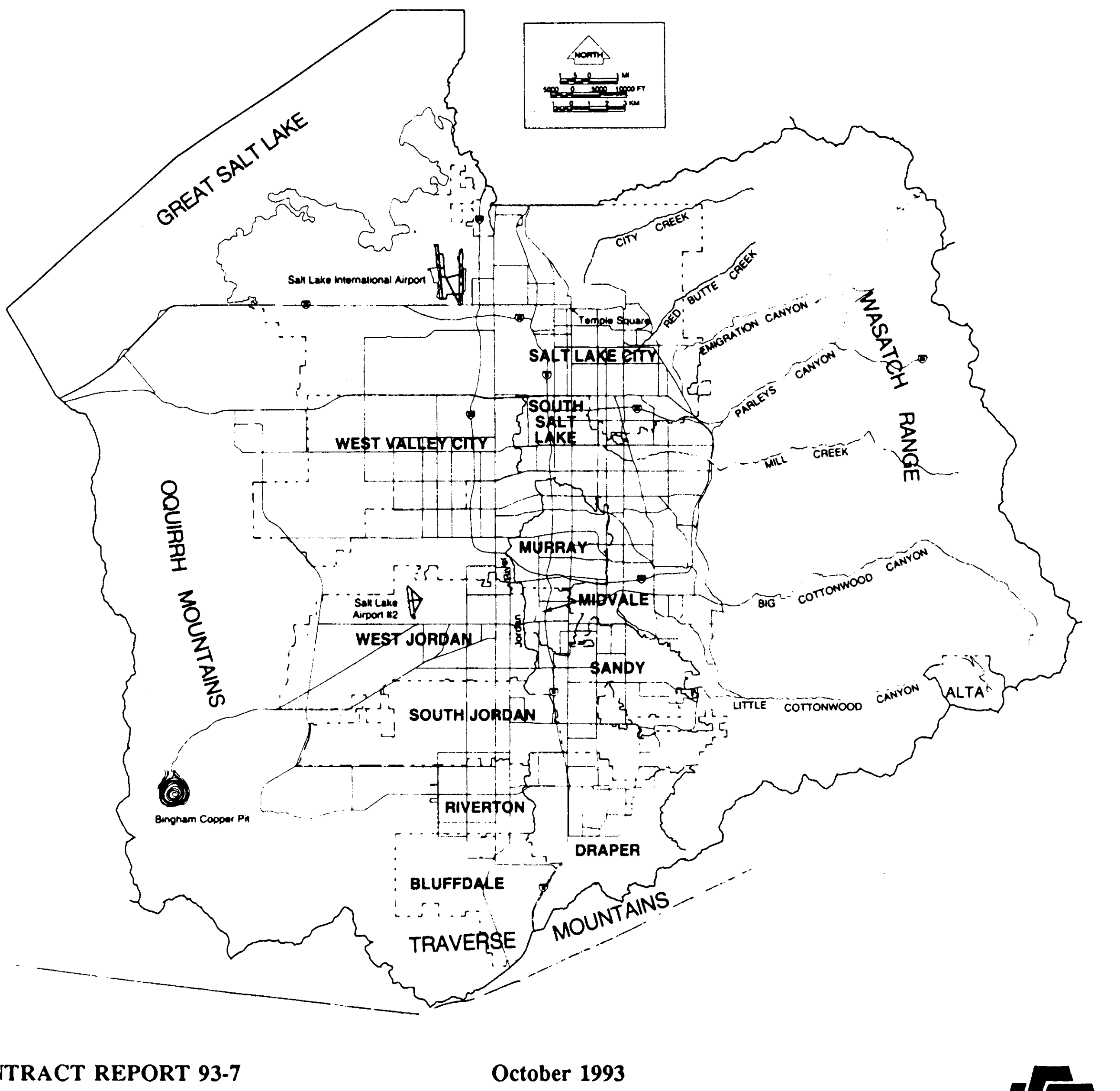
EARTHQUAKE HAZARD EVALUATION OF THE WEST VALLEY FAULT ZONE IN THE SALT LAKE CITY URBAN AREA, UTAH

by
Jeffrey R. Keaton[1], and Donald R. Currey[2]



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ABSTRACT

The West Valley fault zone consists of several north- to northwest-trending, east-dipping normal faults and monoclinal folds late Quaternary sediments in north-central Salt Lake County, Utah. Two prominent traces were discovered in 1960 by Marsell and Threet south of 2100 South Street, and considered in a 1964 ground water investigation of Salt Lake Valley by Marine and Price. A number of fault and fold traces were identified north of 2100 South Street by Keaton and others (1987) during an Earthquake Hazards Reduction Program research project sponsored by the U.S. Geological Survey. The present report pertains to these newly discovered traces of the fault zone.

Since the 1960s, and primarily since the early 1980s, many of the details of the stratigraphic record of the late Quaternary pluvial lakes and inter-lacustral periods have become increasingly understood. The current stratigraphic model permits paleoseismic investigations to be conducted on the basis of subsurface information collected from bore holes. Available logs of borings drilled by consulting firms for commercial purposes were found to have only limited usefulness even where the stratigraphic model was exceptionally well known. The reasons for this limited usefulness appear to be (1) relatively widely spaced sampling intervals which permit important, but thin, stratigraphic units to be missed during field investigations; (2) a general lack of understanding or appreciation of the stratigraphic context, hence key units are not anticipated; and (3) typically non-geological background of individuals logging the borings and test pits.

A total of 24 borings were drilled at three localities on traces of the West Valley fault zone. The Goggin Drain Locality, southwest of the intersection of Interstate Highway 80 and the 4000 West Freeway, was investigated by drilling six borings on the up-thrown side of a scarp, and six borings on the down-thrown side. Stratigraphy correlated on each side of the fault permitted determinations to be made of the orientation of surfaces and correlation across the fault permitted estimation of vertical separations and slip rates. Orientations of surfaces were calculated by three-point problem methods and by first-order trend surfaces. It appears that two surface faulting earthquakes have occurred at this locality within the past 22 to 28 ky. Post-Bonneville red beds, estimated at 11.5 to 12.5 ka

B.P. by Currey (1989), appear to be offset about 1.5 m. The ground surface, probably less than 9 ka but more than 6 ka, is also offset about 1.5 m. The Fielding Geosol, formed on Cutler Dam Alloformation deposits (between 72 and 58 ka B.P.) and buried by Bonneville Alloformation (between 28 and 12.5 ka B.P.), appears to be offset 3.6 m.

The Three Flags Locality, south of the three flags at the southeast corner of the International Center, was investigated by drilling two borings on each side of a 0.5- to 0.8-m high scarp. These borings revealed about 0.7 m of separation of the post-Bonneville red beds between borings spaced 23 m apart. This amount of separation over such a horizontal distance could easily be caused by monoclinal folding during a single event.

The 1300 South Locality, northwest of the intersection of the 2100 South Freeway and the 4000 West Freeway, was investigated by drilling four borings on each side of scarp. The area has been disturbed by construction of a canal, a railroad spur, roads, and settling ponds. The scarp appears to be 1.3 m high. The post-Bonneville red beds appear to be offset as much as 3.0 m, but this figure is uncertain owing to the sets of borings on opposite sides of the fault being more than 90 m apart. Consequently, the trend surfaces must be projected substantial distances. The Fielding Geosol appears to be offset on the order of 4.5 m, assuming that this surface is parallel to the red bed surface. The apparent separation of the layers varies along the fault because the surfaces on opposite sides dip in opposite directions. Nonetheless, the evidence at this locality suggests that three events of about 1.5 m of surface offset have occurred within the last 22 to 28 ky.

The relationship of the West Valley fault zone to the Salt Lake City segment of the Wasatch fault zone remains uncertain. The West Valley fault zone certainly represents a surface fault rupture hazard; however, its potential for generating strong ground motion independent of the Wasatch fault zone remains unclear. Specific details about the timing of late Quaternary surface faulting events on each fault zone are needed to resolve this issue. Until such details are known, the prudent approach to earthquake hazard reduction in the urban area of Salt Lake City would consider the West Valley fault zone to be capable of generating strong ground motion as well as surface fault rupture or coseismic monoclinal folding.

A procedure outlined by Youngs and others (1987) permits estimation of the probability of a recurring event given the average time between events and the time since the most recent event. Our interpretation of the late Quaternary history of the north-central Salt Lake Valley described in this report suggest that a surface faulting or monoclinal folding event on the northern West Valley fault zone has a probability of 0.20 in the next 50 years

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INTRODUCTION

The West Valley fault zone consists of several normal faults in the northern part of the Salt Lake Valley. Two subparallel, east-facing scarps located in lacustrine sediments were first interpreted as faults by Marsell and Threet (1960). Marine and Price (1964) named the scarps the Taylorsville fault and the Granger fault, and collectively called them the Jordan Valley fault zone after the Jordan River which flows northward in the center of the valley. The name "Jordan Valley" is not an officially recognized geographic name in Utah; therefore, Keaton and others (1987) proposed the name "West Valley fault zone" for the fault traces in the central northern half of Salt Lake Valley because of their proximity to West Valley City. The names "Granger" and "Taylorsville" were based on the communities through which they pass and have been retained by Keaton and others (1987).

The initial research on the West Valley fault zone by Keaton and others (1987) focused on the two subparallel, east-facing fault scarps identified by Marsell and Threet (1960) and named by Marine and Price (1964). During the course of the research project, a complicated zone of faulting was discovered extending north of the northern limit of the scarps mapped by Marine and Price (1964). This discovery led to the present research project.

The purpose of this project was two-fold: first, to assess the utility of available geotechnical logs of borings and test pits in paleoseismic analyses of faults in urban areas where the late Quaternary stratigraphy is distinct and very well known; and second, to evaluate suspected traces of the West Valley fault zone identified during the initial research project. Geotechnical logs of borings and test pits in the vicinity of the northern part of the West Valley fault zone were collected from the files of Dames & Moore and Bingham Engineering. These logs were examined in the context of the stratigraphic model and interpreted in a paleoseismic sense.

Shallow ground water conditions over much of the central northern Salt Lake Valley prohibit use of conventional trench excavations to expose fault relationships; therefore, borings were used at three localities to provide a means for assessing the faulted stratigraphy. The borings were drilled with a CME 750 drill mounted on an all-terrain vehicle. The borings were advanced with a hollow-stem continuous-flight auger which had a 3-3/4-in. (9.53-cm) diameter internal annulus. A CME continuous sampler was used to collect a 3-in. (7.62-cm) diameter core; core recovery was nearly 100 percent, even in soft, organic clays, and core condition was excellent. The most significant difficulty with the sampler was experienced when it encountered clean, coarse sand or gravel which blocked the bit, permitting the blocked sampler to be pushed into underlying soft clay. Since most of the sediments in the study area were lacustrine, this difficulty was limited to channel facies of the early Holocene Jordan River.

Trench excavations were used at one locality where the primary objective was to assess the presence or absence of fault traces or monoclinal fold axes. Ground water was encountered in some of the trenches at depths on the order of 1.5 m. Ground water in one of the borings drilled specifically for this project exhibited artesian pressures of a few cm from a depth of approximately 7.5 m.

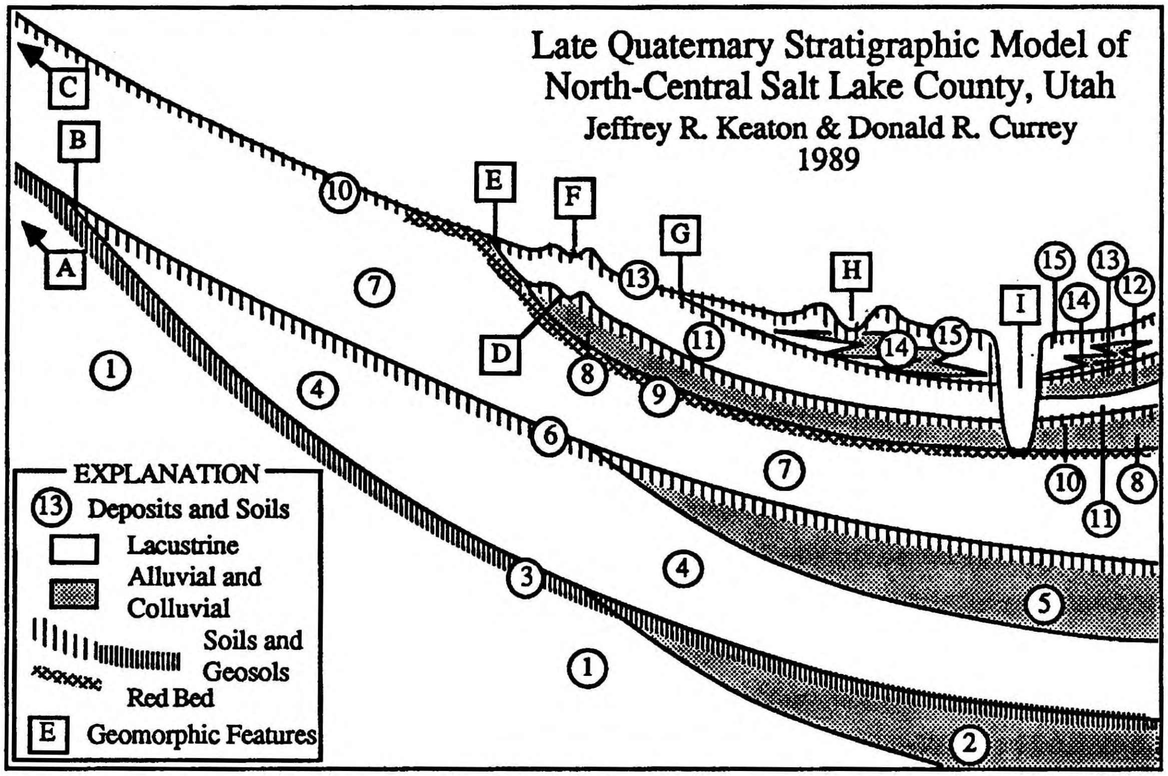
STRATIGRAPHIC MODEL

Studies of the Quaternary stratigraphy in the Salt Lake Valley began more than a century ago (Gilbert, 1890). Detailed study by Morrison (1965a, b) resulted in recognition of several important soil profiles indicative of prolonged subaerial exposure which were buried by lacustrine deposits. The understanding of the late Quaternary stratigraphy of the Bonneville basin was greatly enhanced by Scott and others (1983), Currey and others (1984), and Currey and Oviatt (1985) with the aid of a growing number of high quality radiocarbon dates from key localities. The understanding was further refined with the application of newer dating techniques in the Bonneville basin: McCalpin (1986) applied thermoluminescence techniques to inorganic silt-rich sediment, and McCoy (1987) employed amino acid stereo chemistry to estimate the ages of specific species of moluscan fauna.

As the details of the late Quaternary stratigraphy began to emerge, it became increasingly clear that several major lakes had occupied the Bonneville basin over the last 150 ky. The characteristics of lacustrine facies, non-lacustrine facies, and intercalated soil profiles began to be recognized at numerous localities throughout the basin. A schematic representation of key features of the late Quaternary stratigraphy in the north-central part of the Salt Lake Valley surrounding the West Valley fault zone is shown on Figure 1.

The principal features of the stratigraphy leading to the model used in the present paleoseismic analysis consists of five sequences of lacustrine deposits overlain by non-lacustrine deposits on which a soil profile had developed. In some places, depending upon the altitude within the basin, lacustrine deposits constituted parent materials for soil development. These two basic stratigraphic sequences are illustrated schematically on Figure 1.

The oldest stratigraphic sequence of importance in late Quaternary paleoseismology in the Salt Lake Valley began with deposition of the Little Valley Alloformation (McCoy, 1987; Scott et al., 1983). A lake cycle beginning 150 ka (?) B.P. and terminating approximately 128 ka B.P. has been named the Little Valley cycle for deposits at Little Valley in the southern Promontory Mountains in Box Elder County. The deposits of this lake cycle include transgressive coarse clastic sediments, grading upward into deep-water ostracodal calcareous silty clay, grading upward into regressive clastic sediments. The high stand of the Little Valley lake cycle reached an altitude of approximately 1493.5 m (4900 ft). As the lake receded, alluvial and eolian-rich colluvial sediments accumulated over parts of the basin, burying the lacustrine deposits. The basin above an altitude of possibly 1274 m (4180 ft) was exposed to subaerial processes and soil formation for up to



DEPOSITS AND SOILS

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C. Bonneville lake cycle high stand (1585 m, 5200 ft) (Currey and Oviatt, 1985).
B. Cutler Dam lake cycle high stand (1341.1 m, 4400 ft) (Oviatt et al., 1987).
A. Little Valley lake cycle high stand (1493.5 m, 4900 ft) (Scott et al, 1983).

Figure 1. Schematic profile showing stratigraphic relationships and key geomorphic features in the vicinity of the West Valley fault zone, north-central Salt Lake County, Utah.

approximately 56 ky. The soil that formed during this interval in the Bonneville basin has been named the Promontory Geosol (Morrison, 1965b; McCoy, 1987). Deposits of the Little Valley Alloformation are not exposed in north-central Salt Lake Valley; they are, however, encountered in borings.

A second major lake cycle began about 72 ka B.P. and terminated approximately 58 ka B.P. (McCalpin, 1986). The deposits of this lake cycle have been named the Cutler Dam Alloformation for exposures along the Bear River below Cutler Dam in Box Elder County (Oviatt et al., 1987). The deposits of this lake cycle seem to have a higher percentage of silt than either the Little Valley Alloformation below it, or the Bonneville Alloformation above it. Abundant ostracodes have not been found in deposits of the Cutler Dam Alloformation, which reached an altitude of approximately 1341.1 m (4400 ft). As the lake receded, alluvial and eolian-rich colluvial sediments accumulated over parts of the basin, burying the lacustine deposits. The basin lowlands were again exposed to subaerial processes and soil formation, this time for approximately 30 ky. The soil that formed during this interval in the Bonnevile basin has been named the Fielding Geosol (Oviatt et al., 1987). Exposures of the Cutler Dam Alloformation in north-central Salt Lake Valley are extremely rare, as are exposures of the Fielding Geosol; these deposits are, however, encountered in borings.

A tributary of the Bonneville basin captured the Bear River near Soda Springs in southeast Idaho at the beginning of the Bonneville lake cycle. The Bear River is a very important source of water for the Bonneville basin, since it drains the western end of the Uinta Mountains where glaciers accumulated during the late Pleistocene ice age. The lake which occupied the basin from about 28 ka to about 12 ka B.P. was the largest of the lakes, attaining an altitude of approximately 1585 m (5200 ft), and has been named the Bonneville lake cycle. Deposits of the Bonneville Alloformation consist of transgressive coarse clastic sediments which are overlain by deep-water ostracodal calcareous silty clays which are overlain by regressive clastic sediments (Currey et al., 1984; McCoy, 1987). As the lake receded, initially due to catastrophic erosion at the outlet on a tributary of the Snake River in southeast Idaho, alluvial and eolian-rich colluvial sediments accumulated in many parts of the basin. An important marker bed was created as Bonneville Alloformation deep water sediments, which apparently contained iron sulfide minerals, were reddened and washed basinward onto mudflats and sandflats that were marginal to the receding brines of the former Lake Bonneville (Currey et al., 1988). Disseminated iron sulfides may have oxidized readily under the climate that accompanied the Milankovitch-forced summer insolation abnormality that occurred during terminal Bonneville and early post-Bonneville time (Currey et al., 1988). The apparent upper altitude limit of these post-Bonneville red beds is approximately 1310.6 m (4300 ft) (Currey, 1989). The red beds were reddened off-site and transported to the mudflats and sandflats; however, a soil also formed on the Bonneville Alloformation and post-Bonneville alluvial and colluvial parent material. This soil, named the Graniteville soil by Morrison (1965a), is buried over much of north-central Salt Lake Valley, but above an altitude of approximately 1295.4 m (4250 ft), it is commonly present at the modern ground surface.

At approximately 12 ka B.P., a fourth late Quaternary lacustral episode occurred. This one reached a maximum altitude of approximately 1295.4 m (4250 ft) and has been named the Gilbert lake cycle (Currey, 1989; Murchison, 1989). The Gilbert lake cycle apparently consisted of a number of relatively minor rises and falls. The evidence for these rises and falls includes numerous distinct sand partings in otherwise relatively deep-water silty clay deposits and death assemblages of mollusks in channel sand deposits inset into coastal marshes. The death assemblages appear to result from minor rises of salty lake water which inundated the fresh-water marshes where the mollusks lived (Currey, 1989). The Gilbert lake cycle terminated at approximately 10.0 to 10.3 ka B.P. Post-Gilbert alluvial, eolian, and colluvial sediments accumulated over the lacustrine deposits and were exposed to subaerial weathering for about 7 ky. The soil which formed on the lacustrine and non-lacustrine parent material has been named the Midvale soil by Morrison (1965a). This soil is widespread at the modern ground surface between altitudes of 1295.4 m (4250 ft) and 1286.6 m (4221 ft) where it has not been disturbed by urbanization.

A fifth lacustral episode occurred during late Holocene time in the Bonneville basin. This episode, which has been named the Holocene high stand, consisted of an expansion of the Great Salt Lake at approximately 2.6 ka B.P. (Currey, 1989; Murchison, 1989). The Holocene high stand reached an altitude of 1286.6 m (4221 ft) and was the base level which controlled the Jordan River. Thus, distributary channels and levees were created and modified as the Great Salt Lake receded (Keaton et al., 1987). In the vicinity of the West Valley fault zone, the Jordan River cut down to the post-Bonneville red beds. In the past 2.6 ky, a modern soil profile has developed on the landscape below the Holocene high stand. This soil is dominated by sodium deflated from the nearby salt flats, resulting in a natric profile. The sodium acts as a catalyst for soil profile development, creating in a short time features in some of the soil horizons which under non-natric conditions require substantial time (e.g., tens of thousands of years) to form.

The stratigraphic model described above was successfully applied to a paleoseismic assessment of part of the West Valley fault zone by Keaton and others (1987). The general rise in base level in the Bonneville basin over the past 150 ky has resulted in relatively continuous deposition which preserves the underlying stratigraphy. Most of the preserved stratigraphy, exceptional useful in Quaternary studies, including paleoseismic assessments, is not exposed. Thus, shallow excavated exposures and drill cores must be employed in application of stratigraphic interpretations to paleoseismic and other problems.

UTILITY OF GEOTECHNICAL LOGS

The stratigraphic model described above consists of a sequence of distinctive features which should be easy to identify in drill cores. Hundreds of exploratory borings and test pits have been drilled and excavated in the north-central Salt Lake Valley by consulting firms and the Utah Department of Transportation for geotechnical investigations of sites for planned development. Consequently, a substantial effort was made to interpret existing geotechnical logs in the context of the late Quaternary stratigraphic model of north-central Salt Lake Valley described above. The logs of geotechnical borings and test pits collected from consulting firms and the Utah Department of Transportation for previous research on earthquake-induced liquefaction (Anderson et al., 1986) were updated to provide a catalog of subsurface information which was as complete as possible.

The geotechnical logs at specific localities where prior detailed knowledge existed of the late Quaternary stratigraphy were examined initially to provide a means for assessing the utility of the logs. The post-Bonneville red beds had been previously observed in drainage canal excavations in the vicinity of the International Center (Sections 35 and 36, T. 1 N., R. 2 W., SLB&M); therefore, the geotechnical logs of this area were used to assess their utility for late Quaternary stratigraphic assessments. Logs of 74 borings and test pits at the International Center prepared under the direction of Bingham Engineering were examined in the context of the late Quaternary stratigraphic model; only 34 logs (46 percent) contained information that could be interpreted with confidence.

The data from these 34 logs was used in a simple trend surface analysis, although traces of the West Valley fault zone were located to the east of the International Center. The analysis was done using Universal Transverse Mercator (UTM) coordinates and elevations in meters. The coordinates of the borings and test pits at the International Center were referenced to the State Plane (SP) system; therefore, a conversion was required. This conversion was accomplished by carefully measuring the UTM coordinates to the nearest 5 m on conventional 7.5-minute topographic quadrangles of north-central Salt Lake Valley for points on the corners of a block encompassing the northern part of the West Valley fault zone for which the SP coordinates were known. The coordinates of these points are listed in Table 1. The following conversion equations were developed by conventional multiple regression techniques using a commercially available statistics program:

$$\text{UTM East} = -153688.75 + 0.30475 \text{ SP East} + 0.00225 \text{ SP North} \quad \text{(1a)}$$

$$\text{UTM North} = 4247526.25 - 0.00225 \text{ SP East} + 0.30475 \text{ SP North} \quad \text{(1b)}$$

Table 1. Points used to compute multiple regression equations for converting State Plane coordinates to Universal Transverse Mercator coordinates in north-central Salt Lake Valley. The State Plane coordinates are for the central zone; the Universal Transverse Mercator coordinates are for zone 12.

Point	State Plane		Universal Transverse Mercator	
Identification	East	North	East	North
Southwest	1,860,000	880,000	415,125	4,511,080
Southeast	1,870,000	880,000	418,175	4,511,060
Northeast	1,870,000	890,000	418,195	4,514,100
Northwest	1,860,000	890,000	415,150	4,514,125

The equation of the first-order trend surface on the top of the post-Bonneville red beds at the International Center was determined by conventional multiple regression techniques using a commercially available statistics program as follows:

Elev = 1316.994 - 0.001046 UTM East - 0.001072 UTM North ($n = 34$; $r^2 = 0.474$).... (2)

where Elev is the elevation in m. A graphical representation of the trend surface is shown on Figure 2. The residuals of Elev with respect to UTM East and UTM North are shown on Figure 3. The general trend of the first-order surface (Figure 2) slopes to the northeast at approximately 0.0015. This trend surface is reasonable, but a more north-trending slope would be more appropriate for the International Center locality. The residuals (Figure 3) show no apparent trend; therefore, trend surfaces of higher order were not computed.

Hundreds of additional logs of borings and test pits were reviewed in the context of the late Quaternary stratigraphic model described earlier in this report. In many cases, isolated elements of the model could be identified with reasonable confidence. However, in only a few cases could enough of the elements of the model be identifed with sufficient confidence to permit stratigraphic interpretation. Even then, the same stratigraphic elements could rarely be identified in adjacent borings. Thus, in general, existing geotechnical logs provide unsuitable stratigraphic data for use in applications where detailed information is required. Three principal factors may contribute to the lack of suitability of the geotechnical logs: (1) sampling interval, (2) lack of understanding or appreciation of the stratigraphic context, and (3) non-geological background of individuals logging the borings and test pits.

Geotechnical borings are sampled on a conventional 1.5-m (5-ft) interval. The stratigraphy between samples is described on the basis of the cuttings brought to the

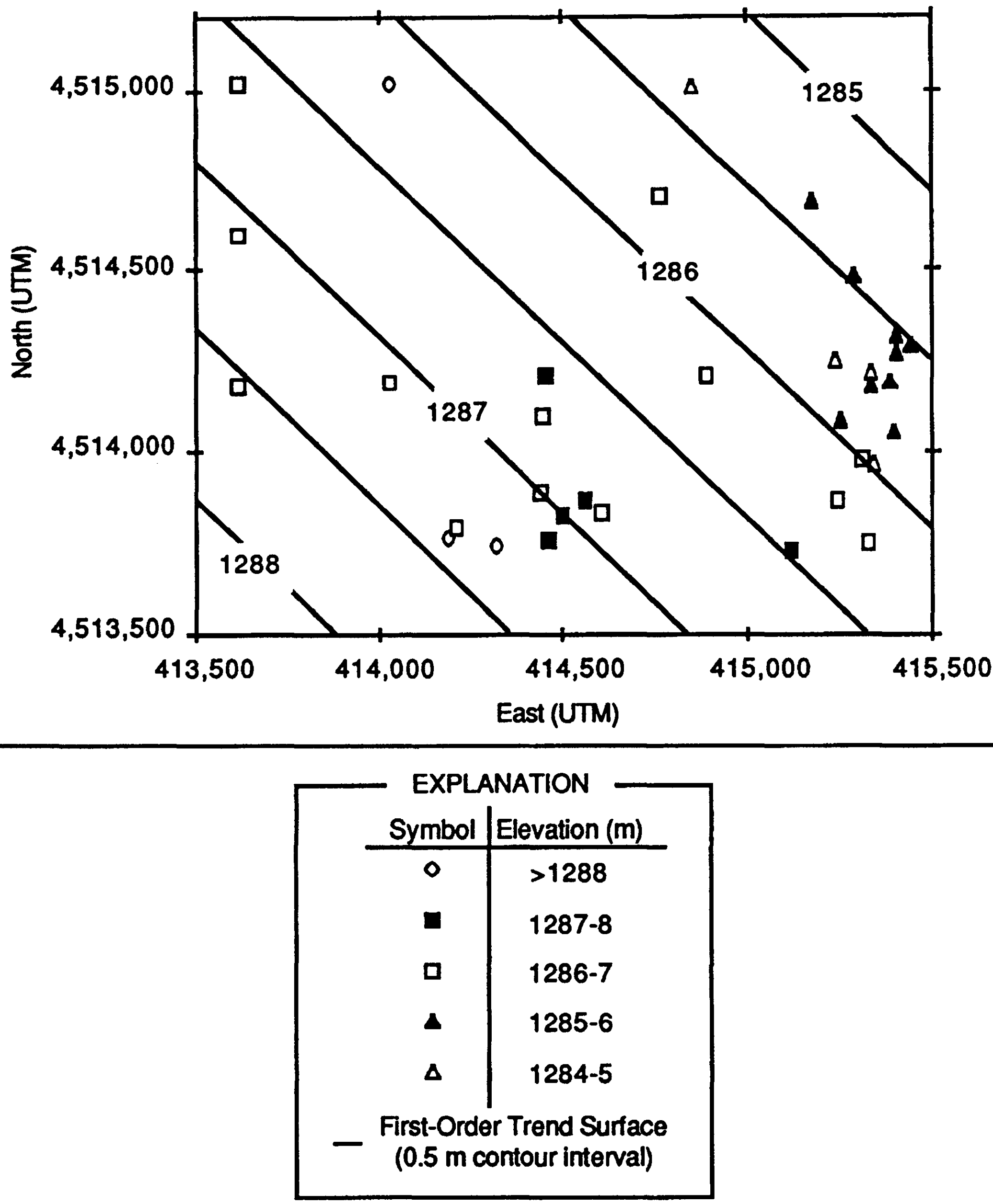

Figure 2. First-order trend surface on the top of the post-Bonneville red beds at the International Center (Sections 35 and 36, T. 1 N., R. 2 W., SLB&M).

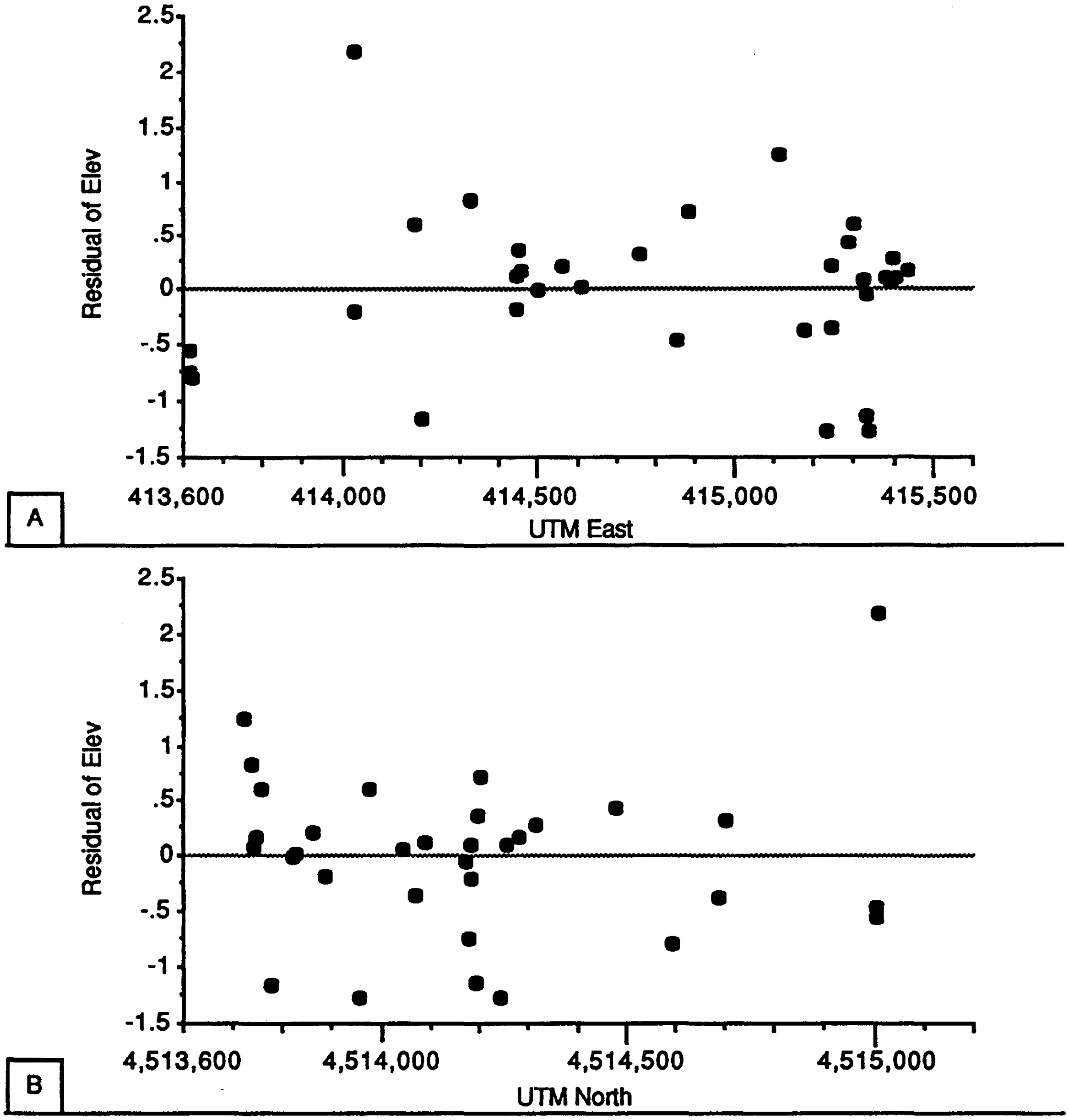

Figure 3. Residuals of Elev from the first-order trend surface shown in Figure 2. Diagram A: Residual of Elev as a function of UTM East; Diagram B: Residual of Elev as a function of UTM North.

ground surface by circulating drilling fluid for rotary wash borings or by the flights on continuous flight auger borings. In either case, the quality of the information is compromised by blending of cuttings from different places in the boring and by the destruction of primary and secondary sedimentary structures (i.e., bedding and soil structures).

Conventional geotechnical investigations commonly are based on the concept that the characteristics of any specific site, while generally related to surronding sites, are unique. The geotechnical parameters important for design, such as bearing capacity and coefficient of consolidation, are determined for each site by testing samples collected at each site. Correlations across any site are based on borings drilled within the boundaries of that site. The geological context of the site generally is of limited importance in conventional geotechnical investigation. This limited importance of geology greatly reduces the need to conduct geotechnical investigations within a framework of understanding of the late Quaternary stratigraphy.

The field portion of conventional geotechnical investigations commonly is performed by technicians or engineers whose geological background is limited or nonexistant. Consequently, important stratigraphic details, such as the presence of ostracodes, reddened layers, and clay films, are easily missed in the operation of logging cuttings and preparing samples for transportation to the laboratory. Furthermore, all uncemented sediment is collectively considered to be "soil" in an engineering sense and color is generally regarded as a mediocre parameter. Most "soils" are described as "brown", "gray", or combinations of the two colors. Thin layers are easily missed and generally may be considered relatively unimportant in the foundation of a proposed building. Generalized descriptions of "soil" layers commonly are recorded, such as a description of "light brown silty clay with occasional silty sand layers to 1 inch thick" for a 14-ft thick unit.

An additional factor which reduces the utility of many conventional geotechnical logs is the lack of a ground surface elevation reported on the log. General elevations only may be estimated from 7.5-minute topographic quadrangle maps.

Thus, it appears that generally available conventional geotechnical logs have only marginal utility, at best, in applications where detailed elements of stratigraphy are needed for paleoseismic interpretations. This generalization appears to be true even in localities where the details of the stratigraphy are exceptionally well known and include numerous distinctive elements, such as is the case in the north-central Salt Lake Valley in the vicinity of the West Valley fault zone.

INVESTIGATIONS

General

Field localities were selected for two reasons: first, to permit verification that the scarps observed during aerial photograph analysis as part of the earlier research project were, in fact, tectonic; and second, to permit estimation of the amount of stratigraphic separation across the feature. Three localities were selected for subsurface investigation: Goggin Drain, Three Flags, and 1300 South. These localities are shown on Figure 4 in relation to the West Valley fault zone and geographic features in north-central Salt Lake Valley.

A fourth locality, the Pioneer Square locality, is included in this report because it is timely and appropriate; however, the investigation was contracted by Price Development Company to Sergent, Hauskins & Beckwith Engineers, Inc., independent of the U.S. Geological Survey research grant award to Dames & Moore. This locality is also shown on Figure 4.

Borings were drilled at the Goggin Drain, Three Flags, and 1300 South Localities; shallow trenches were excavated at the Pioneer Square Locality. The borings permitted verification that the aerial photograph lineaments were tectonic scarps. However, the trenches showed that lineaments interpreted from 1937 stereoscopic aerial photographs at the Pioneer Square Locality were not tectonic, since unfaulted deposits of the Gilbert Alloformation were exposed in all but one of the trenches.

Goggin Drain Locality

This locality is situated in the SW. 1/4, SE. 1/4, NE. 1/4, Sec. 6, T. 1 S., R. 1 W., SLB&M. The height of the scarp at this locality is approximately 1.8 to 2 m and the strike azimuth [1] is approximately 340°. The down-thrown side of the scarp is a small saltflat which appears to have lost some material to deflation processes. Hence, the scarp height may exceed the tectonic displacement. Furthermore, this locality is situated at the maximum extent of the Holocene high stand of the Great Salt Lake, but no deposits clearly associated with this lacustral excursion were identified in the borings; hence, some erosion of the down-dropped side of the scarp could have occurred.

This locality was investigated by drilling 12 borings to depths ranging from 2.70 to 14.78 m at locations shown on Figure 5. Logs of the borings are summarized in Appendix A. Generalized geologic interpretations of the logs are presented in Figures 6 and 7.

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[1] Azimuth of strike in this report refers to the direction from which the downward dip is clockwise. This is also refered to as the "right hand rule" since, if one is facing in the direction reported for strike, the downward dip is to the right hand side of the observer.

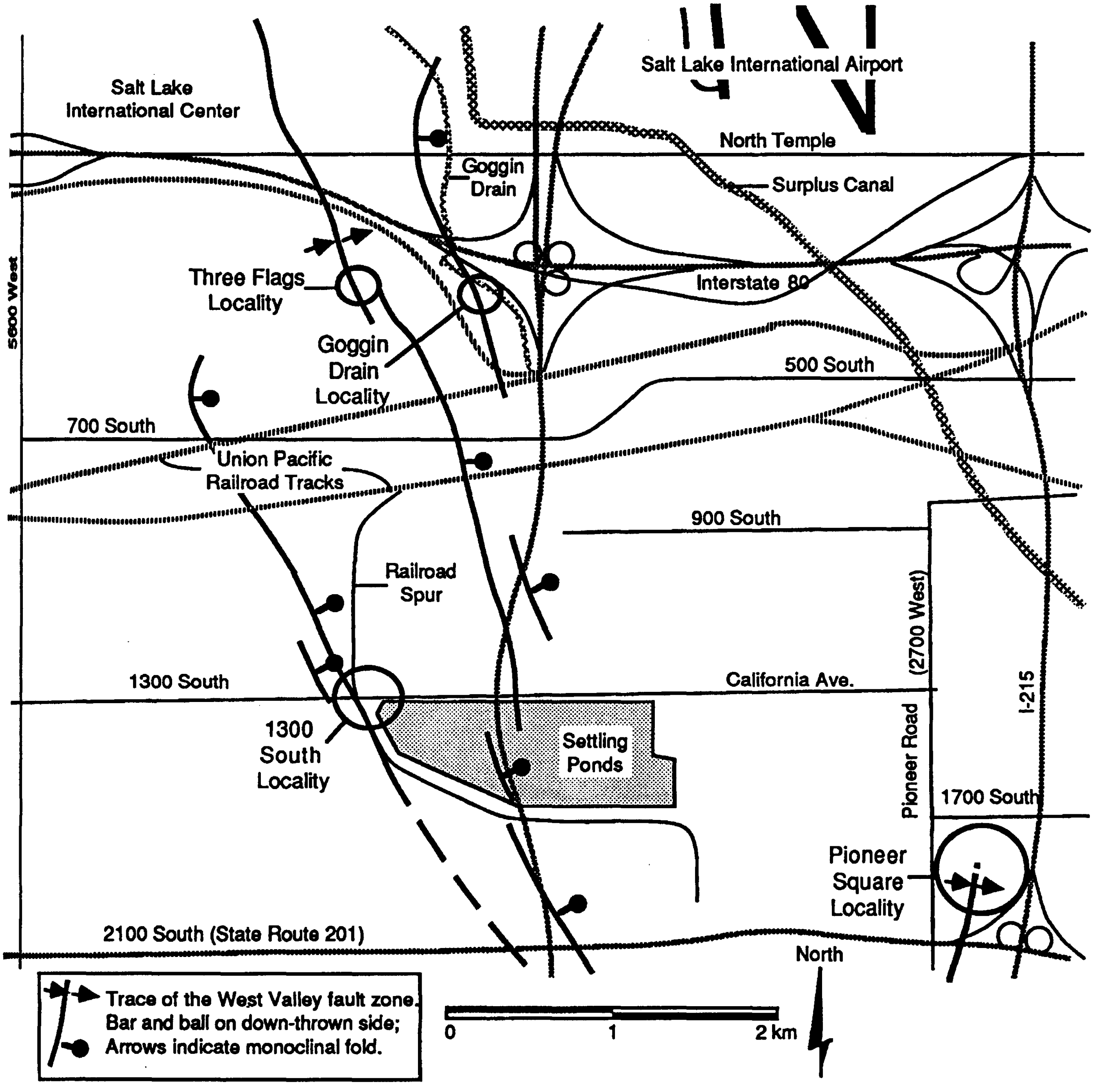

Figure 4. Localities on the West Valley fault zone described in this report. Features sketched from an aerial photograph.

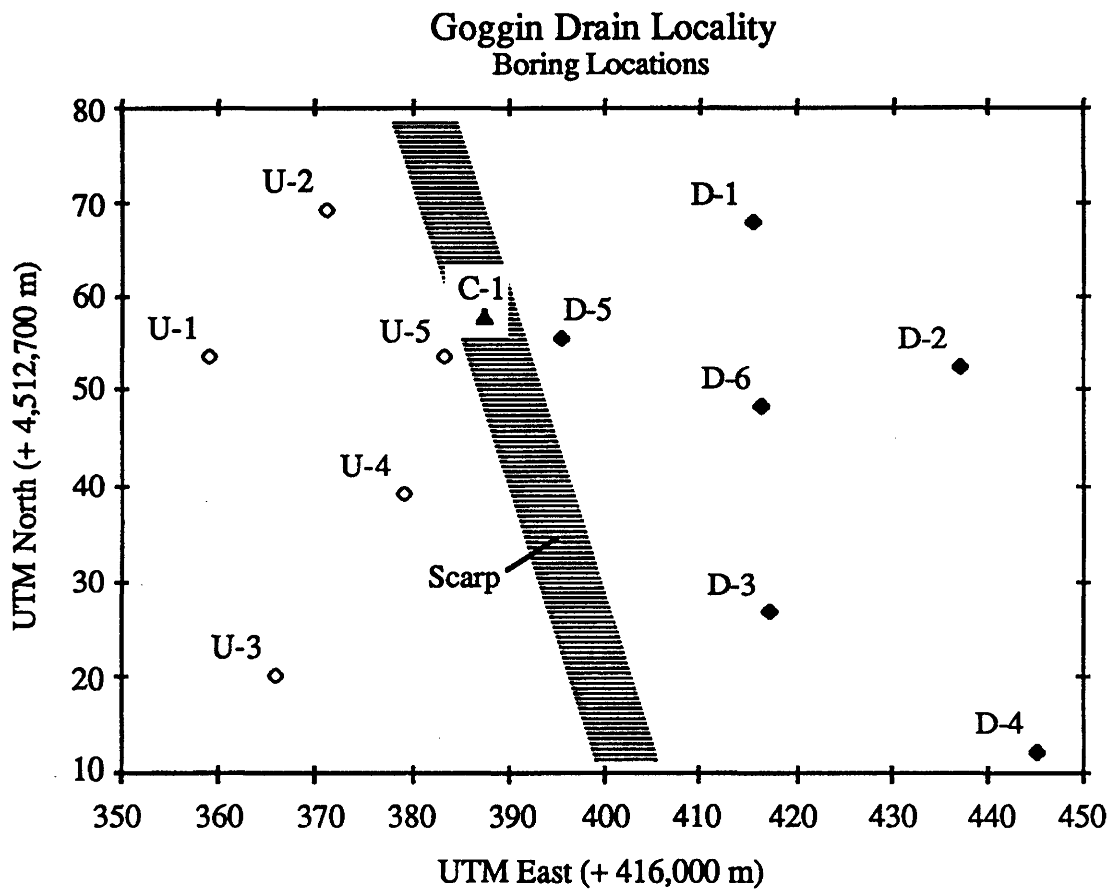

Figure 5. Locations of borings drilled at the Goggin Drain Locality.

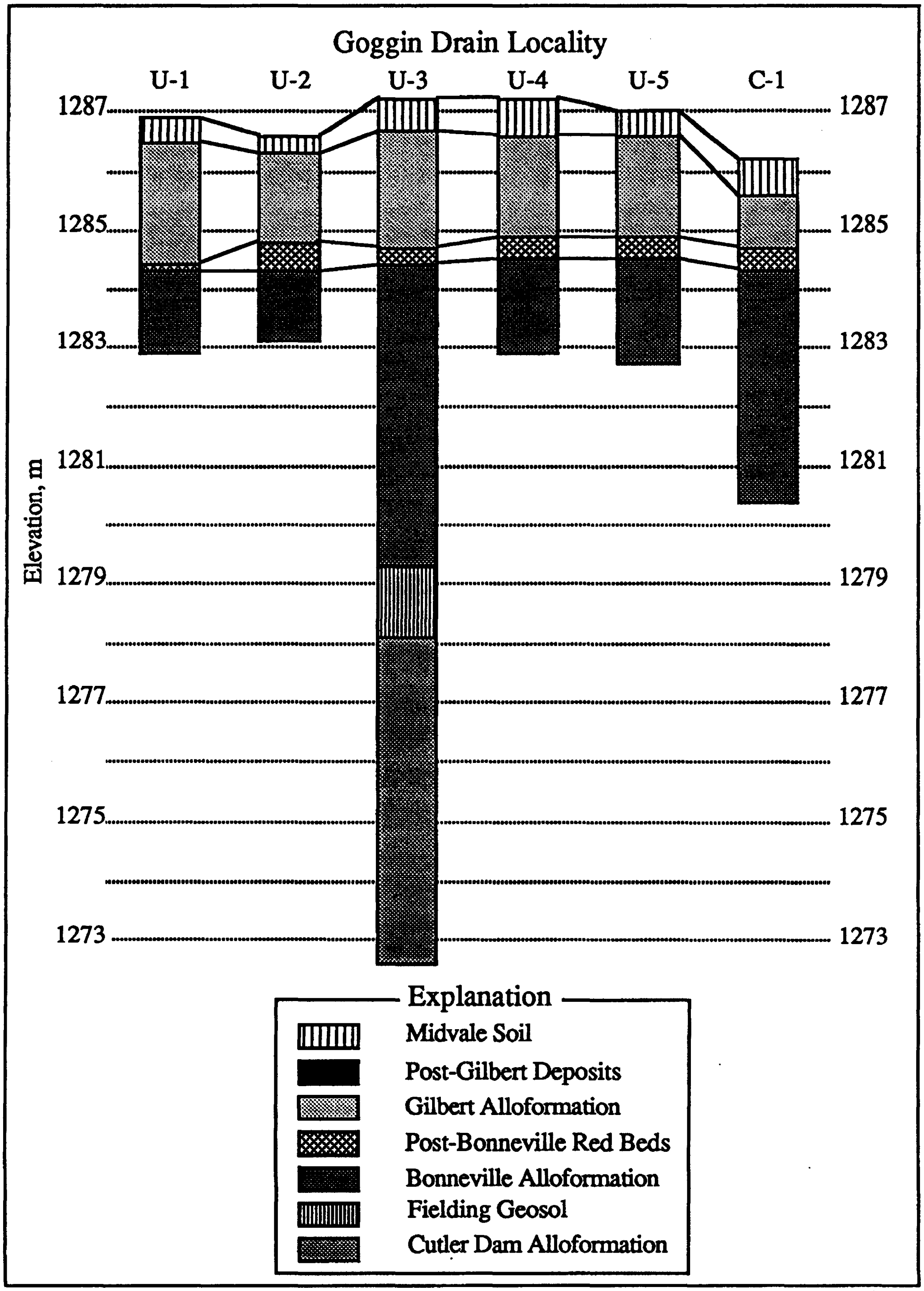

Figure 6. Geologic interpretation of borings drilled on the up-thrown side of a trace of the West Valley fault zone at the Goggin Drain Locality.

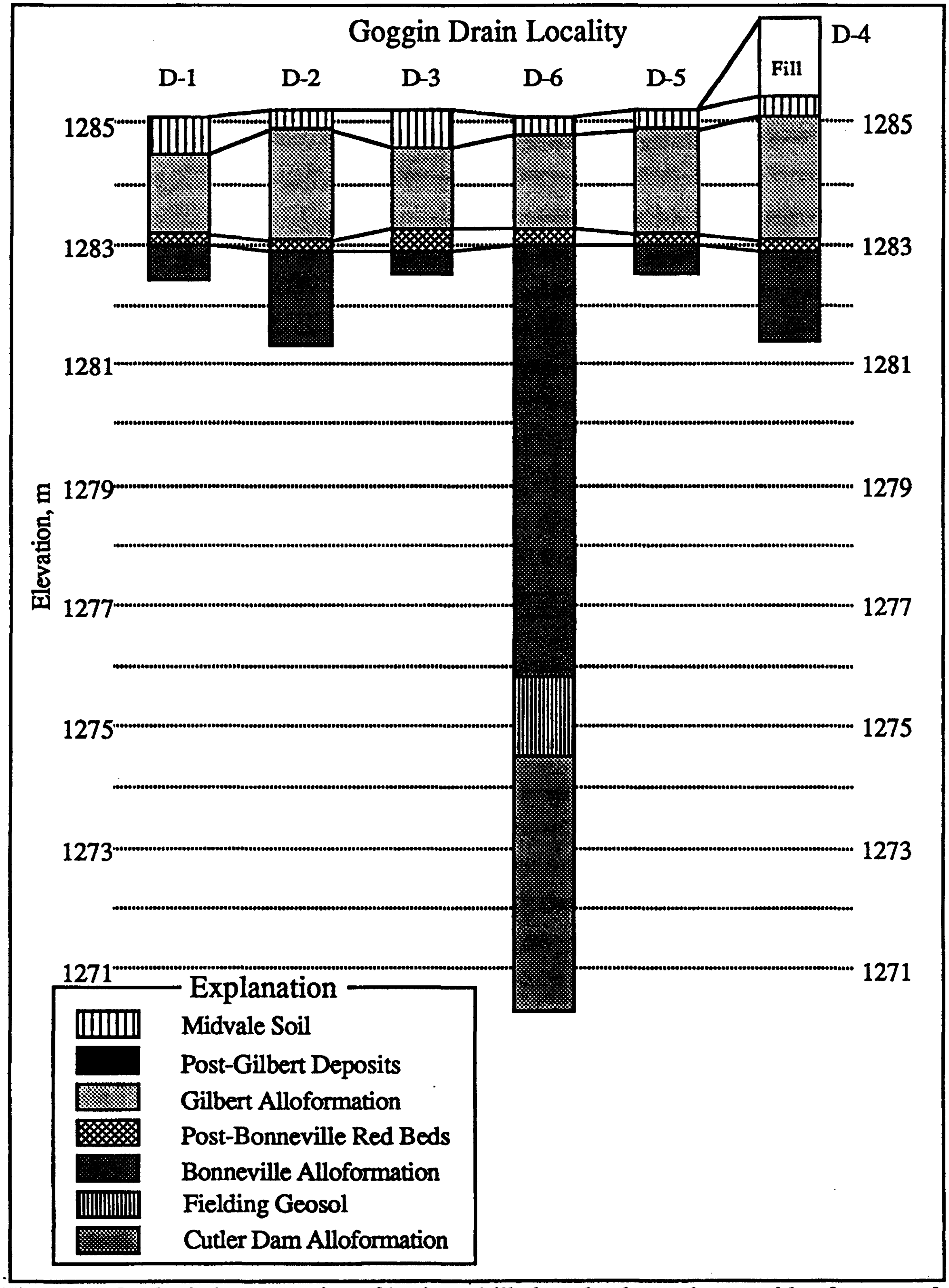

Figure 7. Geologic interpretation of borings drilled on the down-thrown side of a trace of the West Valley fault zone at the Goggin Drain Locality.

Figure 6 shows the borings drilled on the up-thrown side of the scarp; Figure 7 shows borings on the down-thrown side. The subsurface stratigraphy in the borings correlated well to the stratigraphic model presented earlier in this report.

Strike and dip of the base of the post-Bonneville red bed layer was determined by the three-point problem method. A BASIC language program was written to solve three-point problems; the source code for this program is presented in Appendix B. The solutions of the three-point problems using the bottom of the red bed layer are summarized in Table 2. Statistical analyses of the mean values of the strikes and dips from the up-thrown and down-thrown sides of the scarp support the conclusion that the scarp has a tectonic origin (Ho: $\mu_{AZU} = \mu_{AZD}$, $t = 4.341$, $df = 19$, $p \leq 0.0005$; Ho: $\mu_{DIPU} = \mu_{DIPD}$, $t = 2.882$, $df = 19$, $0.0005 < p \leq 0.005$; Ho: $\mu_{AZD} = \mu_{AZU}$, $t = -4.824$, $df = 17$, $p \leq 0.0005$; Ho: $\mu_{DIPD} = \mu_{DIPU}$, $t = -28.749$, $df = 17$, $p \leq 0.0005$).

Deformation of the bottom surface of the post-Bonneville red bed was also evaluated using a first-order trend surface. The surface is discontinuous across the scarp as shown on Figure 8. The equations for the surfaces are:

$Bot_{RBU} = 83.01581 + 0.00386$ UTM East $- 0.00165$ UTM North ($n = 6, r^2 = 0.44$)..... (3)

$Bot_{RBD} = 83.81312 - 0.00217$ UTM East $+ 0.00119$ UTM North ($n = 6, r^2 = 0.89$)..... (4)

where Bot_{RBU} is the elevation of the bottom of the red bed on the up-thrown side of the scarp and Bot_{RBD} is the elevation on the down-thrown side of the scarp. Elevations should be added to 1200 m for m.s.l. datum; UTM East coordinates should be added to 416,000 m, and UTM North coordinates should be added to 4,512,700 m for UTM zone 12.

The trace of the West Valley fault zone which passes through the Goggin Drain Locality appears to be a purely dip-slip normal fault, consistent with other observations in the region. The apparent vertical offset of the ground surface is 1.8 to 2.0 m at this locality. The vertical separation of the bottom of the post-Bonneville red beds ranges from about 1.4 m, based on horizontal projection across the scarp, to about 1.5 m, based on the trend surfaces shown in Figure 8. Apparent vertical separation of both the top and the bottom of the Fielding Geosol (hence, the bottom of the Bonneville Alloformation and the top of the Cutler Dam Alloformation) is 3.6 m. However, since little is known about the character of tectonic deformation of the sediments at this locality, the range of separation of the Fielding Geosol could be 3.0 to 4.0 m. Some back-tilting of the post-Bonneville red beds on the down-dropped side of the scarp is suggested by the first-order trend surfaces shown on Figure 8. The surface on the up-thrown side of the scarp dips at 0.24° at an azimuth of 293.5°, while the surface on the down-thrown side dips at 0.14° at an azimuth of 118.7°.

Table 2. Summary of strike and dip determinations from three-point problems using the bottom of the post-Bonneville red bed deposits at the Goggin Drain Locality. Borings with the prefix U are on the up-thrown side of the scarp; borings with the prefix D are on the down-thrown side. Boring C1 was drilled on the scarp; however, the stratigraphy indicates that it is on the up-thrown side of the scarp. A three-point problem across the scarp using U5, C1, and D5 yields a strike of 043.4° and a of dip 10.1°. Strike and dip were determined analytically using a computer program called 3POINT; the source code for this program is presented in Appendix B.

Borings	Strike Azimuth (°)	Dip (°)	Borings	Strike Aximuth (°)	Dip (°)
U1,U2,U3	344.0	0.1	D1,D2,D3	021.9	0.2
U1,U2,U4	311.7	0.4	D1,D2,D4	006.1	0.2
U1,U2,U5	025.9	0.4	D1,D2,D5	238.5	0.2
U1,U2,C1	308.6	0.1	D1,D2,D6	056.0	0.3
U1,U3,U4	129.0	0.4	D1,D3,D4	032.6	0.1
U1,U3,U5	184.0	0.4	D1,D3,D5	106.8	0.1
U1,U3,C1	050.4	0.1	D1,D3,D6	3 points on straight line	
U1,U4,U5	188.9	0.4	D1,D4,D5	065.5	0.1
U1,U4,C1	073.7	0.4	D1,D4,D6	076.4	0.3
U1,U5,C1	079.9	2.5	D1,D5,D6	Horizontal plane	
U2,U3,U4	190.2	0.5	D2,D3,D4	016.1	0.1
U2,U3,U5	190.2	0.5	D2,D3,D5	012.1	0.1
U2,U3,C1	291.6	0.04	D2,D3,D6	027.2	0.3
U2,U4,U5	190.3	0.5	D2,D4,D5	020.4	0.1
U2,U4,C1	284.7	0.3	D2,D4,D6	004.0	0.3
U2,U5,C1	277.2	1.3	D2,D5,D6	078.0	0.5
U3,U4,U5	190.3	0.5	D3,D4,D5	357.5	0.2
U3,U4,C1	211.1	2.9	D3,D4,D6	060.8	0.2
U3,U5,C1	029.7	3.5	D3,D5,D6	099.5	0.2
U4,U5,C1	015.5	2.2	D4,D5,D6	097.4	0.3
Mean	178.3	0.9	Mean	076.5	0.2
Standard Deviation	104.9	1.03	Standard Deviation	089.6	0.10

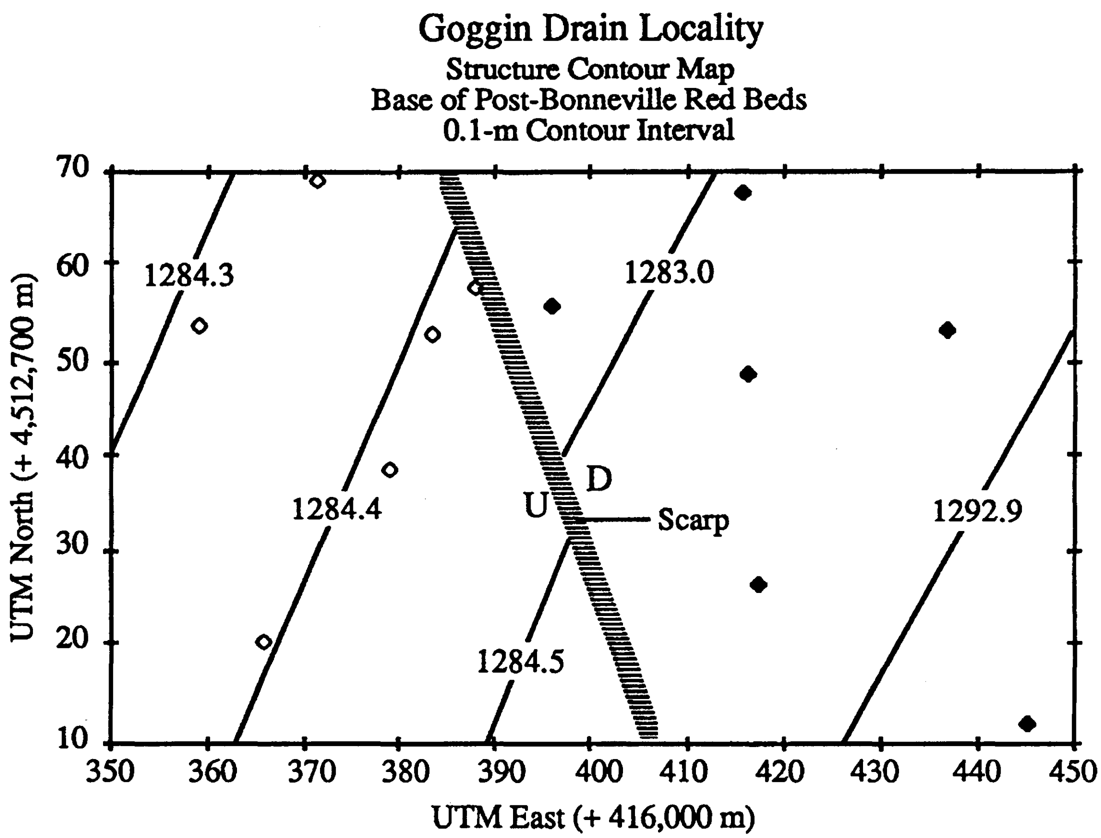

Figure 8. Structure contour map on the bottom of the post-Bonneville red bed at the Goggin Drain Locality. Contours represent the first-order trend surface computed separately for the up-thrown and down-thrown sides of the scarp.

Offset of the Fielding Geosol probably occurred after it had been inundated by Lake Bonneville, or late in its development because the bottom of the Bonneville Alloformation is offset the same amount. Inundation of the basin at the beginning of the Bonneville lake cycle occurred about 28 ka B.P.; therefore, 28 ka is taken as the early limit of the offset of the Fielding Geosol shown on Figure 9. The amount of offset of the post-Bonneville red beds is less than half of the offset of the Fielding Geosol; therefore, the offset of the Fielding Geosol probably occurred early in Lake Bonneville time. Lake Bonneville reached an altitude of 1371.6 m (4500 ft) at about 22 ka B.P. (Currey and Oviatt, 1985). Thus, the Goggin Drain Locality, at an altitude of about 1287 m, was inundated prior to 22 ka B.P. The later limit of offset of the Fielding Geosol shown on Figure 9 is assumed to be 22 ka.

The post-Bonneville red bed at the Goggin Drain Locality probably was deposited between 12.5 and 11.5 ka B.P. (Murchison, 1989). Inclined sand partings were observed in borings U-3 and D-5. Boring U-3 is approximately 30 m away from the scarp, and the sand parting inclined at 45° observed at a depth of 3.7 to 3.8 m is interpreted to be deformation induced by a distant earthquake occurring between 22 ka and 16 ka B.P., perhaps on one of the segments of the nearby Wasatch fault zone. Boring D-5 is at the base of the scarp and would be expected to penetrate the fault trace at relatively shallow depth. Inclined sand partings were observed in boring D-5 at depths of 1.8 to 2.3 m. The lower sand partings, in Bonneville Alloformation deposits, were inclined at about 15° while the upper sand partings, in Gilbert Alloformation deposits, were inclined at 10° to 15°. The similarity in inclination of the sand partings in both alloformations suggests that the offset occurred after deposition of the Gilbert Alloformation. The degree of development of the Midvale soil observed in boring C-1 drilled on the scarp is approximately the same as that observed in other borings on the up-thrown side of the scarp. Therefore, it appears that the scarp had formed early in the development of the Midvale soil, perhaps as recently as 6 ka B.P.

Based on the data revealed in the borings suggest that 2 surface faulting events have occurred at the Goggin Drain Locality in the last 22 to 28 ka, or 11 to 14 ky/event. The most recent event appears to have occurred between 12.5 and 6 ka B.P. The slip rate calculated on the basis of a 1.5 m of offset of 11-ka post-Bonneville red beds is 0.136 m/ky. The slip rate calculated on the basis of a 3.0 m offset of 22-ka bottom of the Bonneville Alloformation is 0.136 m/ky. Under these assumptions, an average offset per event would be approximately 1.5 m, a figure consistent with observations of surface expression elsewhere on the West Valley fault zone. The estimate of earthquake recurrence on the Granger fault reported by Keaton and others (1987) was 8 to 10 ky.

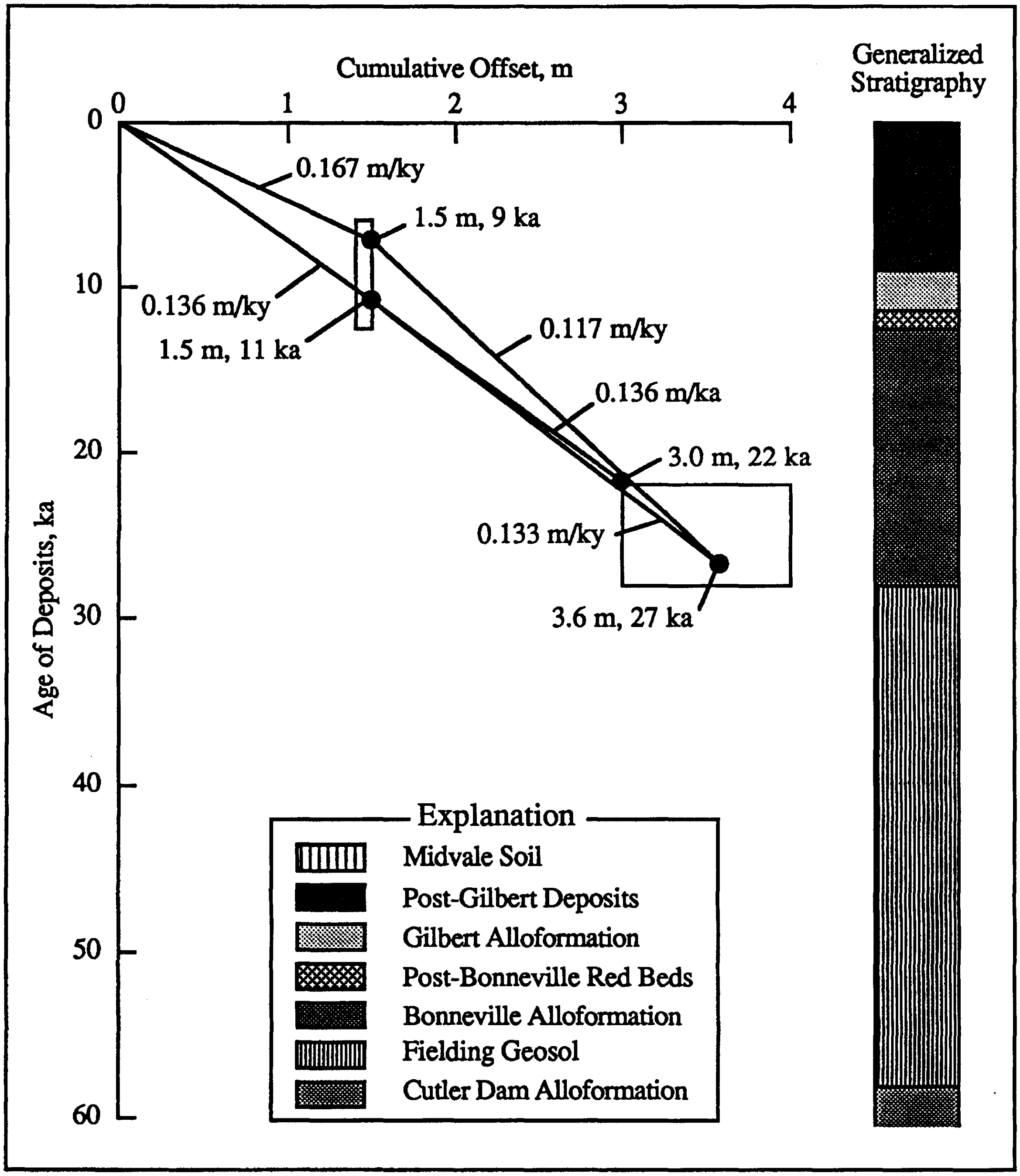

Figure 9. Cumulative offset as a function of age of deposits at the Goggin Drain Locality. Data points and calculated slip rates are shown.

Three Flags Locality

This locality is in the SW. 1/4, SE. 1/4, NW. 1/4, Sec. 6, T. 1 S., R. 1 W., SLB&M, as shown in Figure 4. Four borings were drilled to depths ranging from 4.24 to 4.60 m. The borings were in-line across a 0.5- to 0.8-m high scarp, with two borings on each side, as shown on Figure 10. The logs of these borings are presented in Appendix A and geologic interpretations are shown on Figure 11.

The bottom of the post-Bonneville red bed layer appears to be horizontal on the up-thrown side of the scarp, while it appears to dip to the west at about 0.1° on the down-thrown side. This suggests possible back-tilting of the layer during a tectonic event. Projection of the bottom of the red bed layer to the midpoint of the 23-m distance between borings U-2 and D-1 indicates a vertical separation of about 0.7 m. The apparent vertical separation of the red bed is compatible with the scarp height, suggesting only one earthquake event in the last 12.5 to 9 ka.

Keaton and others (1987) concluded that the surface expression of the Taylorsville trace of the West Valley fault zone was a monoclinal flexure with minor step faulting. The amount of deformation at the Three Flags Locality could be associated with similar neotectonic folding. Shallow trenching would be required to resolve this issue here.

Based on the data from the Three Flags Locality, a slip rate or flexure rate of 0.056 to 0.078 m/ky is calculated from 0.7 m of deformation in 9 to 12.5 ky.

1300 South Locality

The scarp of a trace of the West Valley fault zone at the 1300 South Locality passes through the boundary of Sections 7 and 18 (T. 1 S., R. 1 W., SLB&M). The borings on the up-thrown side of the fault are located in the NE. 1/4, NW. 1/4, NW. 1/4, Sec. 18, while the borings on the down-thrown side are located in the SW. 1/4, SE. 1/4, SW. 1/4, Sec. 7. The locations of the borings are shown on Figure 12. Construction activities at this locality include settling ponds, a drainage canal, two unsurfaced roads, and a railroad spur. As a consequence, the borings on the up-thrown side of the fault are located from 97 to 127 m southwest of the borings on the down-thrown side. The scarp of the fault at this locality is totally obliterated by past construction; hence its height is unknown. It is clearly visible, however, on stereoscopic aerial photographs taken in 1937, prior to much of the development.

Logs of the borings are presented in Appendix A. Geologic interpretations of the borings drilled at this locality are shown on Figures 13 and 14. Figure 13 shows the borings drilled on the up-thrown side of the scarp; Figure 14 shows borings on the down-

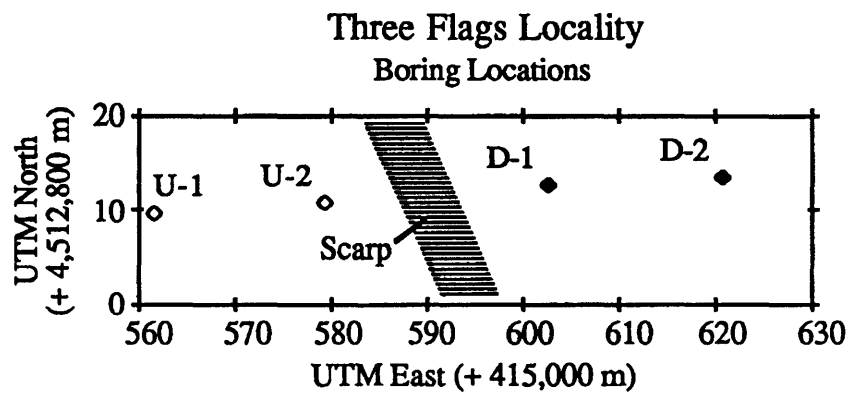

Figure 10. Locations of borings drilled at the Three Flags Locality.

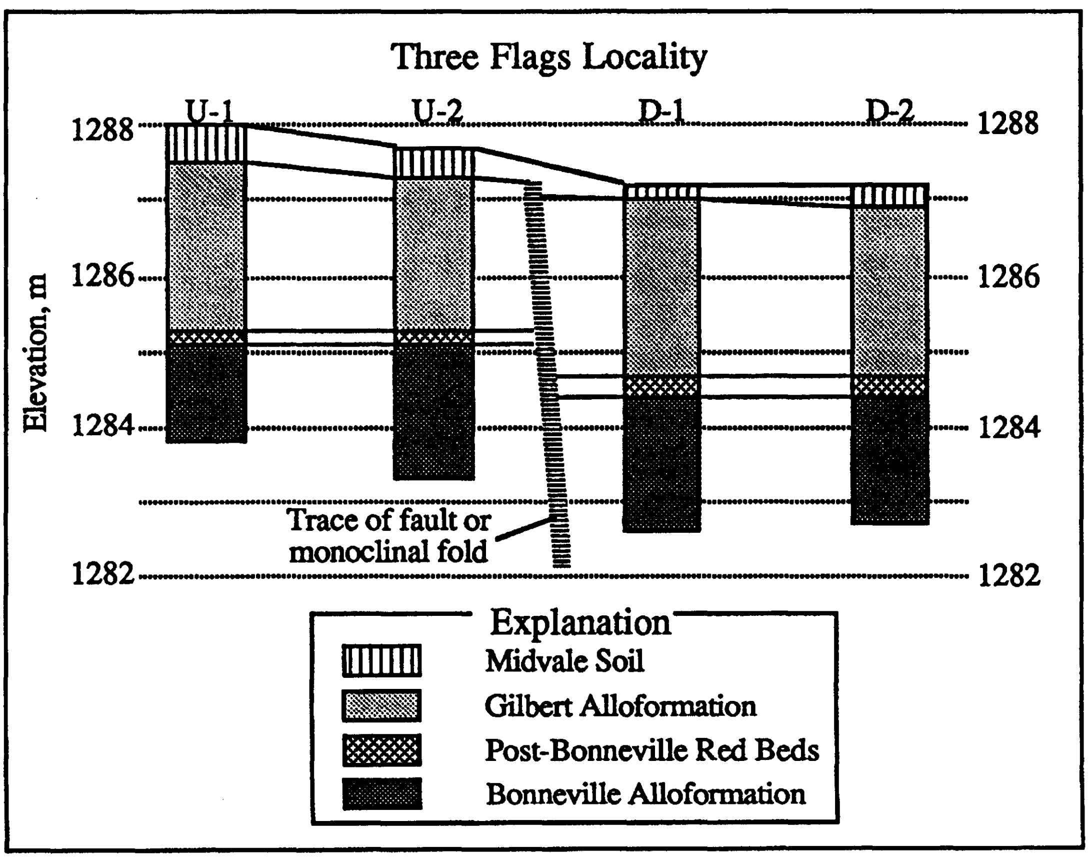

Figure 11. Geologic interpretation of borings drilled at the Three Flags Locality.

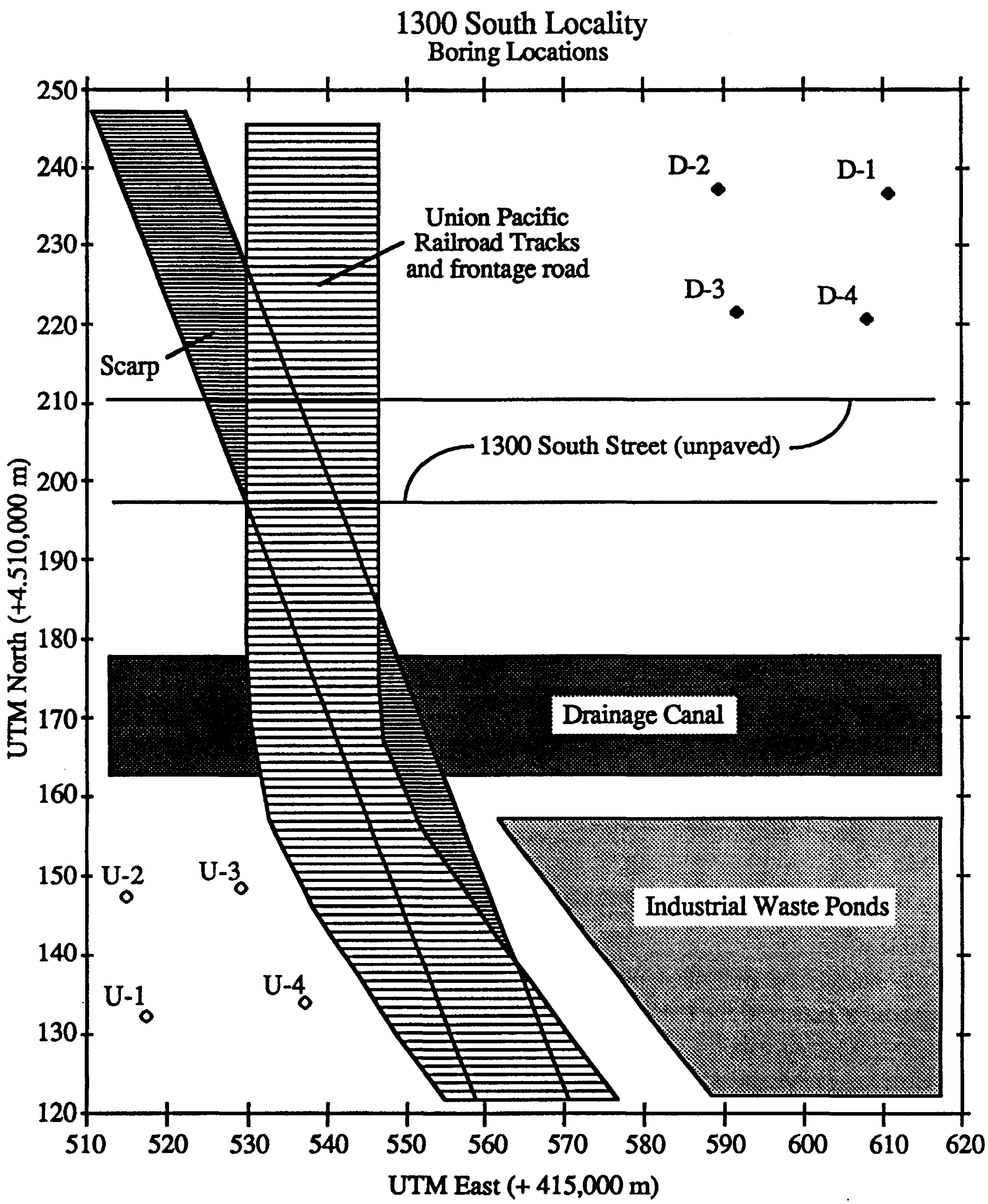

Figure 12. Locations of borings drilled at the 1300 South Locality.

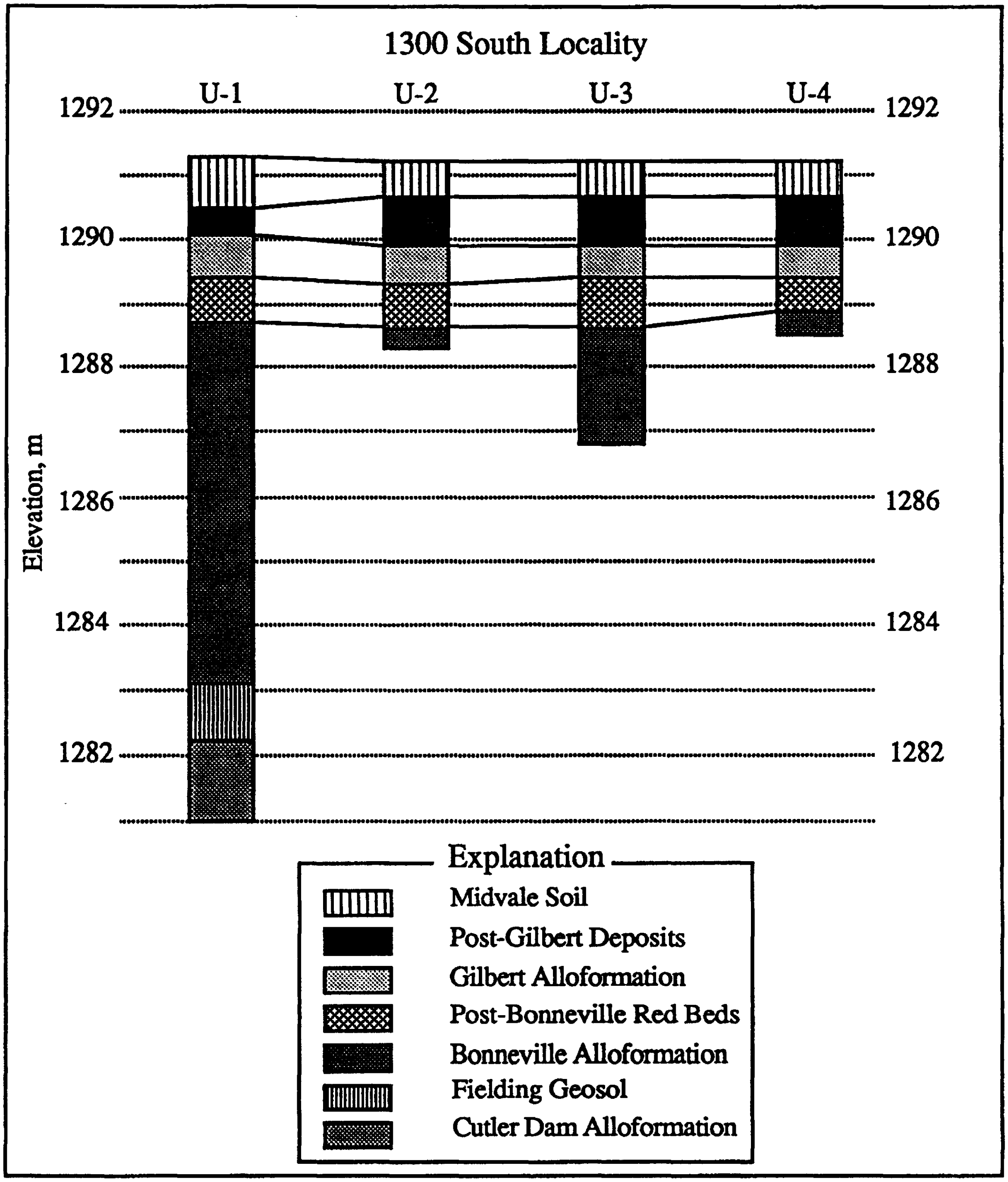

Figure 13. Geologic interpretation of borings drilled on the up-thrown side of a trace of the West Valley fault zone at the 1300 South Locality.

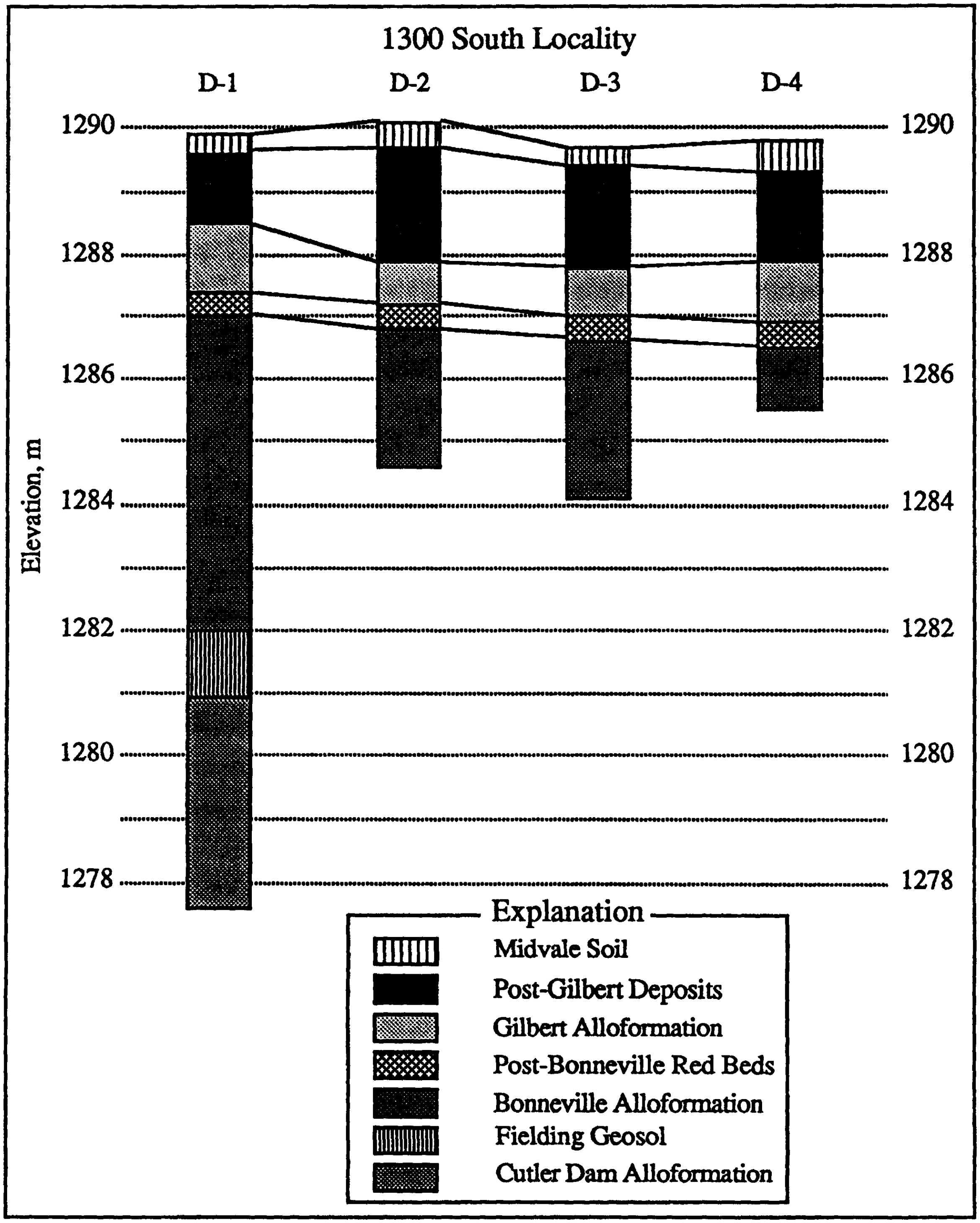

Figure 14. Geologic interpretation of borings drilled on the down-thrown side of a trace of the West Valley fault zone at the 1300 South Locality.

thrown side. The subsurface stratigraphy in the borings correlated well to the stratigraphic model presented earlier in this report.

Strike and dip of the base of the post-Bonneville red bed layer was determined by the three-point problem method. The source code of a BASIC language program written to solve three-point problems is presented in Appendix B. The solutions of the three-point problems using the bottom of the red bed layer are summarized in Table 3. Statistical analyses of the mean values of the strikes and dips from the up-thrown and down-thrown sides of the scarp support the conclusion that the scarp probably has a tectonic origin, although greater uncertainty exists at this locality than at the Goggin Drain Locality because the sets of borings on the up-thrown side are so far from those on the down-thrown side (Ho: $\mu_{AZU} = \mu_{AZD}$, $t = 9.784$, $df = 3$, $0.0005 < p \leq 0.005$; Ho: $\mu_{DIPU} = \mu_{DIPD}$, $t = -3.327$, $df = 3$, $0.01 < p \leq 0.025$; Ho: $\mu_{AZD} = \mu_{AZU}$, $t = -7.303$, $df = 3$, $0.0005 < p \leq 0.005$; Ho: $\mu_{DIPD} = \mu_{DIPU}$, $t = 1.717$, $df = 3$, $0.05 < p \leq 0.10$).

Deformation of the bottom surface of the post-Bonneville red bed was also evaluated using a first-order trend surface. The surface is discontinuous across the scarp as shown on Figure 15. The equations for the surfaces are:

$$Bot_{RBU} = 86.17231 + 0.00760 \text{ UTM East} - 0.01041 \text{ UTM North } (n = 4, r^2 = 0.87) \quad (5)$$

$$Bot_{RBD} = 78.99195 + 0.00448 \text{ UTM East} + 0.02194 \text{ UTM North } (n = 4, r^2 = 0.78) \quad (6)$$

where Bot_{RBU} is the elevation of the bottom of the red bed on the up-thrown side of the scarp and Bot_{RBD} is the elevation on the down-thrown side of the scarp. Elevations should be added to 1200 m for m.s.l. datum; UTM East coordinates should be added to 415,000 m, and UTM North coordinates should be added to 4,510,000 m for UTM zone 12.

Table 3. Summary of strike and dip determinations from three-point problems using the bottom of the post-Bonneville red bed deposits at the 1300 South Locality. Borings with the prefix U are on the up-thrown side of the scarp; borings with the prefix D are on the down-thrown side. Strike and dip were determined analytically using a computer program called 3POINT; the source code for this program is presented in Appendix B.

Borings	Strike Azimuth (°)	Dip (°)	Borings	Strike Aximuth (°)	Dip (°)
U1,U2,U3	266.1	0.4	D1,D2,D3	137.0	0.9
U1,U2,U4	203.1	0.7	D1,D2,D4	110.9	2.0
U1,U3,U4	230.7	1.1	D1,D3,D4	077.3	2.1
U2,U3,U4	266.1	1.2	D2,D3,D4	042.7	0.7
Mean	241.5	0.8	Mean	092.0	1.4
Standard Deviation	030.6	0.37	Standard Deviation	041.0	0.72

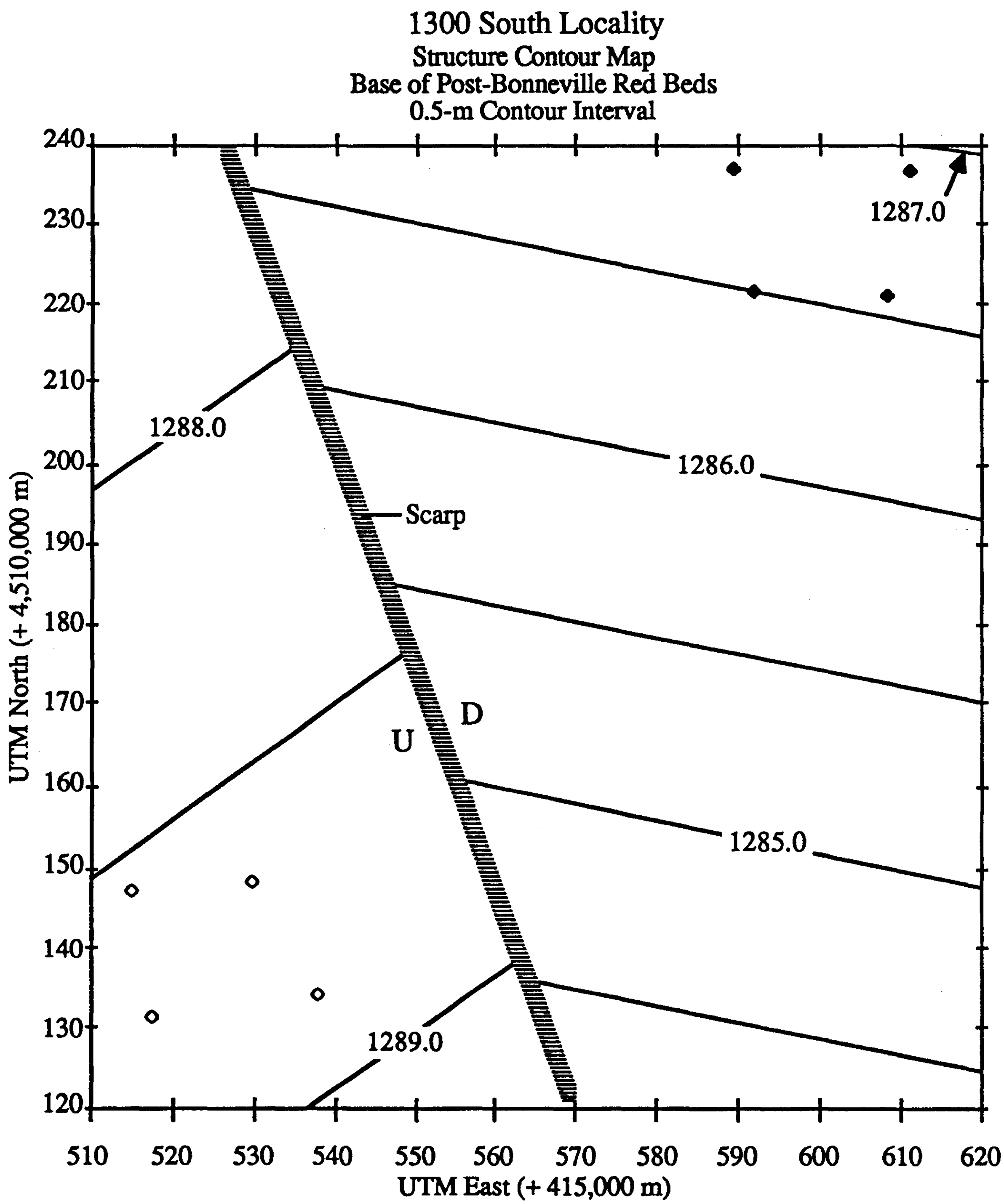

Figure 15. Structure contour map on the bottom of the post-Bonneville red bed at the 1300 South Locality. Contours represent the first-order trend surface computed separately for the up-thrown and down-thrown sides of the scarp.

The trace of the West Valley fault zone which passes through the 1300 South Locality appears to be a purely dip-slip normal fault, consistent with other observations in the region. The apparent vertical offset of the ground surface ranges from 1.3 to 1.6 m at this locality. The vertical separation of the bottom of the post-Bonneville red beds ranges from about 1.6 m, based on horizontal projection across the scarp, to about 3.0 m, based on the trend surfaces shown in Figure 15. The surface on the up-thrown side of the scarp dips at 0.74° at an azimuth of 323.9°, while the surface on the down-thrown side dips at 1.28° at an azimuth of 191.5°; thus, the amount of separation at the fault varies with the position along it. Apparent vertical separation of both the top and the bottom of the Fielding Geosol (hence, the bottom of the Bonneville Alloformation and the top of the Cutler Dam Alloformation) is only 1.1 m based on horizontal projection to the fault. Assuming that the surfaces of the Fielding Geosol are parallel to the post-Bonneville red bed on opposite sides of the fault, the vertical separation of the Fielding Geosol could be on the order of 4.5 m. However, since little is known about the character of tectonic deformation of the sediments at this locality, and since the separation appears to vary along the fault, the range of separation of the Fielding Geosol could be 3.0 to 6.0 m. Back-tilting of the post-Bonneville red beds on the down-dropped side of the scarp is indicated by the first-order trend surfaces shown on Figure 15.

Offset of the Fielding Geosol probably occurred after it had been inundated by Lake Bonneville, or late in its development because the bottom of the Bonneville Alloformation is offset the same amount. Inundation of the basin at the beginning of the Bonneville lake cycle occurred about 28 ka B.P.; therefore, 28 ka is taken as the early limit of the offset of the Fielding Geosol shown on Figure 16. The amount of offset of the post-Bonneville red beds could be on the order of half of the offset of the Fielding Geosol, and the offset of the Fielding Geosol probably occurred early in Lake Bonneville time. Lake Bonneville reached an altitude of 1371.6 m (4500 ft) at about 22 ka B.P. (Currey and Oviatt, 1985). Thus, the 1300 South Locality, at an altitude of about 1291 m, was inundated prior to 22 ka B.P. The later limit of offset of the Fielding Geosol shown on Figure 16 is assumed to be 22 ka. A surface expression of 1.3 to 1.4 m between the two sets of borings is compatible with a 1.5-m per event estimate for other localities along the West Valley fault zone. The age of the surface at the 1300 South Locality, not considering the anthropogenic disturbance, is younger than 9 ka B.P. The character of the scarp on 1937 aerial photographs does not appear to be younger than about 3 ka B.P. Since the amount of offset of the post-Bonneville red bed at the 1300 South Locality may be as much as 3.0 m, it appears that two events may have occurred since the red bed was deposited between 12.5

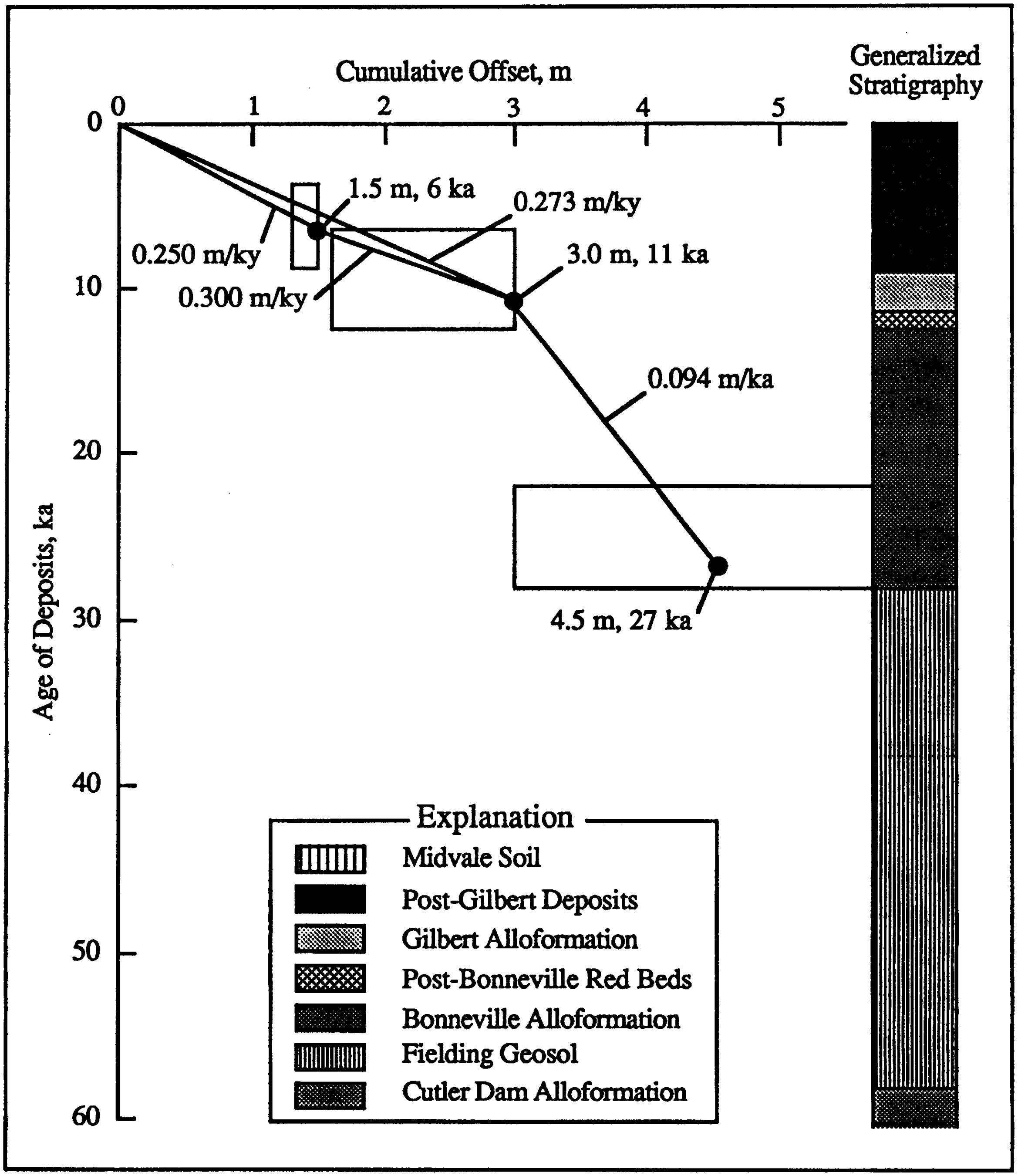

Figure 16. Cumulative offset as a function of age of deposits at the 1300 South Locality.

and 11.5 ka B.P. These figures yield an average recurrence of 5.8 to 6.3 ky. Based on the data revealed in the borings suggest that 3 surface faulting events may have occurred at the 1300 South Locality in the last 22 to 28 ka, or an average recurrence of 7.3 to 9.3 ky. The estimate of earthquake recurrence on the Granger fault reported by Keaton and others (1987) was 8 to 10 ky.

The most recent event may have occurred within the last 6 ka B.P. The slip rate calculated on the basis of 3 m of offset of the 11-ka post-Bonneville red beds is 0.273 m/ky; if a 1.5-m surface displacement event occurred about 6 ka B.P., the slip rate for the last 6 ka would be 0.250 m/ky, and the slip rate for the period 6 to 11 ka would be 0.300 m/ky. The slip rate calculated on the basis of a 4.5 m of offset of 27-ka bottom of the Bonneville Alloformation is 0.094 m/ky, assuming that a subsequent susrface faulting event occurred 11 ka B.P. Under these assumptions, an average offset per event would be approximately 1.5 m, a figure consistent with observations of surface expression elsewhere on the West Valley fault zone. Significant uncertainty exists in the estimation of slip rates at the 1300 South Locality owing to the large distance between the sets of borings and the fact that only one boring on each side of the fault penetrated the Fielding Geosol. A trent surface for the Fielding Geosol needs to be developed on the basis of at least three borings, and preferably more, on each side of the fault.

Pioneer Square Locality

This locality is situated in the center of the SE. 1/4, Sec. 16, T. 1 S., R. 1 W., SLB&M. During earlier research, a shallow trench (Trench 9B) was excavated across a 1.5-m high scarp adjacent to an abandoned canal, part of which had been backfilled. This trench revealed a monoclinal flexure with minor, down-to-the-east step faulting. The horizontal distance over which the flexing was visible was less than 5 m; the vertical component of the shallow subsurface expression of the flexure was no larger than the surface scarp height.

The distribution of surface fault and fold traces presented in the earlier research (Keaton et al., 1987) was based chiefly on aerial photograph analysis north of 2100 South Street. These traces impacted potential development within Salt Lake City and County, which have fault rupture hazard ordinances. Seven additional shallow trenches were excavated at the direction of the Principal Investigator of this research under a contract between Price Development Company and Sergent, Hauskins & Beckwith Engineers, Inc. The trenches were excavated at locations shown on Figure 17. These trenches ranged up to 2.74 m deep, but averaged about 1.5 m. Ground water was encountered in several of the trenches and made observation of stratigraphic relationships more difficult.

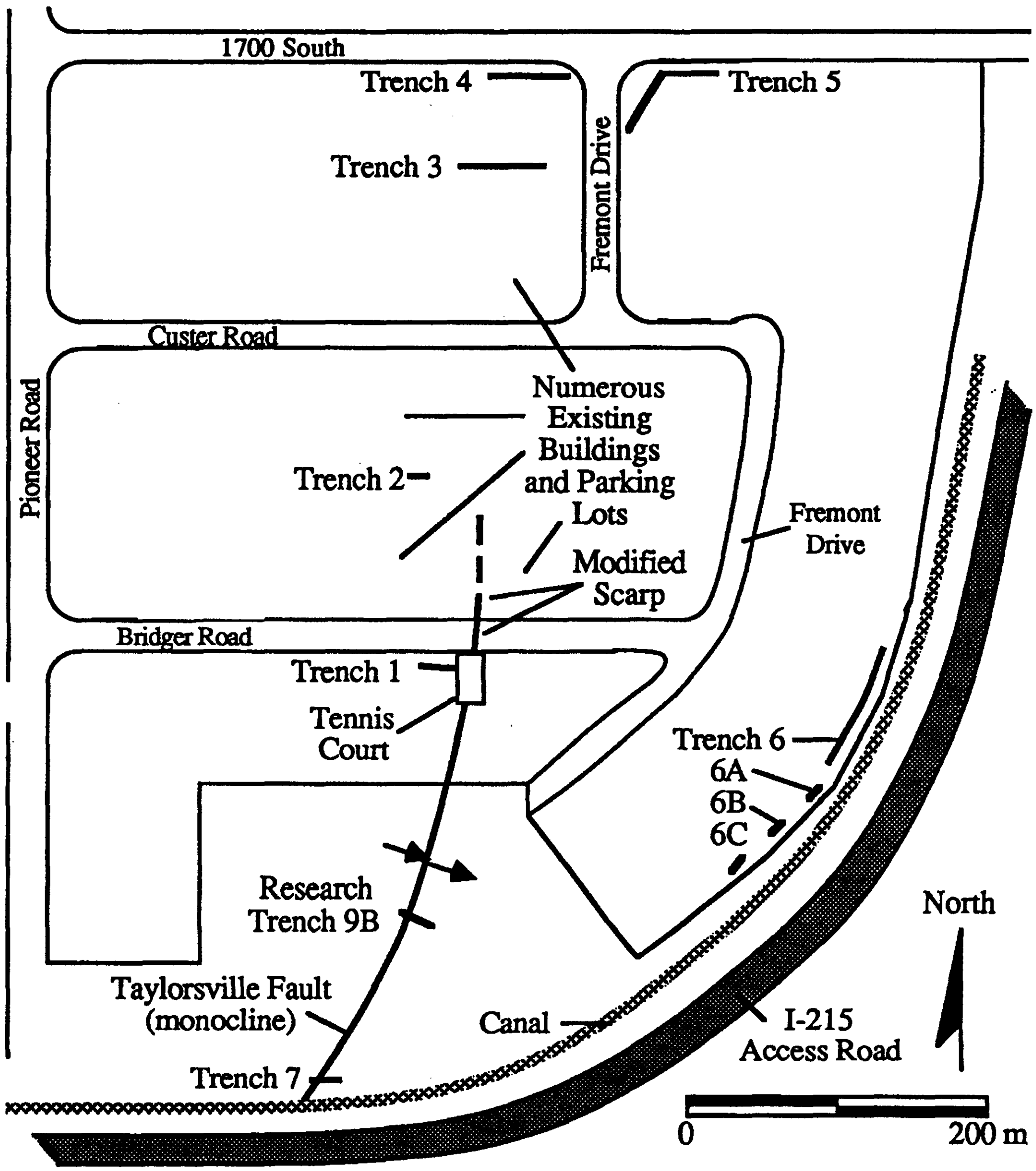

Figure 17. Locations of trenches excavated at the Pioneer Square Locality. These trenches were commissioned by Price Development Company in a contract to Sergent, Hauskins & Beckwith. The field work was completed under the direction of the Principal Investigator of this research project.

The oldest material encountered in the trenches was gray, medium to coarse sand, interpreted to be transgressive deposits of the Gilbert Alloformation. This was overlain by light gray to greenish gray silty clay with occasional sand partings, interpreted to be deeper water facies of the Gilbert Alloformation. Deep water to regressive clayey silt to sand represented the upper part of the Gilbert Alloformation. A gray brown calcareous sandy clay overlying the Gilbert Alloformation deposits was interpreted to be ground water carbonate in latest-stage Gilbert or post-Gilbert deposits. Pedogenic Bk and A horizons formed in sandy clay to clayey silt were the uppermost layers at the Pioneer Square Locality where fill deposits were not present; these pedogenic horizons are part of the Midvale soil.

A contact separating two of the units of the Gilbert Alloformation was observed to be continuous and unfaulted across six of the seven trenches excavated at Pioneer Square. Evidence of faulting and folding in shallow materials was observed only in Trench 7, excavated south of the earlier research trench, as shown on Figure 17. The trace of the Taylorsville fault at Pioneer Square appears to die out north of Bridger Road, as shown on Figure 17. The trace of the fault north of this location, and the trace on the east side of Pioneer Square shown by Keaton and others (1987) apparently do not exist in deposits of the Gilbert Alloformation.

CONCLUSIONS

The stratigraphic model of late Pleistocene deposits in north-central Salt Lake Valley is very useful in conducting paleoseismic investigations. Conventional available geotechnical boring and test pit logs commonly omit critical stratigraphic data needed for detailed interpretations of stratigraphy. These omissions probably result from generally widely spaced samples, general lack of understanding or appreciation of the stratigraphic context in areas investigated by most geotechnical consultants, and typical non-geological background of individuals logging the borings and test pits.

Observations of the walls of shallow trenches permits assessment of most recent displacement, and occasionally the most recent two or three displacements. However, if stratigraphy is well known, then deeper borings can provide valuable information on slip rates over periods of time well beyond the reach of conventional backhoe equipment, particularly in areas of shallow ground water. Significant uncertainty on amounts of offset and slip rate projections is generated by widely or inappropriately spaced borings and insufficient number of borings penetrating key stratigraphic marker units. For example, uncertainty exists at the 1300 South Locality owing from significant distance between sets of borings on opposite sides of the fault. Trend surfaces developed from such data require projection significantly outside the limits of the data used to define the surfaces. An additional need is to develop trend sufrace with more than three borings penetrating each key unit on each side of the fault. The alternatives used at the Goggin Drain and 1300 South Localities are to use horizontal projections or assume that the lower surfaces are parallel to the upper surfaces. Horizontality is known to be incorrect in many cases, and no basis exists to support parallism of sequentially faulted and deformed units.

The subsurface data collected at the Goggin Drain, Three Flags, and 1300 South Localities supports the initial interpretation that scarps at these localities are tectonic in origin. Subsruface data collected at the Pioneer Square Localitiy indicates that the initial interpretation was incorrect and that apparent scarps here are do not disrupt deposits of the Gilbert Alloformation which are older than about 10 ka B.P.

The amounts of offset and calculated slip rates for the Goggin Drain, Three Flags, and 1300 South Localities are compatible with data developed from localities in the southern part of the West Valley fault zone investigated in an earlier research project by Keaton and others (1987). These amounts and rates are less for the West Valley fault zone than published values for segments of the Wasatch fault zone and summarized by Youngs and others (1987).

The relationship of the West Valley fault zone to the Salt Lake City segment of the Wasatch fault zone is uncertain. It is clear that surface fault rupture or monoclinal folding hazards exist along traces of the West Valley fault zone, whether or not the zone is capable of generating strong ground motion independent of the Wasatch fault zone. Details of slip history for each of the fault zones will have to be thoroughly understood before they can be compared to resolve this issue. Prudence would dictate that the West Valley fault zone be considered capable of generating strong ground motion as well as surface faulting or coseismic folding. Thus, we conclude that the West Valley fault zone represents a significant earthquake hazard in the urban area of Salt Lake City.

The data developed during this research suggest that the average time between earthquakes which cause surface faulting or folding on the West Valley fault zone is 6 to 11 ky. Average recurrence intervals estimated by Keaton and others (1987) for places in the southern part of the West Valley fault zone range from 2.6 to 6.5 ky. The southern traces of the fault zone are higher and more prominent than the northern traces; hence, a shorter average recurrence interval may be appropriate, although the fault zone is relatively short.

The probability of a surface faulting or monoclinal folding event in the next 50 years can be estimated by procedures described by Youngs and others (1987, p. M-84). The character of the development of the Midvale soil on the scarp at the Goggin Drain Locality suggests that the soil may have formed on an existing scarp. Soil formation at this locality began when the Gilbert lake cycle receded at approximately 9 ka B.P. The scarp probably could have formed as late as about 6 ka and still have permitted enough time for the Midvale soil to have developed. Therefore, using 11 ky as the average recurrence, 6 ky as the time since the last event, and 0.7 as the coefficient of variation of the recurrence interval (assumed by Youngs et al., 1987), the probability of a surface faulting or folding event on the northern West Valley fault zone is estimated to be 0.20 in the next 50 years.

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APPENDIX A

LOGS OF BORINGS

APPENDIX A

LOGS OF BORINGS

GOGGIN DRAIN LOCALITY

Borings on the up-thrown side of a trace of the West Valley fault zone.

Boring U-1

UTM East = 416359.1; UTM North = 4512753.3; Elevation = 1286.9 m

Depth, m	Color (moist)	Description
0 - 0.12	7.5YR6/2 (5/2)	Clayey and fine sandy silt, medium crumb structure, abundant fine roots, calcareous, strong effervescence.
0.12 - 0.37	7.5YR6/2 (5/2)	Increasing clay content. **Midvale soil.**
0.37 - 0.76	5Y6/2 (6/2)	Interbedded silty clay and fine sandy and clayey silt. **Gilbert Alloformation.**
0.76 - 0.85	5Y7/2 (6/2)	Fine sandy silt, calcareous, strong effervescence.
0.85 - 1.16	5Y6/2 (6/2)	Silty clay with some fine sand; increasing sand content with depth.
1.16 - 1.43	5Y6/2 (6/2)	Laminated fine sandy clay and fine sandy silt.
1.43 - 2.46	5YR6/3 (6/3)	Silty clay with sand partings at relatively frequent intervals; red sand at 1.57 m, green sand at 1.89 m; other sand partings are white with halos of 5Y6/2. **Gilbert Alloformation.**
2.46 - 2.59	5YR6/3 (6/3)	Laminated fine sandy clay and silt. **Post-Bonneville Red Beds.**
2.59 - 3.14	5Y5/2 (5/2)	Silty clay, calcareous, moderate effervescence; increasing sand below 2.65 m; grades to coarse sand at 2.99 m. **Bonneville Alloformation**
3.14 - 3.35	5YR5/1-6/1 (6/1)	Silty clay, calcareous, weak effervescence; post-Bonneville red beds.
3.35 - 3.61	5YR5/1 (5/1)	Medium to coarse sand; regressive Bonneville.
3.61 - 3.82	N2	Organic silty clay, noncalcareous, occasional fine sand partings.
3.82 - 3.99	10YR6/1 (6/1)	Medium sand, calcareous, weak to moderate effervescence. **Bonneville Alloformation.**

Boring U-2

UTM East = 416371.2; UTM North = 4512769.0; Elevation = 1286.6 m

Depth, m	Color (moist)	Description
0 - 0.09	7.5YR7/2 (4/4)	Silt with minor sand, medium crumb structure, roots, calcareous, strong effervescence.
0.09 - 0.30	7.5YR7/2 (5/4)	Fine sandy silt and silty clay, roots, calcareous, strong effervescence. **Midvale soil.**

Boring U-2 (Continued)

Depth, m	Color (moist)	Description
0.30 - 1.34	5Y6/3 (6/3)	Increasing clay content, calcareous, strong effervescence, frequent iron nodules, color darkens with depth. **Gilbert Alloformation.**
1.34 - 1.71	5Y5/3 (5/3)	Silt and silty clay, calcareous, moderate effervescence.
1.71 - 1.77	5YR5/4 (5/4)	Medium to fine sand, calcareous, moderate effervescence. **Gilbert Alloformation**
1.77 - 2.26	2.5YR5/4 (5/4)	Silty clay, calcareous, moderate effervescence; sand partings at four locations. **Post-Bonneville Red Beds.**
2.26 - 2.38	5Y6/2 (5/2)	Fine sand to silt, calcareous, weak effervescence; green sand. **Bonneville Alloformation.**
2.38 - 2.59	5YR5/3 (5/3)	Silty clay, few mottles, calcareous, weak effervescence.
2.59 - 2.77	5YR5/3 (5/4)	Sandy silt, grades coarser with depth, calcareous, moderate effervescence.
2.77 - 3.05	5YR5/6 (4/6)	Coarse sand, calcareous, weak effervescence, local iron stains; transgressive Gilbert deposits.
3.05 - 3.20	10YR5/2 (5/2)	Silty clay to clay, calcareous, weak effervescence, few mottles; post-Bonneville red beds.
3.20 - 3.23	5Y6/1 (5/1)	Sandy silt, calcareous, weak effervescence.
3.23 - 3.38	2.5Y4/0 (4/0)	Organic silty clay, grades silty to sandy with depth, calcareous, weak effervescence, black mottles.
3.38 - 3.41	N2	Organic silty clay, slightly calcareous, very weak effervescence.
3.41 - 3.44	7.5YR7/0 (5/0)	Sand layer, calcareous, weak effervescence.
3.44 - 3.47	N2	Organic silty clay, calcareous, weak effervescence. **Bonneville Alloformation.**

Boring U-3

UTM East = 416365.8; UTM North = 4512720.1; Elevation = 1287.2 m

Depth, m	Color (moist)	Description
0 - 0.52	7.5YR7/2 (4/4)	Clayey and fine sandy silt, medium to fine weak equigranular structure, cumulic profile, roots, calcareous, strong effervescence. **Midvale soil.**
0.52 - 1.10	7.5YR7/2 (4/4)	Silty clay, calcareous, strong effervescence. **Gilbert Alloformation.**
1.10 - 1.22	10YR4/6-7/3 (5/3)	Silty clay, calcareous, strong effervescence.
1.22 - 1.77	5Y6/2 (6/2)	Silty clay with fine sand partings and organic flecks; calcareous sand, strong effervescence; noncalcareous silty clay.
1.77 - 2.47	5YR5/3 (5/3)	Silty clay with occasional sand partings; red sand at 2.04 m, green sand at 2.21 m; calcareous, weak effervescence. **Gilbert Alloformation.**
2.47 - 2.83	5YR5/3 (5/3)	Silty clay with occasional sand partings. **Post-Bonneville Red Beds.**

Boring U-3 (Continued)

Depth, m	Color (moist)	Description
2.83 - 2.96	5Y6/2 (5/3)	Sandy clay grading to clayey sand at 2.90 m. **Bonneville Alloformation.**
2.96 - 3.05	5Y6/2 (6/2)	Sand, calcareous, weak effervescence.
3.05 - 3.14	5Y6/2 (6/2)	Clay, calcareous, weak effervescence.
3.14 - 3.20	2.5Y6/4 (6/4)	Coarse sand, calcareous, weak to moderate effervescence.
3.20 - 3.66	5Y6/2 (6/2)	Clay, white sand parting at 3.23 m; occasional brown mottled zones at 3.26 and 3.44 m; sand is calcareous, weak to moderate effervescence.
3.66 - 3.75	2.5Y6/4 (5/4)	Coarse sand dipping at 45°, calcareous, weak to moderate effervescence.
3.75 - 3.84	2.5Y6/4 (6/4)	Clay, white sand parting at 3.81 m dipping at 45°; sand is calcareous, weak moderate effervescence.
3.84 - 3.87	N2	Detrital organic clay.
3.87 - 3.99	N2	Sand, calcareous, moderate effervescence.
3.99 - 4.08	5Y5/1 (5/1)	Clay.
4.08 - 4.30	5Y5/1 (5/1)	Sand, calcareous, moderate effervescence.
4.30 - 4.36	N2	Clay.
4.36 - 4.42	5Y5/1 (5/1)	Sand, calcareous, moderate effervescence.
4.42 - 5.18	N2	Clay, laminated at 4.85 to 4.97 m.
5.18 - 5.49	5Y4/1 (4/1)	Clay, with dark gray (5Y3/1) laminae; grades sandy with depth.
5.49 - 7.92	5Y4/1-4/2 (4/2)	Sand with silty and clayey zones, calcareous, moderate effervescence. **Bonneville Alloformation.**
7.92 - 10.82	5Y4/1 (4/1)	Silty clay, laminated with sandy layers; two hematite layers (10R4/4) at 7.99 and 9.02 m; minor red layer at 9.14 m. **Fielding Geosol**
10.82 - 11.89	5Y4/1 (4/1)	Sand, calcareous, moderate effervescence. **Cutler Dam Alloformation.**
11.89 - 12.95	5Y4/1 (4/1)	Clay, laminated, occasional organic flecks and sand layers, calcareous, moderate effervescence.
12.95 - 13.90	5Y4/1 (4/1)	Silty clay, calcareous, moderate effervescence.
13.90 - 14.57	5Y4/1 (4/1)	Sand, calcareous, moderate effervescence. **Cutler Dam Alloformation.**

Boring U-4

UTM East = 416379.4; UTM North = 4512739.2; Elevation = 1287.2 m

Depth, m	Color (moist)	Description
0 - 0.12	7.5YR7/2 (4/3)	Silt and sand, medium to fine weak crumb sturcture, roots, calcareous, strong effervescence.
0.12 - 0.46	7.5YR6/4 (4/4)	Silt and silty sand, medium peds, root hairs, calcareous, strong effervescence.
0.46 - 0.61	7.5YR7/4 (5/6)	Silt, strong crumb structure, roots and root hairs, calcareous, strong effervescence. **Midvale soil.**

Boring U-4 (Continued)

Depth, m	Color (moist)	Description
0.61 - 1.19	5Y7/4 (7/3)	Silt and silty sand, sand partings at 4 intervals, calcareous, moderate effervescence. **Gilbert Alloformation.**
1.19 - 1.68	5Y6/4 (6/4)	Fine sand and silt, mottled with iron stains, calcareous, moderate effervescence.
1.68 - 1.86	2.5Y6/2 (6/2)	Fine sandy silt and silt, calcareous, moderate effervescence.
1.86 - 1.95	5Y6/3 (6/3)	Silt and clay, calcareous, moderate effervescence.
1.95 - 2.22	5Y7/3 (7/3)	Silt and clay with black mottles, calcareous, moderate effervescence. **Gilbert Alloformation.**
2.22 - 2.29	5Y5/4 (5/4)	Fine to medium sand, calcareous, weak effervescence.
2.29 - 2.74	5Y5/3 (5/3)	Silt and clay, sand partings at 4 intervals, calcareous, weak effervescence. **Post-Bonneville Red Beds.**
2.74 - 2.83	5Y6/1 (6/1)	Fine to medium sand, calcareous, moderate effervescence. **Bonneville Alloformation.**
2.83 - 3.11	5Y5/3 (5/3)	Silt and clay with dark mottles, sand partings at 2.90 and 2.93 m, calcareous, moderate effervescence.
3.11 - 3.41	2.5Y4/4 (5/4)	Silt and fine sand with dark mottles, calcareous, weak effervescence.
3.41 - 3.51	5Y5/4 (5/4)	Silt and clay, iron stains, calcareous, weak effervescence.
3.51 - 3.66	10YR5/6 (5/6)	Coarse sand, calcareous, moderate effervescence.
3.66 - 3.72	2.5Y5/2 (5/2)	Silt and clay, calcareous, weak effervescence.
3.72 - 3.75	5Y5/1 (5/2)	Fine sand, iron stains, calcareous, moderate effervescence.
3.75 - 3.96	5Y5/2 (5/2)	Silt and clay, grades more silty, slightly calcareous, very weak effervescence.
3.96 - 4.11	5Y6/1 (5/1)	Fine sand and silt, grades sandy, calcareous, weak effervescence.
4.11 - 4.27	N2	Organic clay, red sand parting at 4.18 m, calcareous, weak effervescence. **Bonneville Alloformation.**

Boring U-5

UTM East = 416383.2; UTM North = 4512753.9; Elevation = 1287.0 m

Depth, m	Color (moist)	Description
0 - 0.18	7.5YR6/4 (4/4)	Silt, medium crumb structure, roots, calcareous, strong effervescence.
0.18 - 0.43	7.5YR5/6 (4/6)	Silt, blocky, root hairs, calcareous, strong effervescence. **Midvale soil.**
0.43 - 0.64	7.5YR6/4 (5/4)	Silt to silty clay, with some sand, calcareous, strong effervescence. **Gilbert Alloformation.**
0.64 - 1.22	5YR6/4 (6/4)	Fine sandy silt and clay, sand partings at 3 intevals, calcareous, moderate to strong effervescence.
1.22 - 1.83	7.5YR7/4 (7/4)	Silty clay with dark gray mottles, calcareous, weak effervescence.

<u>Boring U-5</u>

Depth, m	Color (moist)	Description
1.83 - 2.07	10YR7/4 (7/4)	Silty clay grading sandy, sand parting at 1.95 m, calcareous, moderate effervescence.
2.07 - 2.13	5Y6/2 (5/2)	Fine to medium sand, calcareous, strong effervescence. **Gilbert Alloformation.**
2.13 - 2.53	5Y6/3 (6/3)	Silty clay, few gray mottles, sand partings at 3 intervals, calcareous, weak effervescence. **Post-Bonneville Red Beds.**
2.53 - 2.62	5Y6/2 (5/2)	Fine to medium sand, grades olive green with depth, calcareous, strong effervescence. **Bonneville Alloformation.**
2.62 - 2.87	5Y5/2 (5/2)	Silty clay, calcareous, weak effervescence.
2.87 - 3.23	5Y5/2 (5/1)	Silty sand, calcareous, moderate effervescence.
3.23 - 3.47	5Y5/1 (5/1)	Coarse sand, grades cleaner with depth, calcareous, moderate effervescence.
3.47 - 3.66	2.5Y6/0 (6/0)	Silty clay, slightly calcareous, very weak effervescence.
3.66 - 3.69	2.5Y6/2 (6/2)	Silt and sand, calcareous, moderate effervescence.
3.69 - 3.78	2.5Y4/0 (4/0)	Silty clay, slightly calcareous, very weak effervescence.
3.78 - 3.90	10YR5/1 (5/1)	Silt and sand, calcareous, violent effervescence.
3.90 - 4.08	7.5YR5/0 (4/0)	Coarse sand, calcareous, moderate effervescence.
4.08 - 4.18	N2	Organic silty clay and clay.
4.18 - 4.27	7.5YR7/2 (7/0)	Coarse to medium sand, slightly calcareous, very weak effervescence. **Bonneville Alloformation.**

Borings on the scarp of a trace of the West Valley fault zone.

<u>Boring C-1</u>

UTM East = 416387.8; UTM North = 4512757.7; Elevation = 1286.2 m

Depth, m	Color (moist)	Description
0 - 0.18	7.5YR6/4 (4/4)	Sandy silt, medium blocky structure, roots, calcareous, strong effervescence.
0.18 - 0.58	7.5YR6/4 (5/4)	Sandy silt, fine crumb structure, sand layers at 4 intervals, calcareous, strong effervescence. **Midvale soil.**
0.58 - 0.82	5Y5/2 (5/2)	Silt and sand, calcareous, violent effervescence. **Gilbert Alloformation.**
0.82 - 0.85	5Y7/2 (7/2)	Silt and sand, roots, calcareous, violent effervescence.
0.85 - 0.94	5Y7/2 (5/4)	Silty clay, minor iron stain, calcareous, moderate effervescence.
0.94 - 1.16	5Y8/3 (8/3)	Silty clay, uniform, calcareous, weak effervescence.
1.16 - 1.40	5YR5/4 (5/4)	Silt, grades sandy with depth, calcareous, moderate effervescence.
1.40 - 1.46	5Y6/2 (5/3)	Medium to fine sand, calareous, strong effervescence. **Gilbert Alloformation.**
1.46 - 1.86	5Y5/3 (5/3)	Silty clay with sand partings at 4 intervals, calcareous, weak effervescence. **Post-Bonneville Red Beds.**

Boring C-1

Depth, m	Color (moist)	Description
1.86 - 1.95	5Y5/2 (5/1)	Fine sand and silt, grades lighter in color with depth, calcareous, moderate effervescence. **Bonneville Alloformation.**
1.95 - 2.19	5YR5/3 (5/3)	Silty clay, massive, gray nodules, slightly calcareous, very weak effervescence.
2.19 - 2.44	5YR5/3 (5/4)	Silty sand, iron stains, slightly calcareous, very weak effervescence.
2.44 - 2.68	7.5YR5/8 (6/8)	Coarse sand, slightly calcareous, very weak effervescence.
2.68 - 2.80	5YR5/2 (5/2)	Silty clay, slightly calcareous, very weak effervescence.
2.80 - 3.11	7.5YR3/0 (3/0)	Organic silty clay, grades to sandy silt with depth, calcareous, moderate effervescence.
3.11 - 3.23	7.5YR4/0 (4/0)	Organic silt and sand, calcareous, moderate effervescence.
3.23 - 3.44	N2	Organic silty clay, sand parting at 3.35 m, calcareous, weak effervescence.
3.44 - 3.78	10YR6/2 (5/1)	Medium sand, calcareous, moderate effervescence.
3.78 - 4.33	N2	Organic silty clay, laminated with depth, slightly calcareous, very weak effervescence.
4.33 - 4.54	7.5YR3/0 (3/0)	Organic silty clay, calcareous, weak effervescence.
4.54 - 5.85	5Y4/1 (4/1)	Sandy silt, sand partings at 8 intervals, calcareous, moderate effervescence. **Bonneville Alloformation.**

Borings on the down-thrown side of a trace of the West Valley fault zone.

Boring D-1

UTM East = 416415.8; UTM North = 4512767.4; Elevation = 1285.1 m

Depth, m	Color (moist)	Description
0 - 0.09	7.5YR7/2 (6/2)	Sandy silt, fine crumb structure, roots, calcareous, strong effervescence.
0.09 - 0.64	7.5YR5/4 (5/2)	Sandy silt, sand layer at 0.58 m, calcareous, strong effervescence. **Midvale soil.**
0.64 - 0.67	10YR7/1 (5/2)	Fine sand, calcareous, violent effervescence. **Gilbert Alloformation or post-Gilbert lake deposits.**
0.67 - 0.88	10YR7/3 (7/3)	Silty clay with numerous sand partings throughout, calcareous, violent effervescence.
0.88 - 0.94	10YR7/2 (7/2)	Silty clay, calcareous, moderate effervescence.
0.94 - 1.40	5Y6.4 (6/4)	Sandy silt with interbedded sand, calcareous, moderate effervescence.
1.40 - 1.55	5Y5/2 (5/2)	Silty clay, massive, slightly calcareous, very weak effervescence.
1.55 - 1.83	7.5YR7/2 (7/2)	Silty clay, massive, calcareous, weak effervescence.
1.83 - 1.98	5Y6/2 (6/2)	Silty clay, massive, slightly calcareous, very weak effervescence.
1.98 - 2.01	5Y5.2 (5.3)	Fine sand, calcareous, violent effervescence. **Gilbert Alloformation.**

Boring D-1

Depth, m	Color (moist)	Description
2.01 - 2.10	5YR5/2 (5/2)	Silty clay, calcareous, moderate effervescence. **Post-Bonneville Red Beds.**
2.10 - 2.74	2.5YR4/0 (4/0)	Organic silty clay, grades darker with depth, calcareous, weak effervescence. **Bonneville Alloformation.**

Boring D-2

UTM East = 416437.0; UTM North = 4512752.6; Elevation = 1285.2 m

Depth, m	Color (moist)	Description
0 - 0.12	7.5YR7/2 (5/4)	Silt and sand, fine crumb structure, roots, calcareous, strong effervescence.
0.12 - 0.30	7.5YR7/4 (6/2)	Silt and sand, root hairs, calcareous, strong effervescence. **Midvale soil.**
0.30 - 0.70	10YR6/2 (6/3)	Silty clay, minor iron stains, calcareous, weak effervescence. **Gilbert Alloformation or post-Gilbert lake deposits.**
0.70 - 0.82	10YR6/4 (5/3)	Fine to medium sand, iron stained calcareous, weak effervescence.
0.82 - 1.58	2.5Y7/2 (7/2)	Silty clay with numerous sand partings, calcareous, moderate effervescence.
1.58 - 1.86	5Y6/2 (6/2)	Silty clay, massive, calcareous, moderate effervescence.
1.86 - 2.13	5Y7/2 (7/2)	Silty clay, massive, color grades darker with depth, slightly calcareous, very weak effervescence. **Gilbert Alloformation.**
2.13 - 2.29	10YR6/3 (6/3)	Sand, calcareous, moderately effervescence. **Post-Bonneville Red Beds.**
2.29 - 2.74	5Y5/2 (5/2)	Silty clay, massive, few dark mottles, slightly calcareous, very weak effervescence. **Bonneville Alloformation.**
2.74 - 2.77	2.5Y3/0 (4/0)	Organic sand, calcareous, moderate effervescence.
2.77 - 3.20	N2	Organic silty clay, red layer at 2.99 m, slightly calcareous, very weak effervescence.
3.20 - 3.29	7.5YR4/0 (4/0)	Silty clay, massive, calcareous, moderate effervescence.
3.29 - 3.41	5YR5/2 (5/2)	Fine to medium sand, calcareous, violent effervescence.
3.41 - 3.63	N2	Organic silty clay, slightly calcareous, very weak effervescence.
3.63 - 3.93	5YR5/1 (5/2)	Silt and fine to medium sand, grading to coarse sand, calcareous, moderate effervescence. **Bonneville Alloformation.**

Boring D-3

UTM East = 416417.4; UTM North = 4512726.3; Elevation = 1285.2 m

Depth, m	Color (moist)	Description
0 - 0.18	7.5YR7/2 (5/4)	Silt and fine sand, fine blocky to crumb structure, roots, calcareous, strong effervescence.
0.18 - 0.61	5Y6/2 (7/2)	Silt with fine sand partings at 2 intervals, calcareous, strong effervescence. **Midvale soil.**
0.61 - 0.64	5Y7/1 (6/2)	Medium sand, clean, calcareous, moderate effervescence. **Gilbert Alloformation or post-Gilbert lake deposits.**
0.64 - 0.76	10YR7/3 (7/3)	Silty clay, common dark iron stains, calcareous, moderate effervescence.
0.76 - 0.85	10YR7/2 (6/2)	Medium to fine sand, clean, calcareous, moderate effervescence.
0.85 - 1.22	5Y6/2 (6/2)	Silty clay, grades more silty with depth, iron stains, calcareous, moderate effervescence.
1.22 - 1.58	5Y6/3 (6/3)	Silty clay interbedded with fine sand, calcareous, weak effervescence.
1.58 - 1.86	10YR5/2 (5/2)	Silty clay, massive with some silt, calcareous, weak effervescence. **Gilbert Alloformation.**
1.86 - 2.26	5Y7/2 (7/2)	Silty clay, color grades darker with depth, slightly calcareous, very weak effervescence. **Post-Bonneville Red Beds.**
2.26 - 2.44	5Y5/2 (5/2)	Silty clay, massive, sand parting at 2.32 m, calcareous, moderate effervescence. **Bonneville Alloformation.**
2.44 - 2.47	5Y4/2 (3/2)	Sand, calcareous, violent effervescence.
2.47 - 2.74	N2	Silty clay, grades to organic silty clay with depth. **Bonneville Alloformation.**

Boring D-4

UTM East = 416445.3; UTM North = 4512711.8; Elevation = 1286.7 m

Depth, m	Color (moist)	Description
0 - 0.06	7.5YR7/2 (5/4)	Silt and sand, crumb to platy structure, abundant roots, calcareous, strong effervescence; spoil from canal. **Fill.**
0.06 - 0.24	7.5YR6/2 (6/4)	Silt and sand, blocky structure, roots, calcareous, strong effervescence; spoil from canal.
0.24 - 0.49	7.5YR6/6 (5/4)	Silt and sand, roots, calcareous, strong effervescence.
0.49 - 0.67	5Y4/3 (3/2)	Silt and sand, root hairs, slightly calcareous, very weak effervescence; spoil from canal.
0.67 - 0.98	5Y6/3 (4/3)	Silt, abundant roots and root hairs, calcareous, strong effervescence; spoil from canal.
0.98 - 1.25	10YR7/3 (4/2)	Silt, root hairs, calcareous, strong effervescence; spoil from canal. **Fill.**

Boring D-4 (Continued)

Depth, m	Color (moist)	Description
1.25 - 1.49	5YR5/4 (5/4)	Silty clay with some fine sand, calcareous, violent effervescence. **Midvale soil.**
1.49 - 1.52	5YR7/3 (6/4)	Medium sand, calcareous, violent effervescence. **Midvale soil.**
1.52 - 1.95	10YR6/3 (6/3)	Silty clay with some fine sand, calcareous, violent effervescence. **Gilbert Alloformation or post-Gilbert lake deposits.**
1.95 - 2.16	10YR7/2 (7/2)	Silty clay with dark iron mottles, calcareous, moderate effervescence.
2.16 - 2.26	10YR5/2 (4/2)	Sand, grades silty with depth, calcareous, violent effervescence.
2.26 - 3.26	5Y6/1 (6/1)	Silty clay with interbedded sand layers, calcareous, moderate effervescence.
3.26 - 3.60	10YR7/1 (7/3)	Silty clay, color decreases in value with depth, calcareous, moderate effervescence. **Gilbert Alloformation.**
3.60 - 3.84	5Y5/2 (5/2)	Silty clay, grades organic with depth, calcareous, moderate effervescence. **Post-Bonneville Red Beds.**
3.84 - 4.79	N2	Organic silty clay, red sand parting at 4.24 m, calcareous, moderate effervescence. **Bonneville Alloformation.**
4.79 - 4.94	10YR5/1 (5/1)	Sand, calcareous, violent effervescence.
4.94 - 5.15	5YR5/1 (5/1)	Silty clay with some organic matter, calcareous, violent effervescence.
5.15 - 5.27	N2	Organic silty clay, red sand parting at 5.24 m, calcareous, weak effervescence. **Bonneville Alloformation.**

Boring D-5

UTM East = 416395.7; UTM North = 4512755.1; Elevation = 1285.2 m

Depth, m	Color (moist)	Description
0 - 0.09	7.5YR7/2 (4/4)	Silt and sand, crumb structure, many roots, calcareous, strong effervescence.
0.09 - 0.30	7.5YR7/2 (5/4)	Silt and silty clay, few roots, calcareous, strong effervescence. **Midvale soil.**
0.30 - 0.34	7.5YR7/0 (6/0)	Sand with some silt. **Gilbert Alloformation or post-Gilbert lake deposits.**
0.34 - 0.79	5Y7/2 (7/2)	Silt and silty clay, calcareous, moderate effervescence.
0.79 - 0.85	5Y6/2 (6/2)	Fine sand and silt, calcareous, moderate effervescence.
0.85 - 1.10	5Y6/0 (6/0)	Fine sand and silt, grades clayey with depth, calcareous, moderate effervescence.
1.10 - 1.28	5Y8/2 (8/2)	Silt and silty clay, calcareous, weak effervescence.
1.28 - 1.52	5Y6/2 (6/2)	Silty clay, sand parting at 1.49 m, calcareous, weak effervescence.

Boring D-5 (Continued)

Depth, m	Color (moist)	Description
1.52 - 1.58	5Y5/2 (5/3)	Fine sand and silt.
1.58 - 2.04	5YR5/3 (5/3)	Silty clay, sand partings at 3 intervals (two partings dipping at 10° to 15°), calcareous, weak effervescence. **Gilbert Alloformation.**
2.04 - 2.19	2.5YR6/8 (5/6)	Medium to coarse sand, grades gray with depth, slightly calcareous, very weak effervescence. **Post-Bonneville Red Beds.**
2.19 - 2.44	2.5Y4/1 (4/1)	Organic silty clay, sand partings at 3 intervals (dipping at 15°), calcareous, weak effervescence. **Bonneville Alloformation.**
2.44 - 2.59	2.5Y5/0 (5/0)	Silt and sand, calcareous, moderate effervescence.
2.59 - 2.70	10YR6/1 (5/1)	Coarse sand. **Bonneville Alloformation.**

Boring D-6

UTM East = 416416.6; UTM North = 4512748.4; Elevation = 1285.1 m

Depth, m	Color (moist)	Description
0 - 0.12	7.5YR7/2 (6/2)	Silt and sand, crumb structure, root hairs, calcareous, strong effervescence.
0.12 - 0.30	7.5YR5/3 (6/2)	Silty sand and silt, few root hairs, calcareous, strong effervescence.
0.30 - 0.61	7.5YR7/2 (7/2)	Same as above except for color. **Midvale soil.**
0.61 - 0.73	5Y6/2 (6/3)	Silt with numerous sand partings, calcareous, moderate effervescence. **Gilbert Alloformation or post-Gilbert lake deposits.**
0.73 - 0.91	5Y6/2 (6/2)	Silty clay, numerous iron mottles, calcareous, moderate effervescence.
0.91 - 1.04	2.5Y6/4 (5/4)	Fine to medium sand with interbedded silty clay, calcareous, moderate effervescence.
1.04 - 1.83	10YR6/2 (6/2)	Silty clay with numerous sand partings, few mottles with depth, calcareous, moderate effervescence. **Gilbert Alloformation.**
1.83 - 2.10	5Y7/2 (7/2)	Silty clay, massive, calcareous, moderate effervescence. **Post-Bonneville Red Beds.**
2.10 - 2.41	5Y5/2 (5/2)	Silty clay, grades to silt at depth, calcareous, moderate effervescence. **Bonneville Alloformation.**
2.41 - 2.44	10YR6/3 (5/3)	Sand, calcareous, weak effervescence.
2.44 - 2.68	10YR5/2 (5/2)	Silty clay, massive, calcareous, weak effervescence.
2.68 - 2.77	5Y5/2 (5/2)	Silty clay, calcareous, weak effervescence.
2.77 - 3.38	N2	Organic silty clay, with sand partings at 3 intervals; sand at 2.96 m contains abundant ostracodes; calcareous, weak effervescence.
3.38 - 3.51	2.5Y5/0 (5/0)	Silty clay, grades to silt at depth, slightly calcareous, very weak effervescence.
3.51 - 3.60	7.5YR4/0 (4/2)	Sand, calcareous, moderate effervescence.

Boring D-6 (Continued)

Depth, m	Color (moist)	Description
3.60 - 3.69	2.5Y4/0 (4/0)	Silty clay, color decreases in value with depth, calcareous, moderate effervescence.
3.69 - 3.90	N2	Organic silty clay, slightly calcareous, very weak effervescence.
3.90 - 4.18	2.5Y5/0 (5/0)	Silt, uniform, massive, slightly calcareous, very weak effervescence.
4.18 - 4.21	N2	Organic silty clay, slightly calcareous, very weak effervescence.
4.21 - 4.51	2.5Y5/2 (5/2)	Coarse sand, calcareous, modeate effervescence.
4.51 - 4.75	N2	Organic silty clay, slightly calcareous, very weak effervescence.
4.75 - 4.79	2.5Y5/2 (5/2)	Medium to fine sand, slightly calcareous, very weak effervescence.
4.79 - 5.00	N2	Organic silty clay, slightly calcareous, very weak effervescence.
5.00 - 5.30	2.5Y5/2 (5/2)	Coarse sand, calcareous, moderate effervescence.
5.30 - 5.36	N2	Organic silty clay, slightly calcareous, very weak effervescence.
5.36 - 5.39	2.5Y5/2 (5/2)	Coarse sand, calcareous, moderate effervescence.
5.39 - 5.58	7.5YR4/0 (4/0)	Silty clay, sand parting at 5.43 m, calcareous, weak effervescence.
5.58 - 5.61	7.5YR4/0 (3/0)	Sand, calcareous, violent effervescence.
5.61 - 5.67	7.5YR4/0 (4/0)	Silty clay, grades to silt with depth, slightly calcareous, very weak effervescence.
5.67 - 5.79	7.5YR4/2 (4/0)	Silty sand, grades sandy with depth, calcareous, moderately effervescence.
5.79 - 5.97	7.5YR4/2 (4/2)	Medium to coarse sand, calcareous, moderate effervescence.
5.97 - 6.10	2.5Y5/2 (5/2)	Organic silty clay, slightly calcareous, very weak effervescence.
6.10 - 6.31	5YR5/1 (5/2)	Sand, organic sand partings at 2 intervals, calcareous, moderate effervescence.
6.31 - 7.50	7.5YR3/0-N2	Organic silty clay, laminated below 6.43 m, calcareous, moderate effervescence.
7.50 - 7.53	5Y3/2 (5/1)	Sand, slightly calcareous, very weak effervescence.
7.53 - 9.08	10YR3/1 (3/1)	Medium to coarse sand, grades to silty sand with depth, calcareous, moderate effervescence.
9.08 - 9.33	2.5Y5/2 (5/2)	Silty clay, grades to interbedded sand and silt, calcareous, moderate effervescence. **Bonneville Alloformation.**
9.33 - 10.36	2.5Y4/2 (4/2)	Interbedded sands and silts, calcareous, moderate effervescence. **Fielding Geosol.**
10.36 - 10.64	10YR5/2 (5/2)	Coarse sand, calcareous, moderate effervescence. **Cutler Dam Alloformation.**
10.64 - 12.62	5Y4/1 (4/1)	Silty to sandy clay, numerous sand partings throughout, calcareous, moderate effervescence.
12.62 - 12.83	5YR5/3 (5/3)	Coarse sand, calcareous, moderate effervescence.
12.83 - 13.14	5YR4/1 (4/1)	Silty clay, grades to include sand partings, calcareous, moderate effervescence.

Boring D-6 (Continued)

Depth, m	Color (moist)	Description
13.14 - 13.26	5YR5/2 (5/2)	Medium sand, silty clay layer at 13.20 m, slightly calcareous, very weak effervescence.
13.26 - 13.90	7.5YR5/0 (5/2)	Organic sand, grades to silty clayey sand with depth, calcareous, violent effervescence.
13.90 - 14.78	7.5YR5/2 (5/2)	Silty clay, sand partings at 5 intervals, calcareous, violent effervescence. **Cutler Dam Alloformation.**

THREE FLAGS LOCALITY

Borings on the up-thrown side of a trace of the West Valley fault zone.

Boring U-1

UTM East = 415561.6; UTM North = 4512809.3; Elevation = 1288.0 m

Depth, m	Color (moist)	Description
0 - 0.15		Core missing.
0.15 - 0.30	7.5YR5/4 (4/2)	Silt, medium crumb structure, calcareous, strong effervescence.
0.30 - 0.46	7.5YR4/4 (4/2)	Silty clay, platy structure, calcareous, weak effervescence. **Midvale soil.**
0.46 - 0.73	5Y5/3 (5/3)	Silty clay and silt, color increases in value with depth, calcareous, strong effervescence. **Gilbert Alloformation.**
0.73 - 1.16	5Y6/4 (6/4)	Fine sand and silt, grades clayey with depth, calcareous, moderate effervescence.
1.16 - 1.25	5Y7/2 (6/1)	Medium to fine sand, calcareous, moderate effervescence.
1.25 - 1.40	5YR5/3 (5/3)	Silty clay, uniform, slightly calcareous, very weak effervescence.
1.40 - 1.71	5Y5/4 (5/4)	Medium to fine sand, iron stains, calcareous, strong effervescence.
1.71 - 1.74	5YR6.4 (6/4)	Clayey silt.
1.74 - 1.95	5Y7/3 (5/4)	Medium to coarse sand, iron stains.
1.95 - 2.23	5YR5/4 (5/4)	Clayey silt, massive.
2.23 - 2.41	5Y5/4 (5/4)	Fine to coarse sand, grades to include iron stains with depth, calcareous, weak effervescence.
2.41 - 2.53	7.5YR6/4 (6/4)	Silty clay and clay, sand layer at 2.50 m, calcareous, weak effervescence.
2.53 - 2.65	5Y6/4 (6/2)	Fine to medium sand, calcareous, modeate effervescence.
2.65 - 2.71		Core missing.
2.71 - 2.80	5Y6/4 (6/2)	Fine to medium sand, calcareous, moderate effervescence. **Gilbert Alloformation.**
2.80 - 2.90	5YR5/4 (5/4)	Silty clay to clay, wavy contact with overlying sand, calcareous, moderate effervescence. **Post-Bonneville Red Beds.**
2.90 - 2.96	5YR6/1 (6/1)	Fine to medium sand, calcareous, moderate effervescence. **Bonneville Alloformation.**
2.96 - 3.54	2.5Y4/0 (4/0)	Organic silty clay and clay, slightly calcareous, very weak effervescence.
3.54 - 4.02	N2	Organic silty clay and clay, organic-rich layers from 3.63 to 3.78 m.
4.02 - 4.24	10R4/1 (4/1)	Silt and fine sand, calcareous, moderate effervescence. **Bonneville Alloformation.**

Boring U-2

UTM East = 415579.8; UTM North = 4512810.5; Elevation = 1287.7 m

Depth, m	Color (moist)	Description
0 - 0.3		Core missing.
0.3 - 0.43	7.5YR5/2 (4/4)	Silt with some sand, fine crumb structure, roots, calcareous, strong effervescence. **Midvale soil.**
0.43 - 0.70	7.5YR5/4 (5/6)	Silty clay, scattered carbonate nodules, calcareous, strong effervescence. **Gilbert Alloformation.**
0.70 - 1.13	5Y6/3 (6/3)	Silty clay, calcareous, weak effervescence.
1.13 - 1.16	5Y7/2 (6/2)	Medium to fine sand.
1.16 - 1.28	5YR5/4 (5/4)	Silty clay, slightly calcareous, very weak effervescence.
1.28 - 1.52	5Y6/4 (5/3)	Coarse to medium sand, iron stains.
1.52 - 1.55	5YR5/4 (5/4)	Clayey silt, calcareous, weak effervescence.
1.55 - 1.80	5Y7/4 (5/3)	Medium sand, local iron stains.
1.80 - 2.10	5YR5/3 (5/3)	Clayey silt to clay, sand layer at 1.89 m.
2.10 - 2.38	10YR4/4 (4/4)	Medium to fine sand, color increases in value with depth, iron stains. **Gilbert Alloformation.**
2.38 - 2.59	5YR6/3 (6/3)	Clayey silt to clay, mottled. **Post-Bonneville Red Beds.**
2.59 - 2.77	10YR4/4 (4/4)	Medium to fine sand. **Bonneville Alloformation.**
2.77 - 2.90	5YR5/1 (5/1)	Clayey silt to clay, slightly calcareous, very weak effervescence.
2.90 - 3.29	N2	Organic clayey silt and clay, scattered black nodules.
3.29 - 3.81	N2	Organic clay, laminated.
3.81 - 3.93	2.5Y4/0 (4/0)	Clayey silt and clay.
3.93 - 4.39	5Y5/2 (5/2)	Fine sand, grades to sandy clay at 4.15 m, grades to silty clay at 4.39 m. **Bonneville Alloformation.**

Borings on the down-thrown side of a trace of the West Valley fault zone.

Boring D-1

UTM East = 415602.9; UTM North = 4512812.2; Elevation = 1287.2 m

Depth, m	Color (moist)	Description
0 - 0.21	7.5YR7/2 (6/4)	Silt, medium crumb structure, roots, calcareous, strong effervescence. **Midvale soil.**
0.21 - 0.37	7.5YR5/4 (5/2)	Silty fine sand, calcareous, moderate effervescence. **Gilbert Alloformation.**
0.37 - 0.52	5Y7/2 (6/2)	Silt and clayey silt, calcareous, moderate effervescence.
0.52 - 0.88	5YR7/2 (6/2)	Silty clay, calcareous, violent effervescence.
0.88 - 0.98	5Y7/3 (7/3)	Silt and fine sandy clay, calcareous, moderate effervescence.
0.98 - 1.52	5Y6/3 (6/3)	Silty clay, calcareous, moderate effervescence.
1.52 - 1.74	5Y5/2 (5/2)	Silty clay, mottled with iron stains, sand layers at 1.52 and 1.57 m, sand is 2.5Y7/2, calcareous, moderate effervescence.
1.74 - 1.80	5Y6/6-6/2	Sand, calcareous, moderate effervescence.

Boring D-1 (Continued)

Depth, m	Color (moist)	Description
1.80 - 2.01	5Y6/4 (6.4)	Silty clay, mottled, sand layer at 1.98 m, slightly calcareous, very weak effervescence.
2.01 - 2.35	5Y7/3 (6/3)	Sandy silt, grading to coarse sand, mottled.
2.35 - 2.53	2.5Y5/4 (5/4)	Coarse sand. **Gilbert Alloformation.**
2.53 - 2.80	2.5Y6/2 (6/2)	Sandy silt to clayey silt, calcareous, weak effervescence. **Post-Bonneville Red Beds.**
2.80 - 3.29	10R4/1 (4/1)	Sandy silt to sand, uniform. **Bonneville Alloformation.**
3.29 - 3.81	5YR4/1 (4/1)	Silt and clay, fine sand layer from 3.49 to 3.66 m.
3.81 - 3.96	5YR4/1 (4/1)	Silt to fine sand.
3.96 - 4.60	N2	Organic silty clay, sightly calcareous, very weak effervescence. **Bonneville Alloformation.**

Boring D-2

UTM East = 415620.8; UTM North = 4512813.0; Elevation = 1287.2 m

Depth, m	Color (moist)	Description
0 - 0.15	7.5YR6/2 (4/2)	Silty clay, fine crumb structure, roots, calcareous, strong effervescence.
0.15 - 0.30	5Y5/3 (5/3)	Clayey silt, very fine crumb structrue, root hairs, calcareous, strong effervescence. **Midvale soil.**
0.30 - 0.73	5Y7/2 (7/3)	Silty clay to clay with some fine sand, root hairs, calcareous, violent effervescence. **Gilbert Alloformation.**
0.73 - 1.22	5Y5/3 (5/3)	Silty clay, uniform, calcareous, strong effervescence.
1.22 - 1.40		Core missing.
1.40 - 1.58	5Y5/3 (5/3)	Clay with some silt, calcareous, weak effervescence.
1.58 - 1.68	5Y5/6 (5/4)	Fine to coarse sand.
1.68 - 1.85	5YR5/6 (5/6)	Clayey silt, uniform, few mottles.
1.85 - 2.16	5YR4/2 (4/2)	Sandy silt and clay, calcareous, moderate effervescence.
2.16 - 2.29	5YR5/6 (5/6)	Clayey silt, sand layer at 2.03 m.
2.29 - 2.50	10YR4/3 (4/3)	Medium to coarse sand, calcareous, weak effervescence. **Gilbert Alloformation.**
2.50 - 2.77	10YR5/4 (5/4)	Clayey silt to clay. **Post-Bonneville Red Beds.**
2.77 - 3.02	10R5/1 (5/1)	Medium to coarse sand. **Bonneville Alloformation.**
3.02 - 3.57	10R3/1 (3/1)	Clayey silt to clay, some organic material, sand layer at 3.47 m.
3.57 - 3.72	10R5/1 (5/1)	Fine to medium sand.
3.72 - 3.78	10R3/1 (3/1)	Clayey silt to clay, organic.
3.78 - 3.84	10R5/1 (5/1)	Fine to medium sand.
3.84 - 4.45	N2	Organic clay and silt, laminated below 4.33 m. **Bonneville Alloformation.**

1300 SOUTH LOCALITY

Borings on the up-thrown side of a trace of the West Valley fault zone.

Boring U-1

UTM East = 415517.5; UTM North = 4510131.4; Elevation = 1291.3 m

Depth, m	Color (moist)	Description
0 - 0.09		Plant fragments with some mineral soil.
0.09 - 0.64	7.5YR6/3 (4/3)	Silt with some sand, root hairs, calcareous, strong effervescence.
0.64 - 0.76	7.5YR7/2 (5/2)	Silt, few root hairs, calcareous, strong effervescence. **Midvale soil.**
0.76 - 0.85	7.5YR5/6 (4/2)	Coarse sand, slightly calcareous, very weak effervescence. **Post-Gilbert Jordan River deposits.**
0.85 - 0.88	7.5YR7/2 (5/2)	Silt, calcareous, strong effervescence.
0.88 - 0.91	7.5YR5/6 (4/2)	Coarse sand, root hairs, slightly calcareous, very weak effervescence.
0.91 - 1.19	10YR7/3 (6/2)	Silt with some clay, root hairs, calcareous, moderate effervescence.
1.19 - 1.22	5YR7/3 (6/4)	Sand and gravel, calcareous, violent effervescence. **Post-Gilbert Jordan River deposits.**
1.22 - 1.55	10YR6/3 (6/3)	Silty clay, sand partings at two intervals, calcareous, violent effervescence. **Gilbert Alloformation.**
1.55 - 1.68	10YR6/4 (5/3)	Sandy silt, grades coarse with depth, calcareous, violent effervescence.
1.68 - 1.83	7.5YR7/2 (5/2)	Coarse to medium sand, calcareous, moderate effervescence. **Gilbert Alloformation.**
1.83 - 2.59	5YR5/3 (5/3)	Silty clay, numerous sand partings, mottles and iron stains, clacareous, moderate effervescence. **Post-Bonneville Red Beds.**
2.59 - 3.17	5YR5/4 (5/4)	Silt with some clay, grades sandy with depth, calcareous, moderate effervescence. **Bonneville Alloformation.**
3.17 - 5.18	5YR4/2 (5/2)	Sand with silty clay layers at 3 intervals, calcareous, moderate effervescence.
5.18 - 5.82	5YR5/2 (5/3)	Coarse sand, calcareous, moderate effervescence.
5.82 - 6.52	7.5YR4/0 (4/0)	Sand and silty clay, laminated, calcareous, moderate effervescence.
6.52 - 6.55	7.5YR6/2 (6/2)	Fine sand, slightly calcareous, very weak effervescence.
6.55 - 7.04	7.5YR4/0 (4/0)	Silty clay with interbedded sand, calcareous, moderate effervescence.
7.04 - 7.44	N2	Organic silty clay, red sand parting at 7.32 m.
7.44 - 7.80	10YR5/1 (5/1)	Silty clay interbedded with sand, calcareous, moderate effervescence.
7.80 - 7.92	5YR5/1 (4/1)	Silt, grades sandy with depth, calcareous, moderate effervescence.
7.92 - 8.23	5YR5/3 (5/3)	Sandy silt, grades to silty clay with depth, calcareous, violent effervescence. **Bonneville Alloformation.**

Boring U-1 (Continued)

Depth, m	Color (moist)	Description
8.23 - 8.78	5YR5/3 (5/3)	Silty clay, massive, calcareous, violent effervescence. **Fielding Geosol.**
8.78 - 9.08	5YR5/3 (5/3)	Same as above, except more silt. **Cutler Dam Alloformation.**
9.08 - 9.48	5YR5/4 (5/4)	Silty clay, massive, darker from 9.14 to 9.20 m, calcareous, violent effervescence.
9.48 - 9.94	5YR5/3 (5/3)	Silty clay interbedded with medium to coarse sand, calcareous, moderate effervescence.
9.94 - 9.97	5YR5/4 (5/3)	Coarse sand, calcareous, violent effervescence.
9.97 - 10.21	5YR5/3 (5/4)	Fine to medium sand, iron stains, calcareous, moderate effervescence.
10.21 - 10.24	5YR4/3 (4/3)	Silty clay, slightly calcareous, very weak effervescence.
10.24 - 10.30	5YR5/3 (5/3)	Medium sand, calcareous, violent effervescence. **Cutler Dam Alloformation.**

Boring U-2

UTM East = 415514.7; UTM North = 4510147.1; Elevation = 1291.2 m

Depth, m	Color (moist)	Description
0 - 0.27	7.5YR6/2 (3/4)	Silty sand, roots, calcareous, strong effervescence.
0.27 - 0.55	10YR6/3 (4/4)	Silty sand, root hairs, calcareous, strong effervescence. **Midvale soil.**
0.55 - 0.85	10YR7/3 (5/3)	Sandy silt, root hairs, calcareous, strong effervescence. **Post-Gilbert Jordan River deposits.**
0.85 - 1.22	5Y5/2 (5/3)	Sand and silt, root hairs, calcareous, strong effervescence.
1.22 - 1.28	5YR7/3 (6/4)	Sand and fine gravel, calcareous, violent effervescence. **Post-Gilbert Jordan River deposits.**
1.28 - 1.43	2.5Y7/6 (6/6)	Silt to silty clay, calcareous, moderate effervescence. **Gilbert Alloformation.**
1.43 - 1.46	2.5Y6/0 (6/2)	Fine sand, includes ostracodes at depth, calcareous, moderate effervescence.
1.46 - 1.65	5YR6/3 (6/3)	Silty clay, grades to silt, calcareous, violent effervescence.
1.65 - 1.92	5YR7/2 (5/2)	Sand, calcareous, violent effervescence. **Gilbert Alloformation.**
1.92 - 2.71	5YR5/3 (5/3)	Silty clay, numerous sand partings, grades to include iron mottling with depth, calcareous, moderate effervescence. **Post-Bonneville Red Beds.**
2.71 - 2.90	5YR5/4 (4/3)	Silt, grades sandy with depth, heavily mottled, calcareous, violent effervescence. **Bonneville Alloformation.**

Boring U-3

UTM East = 415529.4; UTM North = 4510148.1; Elevation = 1291.2 m

Depth, m	Color (moist)	Description
0 - 0.27	7.5YR6/2 (3/2)	Silt (loess), few root hairs, calcareous, violent effervescence.
0.27 - 0.52	7.5YR7/4 (5/4)	Silt with some sand, roots and root hairs, fine crumb structure, calcareous, strong effervescence. **Midvale soil.**
0.52 - 0.70	10YR5/3 (5/3)	Sandy silt, grades to silty sand, root hairs, calcareous, strong effervescence. **Post-Gilbert Jordan River deposits.**
0.70 - 0.76	10YR5/4 (4/3)	Sand, calcareous, moderate effervescence.
0.76 - 0.79	10YR7/2 (5/3)	Sandy silt, calcareous, violent effervescence.
0.79 - 0.85	5YR7/3 (5/3)	Sand, grades coarse with depth, calcareous, violent effervescence.
0.85 - 1.28	5Y7/3 (6/3)	Silty clay, some sand, calcareous, violent effervescence.
1.28 - 1.31	5YR7/3 (6/4)	Sand and gravel, calcareous, violent effervescence. **Post-Gilbert Jordan River deposits.**
1.31 - 1.58	10YR6/4 (6/4)	Silty clay, calcareous, violent effervescence. **Gilbert Alloformation.**
1.58 - 1.65	5YR7/3 (5/3)	Silty sand, grades coarse with depth, calcareous, violent effervescence.
1.65 - 1.80	7.5YR7/2 (6/4)	Coarse sand, calcareous, violent effervescence. **Gilbert Alloformation.**
1.80 - 2.71	5YR5/3 (5/3)	Silty clay, numerous sand partings, mottled, iron stains, calcareous, moderate effervescence. **Post-Bonneville Red Beds.**
2.71 - 2.77	5YR5/6 (5/6)	Silt, grades to silty clay with depth, calcareous, moderate effervescence. **Bonneville Alloformation.**
2.77 - 3.14	5YR4/4 (4/4)	Silty clay, massive calcareous, moderate effervescence.
3.14 - 3.81	7.5YR4/2 (4/2)	Silt, interbedded fine sand from 3.14 to 3.41 m, calcareous, moderate effervescence.
3.81 - 4.42	5YR4/2 (4/2)	Sand, some silt, calcareous, violent effervescence. **Bonneville Alloformation.**

Boring U-4

UTM East = 415537.5; UTM North = 4510133.8; Elevation = 1291.2 m

Depth, m	Color (moist)	Description
0 - 0.37	7.5YR5/2 (3/2)	Silt, very fine crumb structure, roots, calcareous, strong effervescence.
0.37 - 0.58	7.5YR6/2 (4/4)	Silt, fine crumb structure, root hairs, calcareous, strong effervescence. **Midvale soil.**
0.58 - 0.79	7.5YR7/2 (7/4)	Silt, grades to sand with depth, root hairs, calcareous, strong effervescence. **Post-Gilbert Jordan River deposits.**

Boring U-4 (Continued)

Depth, m	Color (moist)	Description
0.79 - 1.01	10YR6/3 (4/4)	Medium to coarse sand, calcareous, violent effervescence.
1.01 - 1.25	10YR6/2 (5/3)	Silt, root hairs, calcareous, violent effervescence.
1.25 - 1.28	5Y7/3 (6/2)	Coarse sand, some silt cementation, calcareous, moderate effervescence. **Post-Gilbert Jordan River deposits.**
1.28 - 1.31	5Y5/2 (5/2)	Silty clay, calcareous, moderate effervescence. **Gilbert Alloformation.**
1.31 - 1.34	5YR7/3 (6/4)	Sand and fine gravel, calcareous, violent effervescence.
1.34 - 1.71	2.5Y7/6 (6/6)	Silt to silty clay, sand partings at 2 intervals, calcareous, moderate effervescence.
1.71 - 1.83	5YR6/1 (5/1)	Coarse sand, calcareous, moderate effervescence. **Gilbert Alloformation.**
1.83 - 2.29	5YR5/2 (5/2)	Silty clay, sand partings at 3 intervals, mottled, slightly calcareous, very weak effervescence. **Post-Bonneville Red Beds.**
2.29 - 2.74	5YR5/1 (5/1)	Silty clay, grades mottled with depth, calcareous, weak effervescence. **Bonneville Alloformation.**

Borings on the down-thrown side of a trace of the West Valley fault zone.

Boring D-1

UTM East = 415610.7; UTM North = 4510236.6; Elevation = 1289.9 m

Depth, m	Color (moist)	Description
0 - 0.06	7.5YR7/2 (5/4)	Silt, fine platy structure, roots, calcareous, strong effervescence.
0.06 - 0.09	7.5YR5/2 (4/2)	Silt, fine blocky structure, roots, calcareous, strong effervescence.
0.09 - 0.40	7.5YR6/4 (6/4)	Sandy silt, root hairs, calcareous, strong effervescence.
0.40 - 0.43	7.5YR7/4 (7/4)	Silt, massive, calcareous, strong effervescence. **Midvale soil.**
0.43 - 0.61	7.5YR6/4 (5/2)	Fine sand, grades coarser with depth, root hairs, calcareous, violent effervescence. **Post-Gilbert Jordan River deposits.**
0.61 - 0.85	7.5YR6/4 (5/4)	Interbedded silty clay and coarse to medium sand, calcareous, violent effervescence.
0.85 - 0.98	7.5YR7/4 (6/4)	Coarse sand, calcareous, moderate effervescence.
0.98 - 1.07	10YR6/2 (5/2)	Medium to fine sand, calcareous, moderate effervescence.
1.07 - 1.28	10YR5/3 (5/3)	Silty clay, interbedded with fine sand, iron stains, grades to coarse sand with depth, calcareous, violent effervescence.
1.28 - 1.43	10YR5/6 (4/4)	Coarse sand, slightly calcareous, very weak effervescence. **Post-Gilbert Jordan River deposits.**

Boring D-1 (Continued)

Depth, m	Color (moist)	Description
1.43 - 2.19	5YR6/3 (6/3)	Silty clay, irregular interbedded fine sand, iron mottles, calcareous, moderate effervescence. **Gilbert Alloformation.**
2.19 - 2.56	10YR6/2 (5/2)	Sand, interbedded with silt, calcareous, violent effervescence. **Gilbert Alloformation.**
2.56 - 2.68	10YR7/2 (7/2)	Silty clay, calcareous, violent effervescence. **Post-Bonneville Red Beds.**
2.68 - 2.90	10YR5/3 (5/3)	Silty clay, grades to sandy silt with depth, calcareous, violent effervescence. **Post-Bonneville Red Beds.**
2.90 - 3.17	10YR5/2 (5/2)	Silty clay, massive, sand parting at 3.02 m, slightly calcareous, very weak effervescence. **Bonneville Alloformation.**
3.17 - 3.51	10YR4/1 (4/1)	Silt, grades to include organic material with depth, calcareous, moderate effervescence.
3.51 - 3.84	10YR5/1 (5/1)	Silt, increasing organic material with depth, calcareous, moderate effervescence.
3.84 - 5.00	N2	Organic silty clay, local ostracodes, sand parting at 4.60 m, slightly calcareous, very weak effervescence.
5.00 - 5.03	5YR5/1 (5/1)	Sand, slightly calcareous, very weak effervescence.
5.03 - 5.06	5YR4/1 (4/1)	Silty clay.
5.06 - 5.09	5YR5/1 (5/1)	Sand.
5.09 - 5.12	10YR5/1 (5/1)	Silty clay.
5.12 - 5.15	N2	Organic silty clay.
5.15 - 5.27	10YR4/1 (4/1)	Medium to fine sand.
5.27 - 6.00	5YR4/2 (4/2)	Coarse sand.
6.00 - 6.43	5YR4/1 (4/1)	Silt, some organic material, calcareous, moderate effervescence.
6.43 - 6.80	5YR5/2 (5/2)	Silty clay, organic mottles, sand parting at 6.71 m, calcareous, violent effervescence.
6.80 - 7.13	5YR4/1 (4/1)	Silt, some sand, calcareous, moderate effervescence.
7.13 - 7.89	5YR4/2 (4/2)	Coarse sand, slightly calcareous, very weak effervescence; slough between 7.04 and 7.50 m. **Bonneville Alloformation.**
7.89 - 9.05	5YR4/2 (4/2)	Silt with interbedded sand, calcareous, moderate effervescence; 0.61 m of core missing. **Fielding Geosol.**
9.05 - 9.42	7.5YR4/2 (4/2)	Silty clay, sand partings at 6 intervals, calcareous, weak effervescence. **Cutler Dam Alloformation.**
9.42 - 9.48	7.5YR5/2 (4/2)	Silty clay, calcareous, moderate effervescence.
9.48 - 10.15	7.5YR4/0 (4/0)	Silty clay, grades to silt with depth, calcareous, moderate effervescence.
10.15 - 11.52	7.5YR4/0 (5/2)	Silt and sand, grades sandy with depth, calcareous, moderate effervescence.
11.52 - 11.58	7.5YR5/2 (5/2)	Coarse sand, slightly calcareous, very weak effervescence.
11.58 - 11.64	7.5YR3/2 (3/2)	Silt, some organic material, calcareous, moderate effervescence.
11.64 - 12.25	7.5YR5/2 (5/2)	Coarse sand, some small pebbles, slightly calcareous, very weak effervescence.

Boring D-1 (Continued)

Depth, m	Color (moist)	Description
12.25 - 12.34	N2	Coarse sand, grading to silt with depth, abundant organic material, calcareous, moderate effervescence. **Cutler Dam Alloformation.**

Boring D-2

UTM East = 415589.3; UTM North = 4510237.0; Elevation = 1290.1 m

Depth, m	Color (moist)	Description
0 - 0.06		Pland material and roots.
0.06 - 0.24	7.5YR6/2 (5/4)	Silt, medium crumb structure, root hairs, calcareous, strong effervescence.
0.24 - 0.40	7.5YR5/2 (5/2)	Silt, medium blocky structure, root hairs, calcareous, strong effervescence. **Midvale soil.**
0.40 - 0.88	10YR5/3 (5/3)	Silt, roots, calcareous, strong effervescence. **Post-Gilbert Jordan River deposits.**
0.88 - 1.07	10YR5/2 (5/3)	Silt, color decreases in value with depth, calcareous, violent effervescence.
1.07 - 1.19	10YR3/1 (2/1)	Silt to silty clay, slightly calcareous, very weak effervescence.
1.19 - 1.40		Core missing.
1.40 - 1.89	10YR5/2 (5/2)	Silt to silty clay, massive, root hairs, calcareous, violent effervescence.
1.89 - 2.01	10YR5/3 (5/3)	Coarse sand, slightly calcareous, very weak effervescence.
2.01 - 2.07	10YR5/2 (5/2)	Silty clay with some sand, calcareous, moderate effervescence.
2.07 - 2.19	10YR5/3 (5/3)	Coarse sand, slightly calcareous, very weak effervescence. **Post-Gilbert Jordan River deposits.**
2.19 - 2.23	10YR5/2 (5/2)	Silty clay and sand, calcareous, moderate effervescence. **Gilbert Alloformation.**
2.23 - 2.90	10YR5/3 (5/3)	Gravel and coarse sand, slightly calcareous, very weak effervescence. **Gilbert Alloformation.**
2.90 - 3.35	5YR5/3 (5/3)	Silty clay, massive, calcareous, moderate effervescence. **Post-Bonneville Red Beds.**
3.35 - 3.38	5YR4/1 (4/1)	Silt and laminated sand, calcareous, violent effervescence. **Bonneville Alloformation.**
3.38 - 3.63	5YR4/2 (4/2)	Silty clay, massive, calcareous, moderate effervescence.
3.63 - 4.05	5YR4/1 (4/1)	Silt and fine sand, calcareous, moderate effervescence.
4.05 - 4.39	5YR4/1 (4/1)	Silty clay, sand partings, calcareous, moderate effervescence.
4.39 - 4.48	7.5YR4/0 (4/0)	Sand, calcareous, moderate effervescence.
4.48 - 5.46	N2	Organic silty clay, sand partings at 3 intervals, calcareous, moderate effervescence. **Bonneville Alloformation.**

Boring D-3

UTM East = 415591.5; UTM North = 4510221.1; Elevation = 1289.7 m

Depth, m	Color (moist)	Description
0 - 0.03		Plant material and roots.
0.03 - 0.18	7.5YR5/2 (5/2)	Silt, platy structure, grades to blocky structure, root hairs, calcareous, strong effervescence.
0.18 - 0.34	7.5YR6/2 (5/2)	Silt, blocky structure, roots, calcareous, strong effervescence. **Midvale soil.**
0.34 - 0.82	10YR6/4 (6/3)	Silt, grades to sand, calcareous, strong effervescence. **Post-Gilbert Jordan River deposits.**
0.82 - 1.77	10YR7/3 (7/3)	Silty clay, mottled with iron stains, grades to silt with sand partings below 1.00 m, calcareous, moderate effervescence.
1.77 - 1.86	10YR4/6 (4/4)	Silty sand, iron stained, calcareous, moderate effervescence.
1.86 - 1.89	7.5YR5/2 (5/2)	Silty clay, slightly calcareous, very weak effervescence.
1.89 - 1.92	10YR4/6 (4/4)	Coarse sand, slightly calcareous, very weak effervescence. **Post-Gilbert Jordan River deposits.**
1.92 - 1.98	7.5YR5/2 (5/2)	Silty clay, slightly calcareous, very weak effervescence. **Gilbert Alloformation.**
1.98 - 2.80	10YR4/6 (4/4)	Pebbles and coarse sand. **Gilbert Alloformation.**
2.80 - 3.57	5YR5/3 (5/3)	Silty clay, organic mottles, numerous sand partings, slightly calcareous, very weak effervescence. **Post-Bonneville Red Beds.**
3.57 - 3.87	5YR5/2 (5/2)	Coarse sand, calcareous, moderate effervescence. **Bonneville Alloformation.**
3.87 - 4.27		Core missing.
4.27 - 4.45	5YR5/1 (5/2)	Silty clay, grades to silt with depth, calcareous, moderate effervescence.
4.45 - 4.57	5YR5/1 (5/1)	Silt and sand, grades to include organic material, calcareous, moderate effervescence.
4.57 - 5.55	N2	Organic silty clay, sand partings at 4 intervals, calcareous, moderate effervescence.
5.55 - 5.61	10YR5/1 (5/1)	Silt, calcareous, moderate effervescence. **Bonneville Alloformation.**

Boring D-4

UTM East = 415591.5; UTM North = 4510221.1; Elevation = 1289.7 m

Depth, m	Color (moist)	Description
0 - 0.15	7.5YR7/2 (5/2)	Silt, blocky structure, roots, calcareous, strong effervescence.
0.15 - 0.52	7.5YR5/4 (5/4)	Silt, root hairs, calcareous, strong effervescence. **Midvale soil.**
0.52 - 1.19	10YR5/2 (5/2)	Silt, calcareous, violent effervescence. **Post-Gilbert Jordan River deposits.**

Boring D-4 (Continued)

Depth, m	Color (moist)	Description
1.19 - 1.68	10YR4/1 (4/1)	Silt, blocky structure, calcareous, moderate effervescence.
1.68 - 1.86	10YR5/3 (5/3)	Silt with some sand, grades sandy with depth, calcareous, moderate effervescence. **Post-Gilbert Jordan River deposits.**
1.86 - 2.23	10YR6/2 (6/2)	Coarse sand, grades to include gravel at depth, calcareous, moderate effervescence. **Gilbert Alloformation.**
2.23 - 2.68		Core missing.
2.68 - 2.90	5YR5/3 (5/3)	Silty clay. **Gilbert Alloformation.**
2.90 - 3.35	5YR5/3 (5/3)	Silty clay, grades to include organic material at depth, sand partings at 2.93 m, calcareous, moderate effervescence. **Post-Bonneville Red Beds.**
3.35 - 3.84	5YR4/1 (5/2)	Silt, grades sandy with depth, calcareous, moderate effervescence. **Bonneville Alloformation.**
3.84 - 4.27	5YR4/1 (4/1)	Coarse to medium sand, calcareous, weak effervescence. **Bonneville Alloformation.**

APPENDIX B

BASIC CODE FOR "3POINT" PROGRAM

APPENDIX B

BASIC CODE FOR "3POINT" PROGRAM

This appendix contains the source code for an interactive BASIC language program which calculates strike and dip from x, y, z data for three points (a conventional 3-point problem). The input/output commands are configured for an Apple™ Macintosh™ computer.

```
REM   PROGRAM "3POINT" J.R.KEATON 7-18-88;REV 7-21-88,9-9-89
REM   COMPUTES STRIKE AND DIP FROM X,Y,Z DATA FOR
REM   THREE POINTS BASED ON LINEAR INTERPOLATION.
REM   INPUT PARAMETERS: X1,Y1,Z1; X2,Y2,Z2; X3,Y3,Z3.

CALL TEXTSIZE(9)
CALL TEXTFONT(4)

1     PRINT TAB(16);
PRINT "3-POINT PROBLEM"
PRINT "ENTER ID, EAST, NORTH, AND ELEVATION FOR 3 POINTS"
PRINT
INPUT "POINT 1 ID = ", P1$
INPUT "POINT 1 EASTING, X1 = ", X1
INPUT "POINT 1 NORTHING, Y1 = ", Y1
INPUT "POINT 1 ELEVATION, Z1 = ", Z1
INPUT "POINT 2 ID = ", P2$
INPUT "POINT 2 EASTING, X2 = ", X2
INPUT "POINT 2 NORTHING, Y2 = ", Y2
INPUT "POINT 2 ELEVATION, Z2 = ", Z2
INPUT "POINT 3 ID = ", P3$
INPUT "POINT 3 EASTING, X3 = ", X3
INPUT "POINT 3 NORTHING, Y3 = ", Y3
INPUT "POINT 3 ELEVATION, Z3 = ", Z3

REM    CHECK FOR ALL 3 POINTS AT THE SAME ELEVATION
IF Z1 = Z2 AND Z1 = Z3 GOTO 3
GOTO 4
3     PRINT "ALL 3 POINTS ARE AT THE SAME ELEVATION"
      PRINT "  THEREFORE, THE SURFACE IS HORIZONTAL"
GOTO 500

4     REM CHECK FOR 2 POINTS WITH THE SAME ELEVATION

IF Z1 = Z2 GOTO 400
IF Z1 = Z3 GOTO 410
IF Z2 = Z3 GOTO 420
GOTO 5

400    LET ZA = Z1 : LET XA = X1 : LET YA = Y1
       LET ZB = Z2 : LET XB = X2 : LET YB = Y2
       LET ZC = Z3 : LET XC = X3 : LET YC = Y3
GOTO 430
```

```
410     LET ZA = Z1 : LET XA = X1 : LET YA = Y1
        LET ZB = Z3 : LET XB = X3 : LET YB = Y3
        LET ZC = Z2 : LET XC = X2 : LET YC = Y2
GOTO 430
420     LET ZA = Z2 : LET XA = X2 : LET YA = Y2
        LET ZB = Z3 : LET XB = X3 : LET YB = Y3
        LET ZC = Z1 : LET XC = X1 : LET YC = Y1

430  PRINT
PRINT "THE FIRST TWO POINTS ARE AT THE SAME ELEVATION"
PRINT TAB(22);
PRINT "EAST";
PRINT TAB(33);
PRINT "NORTH";
PRINT TAB(46);
PRINT "ELEV"
PRINT "POINT ONE   = ";
PRINT USING "#########.##"; XA;YA;ZA
PRINT "POINT TWO   = ";
PRINT USING "#########.##"; XB;YB;ZB
PRINT "POINT THREE = ";
PRINT USING "#########.##"; XC;YC;ZC
PRINT

REM    DETERMINE ANGLE BAC BY LAW OF COSINES

AB = SQR((XA - XB)^2 + (YA - YB)^2)
AC = SQR((XA - XC)^2 + (YA - YC)^2)
BC = SQR((XB - XC)^2 + (YB - YC)^2)
COSA = (AB^2 + AC^2 - BC^2)/(2*AB*AC)
A = ATN(SQR(ABS(1-COSA^2))/COSA)    'ARCCOS

REM    DETERMINE DISTANCE FROM LINE OF STRIKE TO POINT C

LC = AC * SIN(A)

REM   DETERMINE COORDINATES OF POINT ON LINE OF STRIKE (PT L)

AL = AC*COSA
DX = ABS((XB-XA)*AL/AB)
DY = ABS((YB-YA)*AL/AB)
XL = XA+DX
YL = YA+DY

REM   DETERMINE AZIMUTH OF LINE FROM L TO C (AZLC)

DLX = XC-XL
DLY = YC-YL
AZLC = ATN(DLX/DLY)
IF DLX > 0 AND DLY <= 0 THEN AZLC = 3.14159 - ABS(AZLC)
IF DLX <= 0 AND DLY < 0 THEN AZLC = 3.14159 + ABS(AZLC)
IF DLX < 0 AND DLY => 0 THEN AZLC = AZLC + 6.28319
```

```
REM  DETERMINE AZIMUTH OF LINE OF STRIKE

IF ZA > ZC THEN LET AZST = AZLC + 4.71239
IF ZC > ZA THEN LET AZST = AZLC + 1.5708

REM  DETERMINE DIP MAGNITUDE

DIPR = ATN(ABS(ZA-ZC)/LC)

GOTO 440

5    REM    SORTING HIGH, LOW, AND MIDDLE ELEVATIONS

     IF Z1 > Z2 GOTO 10
     IF Z2 > Z3 GOTO 20
     LET ZH = Z3 : LET XH = X3 : LET YH = Y3
     GOTO 40
10   IF Z1 > Z3 GOTO 30
     LET ZH = Z3 : LET XH = X3 : LET YH = Y3
     GOTO 40
20   LET ZH = Z2 : LET XH = X2 : LET YH = Y2
     GOTO 50
30   LET ZH = Z1 : LET XH = X1 : LET YH = Y1
     GOTO 60
40   IF Z1 > Z2 GOTO 70
     LET ZM = Z2 : LET XM = X2 : LET YM = Y2
     LET ZL = Z1 : LET XL = X1 : LET YL = Y1
     GOTO 100
70   LET ZM = Z1 : LET XM = X1 : LET YM = Y1
     LET ZL = Z2 : LET XL = X2 : LET YL = Y2
     GOTO 100
50   IF Z1 > Z3 GOTO 80
     LET ZM = Z3 : LET XM = X3 : LET YM = Y3
     LET ZL = Z1 : LET XL = X1 : LET YL = Y1
     GOTO 100
80   LET ZM = Z1 : LET XM = X1 : LET YM = Y1
     LET ZL = Z3 : LET XL = X3 : LET YL = Y3
     GOTO 100
60   IF Z2 > Z3 GOTO 90
     LET ZM = Z3 : LET XM = X3 : LET YM = Y3
     LET ZL = Z2 : LET XL = X2 : LET YL = Y2
     GOTO 100
90   LET ZM = Z2 : LET XM = X2 : LET YM = Y2
     LET ZL = Z3 : LET XL = X3 : LET YL = Y3

100  PRINT
PRINT TAB(22);
PRINT "EAST";
PRINT TAB(33);
PRINT "NORTH";
PRINT TAB(46);
PRINT "ELEV"
PRINT "HIGH POINT   = ";
```

```
PRINT USING "#########.##"; XH;YH;ZH
PRINT "MIDDLE POINT = ";
PRINT USING "#########.##"; XM;YM;ZM
PRINT "LOW POINT    = ";
PRINT USING "#########.##"; XL;YL;ZL
PRINT

REM   CALCULATE THE X,Y POSITION OF ZM ON THE LINE ZH-ZL

HLZ = ZH - ZL
HLD = SQR(((XH - XL)^2) + ((YH - YL)^2))
MLZ = ZM - ZL
SLD = (MLZ / HLZ) * HLD
XS = (SLD / HLD) * (XH - XL) + XL
YS = (SLD / HLD) * (YH - YL) + YL

REM   CHECK FOR STRAIGHT LINE

IF XM <> XS AND YM <> YS GOTO 200
PRINT "ALL THREE POINTS FALL ON A STRAIGHT LINE"
GOTO 500
200    HMD = SQR(((XH - XM)^2) + ((YH - YM)^2))
HLX = XL - XH
HMX = XM - XH
SINHL = ABS(HLX / HLD)
SINHM = ABS (HMX / HMD)
IF SINHL <> SINHM GOTO 210
PRINT "ALL THREE POINTS LIE ON A STRAIGHT LINE"
GOTO 500

210  REM  CALCULATE AZIMUTH OF STRIKE (LINE XS,YS - XM,YM)
REM  AND THE AZIMUTH OF THE LINE FROM S TO L.  THEN CALCULATE
REM  THE ANGLE BETWEEN SM AND SL

SLX = XL - XS
SLY = YL - YS
ARGSL = SLX / SLD
AZSL = ATN(ARGSL / SQR(1-ARGSL^2))     'ARCSIN
IF SLX > 0 AND SLY <= 0 THEN AZSL = 3.1416 - ABS(AZSL)
IF SLX <= 0 AND SLY < 0 THEN AZSL = 3.1416 + ABS(AZSL)
IF SLX < 0 AND SLY => 0 THEN AZSL = AZSL + 6.2832
SMX = XM - XS
SMY = YM - YS
SMD = SQR((SMX^2) + (SMY^2))
ARGSM = SMX / SMD
AZSM = ATN(ARGSM / SQR(1-ARGSM^2))     'ARCSIN
IF SMX > 0 AND SMY <= 0 THEN AZSM = 3.1416 - ABS(AZSM)
IF SMX <= 0 AND SMY < 0 THEN AZSM = 3.1416 + ABS(AZSM)
IF SMX < 0 AND SMY => 0 THEN AZSM = AZSM + 6.2832
ANGL = AZSM - AZSL
   IF ANGL < 0 GOTO 320
   IF ANGL > 3.1416 GOTO 320
   AZST = AZSM + 3.1416
```

```
   GOTO 325
320  AZST = AZSM
325  IF AZST > 6.2832 THEN AZST = AZST - 6.2832

REM  CALCULATE THE DIP OF THE LINE FROM STRIKE LINE TO XL,YL

ALPHA = ABS(AZST - AZSL)
DIPH = SLD * ABS(SIN(ALPHA))
DIPR = ATN(MLZ / DIPH)

440  REM  CONVERT STRIKE AND DIP FROM RADIANS TO DEGREES

STD = AZST * 57.2958
DIPD = DIPR * 57.2958
IF STD > 360 THEN STD = STD - 360

PRINT
PRINT "3-POINT PROBLEM USING: "; P1$;
PRINT " AS POINT 1; "; P2$;
PRINT " AS POINT 2; AND "; P3$;
PRINT " AS POINT 3"
PRINT "THE STRIKE AZIMUTH (RIGHT HAND RULE) IS ";
PRINT USING "###.###"; STD;
PRINT "° AND THE DIP IS ";
PRINT USING "###.###"; DIPD;
PRINT "°"
PRINT
PRINT

500  INPUT "DO ANOTHER ANALYSIS"; AN2$
     IF LEFT$(AN2$,1)="Y" GOTO 1

STOP
```