 or more streamflow-gaging stations along the front. Approximate drainage areas, periods of record, average discharges, recorded extremes (maximum and minimum), and number of recorded cloudburst floods are tabulated.

For the northern Wasatch Front area, nearly the entire surface-water supply, averaging approximately 2 million acre-feet per year, comes from the Bear and Weber river systems. The surface-water supply for the central Wasatch Front area averages approximately 600,000 acre-feet per year. Most of this supply comes from the Jordan River, central Wasatch Front streams, and imports. The average annual surface-water inflow to the southern Wasatch Front area is also on the order of 600,000 acre feet. Most of the inflow comes from the Provo River and Spanish Fork. Hydrographs portray the monthly discharges, recorded extremes, and mean annual runoffs for all the major and some moderately flowing streams.

Surface-water in the northern Wasatch Front area ranges from fresh to moderately saline. Surface-water in the central Wasatch Front area ranges from fresh to briny. Surface-water in the southern Wasatch Front area generally ranges from fresh to slightly saline according to the following USGS classification:

Class	Dissolved-Solids Concentration (milligrams/liter)
Fresh	less than 1,000
Slightly saline	1,000 - 3,000
Moderately saline	3,000 - 10,000
Very saline	10,000 - 35,000
Briny	more than 35,000

The Ground-Water Resources Maps (C-Series)

Unconsolidated and partly consolidated valley fill (chiefly alluvial and lacustrine deposits) contains most of the ground-water available for development by wells in the northern and central Wasatch Front areas. This fill, of Tertiary and Quaternary age, consists chiefly of interbedded clay, silt, sand, and gravel and local intermixtures of those materials along with cobbles and boulders. The coarser materials are dominant near the mountains, whereas the finer materials are dominant in the lower valley areas. The fill exceeds a thickness of 1,000 feet in Cache Valley and it probably exceeds 2,000 feet in the lower Bear River Valley. In the East Shore area (Ogden and North Ogden areas) it probably exceeds 5,000 feet. Locally the fill is fully saturated. In Jordan Valley the maximum thickness of the fill exceeds 4,000 feet and in parts of the lower valley areas that fill is saturated to the land surface.

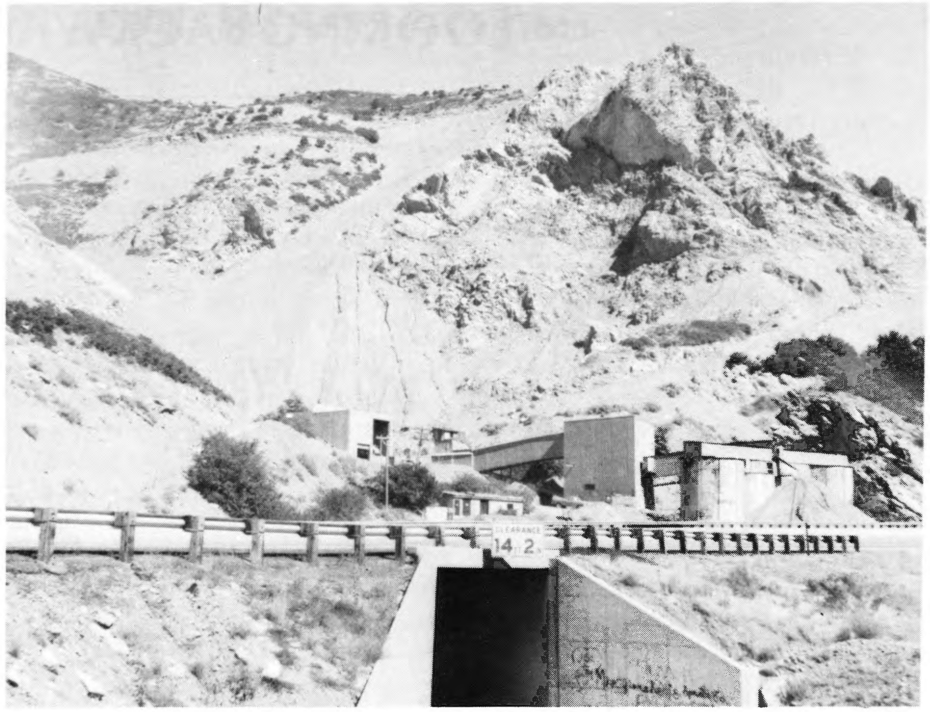
The volume of recoverable water in the upper 100 feet of saturated fill in the northern Wasatch Front area is computed to total more than 4 million acre-feet. Considerably more water is available from the fill at greater depth. The volume of recoverable water in the upper 100 feet of saturated fill in Jordan Valley, Tooele Valley, and East Shore areas is estimated at 5.6 million acre-feet. Again, more water is available at greater depths. Estimates of annual recharges to the ground-water for these areas are given in the reports. Annual withdrawals from the ground-water are also given. The approximate altitude and configuration of the potentiometric surface of water in the valley fill areas are shown on the maps. These maps show the general areas in which wells that tap one or more deep confined aquifers in the fill will flow under artesian pressure.

Ground-water in the Wasatch Front area generally ranges from fresh to moderately saline. Water in the consolidated rocks of the Wasatch Mountains is generally fresh and in most places contains less than 500 milligrams per liter of dissolved solids.

The Mineral Resources and Petroleum Potential Maps (D-Series)

The mineral resources maps will show lithologies rather than formations. The lithologies portrayed will be metamorphic rocks, carbonate rocks (limestone and dolomite), igneous intrusives, igneous extrusives, coarse clastics, and fine clastics. Unconsolidated deposits (Quaternary and Late Tertiary) will be shown in two categories; (1) sand and gravel, and (2) other deposits. Each group provides unique environments in which certain types of mineral deposits are favored.

Smaller scale petroleum potential maps depict five categories of areas ranked according to petroleum potential. The categories range from "best" prospects for petroleum to "very poor or no" prospects for petroleum. The "best" prospects appear to be the deeper parts of the Great Salt Lake Cenozoic basin. A table shows the wells drilled for petroleum along the Wasatch Front areas. The data include the operator, lease, location, completed date, elevation, total depth, the formation at total depth, and pertinent remarks (tops, etc.).



A view of the cement rock quarry of the Portland Cement Company of Utah on the north side of Parley's Canyon. The formation is the Twin Creek Limestone of Jurassic age (photo H. H. Doelling).

The mineral resources have been divided into three categories. They are shown on the map by a symbol and are listed on one of the tables; metallic mineral resources on Table 1, nonmetallic mineral resources on Table 2, and construction materials on Table 3.

The Wasatch Front lies astride an east-northeast alignment of intrusive rocks that extend through the Stansbury Mountains, the Oquirrh Range, the Wasatch Mountains, and almost to the Uinta Mountains. A number of important metal mining districts are closely associated with the intrusives along the alignment. The zoned ore deposits in the huge Bingham Canyon open-pit mine are discussed as well as the replacement deposits in the Carr Fork area. The potential for finding additional metallic mineral deposits is present in the Wasatch Front area. They will be more difficult and expensive to find than in the past.

Several non-metallic minerals are presently being exploited along the Wasatch Front. Sodium chloride ($NaCl$), sodium sulfate (Na_2SO_4), potassium sulfate (K_2SO_4), and magnesium brine ($MgCl_2$) are currently harvested from solar evaporation ponds utilizing Great Salt Lake brines. In June 1976 the total dissolved ion load was 4.6 billion tons in the Great Salt Lake. The salt industry on the Great Salt Lake is not limited by the resource; present production extracts only 40 percent of the total annual dissolved solids inflow to the lake. The potential also exists for the extraction of compounds of lithium, boron, bromine, and especially potassium chloride.

Common clay, mostly for brick making, has been mined from numerous pits in Utah County. About 75 percent of the production has been from pits in weathered Manning Canyon Shale of Mississippian-Pennsylvanian age in the western part of the county. Holocene lacustrine-alluvial clays have also been mined. In Salt Lake County several clay pits in Lake Bonneville strata were mined along the east bench of Salt Lake City. The Cottonwood Mine of the Interstate Brick Company in the NW 1/4 Sec. 24, T 2 S., R. 1 E was abandoned in 1981. Hydrothermally altered shale of the Big Cottonwood Formation (Precambrian) was mined and used in the manufacture of common bricks. Growth of the clay

(see page 15)

LOOKING BACKWARD

By Wm. LEE STOKES

In the Land of Paradox

A journey with J. Wesley Powell down the Green River to its junction with the Colorado (formerly the Grand) brings us into the heart of Canyonlands or Standing-up Country, as the cowboys call it. Here our pioneer geologist is J. S. Newberry who was attached to an United States Army expedition sent out in 1859 to locate the junction of the Grand and Green Rivers.

His report reads something like an Alice in Wonderland story. Newberry gave a good description of the scenery, but, except for fossils, he couldn't correlate much of what he saw. The expedition literally got lost in the canyonlands and failed to reach its objective, the river junction, by many miles. Newberry wrote: "Perhaps four miles below our position it (the Grand) is joined by another great gorge coming in from the northwest, said by the Indians to be that of the Green River. From the point where we were it was inaccessible, but we have every reason to credit their report in reference to it." This is what might be called geology according to the local natives and the "you can't get there from here" philosophy.

Looking Backward
Fourth article in a continuing series

Newberry was probably the first geologist to see the Navajo Sandstone. And his is the first conjecture as to how it originated. He reports: "It exhibits the most striking example of oblique stratification which has ever come under by observation. The slopes of the inclined layers are often 50 or 60 feet in length showing they were deposited from water, at times very much agitated. It is a rather remarkable fact, that with such inclined and contorted layers of deposition this rock should include so little coarse material, and it is impossible to resist the conclusion that it is far more a chemical than mechanical precipitate, and that the period of its deposition was the commencement of a great epoch, during which peculiar physical conditions prevailed over not only the greater part of our continent, but of the world, so peculiar and so widespread that we may almost call them cosmical." It would be interesting to know what Newberry had in mind when he wrote this. Did he or did he not believe in Noah's universal flood? It goes without saying that still, after 125 years, the origin of the Navajo Sandstone is a hotly contested subject. I believe it was Herbert E. Gregory who first proposed an aeolian origin. The debate goes on and we pass to other topics.

Newberry's expedition of 1859, Hayden's Survey of the 1870's and Cross' reconnaissance of 1905 made known the surface stratigraphy of the eastern Colorado Plateau, but none of them perceived the meaning of the dominant structures of the region. The Atlas of Colorado, compiled by the Hayden Survey, and published in 1881, is the first map of the region, it shows the fossiliferous Carboniferous in some of the salt anticlines and accounts for these exposures by simple erosion of anticlinal folds.

The first geologic maps of entire salt anticlines were those of R. C. Coffin, published in Bulletin 16 of the Colorado Geological Survey, representing work done in 1914-18. Coffin's maps covered the Colorado section of the salt anticline region and included Gypsum, Paradox, and Sinbad Valleys. Coffin discussed and portrayed all he saw in terms of ordinary folding and faulting — the term salt is used only once in connection with a brine well in Paradox Valley. To him the anticlines were breached folds eroded to the Carboniferous. His cross-sections show full thicknesses of all the formations in and adjacent to the folds. Any anomalous thinning he took care of by liberal use of normal faults.

The realization that these impressive structures were produced and shaped by flowage and dissolution of salt came quite suddenly when they were examined by geologists with the proper (see page 12)

Typical outcrop of the Navajo Sandstone. The origin of the cross-bedding and other primary structures has been a subject of intense interest since the formation was first discussed by Newberry in 1859 (photo William L. Stokes).

NCIC STATE AFFILIATES MEET AT UGMS

The State Affiliates of the National Cartographic Information Center (NCIC) held their annual meeting in Utah, at the UGMS, on September 19 and 20, 1983. After a welcome speech by Genevieve Atwood, Director of the UGMS, Bill Graser, Acting Chief of the NCIC Rocky Mountain Mapping Center, presented a report on new developments. Karla Springer, EROS Data Center Coordinator, reported on the user services at the EROS Data Center in Sioux Falls, South Dakota, the repository of all U.S. Department of Interior film. State Affiliate representatives from New Mexico, Texas, Arizona, Montana, and Utah discussed their problems and successes with the program. Mage Yonetani, UGMS librarian, is in charge of the Utah State Affiliate Office.

What is the NCIC? Who needs it? How does it work?

The Utah State Affiliate of the NCIC provides information on the availability of satellite imagery and aerial photography, maps and charts, map data in digital form, and geodetic control.

The EROS Data Center in Sioux Falls presently has on file more than 6 million frames of space imagery and aerial photography. The Utah NCIC office can order a customized computer search of this file and will furnish, at no charge, a printout itemizing the products which best fit your specifications.

NCIC has access to the holdings of aerial photography of Utah and throughout the United States, which has been generated by over 105 contributors including Federal and State agencies and commercial firms. What is not available locally can be ordered through the NCIC or from the agency or company which holds the photography.

Most of the published USGS maps of Utah and adjoining states are available from the USGS Public Inquiries Office, 125 South State Street, Salt Lake City, UT, 84138, (801/524-5652). Maps of many Utah Mines are available from the UGMS on special order.

The Utah State NCIC Affiliate has map indexes and listings on microfiche for the following imagery and photography. Orders for these products can be placed through the Utah State Affiliate.

A. Satellite Imagery Availability

1. **Landsat:** Listings of United States coverage, on microfiche for all Landsat Imagery, showing quality, cloud coverage, etc. Imagery can be ordered in black and white or false color composites, at scales of 1:1,000,000, 1:500,000 or 1:250,000.
2. **Skylab:** Listings of United States coverage, on microfiche, for black and white and color photography, at various scales from 1:1,000,000 to 1:125,000.

B. Aerial Photography Availability

1. **USGS Aerial Mapping Photography:** Microimages and index maps on microfiche of all available USGS photography of Utah and portions of adjoining states. Coverage for other states can be ordered through the NCIC, Rocky Mountain Mapping Center, USGS, Box 25046, Stop 504, Federal Center, Denver, CO 80225 (303/234-2326).
2. **NASA Photography (U-2 and RB-57):** Listings for all coverage in Utah and portions of adjoining states. Coverage for other states can be ordered through the NCIC in Denver.

C. Map Availability

We have indexes for and can provide information on the availability of the following kinds of maps. All USGS published maps of Utah and adjoining states can be purchased directly from the USGS Public Inquiries Office in Salt Lake City.

1. **Topographic Maps (USGS):** Indexes for Utah, Arizona, Colorado, Idaho, Nevada, New Mexico, and Wyoming. We also have indexes of the status of the topographic mapping program for Utah and the United States. Preliminary copies of topographic maps of these states may be purchased from NCIC in Denver.
2. **Aeromagnetic Coverage (USGS):** Indexes of the western states.
3. **Geologic Maps (USGS):** Indexes for Utah, Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, and Wyoming.
4. **Historical Maps (Topographic) (USGS):** We have 35mm microfilm of out-of-print topographic quadrangle maps of Utah, Idaho, Nevada, New Mexico, Wyoming, and Colorado. We will provide copies of these maps upon request for cost of reproduction plus $1.00 service charge.
5. **Land Use and Landcover Maps (USGS):** Index for the United States.
6. **Mine Maps:** We have an index on microfilm and listings of many Utah mines from the U.S. Bureau of Mines. We also have copies of these maps on file. These can be seen at the USGS and copies can be made for cost of reproduction plus $1.00 service charge.
7. **Orthophotoquads (USGS):** Map showing status and availability in Utah and the United States. Quads for Utah can be seen in our office and can be ordered from NCIC in Denver.
8. **Orthophotomaps (USGS):** Listings of the United States (1:24,000 scale).
9. **1:100,000 Scale Quadrangle Format Maps (USGS):** Indexes and status for United States.
10. **1:50,000 and 1:100,000 Scale County Format Maps (USGS):** Indexes and status for United States.
11. **State Maps (USGS):** 1:500,000 and 1:1,000,000 scales; base, topographic and relief maps; listings and order forms.
12. **Maps of Moon and Other Planets:** Listings and order forms.

D. Digital Data Availability (Computer Generated Earth Terrain Models)

We have information on availability of Digital Terrain Models (DTM) (1:250,000 series) and for Digital Elevation Models (DEM) (1:24,000 series).

E. Utah Multipurpose Maps Scale 1:250,000

Order from Utah Travel Council, Council Hall, Salt Lake City, UT 84114, (801/533-5681) at $.50 each or $4.00 per set of eight. ■

UGMS Maps

Need a map? The UGMS has been publishing a variety of maps since the late 1940s of many aspects of the geology and mineral resources of Utah.

The present best seller is the *Geologic Map of Utah,* scale 1:500,000, in full color, with a second sheet showing the key to the formations, lithologic sections, and structural cross sections of selected areas of the State. This map sells for $18.00, prepaid (all prices quoted here include postage and mailing tube for rolled maps but not Utah sales tax).

A new series of maps, also in full-color, depicts the geology, surface-water resources, ground-water resources, and mineral resources of the Wasatch Front between the Idaho state line on the north and Mona Reservoir on the south. Published at a scale of 1:100,000, geologic maps of the Central Wasatch Front (Map 54-A, Salt Lake Valley) and the Southern Wasatch Front (Map 55-A, Utah Valley) are completed ($6.50 each, includes two sheets). All three surface-water resource maps (Maps 53-B, 54-B, and 55-B) are also available ($5.50 each, includes two sheets). The other maps will be available soon.

The geology of the Big Cottonwood area, southeast of Salt Lake City, is shown on Map 49, also in full-color, scale 1:24,000, for $8.00. This map was published in 1978.

The county map series has always been popular. Some "oldies but goodies" that are still available are the colored geologic maps of Cache (Map 12, 1958; $5.50), Daggett (included in Bulletin 66, 1959; $11.50), Washington (Map 14, 1960; $4.00), and Uintah (Map 16, 1964; $6.50) Counties. A reconnaissance map of Eastern Iron County (Map 1), published in 1950, is still available for $2.50. More recent county maps are those of Garfield (included in Bulletin 107; $11.50) and Box Elder (Map 57; $11.50) Counties. Maps for the counties of Emery (Bulletin 52), Piute (Bulletin 102), Salt Lake (Map 15, Bulletin 69), San Juan (Special Studies 24), and Sanpete (Bulletin 85) are now out-of-print but are available on microfiche in the UGMS library.

Another group of "best sellers" includes the various commodity maps. Most in demand is Map 68, *Energy Resources Map of Utah*, newly revised in 1983, and published in ten-colors at a scale of 1:500,000 ($9.00). Shown on it are the coal, geothermal, tar sand, oil shale, oil and gas, and uranium deposits of the State. Map 61, *Oil and Gas Fields of Utah*, scale 1:750,000 ($6.50), gives the name, status, and producing formations of each coal field. Map 66 delineates the *Coal Fields of Utah* (scale 1:100,000) and includes locations of coal mines active in 1982; it is available for $3.00. Map 50 (scale 1:250,000) shows active oil shale operations in the eastern Uinta Basin ($3.50). Map 51 (scale 1:1,000,000) shows the locations of Utah's active and historic mining districts ($3.50). Two new maps (scale 1:750,000) showing the metallic and nonmetallic mineral resources of Utah are now in press and will be available in December 1983.

Other UGMS maps include geologic quadrangles, gravity maps, and engineering geology maps. Map 69 shows the geology of the Thistle landslide area east of American Fork, where the landslide blocked the river and created a large lake ($4.00).

All of these maps, and more, are available at the UGMS Sales Office. For more information call (801) 581-6832. ■

("G.K. Gilbert's Warning" cont'd. from page 3)

Again, the writer states misinformation. Apparently he felt that the Wasatch rose in the distant past, and then uplift ceased. In fact, a major point of Gilbert's article was that uplift continues, but that the time of occupation of the region has been short in comparison to the recurrence interval of major seismic events.

> "If so, if it is to be, and Zion is to rise and fall, instead of rise and shine, we shall repeat the old man's by-word, 'There's no great loss without some small gain,' that is if it spares us and our house."

The conclusion reverts back to semi-seriousness. But the final statement reflects a common reaction to natural hazards. Concern is greatest among those who are directly affected or suffer the most as a result of the event.

This editorial offers a testimony to the apparently minor change in human reaction to earthquake hazard since the time of Gilbert. Even though the editorial was written one hundred years ago, many of the statements have a familiar ring. A number of the arguments presented, such as the discussion of real estate values, are similar to current public perceptions of earthquake hazards. The author's mis-interpretations of geologic literature suggest some important themes concerning the true nature of the problem, particularly relating to the active nature of the Wasatch fault zone. Our scientific knowledge has increased in the last century, but like Gilbert, our ability as scientists to effectively educate the public in the area of natural hazards apparently remains limited. Research efforts should be matched by a level of equal commitment toward effective public communication. The facts need to be stated clearly and in a jargon-free manner, emphasizing what is known and avoiding points that are problematic academic concerns. The public should not misunderstand the scientific debate concerning earthquake hazard in the Wasatch Front region. While there may be much difference in opinion on some of the finer points, there is widespread agreement of the hazard potential of a major earthquake along the Wasatch.

The events of 1983 were a painful reminder to Utahns of the susceptibility of their state to nature's destructive forces. This is a time when the public should be particularly receptive to information concerning geologic hazards.

The Governor's Conference on Geologic Hazards, held in August and coordinated by the Utah Geological and Mineral Survey, represents an important step toward developing a meaningful exchange of information and ideas between government officials, scientists,

(see page 15)

Governor Scott M. Matheson addressing opening session of geologic hazards conference at the University of Utah (photo R. Ollins, DNR Public Affairs).

Governor's Conference on Geologic Hazards

At the request of Governor Matheson, a conference on the geologic hazards of Utah was held at the University of Utah on August 11 and 12, 1983. The conference was sponsored by the U.S. Geological Survey, Federal Emergency Management Agency, Utah League of Cities and Towns, Utah Association of Counties, Utah State Legislature, Division of Comprehensive Emergency Management, and the University of Utah and was coordinated by the Utah Geological and Mineral Survey. The objectives of the conference were: (1) to increase the awareness and understanding of geologic hazards in Utah, (2) to determine that attitude of the public and officials, (3) recommend actions to minimize the losses from geologic hazards.

Governor Matheson opened the conference with a major address outlining his concern about geologic hazards and his commitment to action to protect Utah from these hazards. The remainder of the first session consisted of presentations by national experts describing the geologic hazards of Utah. In the afternoon two concurrent sessions discussed: (1) the 1983 landslides and mudflows, and (2) the emegency response to these events and to flooding. On the second day 35 working groups considered assigned problems relating to geologic hazards and produced 171 recommended actions.

The recommendations of the conference are being compiled into a report scheduled for publication in December 1983. This report will include recommended actions by: (1) the Executive Branch of State Government, (2) the State Legislature, (3) local governments, and (4) Federal agencies. The Governor is considering several executive orders implementing conference recommendations and two or more items of legislation will be proposed for consideration by the budget session of the legislature in January 1984, with additional items requiring further study. ■

COAL PETROLOGY SHORT COURSE ANNOUNCEMENT

The Utah Geological and Mineral Survey is offering a short course in the Foundation and Practice of Coal Petrology at its Salt Lake City location on March 12-15, 1984. For more information contact Alex C. Keith (801) 581-6831.

HEADS UP

By BRUCE N. KALISER

This year's extraordinary number and variety of slope movements made clear that concern should be focused upon the stability of slopes above a building site as well as upon slopes below the site. Any modification to sloping ground above a site has the potential of destabilizing all or a portion of the slope. Too often when the stability of a slope is evaluated, not enough concern is given to what is happening higher on the slope, perhaps even outside of visibility. Yet what is above should certainly be of concern. Let us look now at a number of prospective slope problems for which one should be alert when examining a site.

Runoff and erosion are among the most obvious problems effecting slopes. Resulting removal of material may be very gradual or very rapid. Snow may accumulate on benches or terraces on sloping ground where it may largely infiltrate the soil upon melting. Even so, a combination of warm rain and snow melt has potential for aggravated runoff and erosion below the bench. Drainage across the highest terrace may have been naturally or artificially concentrated onto the face below. The start of gulleying may mean the start of a succession of problems, including possibly landsliding. If there are boulders within the slope material, or an indurated layer such as caliche, slope erosion may undermine the rock and causing it to roll downslope, possibly endangering life as well as property.

Sights on Public Facility Sites
Twelfth article in a continuing series

Even blocks of a bedrock slope can become detached and if they move rapidly downslope can be devastating. Evidence of prior such rockfall events may be scattered about the site or in the site vicinity. It may be prudent, even on a mountain front, to look for evidence of rock in precarious positions either on bare rock faces or enroute downslope on talus or colluvial slopes.

Earth and rock or a combination of the two may be actually sliding or poised, awaiting some slight environmental change, for sliding. The failure surface may be shallow or deep; and expertise should be engaged to make that determination. Even a shallow slide is not to be discounted in its potentially damaging effects. It has been shallow landsliding this year, for the most part, which has caused the extensive debris flows and debris floods which were so destructive along the Wasatch Front north of Salt Lake City. It is possible that a shallow, small slide well above a site could end up in creating a flow down the remainder of the slope distance and onto a site even beyond the break-in-slope. Establishing the probability for such an event is not easy, however, but recognition of any potential problem can lead to preventative measures being designed for the site. In many cases the prospects for larger slides can be better assessed. Larger slides may involve bedrock and may exert upward pressures on foundations beyond the toes of slopes. They have the potential, therefore, of being totally destructive, whether in slow or fast mode.

Observation of upper slopes is requisite to any analysis of potential problems. Important observations include, but are not confined to, vegetative cover, animal burrowing activity, depressions and other topographic anomalies, changes in land use, and the presence of partially lined or unlined canals or ditches. Low points in canal banks, when directly overhead, can be devastating should a landslide block the canal downstream. Backed-up waters will find the low spot and cause havoc below, as happened in Logan in July of this year and on other previous occasions.

Finally, consideration must be given to earth movements induced by earthquakes, both near and distant. The presence of perched ground water is frequently the greatest threat to stability during ground vibration. Liquefaction of saturated silt or sand layers can occur instantly in a moderate or strong ground shaking event and result in a slide and/or flow across a lower site. Springs or seeps higher on a slope may be considered as onimous warning, even if only seasonal in occurrence. Even bedrock ridges can be weakened in a phenomenon known as ridge shatter, or rock dislodgement can occur on talus cones or from fractured rock faces.The October 28th of this year magnitude 7.1 Idaho earthqake provided illustrations of such slope movements in the Intermountain area, including a debris flow delayed in triggering for two days after the event. Rock falls come into residential neighborhoods in the town of Challis.

Focusing attention upon all earth and rock slopes above a site, whether entirely in their natural state or man modified, is quite prudent. A geologic event such as a rock fall, landslide, debris flow or mud deposition may be triggered by a high intensity rainfall, rapid snowmelt, irrigation system malfunction, buried pipeline leak or earthquake but the presence of the malfunction latent hazard should and can be evaluated. Heads up for an awareness of the complete site hazards picture. ■

("Looking Backward" cont'd. from page 8)

background. In a brief paper published in the February 1927 AAPG Bulletin, T. S. Harrison made the uncontestable suggestion that the dominant structures of the area are salt generated. He knew about salt domes in the Gulf Coast and this was the vital connection. In the same AAPG volume, Prommell and Crum, published on the same topic. Wells had already been drilled on the anticlinal theory. At first, those drilled into Paradox salt were terminated at shallow depths. Later, some were pushed as much as 16,000 feet through the salt cores without finding oil. Clearly these are no ordinary anticlines. The one great oil field that really produced from a major salt structure is the Lisbon Valley Field. In it, subsurface conditions are complex and may be unique. ■

UTAH EARTHQUAKE ACTIVITY — April to June, 1983

By WILLIAM D. RICHINS

The University of Utah Seismograph Stations records a 60-station seismic network designed for local earthquake monitoring within Utah, southeastern Idaho, and western Wyoming. During April to June 1983, 200 earthquakes were located within the Utah region (Figure 1).

The largest event occurred on May 3, 1983 at 06:43 AM approximately 10 km southeast of Hanksville, Utah. This magnitude 3.0 earthquake was felt by local residents. Other significant aspects of earthquake activity include:

(1) continued activity near Soda Springs, Idaho, with magnitudes less than 2.5;

(2) on-going microseismicity with magnitudes less than 2.7, east and south of Logan, Utah, beneath the Bear River Range including a magnitude 2.6 event on April 30, 1983 near Huntsville, Utah;

(3) a magnitude 1.8 earthquake felt near Magna, Utah, on April 13, 1983;

(4) a cluster of activity within Goshen Valley approximately 45 km southwest of Provo, Utah, including a magnitude 2.9 earthquake on June 9, 1983 which was felt locally;

(5) continued acitivity in the vicinity of the coal mines southwest of Price, Utah.

Senior staff seismologist, University of Utah Seismograph Stations.

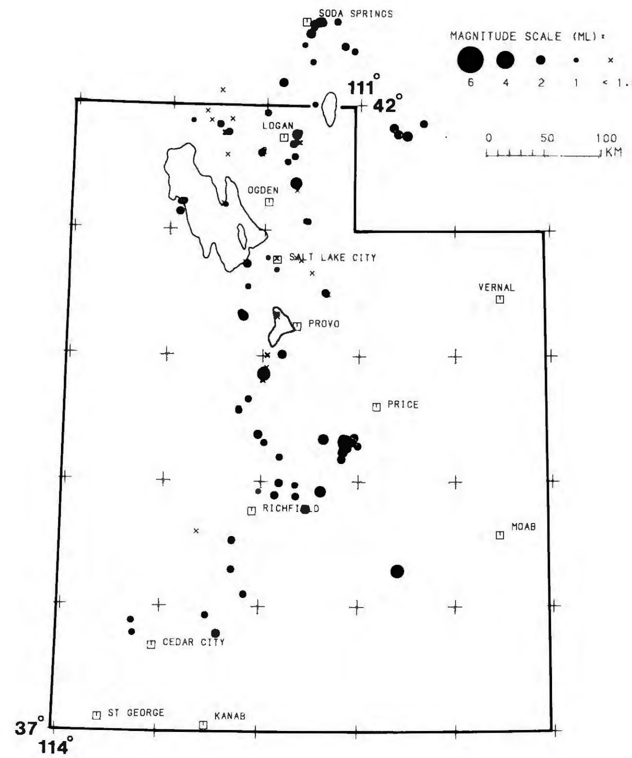


Figure 1. Utah earthquakes: April through June 1983.

CORRECTION: Figures 2 and 3 in the Spring 1983 issue of *Survey Notes* (pages 14 and 15) appeared incorrectly; the two correct maps are shown below.

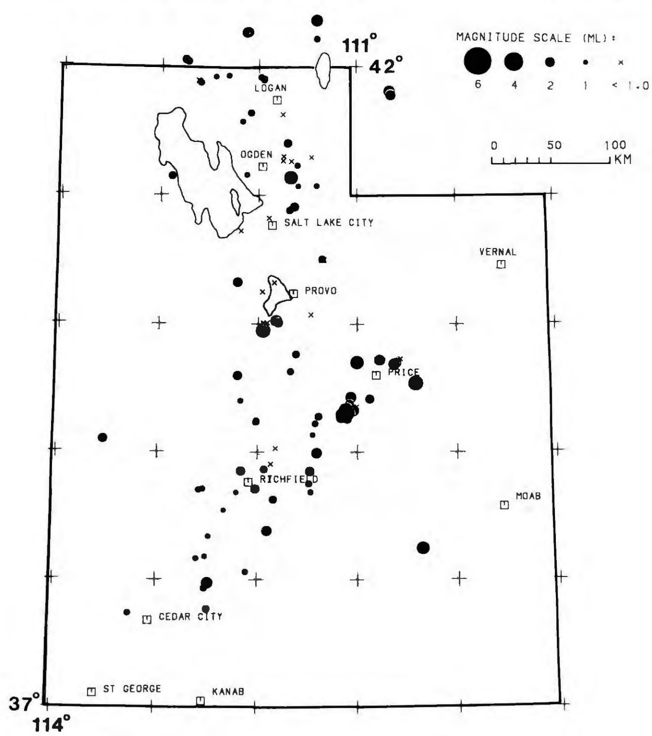


Figure 2 (Spring issue). Utah earthquakes: January through March 1983.

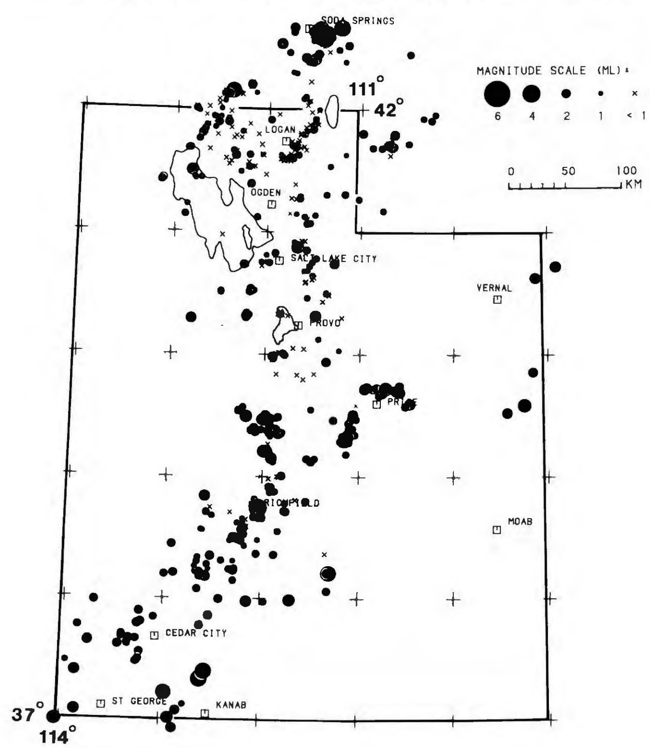


Figure 3 (Spring issue). Figure 2 (this issue). Utah earthquakes: 1982.

Clara Warr Retires — Recalls History of UGMS Growth

Clara Warr joined the UGMS in April 1966 and has watched the Survey grow from a organization of five full-time and four part-time employees to its present size of more than 40 full-time employees and about 10 part-time graduate students.

"For much of the time," Clara recalls, "I was responsible for all the personnel matters, the budget, the accounting, purchasing, paying bills, and seeing that the Survey had all the supplies and equipment it needed to operate. It was a close-knit organization, everyone working closely together." Clara could be counted on to keep things rolling.

However, she began to wonder what the staff was up to when they talked of "ducks" and "duck ponds." She discovered the "ducks" did not quack or lay eggs, they were amphibious boats used for research on Great Salt Lake, and the "duck pond" was a wire-fenced enclosure to store the boats when they were not on the lake.

In 1966, the UGMS was associated with the University of Utah, and had a total budget of $276,000. Two months after Clara joined the staff, Hellmut Doelling, now senior geologist for the Mapping Section, rejoined UGMS as an economic geologist. In September 1966, Bruce Kaliser, now chief of the Hazards Section, joined as engineering geologist, and in January 1967, Howard Ritzma, later assistant director and chief of the Petroleum Section joined as the petroleum geologist (he recently returned to private consulting). "The late 1960s was a period of rapid growth, productivity, and high morale for all of us," Clara remembers.

On July 1, 1973, the UGMS was transferred from the University to the Utah Department of Natural Resources. The following year, Dr. William P. Hewitt, who had been director since 1961, retired and was replaced by Donald T. McMillan. In February 1976, the Survey had outgrown the old Engineering Building on the campus and moved to its present quarters in the University of Utah Research Park. "The new building made working conditions so much better," Clara said, "and gave us more room to expand."

Genevieve Atwood became director and state geologist on July 1981. A new period of expansion began. The UGMS building was recently remodeled to provide for a new Mapping Section, research laboratories, and a new computer system. "The UGMS now has a staff of over 40 full-time employees, with a budget in excess of $2,000,000. One person can no longer do all the things I used to do," Clara says.

"Now I intend to do some traveling and to spend more time with my family and my grandchildren. I really enjoyed working for the Survey. I treasure the friendships I made and the experiences we shared. It was an enjoyable 17-1/2 years.

Clara and husband Al were feted at a farewell banquet at a Salt Lake City restaurant where she was presented with Samsonite luggage and other gifts. Amongst the "other" gifts were a collapsible oriental hat, a framed doctored-up final time sheet, hand carved jadeite stamp, and mounted halite crystal trophy. Attendees were presented "Remember the Warr Years" pins and husband Al was given an "I survived the Warr Years" pin at the appropriate time. A 15 minute blackout did not appear to dampen the high spirits of the evening.

Says Genevieve Atwood, "For the UGMS, the 'Warr Years' represent 17½ years of dedicated service to the UGMS and the State of Utah. Clara handled an exceptionally heavy work loac diligently, putting in extra hours when needed and using resourcefulness and ingenuity to tackle new situations, new regulations, and even new directors. We all miss her and wish her well in her retirement." ■

UGMS Staff Changes

The following staff changes have taken place since the last issue of *Survey Notes* was published:

Clara Warr, administrative assistant, retired on August 31 after working 17½ years for UGMS (see related story). **Ginger Mattulat** is the new administrative assistant. She graduated from the University of California, Irvine with a bachelor's degree in Social Ecology and has previously worked as administrative assistant for the Earth Science Labratory in Salt Lake City.

Richard L. Barker, receptionist, transferred on September 2 to Motor Pool; Richard had been with the Survey since December 28, 1981. His replacements are **Miriam Bugden** and **Cathy Nanz** who will job-share the receptionist position. Miriam has a bachelor's degree in geology and experience with private industry in minerals exploration. Cathy also has a bachelor's degree in geology.

On October 31, **Archie D. Smith,** chief of the Energy Section, was advanced to the position of senior geologist for the Economic Geology Program to replace **Dianne Nielson** who was recently appointed director of the Division of Oil, Gas and Mining.

Archie received his bachelor's degree from Brigham Young University in 1957 and is a candidate for a master's degree from BYU in December 1983. His recent work experience includes six years at the UGMS where he has had a variety of assignments in coal and project management. ■

Dear Fellow Geologists:

We have many inquiries regarding Utah geology, in areas where published geologic coverage is unavailable or inadequate, and where unpublished field mapping or other geologic studies have been done, are being done, or are planned. Therefore, the Utah Geological and Mineral Survey is soliciting your cooperation for our computerized listing of those areas in Utah being studied by geoscientists in your university or agency.

Please circulate this form among your staff for the required information, and return the information by February 15, 1984. On the map on the reverse side of this page, indicate the quadrangles covered (or to be covered) and type(s) of study.

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

You may be interested to know that the Utah Geological and Mineral Survey now has a complete bibliography of the geology of the state on computer; listing of references can be made by type of study, subject, or area. Readouts are available for cost of search plus a $10.00 service fee.

Many thanks for your time and effort.

Genevieve Atwood

Genevieve Atwood, Director
Utah Geological and Mineral Survey

Chief Investigator: ______________________

Your Organization: ______________________

Address: Street or P.O. Box ______________________

City ______________________ State __________ Zip __________

Scope and class (i.e., detailed, reconnaissance, photo interpretation - with or without field checking, etc.) __________

____

Dates: inception: ______________ proposed completion: ______________

Probable location of information (i.e., thesis file only - where; publication - where; etc.) __________

Probable status on completion: (i.e. University thesis; open-file - where; release date and provisions, where; state or technical agency - where; publication - where; company confidential.) __________

____

May we have a copy of the completed report and map for our library? __________

Are you interested in a computer printout of bibliographic references for the area? _____ Yes _____ No If so, we will send you more information.

Please supply the following information, if applicable:

Which Counties are Covered by this Study?

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		

Principal Physiographic Provinces of Utah Covered by this Study

Great Basin Colorado Plateau Northern Rockies High Plateaus

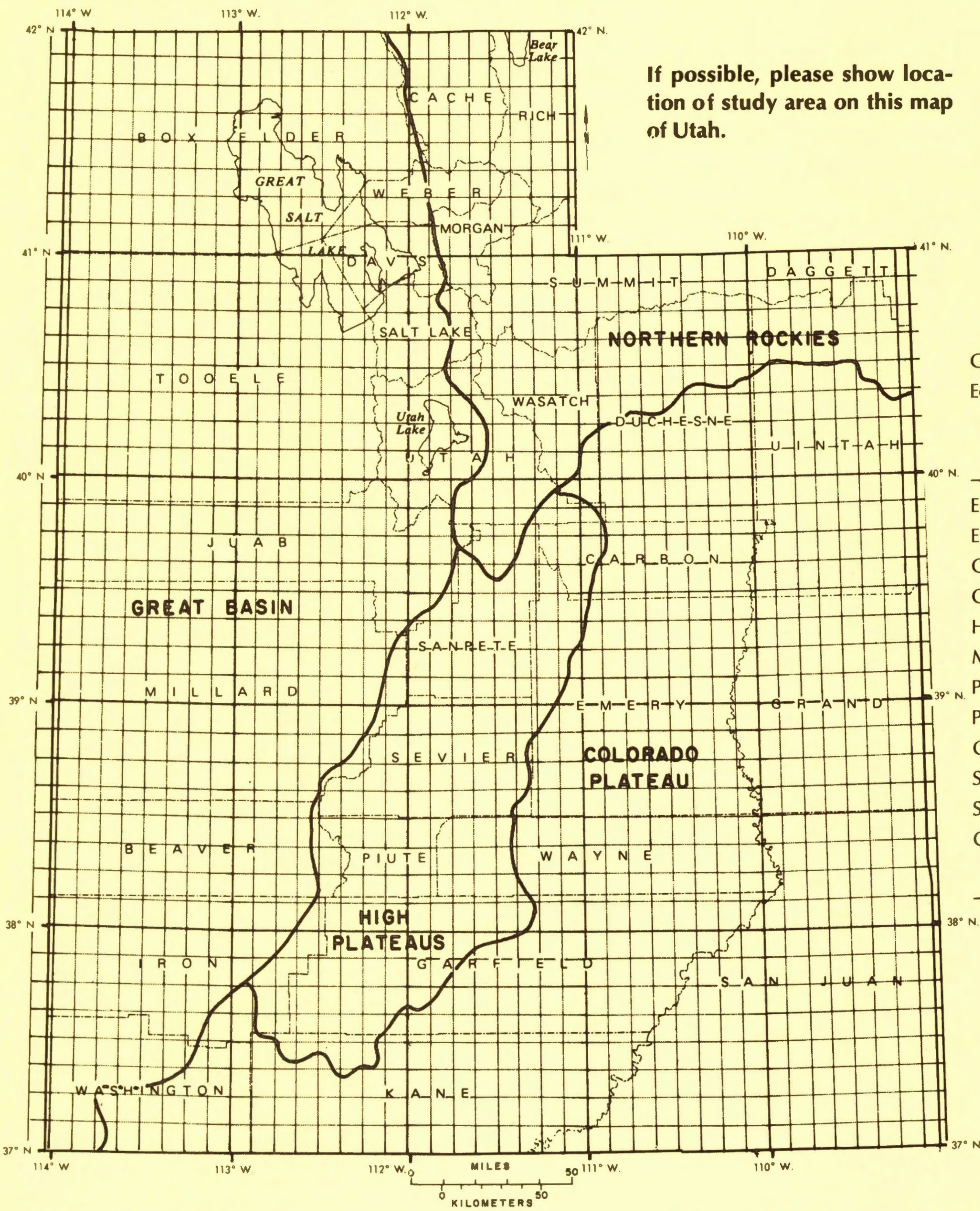
If Site Specific, What is the Section, Township and Range?

________ 1/4 ________ 1/4 ________ 1/4 Section ________

Township ________ Range ________ Meridian ________

Scale of completed maps ________________

If possible, please show location of study area on this map of Utah.



What Type of Study?

Geologic Mapping ______
Economic Geology ______
Commodities ______

____

Engineering Geology ______
Environmental Geology ______
Geochemical ______
Geophysical ______
Hydrological ______
Mineralogical ______
Paleontological ______
Petrological ______
Quaternary Soils ______
Stratigraphic ______
Structural ______
Other (please specify) ______

____

Please return this form to Utah Geological and Mineral Survey, 606 Black Hawk Way, Salt Lake City, Utah 84108. Attn: Information Section.

("G.K. Gilbert's Warning" cont'd. from page 10)

educators, and citizens. The conference encouraged a new era of preparedness. Ignoring or denying the potential for geologic hazards only increases the impact of such disasters. The need for basic seismic research and emergency preparedness planning remains great, but a commitment to public education and dissemination of information should also be a major emphasis of scientific efforts in the future.

In the conclusion of his article, Gilbert (1884, p. 53) asked, "What are the citizens going to do about it?" and answered with his prediction, "Probably nothing." Much of Gilbert's scientific work has been venerated by the scientific community and has withstood the test of time in terms of ideas, insights, innovations and accuracy. We have the opportunity to prove him wrong on one point, that Utahns will do nothing about seismic hazard. The citizens of the Wasatch Front and those of other seismically hazardous areas of Utah may not be as lucky in the next one hundred years as they have been in the last. ■

References

Anonymous, 1883, "Zion and Earthquakes," *The Salt Lake Daily Tribune*, September 19, 1883.

Gilbert, G. K., 1883, "A Theory of the Earthquakes of the Great Basin, with Practical Application," *The Salt Lake Daily Tribune*, September 16, 1883.

________, 1884, "A Theory of the Earthquakes of the Great Basin, with Practical Application," *American Journal of Science*. Third Series, vol. 27, no. 157, p. 49-53.

GREAT SALT LAKE LEVEL

Date (1983)	Boat Harbor South Arm (in feet)	Saline North Arm (in feet)
August 1	4204.70	4201.65
August 15	4204.60	4201.70
September 1	4204.65	4201.80
September 15	4204.65	4201.95
October 1	4204.60	4202.05
October 15	4204.80	4202.20
November 1	4204.95	4202.35
November 15	4205.00	4202.45

Source: USGS Water Level Records.

("Wasatch Front Mapping" cont'd. from page 7)

industry should parallel the population and building trends.

Potential non-metallic resources of the Wasatch Front include the following:

(1) Phosphate from the Permian Park City Formation.

(2) Silica refractories in the quartzite beds of the Mutual Formation, Big Cottonwood Formation, and the Tintic Quartzite.

(3) Argillites and altered shales and siltstones of the Big Cottonwood Formation for ceramic materials. Other possible ceramic resources are the feldspars in the pegmatites and small granitic stocks of the Farmington Canyon Complex and in the quartz monzonite of the Little Cottonwood stock.

Construction materials of the Wasatch Front include cement, dimension stone, lime, and sand and gravel.

The main source of cement rock in Utah is the Twin Creek Limestone (Jurassic) which contains most of the essential materials for Portland Cement. The formation is about 2,800 feet thick, crops out extensively in the central Wasatch Mountains, and is capable of supporting a much larger cement industry if the demand would require it.

The Nugget Sandstone (Triassic and Jurassic) and the Tertiary quartz monzonite (granite) of the Little Cottonwood stock have been quarried and used for dimension stone and/or flagstone. The Farmington Canyon Complex has been used as a source of field stone in the construction of numerous attractive homes. These formations, and possibly others, offer a great potential for building stones.

Sand and gravel, used mainly as concrete aggregate, is abundant along the Wasatch Front. All the presently active pits have been developed in the shore and nearshore deposits of Lake Bonneville (Late Pleistocene). These shore facies represent (1) beach deposits, (2) embankment gravels, (3) spits and bars, and (4) deltas. Commercial pits may produce numerous sizes of aggregate for different construction and paving specifications. The operators are capable of upgrading the material by screening, washing, combining grade sizes, and wasting undesirable fractions. The reserves of good sand and gravel, in many places, are being depleted or are becoming unavailable for mining by zoning practices. As these sources are excluded or depleted, suitable bedrock resources (mostly limestone) will need to be quarried and crushed to obtain concrete aggregate. ■

NEW PUBLICATIONS

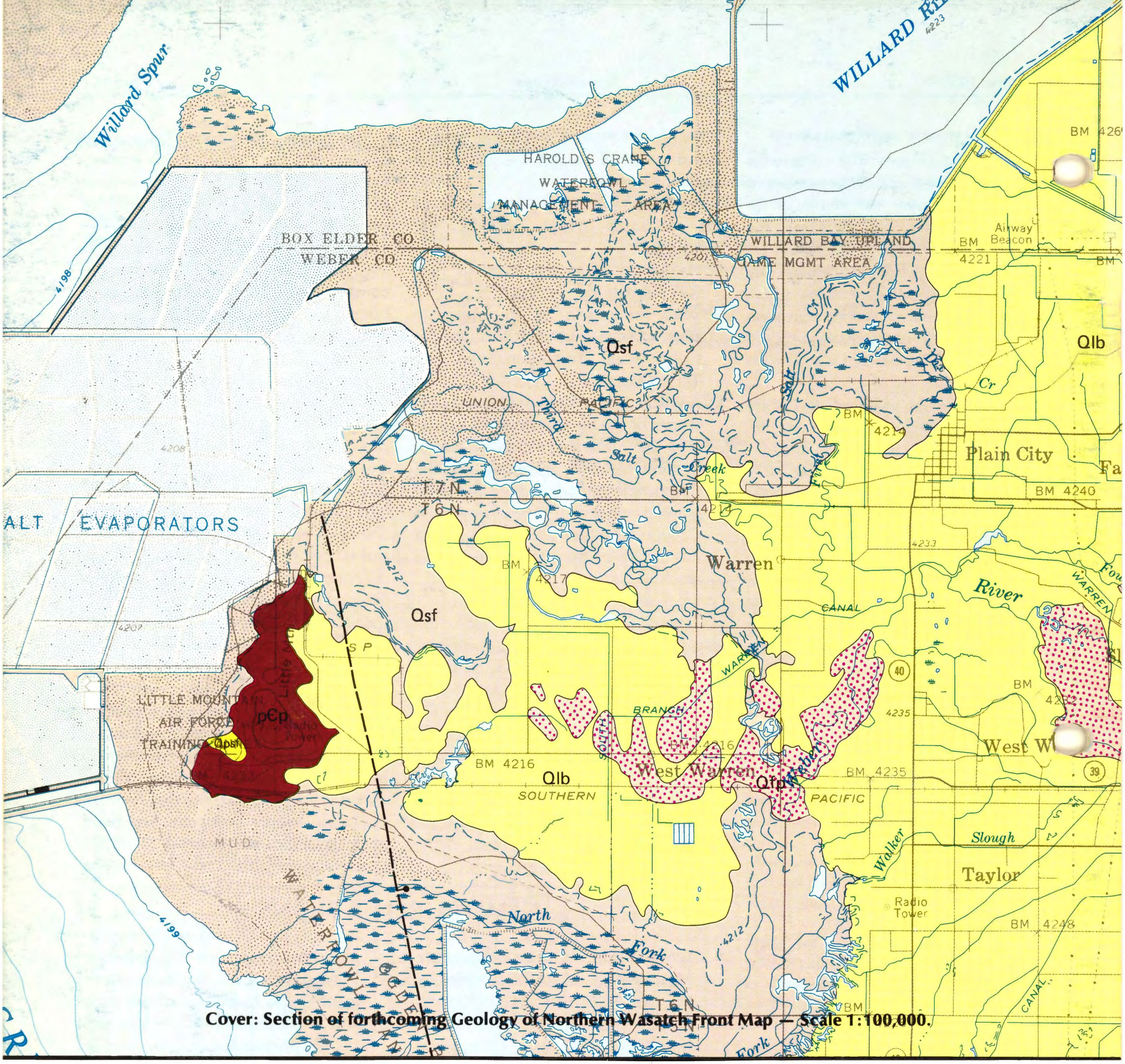
- **Igneous dikes of the eastern Uinta Mountains, Utah and Colorado,** by Howard R. Ritzma, UGMS Special Studies 56, August 1983, 23 p. fronticepiece, 16 figs., 1 table; $5.00 over-the-counter; $6.50 by mail, postpaid.
- **Summary of oil and gas activities in Utah, 1981,** by Karl W. Brown, UGMS Circular 73, August 1983, 13 p., 1 fig., 6 tables; $3.00 over-the-counter; $4.50 by mail, postpaid.

From RMAG - UGA:

- The UGMS is now selling the RMAG-UGA **Basin and Range Symposium Volume** (1979) at its Sales Office at 606 Black Hawk Way in Research Park. This volume contains 52 papers on the geology of the Basin and Range province, including reports on the geologic history, tectonics, structure, stratigraphy, and hydrology of the area, and of its geothermal, mineral and petroleum resources.

The geology of the Basin and Range Province is extremely complex, the result of multiple phases of deformation, and is by no means fully deciphered. These papers represent the latest findings and interpretations by geologists with many years experience, as well as younger geologists with new perspectives.

The volume was edited by Gary Newman and Harry Goode. It is available for only $30.00 by mail, prepaid (add $1.28 for sales tax if purchased in Utah), or $24.00 if purchased over-the-counter. ■



Cover: Section of forthcoming Geology of Northern Wasatch Front Map — Scale 1:100,000.

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