MAPPING AND QUATERNARY FAULT SCARP ANALYSIS OF THE MERCUR AND WEST EAGLE HILL FAULTS, WASATCH FRONT, UTAH

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A series of *en echelon* down-to-the west normal faults bound the western flank of the southern Oquirrh Mountains and comprise the southern Oquirrh Mountain fault zone (SOMFZ). These include the Mercur, West Eagle Hill, Soldier Canyon and Lakes of Kilarney faults, extending a total length of 25 km, which suggests a maximum moment magnitude (M_w) of 6.7 for the SOMFZ. Although these faults pose an earthquake threat to Salt Lake City, Provo, and the nation's chemical weapon cryofracture plant and storage facility at Tooele Army Depot, very little is known about their paleoseismicity, and what is known remains controversial. Therefore, to better understand the Quaternary behavior and earthquake potential of the SOMFZ, we mapped fault scarps and Quaternary deposits along traces of the SOMFZ, focusing on the Mercur and West Eagle Hill faults where faulting is best expressed in unconsolidated alluvium. We also measured 18 scarp profiles to evaluate displacement patterns and excavated 27 soil pits to compare soil development and help distinguish different age surfaces. Based on various field parameters (geomorphic position, crosscutting map relations, degree of incision and dissection, preservation of bar and swale topography, and soil development), we distinguished six different ages of stream and/or fan alluvium (af1 through a6/af6, oldest to youngest respectively). We also distinguished two intermediate age terrace deposits (t3 and t4), and older pediment surfaces that range in height from 6 m (ap2) to over 25 m (ap1) above active drainages. Units a5/af5 and a6/af6 appear unfaulted, burying or draping scarps of both the Mercur and West Eagle Hill faults. Units af5-6 also bury or partially drape the Bonneville Shoreline, indicating they were deposited after 14.5 ka. In contrast, units af4 and t4 are the youngest deposits cut by the Mercur fault, and a t3 terrace is the youngest unit offset by the West Eagle Hill fault. Soils are surprisingly well developed on these deposits (stage III to IV carbonate horizons that are 30-40 cm thick, and carbonate rinds 4.1 $\pm$ 1.7 mm thick), indicating that these units are late Pleistocene or older. Net vertical tectonic displacements (NVTD) of intermediate age surfaces average 5.8 $\pm$ 0.5 m along strike of the Mercur fault whereas they average 1.5 $\pm$ 0.5 m along strike of the West Eagle Hill fault. Maximum displacements are 21.7 m and 2.8 m, respectively. NVTD of older af2 surfaces are also larger on the Mercur fault, ranging between 6 and 10 m, compared to between 3 and 4 m on the West Eagle Hill fault. Displacement patterns indicate that repeated Quaternary movement occurred on both the Mercur and West Eagle faults, but most of the Quaternary offset was partitioned onto the Mercur fault and faulting has shifted basinward on the SOMFZ. Although along-strike displacement patterns are suggestive that coseismic surface-rupture of the Mercur and West Eagle Hill faults may have occurred sometime in the past, at least a couple and probably more of the youngest events appears to have ruptured the Mercur fault but not the West Eagle Hill fault. Finally, although our results suggest that faulting is younger on the Mercur fault, we did not resolve the controversy as to whether the youngest surface rupture occurred post-Bonneville. However, we have selected potential trench sites for future study of the timing and size of the most recent and penultimate events on the Mercur fault.

The Mercur and West Eagle Hill faults are part of a zone of west-dipping normal faults that lie along the west side of the southern Oquirrh Mountains in central Utah. We collectively refer to these faults, which extend from Soldier Canyon south to Fivemile Pass, as the southern Oquirrh Mountains fault zone (SOMFZ) after Wu and Bruhn (1994). The SOMFZ is one of several generally north-striking, west-dipping, range-bounding Quaternary normal faults that extend along the western portion of the Wasatch Front urban corridor (Figure 1), where over 80% of Utah's 2.4 million people live. Despite the many paleoseismic investigations that have been conducted along the Wasatch Front, the paleoseismic behavior of the SOMFZ is poorly understood and controversial. Late Quaternary slip rates, recurrence intervals and paleomagnitudes remain unknown. Additionally, issues regarding rupture segmentation and the timing of most recent faulting remain unresolved. This is significant because not only do large earthquakes on the SOMFZ pose a potential threat to the metropolitan areas of Salt Lake City and Provo, but traces of the Mercur fault lie less than 1 km west of the Tooele Army Depot-South Area, where the nation's chemical weapons storage facility and cryofracture plant are located. Thus, a better understanding of the SOMFZ is necessary for evaluating and mitigating seismic hazards in the region.

1.1 PURPOSE AND SCOPE

This study focused on the Mercur and West Eagle Hill faults because they are the two most recently active and geomorphically prominent faults of the SOMFZ. Together they comprise 17 km of the total along-strike length of 25 km for the SOMFZ. The other faults of the SOMFZ include the Lakes of Killarney and Soldier Canyon faults, which are primarily evident as faults in bedrock or bedrock-alluvial fault contacts (Gilully, 1932; Wu and Bruhn, 1994). The purpose of this study was twofold: (1) to develop a better understanding of the Quaternary behavior of the West Eagle Hill fault and its seismogenic relation to the Mercur fault through mapping and fault scarp profiling; and, (2) to identify potential trench sites for future study along the faults. Our study included: (1) interpretation of black and white stereo aerial photographs at different scales (1:46,000-scale 1987 NAPP, ≈1:36,000-scale 1974 and ≈1:24,000-scale 1959 SCS, and ≈1:62,000-scale 1953 AMS photographs); (2) reconnaissance mapping and detailed field checking of selected sites along the faults; (3) measurement of 18 fault scarp profiles; and (4) excavation and logging of 27 soil pits. We constructed a strip map onto 1:24,000 base maps (Ophir, Mercur, Stockton, and Fivemile Pass 7.5' Quadrangles) that focuses on Quaternary deposits and fault scarps along the Mercur and West Eagle Hill faults. Our study builds on previous mapping by Gilully (1928, 1932), Everitt and Kaliser (1980), Barnhard and Dodge (1988), and Wu and Bruhn (1994). Although our map depicts many normal bedrock fault traces of the SOMFZ, we emphasize that we did not systematically map these faults. They may be important to the evolution of the SOMFZ (Wu and Bruhn, 1994), however, mapping bedrock faults was beyond the scope of this study. In addition, field checking of our mapping was limited to areas outside of the Tooele Army Depot due to access restrictions for the depot.

1.2 GEOLOGIC SETTING

The SOMFZ lies within the central portion of the Intermountain seismic belt, a north-south trending zone of shallow, diffuse intraplate seismicity that extends from Montana, through central Utah, to northern Arizona (Smith and Sbar 1974; Smith and Arabasz, 1991). Although

diffuse seismicity has occurred in the area of the SOMFZ, no historical earthquakes have been directly attributed to the fault zone, a pattern typical of seismic activity in the region (Arabasz *et al.*, 1992).

The SOMFZ also lies 35 km west of the Wasatch fault zone, the most active Quaternary fault in Utah. The Wasatch fault zone forms the eastern boundary of the Basin & Range Province, which is characterized by late Cenozoic east-west extension on numerous, generally north-striking, range-bounding normal faults (Zoback, 1983; Hecker, 1993), such as the SOMFZ. Major west-dipping, range-bounding Quaternary faults that generally lie along strike with the SOMFZ include: the East Great Salt Lake and the Oquirrh fault zones to the north; and the Topliff Hills fault zone and faults along the East Tintic Mountains to the south (Figure 1). Because these faults have a similar sense of displacement and form a north-south-trending, albeit somewhat discontinuous, zone of faults through central Utah, they could be considered individual segments of a large fault zone that extends for 205 kilometers from Rozel Bay in Great Salt Lake south to Furner Pass (Figure 1). In their probabilistic seismic hazard evaluations of the area, both Youngs *et al.* (1987) and Wong *et al.* (1995) combined these faults into one zone that is likely segmented.

There are also north-northwest striking Quaternary faults west of the SOMFZ within Rush Valley. These include the St. John Station fault zone (Barnhard and Dodge, 1988) or the Mid Valley Horst of Everitt and Kaliser (1980) that is within Rush Valley, and the Clover fault zone (Barnhard and Dodge, 1988) or Onaquai east marginal fault of Everitt and Kaliser (1980) that lies along the Western margin of Rush Valley, at the base of the Onaquai Mountains. Most of the scarps of the St. John Station fault zone cut the Tertiary Salt Lake Formation but appear to predate Lake Bonneville deposits, except a series of west-facing scarps that lie about 9½ km west of the northern end of the Mercur fault (Everitt and Kaliser, 1980). East-facing scarps of the Clover fault zone are formed on pre-Bonneville alluvium and are probably late Pleistocene or younger (Barnhard and Dodge, 1988). They lie about 18 km west of the southern half the Mercur fault. The seismogenic relation of the St. John Station and Clover fault zones to the SOMFZ is unknown, but their close proximity within Rush Valley suggests there is at least a structural relation between the faults.

The Quaternary stratigraphic and geomorphic framework of the area is critical to mapping scarps of the SOMFZ and better understanding its most recent behavior. Late Quaternary sedimentation along the western base of the southern Oquirrh Mountains has been dominated by alluvial-fan sediments shed from the mountains and deposition of lacustrine sediments in Rush Valley (Solomon *et al.*, 1992). Unfortunately, very little is known about periods of fan deposition along the southern Oquirrh Mountains, but they likely are strongly influenced by climate with higher deposition rates during pluvial periods.

Rush Valley lies within the Bonneville basin, which was repeatedly inundated by paleolakes during the late Quaternary. The age of associated lacustrine deposits and features can often be used to constrain the timing of faulting events (e.g., Machette *et al.,* 1992; Olig *et al.*, 1994). However, of the three most-recent deep-lake cycles, only the Bonneville cycle was apparently high enough to spill over into Rush Valley (Scott *et al.*, 1983; Currey and Oviatt, 1985; Machette *et al.,* 1992), which generally lies above an elevation of 1512 m. Thus, geologic deposits of the older Cutler Dam or Little Valley lake cycles have not been encountered in Rush Valley.

Lacustrine sediments of Lake Bonneville dominate the surficial geology in central Rush Valley. They form a generally thin mantle over older alluvial deposits and are in turn locally buried by post-lake alluvium, colluvium and eolian deposits. Lake Bonneville reached its highstand, forming the Bonneville Shoreline about 15,000 years ago (Oviatt *et al.*, 1992) and intermittently overflowed its basin until about 14,500 years ago. The lake level then catastrophically dropped about 100 meters to the Provo shoreline during the Bonneville flood. Subsequently, Lake Bonneville was not high enough to extend into Rush Valley, so Rush Lake became isolated from Lake Bonneville and is still separated from the modern Great Salt Lake today.

1.3 PREVIOUS WORK

Although the SOMFZ was first identified in the nineteenth century, its paleoseismic behavior and relation to adjacent faults remains controversial. Gilbert (1890) discovered young normal faults along the west flank of the southern half of the Oquirrh Mountains and interpreted fault scarps near Ophir Canyon to be post-Lake Bonneville and part of the Oquirrh fault, which bounds the northern half of the Oquirrh Mountains from Tooele northward (Everitt and Kaliser, 1980; Barnhard and Dodge, 1988; Solomon, 1996). Atwood (1916) disagreed, believing that the southern end of the range was not faulted. However, through careful mapping of the Stockton and Fairfield 15-minute Quadrangles, Gilully (1928, 1932) provided conclusive evidence of young normal faults along the west flank of the southern Oquirrh Mountains that produced the modern basin-mountain topography of Rush Valley. He cited fault exposures, stratigraphic offsets, structural relief and topographic relief as evidence for a zone of *en echelon* faults, extending from one-mile southeast of Mercur Canyon to just north of Soldier Canyon. He estimated a cumulative throw of 915 to 1524 m down to the west across a "Basin and Range Fault System" that consisted of five principal faults: (1) an unnamed fault south of Mercur Canyon at the range front (this is the northern part of the West Eagle Hill fault); (2) the West Mercur fault, almost continuously exposed from Ophir Canyon to West Mercur; (3) the Lakes of Killarney fault, extending from one mile south of Soldier Creek to south of Silverado Canyon; (4) an unnamed bedrock-alluvial fault contact north of Dry Canyon (which we include with the Lakes of Kilarney fault in our mapping); and, (5) the Soldier Canyon fault that extends from two miles north to two miles south of Soldier Canyon.

Gilully (1932) mapped the West Eagle Hill fault as concealed beneath alluvium, extending along the base of the range from one drainage south of Mercur Canyon to two drainages north of McFait Canyon. He inferred the total throw to be 30 to 61 m down to the west based on an exposure in a shaft, on the downthrown side of the fault, of a black carbonaceous shale that is likely the Long Trail Shale member of the Great Blue Limestone and is not exposed anywhere in the footwall section to the east. Gilully (1928, 1932) identified the West Mercur fault (referred to here as just the Mercur fault) as a range front fault extending from Mercur Canyon to just north of Ophir Canyon. He described a fault scarp trending N30°W that was nearly continuous except at Silverado Canyon. He noted that the fault was exposed in several prospect pits and shafts as a breccia zone separating alluvium from limestone. Drag-folding in the alluvium indicated normal movement down to the west and fault dips ranged from 40° to 60° west. He cited the presence of faulted alluvium exposed in the footwall of one shaft as evidence for repeated movement "on a fault whose scarp had been partly buried by alluvium."

Cook and Berg (1961) identified a 60-mile long continuous gravity gradient of 10 milligals per mile that bounds the west side of the southern Oquirrh, East Tintic and Boulter Mountains. They

attributed the gradient to a range-front fault, the Oquirrh-Boulter-Tintic fault zone. Everitt and Kaliser (1980) followed this nomenclature in their geologic mapping of Rush Valley, referring to faults extending from Ophir Canyon to near Fivemile Pass as the northern Oquirrh-Boulter-Tintic fault zone. Although they included the Lakes of Killarney and Soldier Canyon faults after Gilully (1932), they did not include the West Eagle Hill fault on their 1:50,000-scale maps. They also mapped surficial deposits and fault scarps on alluvium of the Mercur fault, extending it much farther south than Gilully's mapping, to the latitude of Fivemile Pass. They identified three main age categories of deposits along the scarps: (1) QToa, older (pre-Lake Bonneville) alluvium; (2) Qb, Lake Bonneville deposits; and (3) Qya, younger (post-Lake Bonneville) alluvium. Their mapping shows QToa deposits as faulted, whereas Qya deposits are not faulted. Along most of its length, traces of the Mercur fault lie well above the Bonneville Shoreline and associated Qb deposits, except for the western most fault trace at its southern end, where scarps extend down to elevations below 5,200 feet. Here, at a site roughly 4-1/2 km west of Fivemile Pass, Everitt and Kaliser (1980) excavated a trench across a small west-facing scarp that lies just below the Bonneville shoreline. Their trench exposed a west-dipping north-south striking main fault and a 12-m-wide graben. They interpreted the Lake Bonneville deposits exposed in the trench to be faulted based on the presence of shear fabric (B.L. Everitt, personal communication, 1995) and warping of contacts.

In contrast, Barnhard and Dodge (1988) interpreted the youngest movement on the Mercur fault to have occurred prior to formation of the Bonneville shoreline (≥ 15 ka) based on: analysis of the morphology of 11 fault scarp profiles, reinterpretation of Everitt and Kaliser's (1980) trench log, and excavation of a shallow trench located south of Everitt and Kaliser's, where they observed that post-Bonneville alluvium was unfaulted. However, the age of the alluvium was unconstrained and could be very young. Similar to Everitt and Kaliser (1980), neither Bucknam (1977) nor Barnhard and Dodge (1988) included the West Eagle Hill fault on their maps of fault scarps in unconsolidated deposits. However, Barhard and Dodge (1988) did map fault scarps in alluvium of the Mercur fault, extending for 15 km from just north of Ophir Canyon south to Fivemile Pass, similar to Everitt and Kaliser's (1980) mapping. In keeping with these studies, Hecker (1993) did not include the West Eagle Hill fault, either separately or as part of the Mercur fault, on her Quaternary fault map of Utah. However, in their investigation of the SOMFZ, Wu and Bruhn (1994) mapped discontinuous late Quaternary fault scarps in alluvium, extending from Mercur to Sunshine Canyons at the foot of the range. They named these scarps the West Eagle Hill fault. Primarily based on geomorphic map relations, they interpreted the youngest faulted alluvium (their unit Qf_2) to have been deposited early in the Bonneville lake cycle. From this, and their analysis of fault scarp profiles across the West Eagle Hill, Lakes of Killarney, and Mercur faults, Wu and Bruhn (1994) suggested that the youngest faulting anywhere on the SOMFZ occurred prior to formation of the Bonneville shoreline.

Most recently, ongoing cosmogenic isotope studies of the Solider Canyon fault suggest a mid-Holocene rupture occurred on the fault around 4,000 to 5,000 years ago (R.L. Bruhn, University of Utah, personal communication, 1997), possibly contemporaneous with the most-recent event on the Oquirrh fault to the north (Olig *et al.*, 1994; 1996). This raises questions about segmentation of the entire Oquirrh-East Great Salt Lake Fault zone. Table 1 shows available data on the timing of faulting events along the Oquirrh-East Great Salt Lake fault zone. If a mid-Holocene event occurred on the SOMFZ and it ruptured with the Oquirrh fault, the rupture would have been over 52 km long and capable of producing a M_w 7.1 earthquake versus an expected M_w of 6.7 for a 25-km –long rupture of the SOMFZ alone. Not only are these

important seismic hazard issues for Tooele Army Depot but also for the Salt Lake and Provo metropolitan areas, which are located roughly 20 km east of the faults.

Table 1

Ages of Youngest Surface-Faulting Along Sections of the Oquirrh-East Great Salt Lake Fault Zone[1]

	Fault	Holocene	Late Pleistocene
	East Great Salt Lake fault	< 6,800[2]	?[3]
	Oquirrh fault	4,300 - 6,900[4]	20,300 - 26,400[4]; >> 33,000[4]
So. Oquirrh Mountains fault Zone of Wu & Bruhn (1994)	Soldier Canyon fault[5]	mid-Holocene?[6]	?[3]
	Lakes of Killarney fault[7]		> 15,000[8]
	Mercur fault		< 15,000[9] or > 17,000 - 18,000[10,11]
	West Eagle Hill fault		> 15,000[12]
	Topliff Hills fault		> 15,000[10] or < 15,000[9]
	East Tintic fault		>> 15,000 (middle to late Pleistocene)[13]

1 Ages in radiocarbon years before the present.

2 Based on possible offset of Mazama ash bed found in drill holes in Great Salt Lake (D.R. Currey, University of Utah, written communication, 1994).

3 Ages for events prior to the most-recent faulting are unknown.

4 Ages of most recent, penultimate, and antepenultimate events from Olig et al. (1994, 1996).

5 Bedrock fault.

6 Recent results from cosmogenic ^{14}C analyses of samples collected from bedrock scarps believed to have formed in the most recent event suggest ages of 4,000 to 5,000 years (R.L. Bruhn, University of Utah, written communication, 1997).

7 Dominantly bedrock fault.

8 From Wu and Bruhn (1994). Slightly older than the Bonneville shoreline.

9 From Everitt and Kaliser (1980), and B.L. Everitt (Utah Division of Water Resources, personal communication, 1995).

10 From Barnhard and Dodge (1988).

11 Supported by Wu and Bruhn (1994).

12 From Wu and Bruhn (1994). Slightly older than the Bonneville shoreline.

13 From Bucknam and Anderson (1979).

2.1 STRATIGRAPHY AND SOILS

Figure 2 shows our strip map of the SOMFZ. We identified: (1) six different relative ages of fan and stream alluvium (af1 through af6; a5 and a6); (2) two different relative ages of stream terrace deposits (t3 and t4); (3) alluvium on many different levels of pediments (ap1 and ap2); and (4) Lake Bonneville deposits and reworked lacustrine deposits (al) below the Bonneville shoreline. In all cases, numbering of units increases with decreasing age so that units af6 and a6 are youngest. All units are described in more detail in the sections that follow.

Different age alluvial fan units were initially differentiated based on relative geomorphic position, cross-cutting relations, degree of incision and erosion, and preservation of bar and swale topography. We also excavated 27 soil pits to grossly characterize soils as an aid for classifying and distinguishing relative ages of surfaces. As carbonate accumulation dominated most soil profiles (i.e., pedocals), we focused on appropriate field techniques for relatively quantifying carbonate accumulation and morphology development. These included identifying horizons, measuring horizon thicknesses, describing carbonate morphologies, and measuring carbonate-rind thicknesses on clasts. The prevalence of limestone clasts in all the fan deposits precluded using laboratory techniques to measure percent carbonate in soils.

Detailed soil pit data are included in Appendix A. Figures 3a through 3f summarize soil pit data, grouped by units. In general we did not find soils to be a useful tool for distinguishing relative ages of units beyond three broad categories: af5 through af6, af2 through t4/af4, and af1/ap1. There are two apparent reasons for the limited resolution of using soils to assign relative ages for units in the study area. First, we found a large variability between soil profiles from individual map units. This probably reflects both a complex history, including cycles of eolian deposition and stripping, and the likelihood that the fan surfaces for individual units actually span a considerable range of ages. Additionally, we suspect that very high rates of carbonate-dust influx result in initially high carbonate accumulation rates that rapidly peak and level out. Typical soil profile characteristics are discussed in the unit descriptions that follow. First, however, we summarize other soil-forming factors for our study area that need to be considered in using soils to assign relative ages to units.

In addition to time and dust influx, factors affecting the rate of soil development include climate, vegetation, topography and parent material. The study area climate is presently temperate and semiarid with a mean annual temperature of 10.6°C and mean annual precipitation of 41 cm (Schlotthauer et al., 1981). These measurements are from the Tooele weather station. In actuality, temperatures and precipitation vary in the area largely dependent on elevation with an average precipitation of 2 - 5 cm/yr on lower slopes (elevation below 5,000 to 6,000 feet) and 4 - 7 cm/yr on upper slopes (elevation above 5,000 to 6,000 feet) (USDA, 1999). Vegetation includes sage, rabbit brush, prickly pear cactus and sparsely distributed grasses (Indian ricegrass and cheatgrass) on the lower slopes with juniper, pinyon, sage, mountain mahogany, and bluebunch wheatgrass on higher slopes. The change in vegetation above about 5,000 to 6,000 feet is probably related to increasing precipitation. We also noticed evidence of carbonate leaching in soils at these higher elevations (e.g., SP1 and SP25). These observations suggest that at higher elevations soils are reaching the upper moisture limit under which pedocals can form (Machette, 1985), although the lower pH from juniper and pinyon detritus may also contribute to the leaching. Soils are developed on piedmont slopes that range from 15° to < 2°, decreasing valleyward with most soil pits on surfaces that slope less than 10° to the southwest.

Paleozoic limestones, quartzites, dolomites and mudstones make up the southern Oquirrh Mountains, but the range front itself is composed almost entirely of Mississipian Great Blue Limestone. Consequently, limestone clasts dominate the alluvial fan gravels that comprise most of the parent material for the soils.

Descriptions of individual map units and their relation to faults follow.

2.1.1 Youngest Stream (a5, a5-6, a6) and Fan (af5, af5-6, af6) Alluvium

These units include latest Pleistocene to Holocene channel and fan deposits that are dominantly gravels near the range front but fine distally to gravelly sands and silts toward the center of Rush Valley. Deposits include the active portion of channels (a6) and reworked mine tailings are evident along some creeks (e.g., Mercur and Sunshine Creeks). Channels are generally incised into older deposits, except at some locations along portions of the West Eagle Hill fault (from Sunshine Canyon to north of McFait Canyon, Figure 2b), where some a5-6 and af5-6 deposits appear to be agrading onto older fan deposits (af2). The youngest fans (af5, af5-6, af6) are generally small, and show distinct bar and swale topography. Soils are characterized by weakly developed Bk horizons (stage I to I+) that are 25 to ~60 cm thick (Figure 3f). Carbonate rinds are thin (averaging 0.9 $\pm$ 0.80 mm), discontinuous and confined to the bottoms of clasts. The active portion of fans (af6) and channels (a6) were distinguished from older af5 and a5 deposits primarily based on lower geomorphic position, cross-cutting relations and the fresh appearance of bar and swale topography.

All of the youngest stream and fan alluvium appears to be younger than any faulting along the SOMFZ, as these deposits do not appear faulted and in many locations appear to incise, bury or drape scarps of both the Mercur and West Eagle Hill faults. Additionally, these deposits also appear to drape and bury portions of the Bonneville shoreline (e.g., Mercur Creek; Figure 2b) that formed during the highstand of Lake Bonneville about 15 to 14.5 ka (Oviatt et al., 1992). Based on these relations we assign a latest Pleistocene to Holocene age to these units, which is consistent with their morphology and soil development.

2.1.2 Lacustrine and Alluvial Deposits Below the Bonneville Shoreline (al)

The Bonneville shoreline lies just below the 5,200-foot-contour within the southwest corner of the study area (Figure 2). This unit (al) includes undifferentiated Lake-Bonneville, reworked Lake-Bonneville, eolian, ephermeral channel, and slopewash deposits that lie below the Bonneville shoreline. These deposits are primarily fine-grained (sands and silts), but also include sandy gravels, particularly where older fan deposits (af2) have been reworked into curvilinear berms comprising the beachline of the Bonneville shoreline. We did not dig any soil pits into these deposits, but morphostratigraphic relations indicate that they are either close in age to the Bonneville shoreline (~15 ka) or are younger.

Unfortunately the relation between lacustrine deposits and scarps of the Mercur fault is not clear. The distal most-recent fan deposits of Sunshine and Mitchell Creeks bury the Bonneville shoreline (Figure 2b) and south of this location, scarps of the Mercur fault extend below the 5,200-foot-contour and appear to merge with the Bonneville shoreline. Here, scarp heights increase rapidly to the south. Just south of a small "y"-shaped drainage, we observed a broad double-stepped scarp where we measured multiple scarp heights (9.5/5 on Figure 2). The area was disturbed by grading (firebreaks?), so we did not measure scarp profiles, but the

westernmost scarp was about 5 m high, whereas the easternmost scarp was about 4½ m high, resulting in a total height of 9.5 m. We speculate that one of the scarps may represent a shoreline and the other a fault scarp, but which is which and the cross-cutting relations between the two features remain unclear. The dual scarp continues to the southwest but the step disappears. At about this latitude a short, discontinuous fault scarp splays off, trending north-south (Figure 2b). This is the fault trace that Everitt and Kaliser (1980) and Barnhard and Dodge (1988) trenched. Although we show this trace as a dashed fault scarp in unit al (Figure 2b), we emphasize that morphostratigraphic relations are not clear as to whether the fault actually offsets the lake deposits (as interpreted by Everitt and Kaliser, 1980) or the lake deposits are draped over a pre-existing fault scarp (as interpreted by Barnhard and Dodge, 1988). On the surface, we observed fine, loose sands mantling a small scarp that decreases in height southward until it dies out just south of a gravel road. The crest of the scarp is rounded but the scarp itself is prominent on the aerial photographs and on the ground, and so we show this trace as dashed instead of dotted to be consistent with the rest of our mapping.

2.1.3 Intermediate-Age Fan (af3, af4) and Terrace (t3, t4) Alluvium

Intermediate-age alluvial fan (af3, af4) and terrace deposits (t3, t4) are preserved at selected localities along the SOMFZ, including Ophir, Silverado, West Dip Gulch, Mercur and north of McFait Canyons (Figure 2). These units are dominantly composed of coarse gravels but also locally can include finer-grained alluvium, particularly in reaches of fans more distal from the range front (e.g. Silverado Canyon). Terraces are 2 to 7 m above the active channel and are only locally preserved. Fans are small (e.g. West Dip Gulch) to intermediate (e.g. Silverado Canyon) in size, have very subdued bar and swale topography, and are moderately dissected. They range from deeply incised (over 24 m at Silverado Canyon) on the upthrown side of faults to barely incised (under 2 m at West Dip Gulch) on the downthrown side of faults. Soils are moderately to well developed. They are characterized by K horizons that have maximum morphologies of stage III to IV and are typically 30 to 40 cm thick (Figures 3d and 3e), with carbonate rinds that average 4.1 $\pm$ 1.7 mm thick (Appendix A). Units af3 and t3 were distinguished from units af4 and t4 primarily based on morphostratigraphic relations as we only excavated one soil pit on af3/t3 surfaces (SP6).

Units t4 and/or af4 are faulted at Silverado Canyon, West Dip Gulch and Mercur Canyons (Figure 2). These are the youngest deposits that are clearly offset by the Mercur fault. Unit t3 is faulted north of McFait Canyon (Figure 2b) and these are the youngest deposits that are clearly offset by the West Eagle Hill fault.

Unfortunately, absolute age constraints on these deposits are lacking. Based on the degree of soil development (maximum carbonate morphology of stage III to IV) compared with dated soils located elsewhere in the western U.S. with a similar climate, age estimates range from about 100 ka to 5 Ma (Machette, 1985). The maximum estimate appears far too old for the morphology and geomorphic position of the intermediate-age alluvium, which are more consistent with the minimum age estimate, suggesting a late Pleistocene age. This implies that soils developed rapidly, perhaps due to a very high carbonate dust influx in Rush Valley. In comparison, assuming a carbonate-rind accumulation rate of 0.6 mm/10 ky, determined for an area with a somewhat similar climate and a considerable influx of airborne carbonate (Pierce, 1985; Vincent *et al.*, 1994), yields much younger age estimates of 40 to 100 ka. Thus, considerable uncertainties remain in estimating the ages for the intermediate-age alluvial units and the

maximum limiting age of the most recent surface rupture on the Mercur and West Eagle Hill faults.

2.1.4 Older Pediment (ap2) and Fan (af2) Alluvium

Older pediment (ap2) and fan (af2) alluvium is extensive along both the Mercur and West Eagle Hill faults from Mercur Canyon south (Figure 2b). These units are dominantly coarse gravels and include thin fans mantling a shallow bedrock shelf (between 0 and 25 m depth) located between the Mercur and West Eagle Hill faults. Fans are large, coalescing along much of the range front. Bar and swale topography is absent, dissection is moderate and presently active drainages have locally incised into af2 surfaces as much as 30 m.

The only location where ap2 deposits were mapped was on the upthrown side of the West Eagle Hill fault at McFait Canyon (Figure 2b). Here, a small pediment remnant of Great Blue Limestone is mantled by coarse alluvial gravels that are 1.0-1.5 m thick and lie about 6.0 to 6.5 m above the active drainage. Soils on ap2 and af2 surfaces are well developed. They are characterized by K-horizons that range from 30 to 70 cm thick and average about 50 cm thick (Figures 3a and 3c). Maximum morphologies are III to IV and some profiles show evidence of stripping and/or dissolution (e.g. SP3). The SP5 profile may not be truly representative due to case hardening of carbonate on this road-cut exposure. This may explain the apparent lack of a Bw or Bk horizon near-surface and the unusually thick K horizon for this profile (Figure 3c). Carbonate rind thicknesses are extremely variable for af2 and ap2 deposits, ranging from 2.3 ± 0.6 to 7.3 ± 4.2 mm (Figure 3c), with an overall average of 4.2 ± 2.7 mm.

Fault scarps are prominent in af2 and ap2 deposits, but similar to the intermediate-age alluvial deposits, age control is poor for older alluvium. Based on degree of soil development and comparison with dated soils elsewhere (Machette, 1985), age estimates range from about 100 ka to 5 Ma, whereas average carbonate rind thickness suggest younger ages of 25 to 115 ka. Even the af2 surface with the thickest carbonate rinds (SP2), suggests younger ages of 50 to 200 ka. Given the regional Quaternary stratigraphic framework, and based on fan morphology, size, and geomorphic position, we originally interpreted the Mercur Canyon fan and other af2 deposits to roughly correlate with the Little Valley Lake cycle that culminated at about 150 ka and was waning by 130 ka (Scott et al., 1983). Samples have been collected from the Mercur Canyon fan surface for cosmogenic dating (A. Mattson, Univ. of Utah, personal comm., 1999), and hopefully these analyses will help constrain the large uncertainties of the age of older fan alluvium.

2.1.5 Oldest Pediment (ap1) and Fan (af1) Alluvium

Remnants of the oldest pediment (ap1) and fan (af1) alluvium are scattered along the Mercur and West Eagle Hill faults from Dry Canyon to south of Sunshine Canyon, but are best preserved north of Ophir Canyon and south of Mercur Canyon along the West Eagle Hill fault (Figure 2). Pediments that are stripped of alluvium and not distinguished from bedrock on Figure 2a are also preserved in the footwall of the Mercur fault, forming much of the bedrock-alluvium fault contact between Mercur and Ophir Canyons. Af1 fans do not necessarily correlate in age to ap1 pediments, although they may in some cases, as the pediments likely span a large range of ages. Fans are extensively dissected with only remnants preserved. Modern drainages are incised into af1 surfaces up to 40 m.

Proctor (1959) noted the preservation of multiple pediment surfaces along the southwestern flank of the southern Oquirrh Mountains, and Everitt and Kaliser (1980) briefly discussed their relation to the Mercur fault and the implication for a period of tectonic quiescence some time ago along the fault. Pediments show a large variety in elevations above active drainages (up to 25 m) and these surfaces probably represent a large range of ages, but differentiating these was beyond the scope of this study, particularly as soils developed in the alluvium mantling the pediments typically showed evidence for complexities in development such as stripping and dissolution (e.g. SP1). Characteristics consistent between the pediment surfaces include: (1) they all are formed on northwest striking, south-west dipping Paleozoic rocks (mostly Great Blue Limestone); (2) alluvium mantling the surfaces is composed of thin (<a few meters) gravels; (3) fault scarps on pediments are prominent but bedrock is usually exposed in scarp faces; and, (4) surfaces slope 5° to 10° to the west-southwest and southwest. In our map area pediments are confined to the upthrown side of faults, although the shallow bedrock shelf between the Mercur and West Eagle Hill faults is actually an extensive pediment on the downthrown side of the West Eagle Hill fault. In addition, Everitt and Kaliser (1980) discuss pediments developed on the Salt Lake formation within central Rush Valley, west of our study area and on the downthrown side of the Mercur fault.

The pediments suggest that a relatively long period of tectonic quiescence occurred some time ago to allow formation of extensive erosion surfaces along both the Mercur and West Eagle Hill faults. However, when this quiescence occurred is unknown; obviously the pediments formed before af2 fans were deposited and after some amount of uplift occurred along the range front. Extension in the region was underway by the Miocene (Guilluly, 1967) and deposition of the Tertiary Salt Lake Formation in the Rush Valley basin suggests that faulting had initiated along the SOMFZ by this time as well. Thus, the pediments presumably could have formed any time since the Miocene and before the late Quaternary. Obviously, more work is needed to better determine the ages of both ap1 surfaces and af1 fans along the SOMFZ.

2.2 FAULT SCARPS OF THE MERCUR AND WEST EAGLE HILL FAULTS

The Mercur and West Eagle Hill faults are subparallel, strike about N30°W, dip southwest, and together extend for 17 km from Dry Canyon to the southern end of the range, south of Sunshine Canyon (Figure 2). Along much of its length, particularly the central the portion, the Mercur fault is characterized as a bedrock-alluvial fault contact at the base of the range. Fault scarps on alluvium are preserved north of Ophir Canyon, at Silverado Canyon, at West Dip Gulch, at Mercur Canyon, and to the south of Mercur Canyon where the fault branches into two subparallel series of *en echelon* scarps.

The West Eagle Hill fault lies 1 to 1.5 km east of the Mercur fault and overlaps with its southern end for nearly 9 km south of Mercur Canyon. The West Eagle Hill fault primarily consists of a single fault trace at the base of the range that is principally marked by prominent but discontinuous scarps in bedrock or on pediments with a thin veneer of alluvium. Thus, most of the scarps of the West Eagle Hill fault are actually held up by bedrock. Rocks along this portion of the southern Oquirrh Mountains are composed of Mississipian Great Blue Limestone that consistently dips to the southwest, forming the western flank of the Ophir anticline (Gilluly, 1932). This superficially suggests that some scarps could be dip slopes related to erosion and not faulting. However, we observed that bedding dominantly dips about 30° to 40° to the southwest

(Figure 4) and is consistently steeper than the slopes of scarp faces, indicating that scarps are generally not dip slopes and are truly fault-related. A tectonic origin for scarps is also indicated by the clear offsets of pediment and alluvial fan surfaces. Given their tectonic origin, we were surprised at the general sparcity of evidence for brittle deformation (such as breccia, slickenlines or shear zones) along secondary faults in bedrock exposures on scarp faces, but we also emphasize that bedrock faults were not the focus of our investigation. Fault scarps on alluvium are preserved along the West Eagle Hill fault near McFait and Sunshine Canyons (Figure 2b). However, scarps on the Sunshine Canyon fan are small (less than 2 m high), dissected and eroded.

2.2.1 Topographic Profiles

We measured topographic profiles across fault scarps to characterize displacement patterns, including 13 profiles along the Mercur fault and five profiles along the West Eagle Hill fault (Figure 2). Most of the profiles were measured using an abney level and stadia rod placed on the ground surface parallel to the slope gradient. However, some of the longer sections across uniform unfaulted surfaces (e.g., parts of P1, P4 and P6) were measured using a tape measure, stadia road and abney level. The profiles are shown in Appendix B. The resulting net vertical tectonic displacements (NVTD; after Swan *et al.*, 1980) are shown in Table 2 and plotted in Figure 5, which also includes data from Wu and Bruhn (1994), Barnhard and Dodge (1988), and Everitt and Kaliser (1980).

Displacement patterns show some characteristics that are typical for normal faults and they also show complexities indicative of more complex rupture behavior. In general, older surfaces show larger offsets than younger surfaces (Figure 5), indicating repeated faulting occurred along both faults during the Quaternary. However, the maximum NVTD measured along the Mercur fault was nearly 22 m across an af4 surface at Silverado Canyon. This is surprisingly larger than displacements measured on some older surfaces elsewhere on the Mercur fault, but is consistent with along-strike cumulative displacement patterns observed by Wu and Bruhn (1994). They noted that the maximum cumulative displacement (as inferred from range crest elevation in the footwall and basin depth in the hanging wall) along the entire SOMFZ was along the central portion of the fault near Silverado Canyon (see their Figure 2). Alternatively, it is possible that not all of the offset measured on the af4 fan surface actually occurred after af4 fan deposition if some of the relief is due to a pre-existing bedrock scarp. However, we did not see any evidence for shallow bedrock, and fan deposits actually appear to be quite thick (at least >5 m) over the scarps and on the upthrown block, but we cannot preclude from our observations the possibility that bedrock is shallower than 22 m on the upthrown block.

Another pattern evident from the data is that, except for scarps on ap1 pediments, displacements are much higher on the Mercur fault than on the West Eagle Hill fault. The ap1 pediment surfaces probably span a very wide range of ages and unfortunately our data on these surfaces are too sparse to show definite patterns for either fault. NVTD measured on af2/ap2 surfaces range between 6 and 10 m across the entire Mercur fault zone, whereas they range between 3 and 4 m across the West Eagle Hill fault (Figure 5). Similarly, NVTD on intermediate age surfaces are higher on the Mercur fault with a maximum of nearly 22 m on af4 surfaces compared to a maximum of nearly 3 m on t3 surfaces along the West Eagle Hill fault. The estimated along-strike average NVTD of af4/t4 surfaces along the Mercur fault is 5.8 ± 0.5 m, whereas the estimated along-strike average NVTD of t3 surfaces along the West Eagle Hill fault is only 1.5 ±

0.5 m. Larger displacements on younger surfaces along the Mercur fault are consistent with the geomorphic expression of the faults in that scarps on alluvial surfaces are much more continuous, prominent, better preserved, and show larger maximum slope angles along the Mercur fault than along the West Eagle Hill fault.

Thus, displacement patterns on alluvial surfaces indicate that Quaternary slip has preferentially been partitioned onto the Mercur fault and faulting has most recently shifted basinward. However, because of the lack of data on bedrock faults and complexities of along-strike displacement variations, it is difficult to determine how many recent surface-faulting events may have occurred on the Mercur fault that did not rupture the West Eagle Hill fault. Differences in displacements of about 3 to over 6 m on af2 surfaces between the two faults suggest that perhaps many additional events occurred on the Mercur fault. Similarly, differences in average along-strike displacements of over 4 m on intermediate-age surfaces between the two faults suggests at least two, and probably more, additional events occurred on the Mercur fault since formation of af4 surfaces.

Finally, we note that although displacements taper down and eventually die out at the southern end of both faults, the displacements at the northern end of both the Mercur and West Eagle Hill faults appear large and do not appear to be tapering off as might be expected at a fault tip. We speculate that this may be due to transference of slip onto other faults of the SOMFZ along strike to the north. Specifically, slip on the Mercur fault may be transferred to the Soldier Canyon fault, and the Lakes of Kilarney fault may actually be a northward continuation of the West Eagle Hill fault (Figure 2).

Table 2
Scarp Profile Displacement Data for the Mercur (MF) and West Eagle Hill (WEHF) Faults

Profile Number	Location (north to south)	Soil Pits (along profile)	NTVD* (meters)	Surficial Unit (upthrown/downthrown)	Maximum Slope Angle
P18	eastern scarp, north side of Ophir Canyon-MF	--	11.3	ap1/af1	15.5°
P17	western scarp, north side of Ophir Canyon-MF	SP25, SP27	2.7-4.7**	af1/af5-af1	21° mult. bevel
P13 (east)	south side of Silverado Canyon fan-MF	SP14	1.9	af4/af4	8° double bevel
P13 (west)	south side of Silverado Canyon fan-MF	SP15, SP16	19.75	af4/af4	15.5° mult. bevels
P14	north side of West Dip Gulch-MF	SP19, SP20	3.2	af4/af4	18°
P15	terrace, south side of West Dip Gulch-MF	SP21, SP22	3.75 – 4.2	t4/af4	15° double bevel
P16	fan, south side of West Dip Gulch-MF	SP23	3.3	af4/af4	21° mult. bevel
P6	eastern scarp, north lobe, Mercur Canyon fan-MF	--	2.5	af2/af2	7.5° double bevel
P7	middle scarp, north lobe, Mercur Canyon fan-MF	--	1.0	af2/af2	8°
P8	western scarp, north Mercur Canyon fan-MF	--	6.25	af2/af2	22.5° triple bevel
P9	terrace, south side of Mercur Canyon-MF	SP10, SP11	1.2	t4/t4	8°
P10	eastern scarp, south lobe, Mercur Canyon fan-MF	SP12	1.0	af2/af2	8°
P11	middle scarp, south lobe, Mercur Canyon fan-MF	--	0.75	af2/af2	5.5°
P12	western scarp, south lobe, Mercur Canyon fan-MF	SP13	3.75 – 5.5	af2/af2	17.5°
P1	between Mercur and McFait Canyons-WEHF	SP1, SP2	20.75 – 22.0	ap1/af2	18.5° double bevel
P3	north terrace, north of McFait Canyon-WEHF	SP6, SP7	2.75	t3/af2	13°
P4	south terrace, north of McFait Canyon-WEHF	SP8	2.75	t3/af2	13°
P5	south terrace, north of McFait Canyon-WEHF	SP9	2.25	t3/af2	15°
P2	south side of McFait Canyon-WEHF	SP3, SP4	3.6	ap2/af2	15° mult. bevels

* Net vertical tectonic displacement as defined by Swan et al. (1980).

** Accounts for 0.7 m of af5 deposits overlying af1 deposits on downthrown block.

3.1 SUMMARY

A complex series of *en echelon* and overlapping, northwest-striking, southwest-dipping, normal faults forms the SOMFZ. To better understand the Quaternary behavior and seismogenic relation between the faults, we mapped and profiled fault scarps on alluvium along the SOMFZ.

We developed a 1:50,000-scale strip map of surficial deposits along the SOMFZ (Figure 2), focusing on alluvial deposits along the two most geomorphically prominent fault traces of the SOMFZ, the Mercur and West Eagle Hill faults. Based on geomorphic, morphostratigraphic, and pedologic characteristics we identified: (1) six different ages of stream (a5 and a6) and fan (af1 through af6) alluvium; (2) two relative ages of stream terrace deposits (t3 and t4); (3) alluvium on many different levels of pediments (ap1 and ap2); and (4) deposits below the Bonneville shoreline (al) that include Lake Bonneville near-shore sediments, lacustrine sediments reworked as alluvium and colluvium, and eolian deposits. Except for the young stream and fan alluvium (af5, af6, a5, and a6), and the deposits below the Bonneville shoreline, soils are well developed in all the deposits and we infer that rates of dust influx are high enough to rapidly form plugged K horizons (stage III carbonate morphology or greater) on late Pleistocene deposits. However, absolute age constraints for the surfaces are needed to adequately test this hypothesis.

We also measured 18 topographic profiles across scarps of the Mercur and West Eagle Hill faults to determine NVTD. We supplemented these data with displacement data from previous studies by Everitt and Kaliser (1980), Barnhard and Dodge (1988) and Wu and Bruhn (1994) to characterize along-strike displacement patterns for surfaces of different ages (Figure 5). NVTD of late Pleistocene af4/t4 alluvial fans and terraces range up to nearly 22 m, and average about 5.8 ± 0.5 m along the Mercur fault. In contrast, NVTD of late Pleistocene t3 terraces are below 3 m and average about 1.5 ± 0.5 m along the West Eagle Hill fault. Displacements measured on older af2/ap2 surfaces are also larger on the Mercur fault than on the West Eagle Hill fault, ranging between 6 and 10 m on the former, and between 3 and 4 m on the latter. Data are presently too limited to characterize displacement patterns on af1/ap1 surfaces that likely span an extremely wide range of ages.

3.2 QUATERNARY BEHAVIOR AND RELATIONS BETWEEN THE MERCUR AND WEST EAGLE HILL FAULTS

Results from our mapping and scarp profiling provide a variety of insights into the Quaternary behavior and seismogenic relation between the Mercur and West Eagle Hill faults. First, repeated Quaternary activity occurred on both faults as indicated by: 1) overall increasingly larger displacements on increasingly older deposits; 2) large NVTD (up to 22 m) of Quaternary alluvial surfaces; and, 3) multiple bevels evident on many of the larger scarps.

Both our mapping and profiling results suggest that faulting is youngest on the Mercur fault and is most likely late Pleistocene, but we cannot preclude Holocene activity based on our mapping alone. The youngest deposits that are clearly offset by the West Eagle fault are late Pleistocene (?) t3 terrace deposits, whereas the youngest mapped units offset by the Mercur fault are slightly younger late Pleistocene (?) af4 fan and t4 terrace deposits. This suggests that faulting is younger on the Mercur fault than on the West Eagle Hill fault, which is also indicated by the

overall larger offsets of late Pleistocene (?) alluvial surfaces along the Mercur fault, and by differences in fault scarp morphologies. Mercur fault scarps are generally steeper, more prominent and continuous, and often show multiple sharp bevels. In contrast, West Eagle fault scarps are more discontinuous and eroded, have small smaller maximum slope angles and more rounded crests, and lack sharp bevels except in bedrock.

The young stream and fan alluvium (af5, af6, a5, and a6) appears to be the oldest unfaulted deposits along both the Mercur and West Eagle Hill faults. These latest Pleistocene to Holocene alluvial deposits also bury portions of the Bonneville shoreline that formed about 15 to 14.5 ka (Oviatt *et al.,* 1992). However, these relations are not necessarily conclusive that faulting pre-dates the Bonneville shoreline because the young alluvium spans such a wide range of ages. Although the West Eagle Hill fault lies well above the Bonneville Shoreline, the southern end of the western trace of the Mercur fault does drop below the Bonneville Shoreline. Unfortunately, we found that morphostratigraphic relations remain ambiguous as to whether Lake Bonneville deposits are actually faulted, as proposed by Everitt and Kaliser (1980), or whether they merely drape a pre-existing fault scarp, as proposed by Barnhard and Dodge (1988). Better exposures of more precise stratigraphic relations with absolute age constraints are needed to determine the age of the youngest surface faulting event on both the Mercur and West Eagle Hill faults.

Although both faults have been repeatedly active in the Quaternary, a long period of tectonic quiescence likely occurred prior to late Quaternary faulting on both the Mercur and West Eagle Hill faults. This is indicated by extensive pediments that formed across both faults and have subsequently been offset as much as 22 m or more. These pediments likely span an extremely wide range of ages, but their formation must post-date deposition of the Salt Lake Formation and initiation of faulting in the Miocene. Their formation must also pre-date deposition of af2 alluvial fans and subsequent late Quaternary faulting.

Displacement patterns on the Mercur and West Eagle Hill faults also indicate that late Pleistocene slip has been preferentially partitioned onto the Mercur fault and most recently at least two, and probably more, surface-faulting events occurred on the Mercur fault but did not rupture the West Eagle Hill fault. This is indicated by larger NVTD on older (af2/ap2) and intermediate-age (t3/af4/t4) alluvial surfaces along the Mercur fault. Average along-strike displacements on intermediate-age surfaces are about 4.3 m greater on the Mercur fault. Based on a 25-km-long rupture length and using Wells and Coppersmith's (1994) empirical relation for all fault types, we estimate an expected average displacement per event of 0.6 m for the SOMFZ. In comparison, using 17 km for rupture of the Mercur fault alone yields an expected average displacement per event of 0.5 m. This suggests that perhaps as many as seven to nine additional events may have ruptured the Mercur fault and not the West Eagle Hill fault during the late Pleistocene.

The preferential partitioning of Quaternary slip onto the Mercur fault over the West Eagle Hill fault is also indicated by map and geomorphic relations along the faults. The very shallow bedrock shelf (<25 m depth) on the downthrown side of the West Eagle Hill fault, versus the greater than 900 m of basin fill on the downthrown side of the Mercur fault (Everitt and Kaliser, 1980) suggests that the cumulative offset on the Mercur fault is at least an order of magnitude larger than the cumulative offset on the West Eagle Hill fault. Granted, a thick section of Tertiary Salt Lake Formation in the basin fill along the Mercur fault does suggest that at least some of the cumulative offset is actually pre-Quaternary. However, these Tertiary deposits are not present in the hanging wall of the West Eagle Hill fault, either because they were stripped

away due to uplift on the Mercur fault, or because they were never deposited on a topographic high created by greater subsequent uplift on the Mercur fault. Regardless, the shallow bedrock shelf and the preservation of late Quaternary scarps of the Mercur fault on the downthrown side of the West Eagle Hill fault also suggests that rates of late Quaternary activity are relatively higher on the Mercur fault than on the West Eagle Hill fault; otherwise Mercur fault scarps would likely be buried by a thicker package of alluvium deposited on the downthrown side of the West Eagle Hill fault.

Although displacement patterns indicate preferential partitioning of late Quaternary slip onto the Mercur fault, they do not preclude any coseismic surface rupture of the Mercur and West Eagle Hill faults. Indeed, the way that displacements for all different-aged surfaces decrease on the Mercur fault at the same along–strike position that displacements become apparent on the West Eagle Hill fault suggests that slip on the faults may be connected at depth and they may have experienced coseismic rupture during the Quaternary. A more detailed and comprehensive paleoseismic record of specific surface-faulting events on both faults is needed to verify if and when coseismic surface rupture may have occurred.

Finally, displacements are expected to die out at the tips of normal faults unless slip is transferred onto other structures either along strike or on cross-structures. We note that although Quaternary displacements slowly die out at the southern end of both the Mercur and West Eagle Hill faults, the displacements at the northern end of both faults appear large and do not appear to be tapering off. We infer that this may be due to transference of slip onto other faults of the SOMFZ that are along strike to the north. Specifically, slip on the Mercur fault may be transferred to the Soldier Canyon fault, and the Lakes of Kilarney fault may be a northward continuation of the West Eagle Hill fault. This interpretation is also supported by cumulative displacement patterns for the entire SOMFZ that are based on combining range crest elevations and thicknesses of basin fill inferred from gravity data (Wu and Bruhn, 1994). Further investigation of displacement patterns and the timing of events is needed to test this hypothesis. However, the suggestive evidence for Quaternary activity on the Lakes of Kilarney and Soldier Canyon faults (Table 1) does imply coseismic rupture with the Mercur and West Eagle Hill faults is plausible. Taken together with the displacement patterns we observed, and the rather short extent of the Mercur and West Eagle Hill faults alone (17 km), we believe it is prudent to include the Lakes of Kilarney and Soldier Canyon faults when determining a maximum rupture length for the SOMFZ. This results in a total length of 25 km and an expected maximum moment magnitude (M_w) of 6.7 for rupture of the SOMFZ compared to an M_w of 6.5 for a 17-km-long rupture (using Wells and Coppersmith [1994] empirical relation for all fault types that estimates M_w based on surface rupture length).

3.3 RECOMMENDATIONS FOR TRENCH SITES

Based on our observations during mapping and profiling, we identified three potential sites on the Mercur fault and one potential site on the West Eagle Hill fault for future paleoseismic trench investigations. The sites on the Mercur fault are (in order of priority): (1) the north lobe of the Mercur Canyon fan; (2) the t4 terrace south of West Dip Gulch; and, (3) between the trenches of Everitt and Kaliser (1980) and Barnhard and Dodge (1988). Silverado Canyon was excluded because the width of the fault zone and the very large displacements make trenching this site impractical. The south lobe of the Mercur Canyon fan was also considered, but found to be less than ideal because fault scarps are dissected by numerous drainages that typically turn to the

southwest and parallel the base of the scarp. Potential trench sites where af4 surfaces are offset on the north and south sides of West Dip Gulch have similar channel erosion problems. We prefer the northern Mercur Canyon site over the site near previous trenches because the latter is at the end of the fault where displacement is dying out, making event identification potentially difficult. Additionally, a suspected fault trace that is coincident with the Bonneville shoreline lies just to the east and would also need to be trenched for a truly complete record at this site. Both the Mercur Canyon and West Dip Gulch sites are promising for deciphering the latest Pleistocene record of recent faulting events, and both have good access. Still, we slightly prefer the Mercur Canyon site over the West Dip Gulch site because maximum scarp angles are steeper at Mercur, suggesting that the youngest faulting may be better preserved, and because eolian and slopewash deposits suitable for thermoluminescence dating clearly bury the main scarp at Mercur Canyon. The main disadvantage to the Mercur Canyon site is that there are three fault traces that form a wide zone which complicates interpretation of the paleoseismic record. However, a partial fault exposure of the main scarp in a road cut on the north side of Mercur Canyon Road reveals a thick package of colluvial wedge deposits that include intercalated eolian and reworked eolian deposits, suggesting that this site may provide a long and complete record for paleoseismic activity on the Mercur fault, including the potential for vital absolute age constraints on faulting events.

The selected site for the West Eagle Hill fault is north of McFait Canyon where ideally two trenches should be excavated: one across the scarp offsetting the t3 terrace, and one across the scarp offsetting the af2 fan to the north. The former has the best potential for identifying the most recent event, and the latter would provide a longer record of faulting. Shallow bedrock will be a potential problem for many sites along the West Eagle Hill fault, and although bedrock is exposed at this site below where the main drainage transects the fault scarp, the alluvium appears thick enough to provide a good record of faulting. Access along a four-wheel drive road is challenging, but possible. Unlike the Mercur Canyon site, unfortunately there is no indication from the surficial geology or soil pits as to the likelihood of encountering material suitable for dating at this site.

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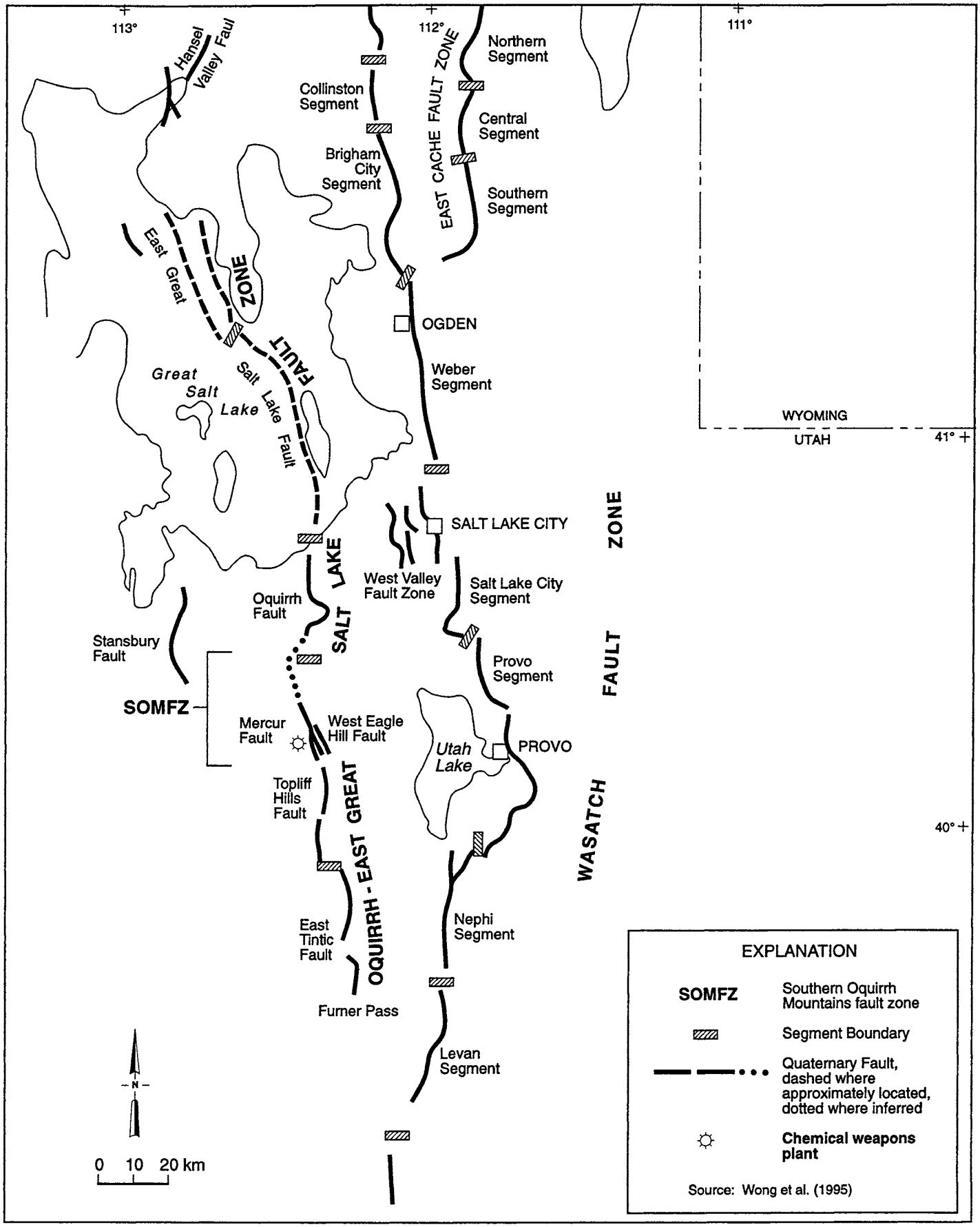
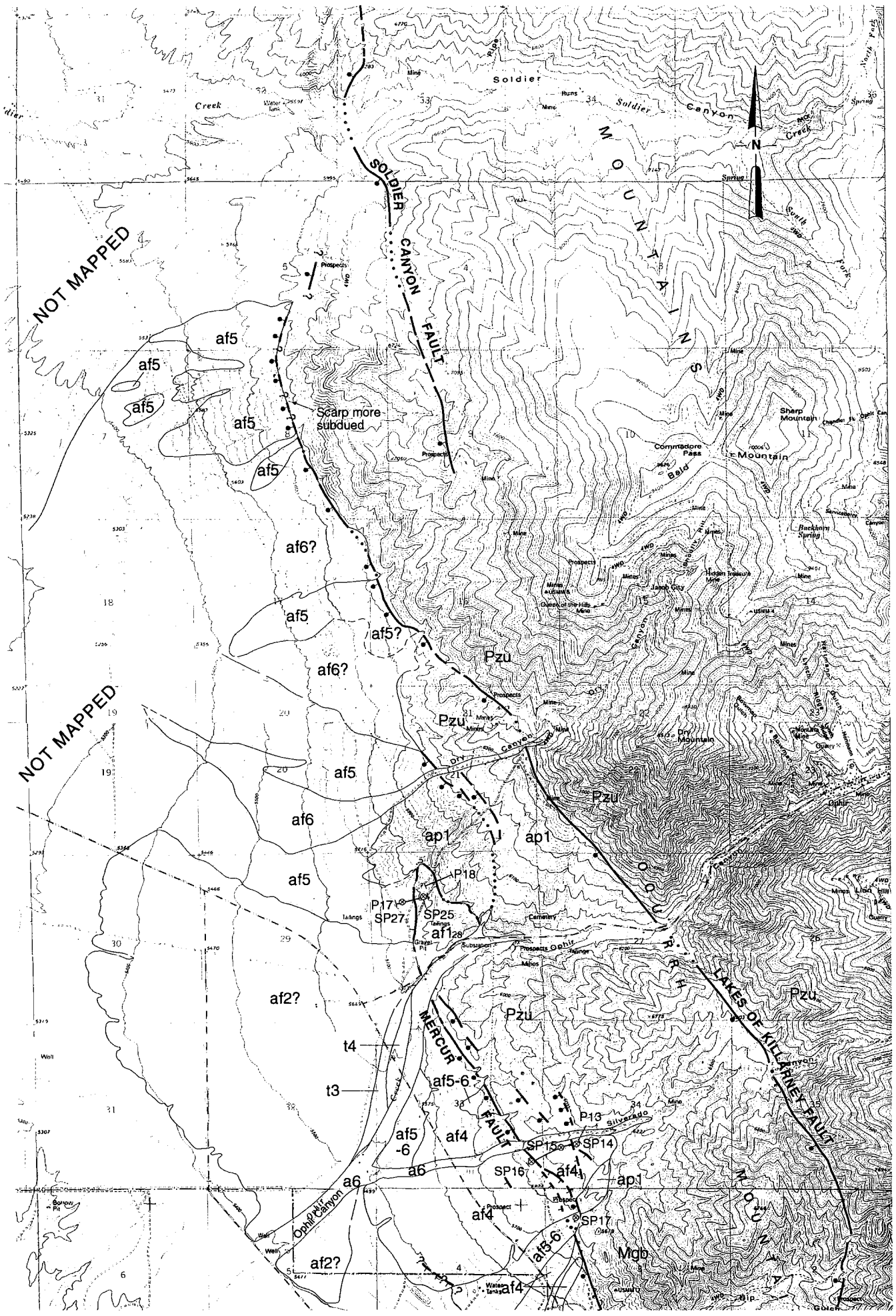


Project No. SK9714	SOMFZ NEHRP	GENERALIZED MAP OF SELECTED FAULTS ALONG THE WASATCH FRONT, UTAH	Figure 1
URSG Woodward Clyde Federal Services			

SK9714-2000/060199/gos



MAP UNITS*

Latest Pleistocene to Holocene

a6	af6
a5-6	af5-6
a5	af5

Youngest stream and fan alluvium – Dominantly gravels proximal to rangefront, fining distally to sands and silts; soils include poorly to moderately developed Bk horizons (stage I- to II carbonate morphology)

al

Lacustrine deposits and reworked alluvium below the Bonneville shoreline

Pleistocene

af4	t4
af3	t3

Intermediate-age terrace and fan alluvium – Dominantly gravels with some sands and silts where deposits extend more distally from rangefront (eg. Silverado Canyon area); Soils include moderately to well-developed K horizons (stage III- to IV+); primarily distinguished from older deposits (eg. af2, af1) based on relative geomorphic position, morphology and cross-cutting relations.

af2	ap2

Older pediment and fan alluvium – Dominantly gravels; includes thin fans mantling shallow bedrock shelf between the West Eagle Hill and Mercur faults; soils generally include thick well-developed K horizons but are variable (stage III- to IV)

Pliocene (?) to Pleistocene

af1	ap1

Oldest pediment and fan alluvium-dominantly gravels; ap1 includes pediment surfaces at many different levels which are *undifferentiated and do not necessarily correlate in age with af1*; soils include well-developed K horizons that are often stripped or show evidence for carbonate dissolution, especially on the upthrown side of faults.

Mgb

Mississippian Great Blue Limestone

Pzu

Undifferentiated Paleozoic rocks

MAP SYMBOLS

P1 — Scarp profile location

Fault scarp in bedrock, ball on downthrown side, dashed where approximately located or inferred, dotted where buried or concealed

Fault scarp in alluvium, tick mark on downthrown side, dashed where approximately located or inferred, dotted where partially buried or concealed

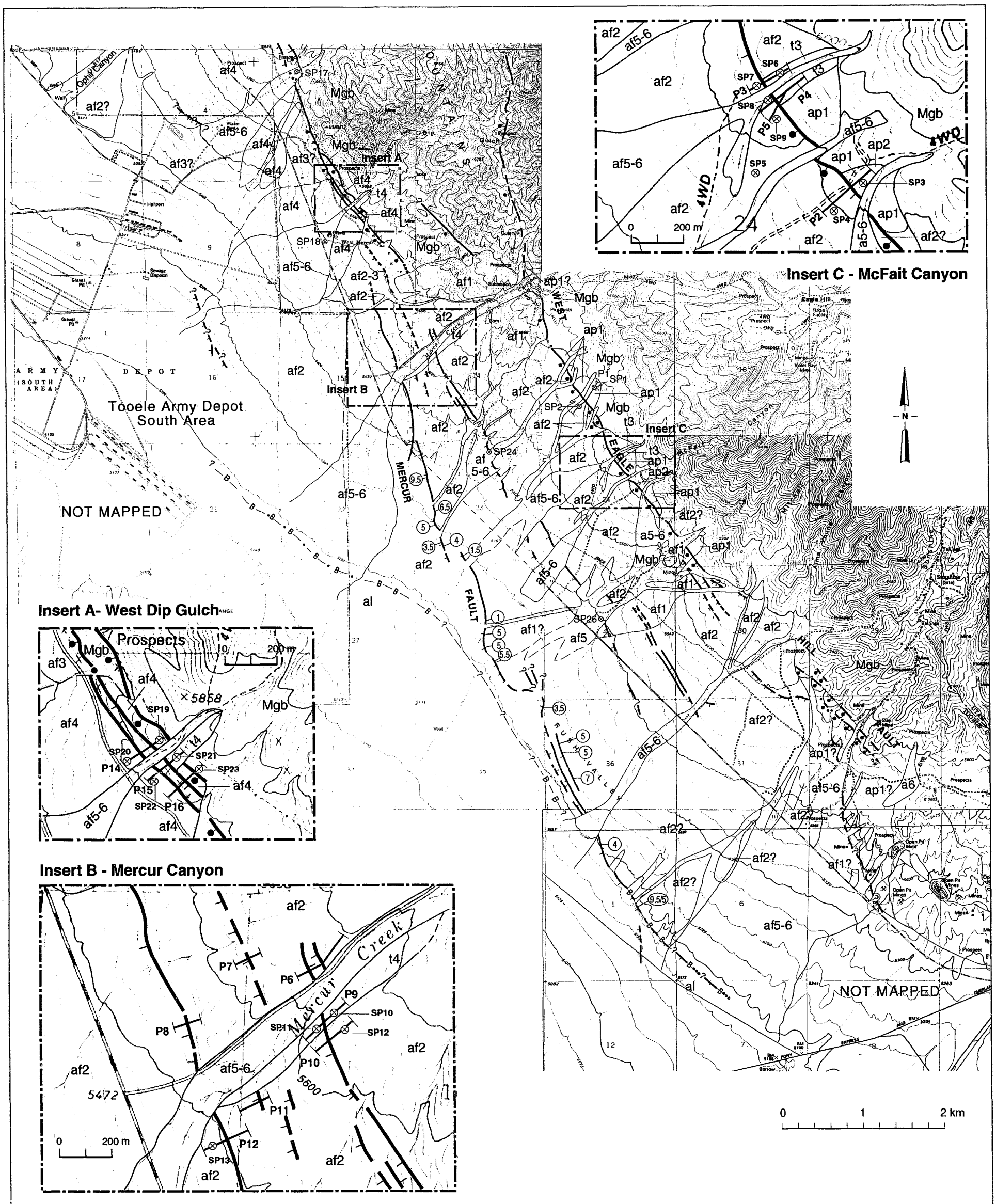
Contact, dashed where inferred or gradational

SP1 ⊗ — Soil pit location

*See text and appendix A for detailed descriptions

Project No. SK9714	SOMFZ NEHRP	SURFICIAL GEOLOGY MAP ALONG THE SOUTHERN OQUIRRH MOUNTAINS FAULT ZONE Northern Half	Figure 2a
URSG Woodward Clyde Federal Services			

SK9714-1000/060499/gos



MAP UNITS*

Latest Pleistocene to Holocene

a6	af6
a5-6	af5-6
a5	af5

Youngest stream and fan alluvium – Dominantly gravels proximal to rangefront, fining distally to sands and silts; soils include poorly to moderately developed Bk horizons (stage I- to II carbonate morphology)

al

Lacustrine deposits and reworked alluvium below the Bonneville shoreline

*See text and appendix A for detailed descriptions.

Pleistocene

af4	t4
af3	t3

Intermediate-age terrace and fan alluvium – Dominantly gravels with some sands and silts where deposits extend more distally from rangefront (eg. Silverado Canyon area); Soils include moderately to well-developed K horizons (stage III- to IV+); primarily distinguished from older deposits (eg. af2, af1) based on relative geomorphic position, morphology and cross-cutting relations.

af2	ap2

Older pediment and fan alluvium – Dominantly gravels; includes thin fans mantling shallow bedrock shelf between the West Eagle Hill and Mercur faults; soils generally include thick well-developed K horizons but are variable (stage III- to IV)

Pliocene (?) to Pleistocene

af1	ap1

Oldest pediment and fan alluvium-dominantly gravels; ap1 includes pediment surfaces at many different levels which are undifferentiated and do not necessarily correlate in age with af1; soils include well-developed K horizons that are often stripped or show evidence for carbonate dissolution, especially on the upthrown side of faults.

Mgb

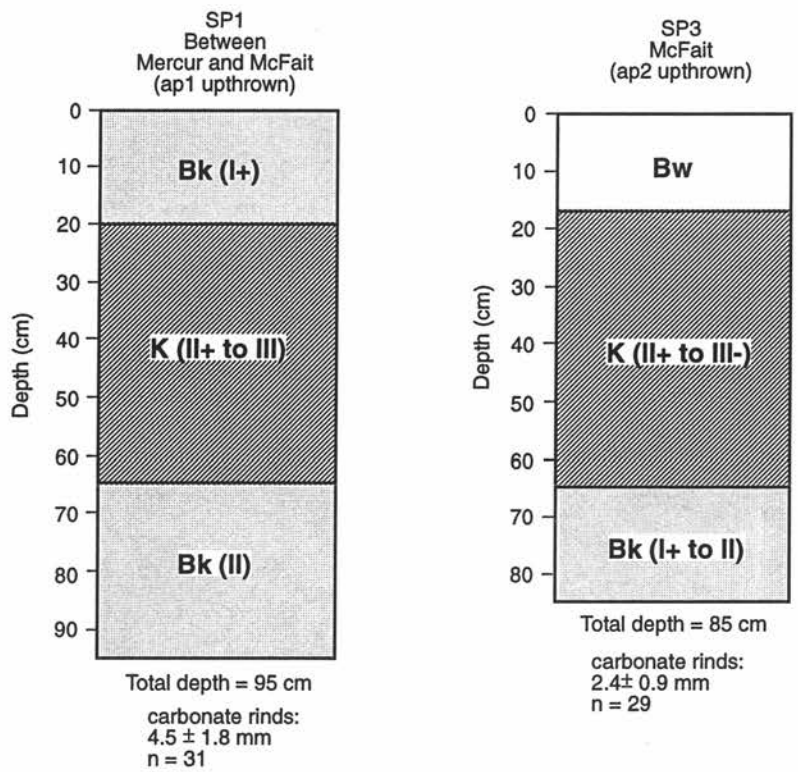
Mississippian Great Blue Limestone

MAP SYMBOLS

P1	Scarp profile location
	Fault scarp in bedrock, ball on downthrown side, dashed where approximately located or inferred, dotted where buried or concealed
	Fault scarp in alluvium, tick mark on downthrown side, dashed where approximately located or inferred, dotted where partially buried or concealed
—B—B—	Bonneville shoreline, queried where inferred, dotted where partially concealed
	Contact, dashed where inferred or gradational
SP1 ⊗	Soil pit location
(5)	Scarp height measurement in meters
B••?B••	Fault scarp and/or Bonneville shoreline, dotted where partially concealed

Project No. SK9714	SOMFZ NEHRP	SURFICIAL GEOLOGY MAP ALONG THE SOUTHERN OQUIRRH MOUNTAINS FAULT ZONE Southern Half	Figure 2b
	URSG Woodward Clyde Federal Services		

SK9714-1000/060499/gos



Project No. SK9714	SOMFZ NEHRP	LOGS OF SOIL PITS ON ap1 and ap2 SURFACES	Figure 3a
URSG Woodward Clyde Federal Services			

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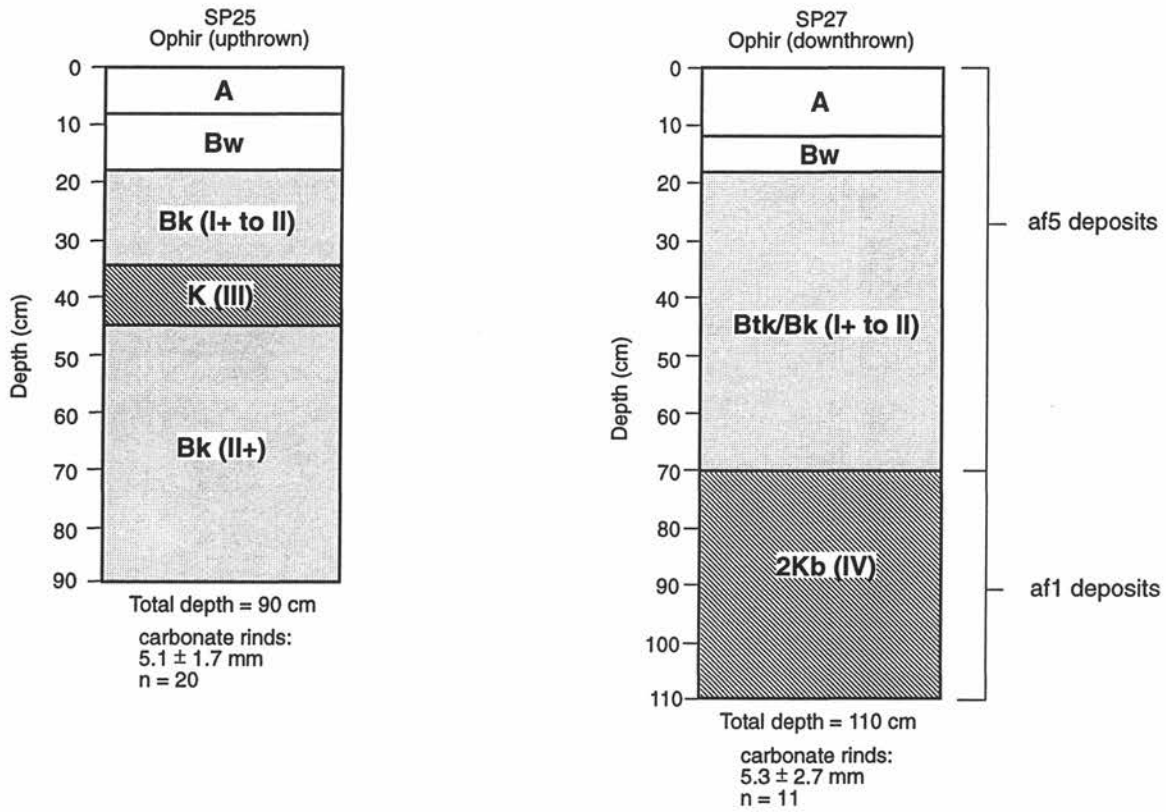

Project No. SK9714	SOMFZ NEHRP	LOGS OF SOIL PITS ON af1 SURFACES	Figure 3b
URSG Woodward Clyde Federal Services			

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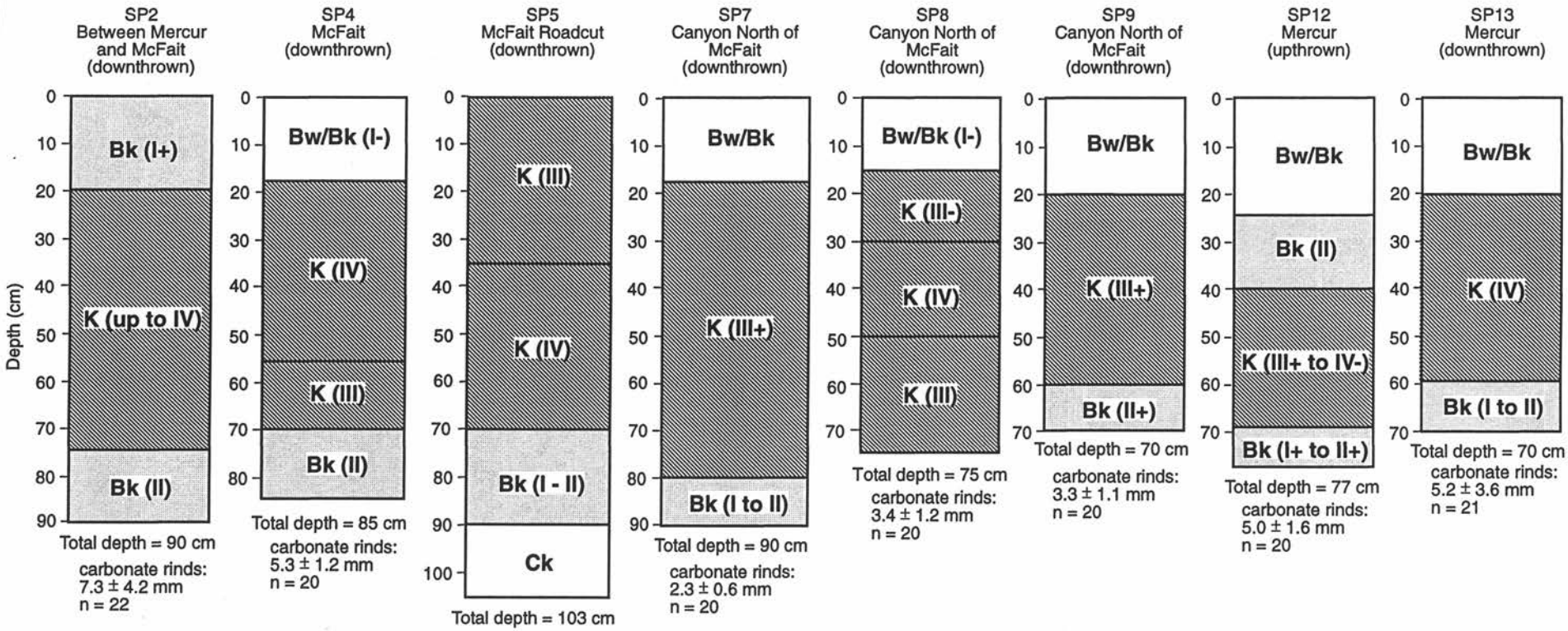
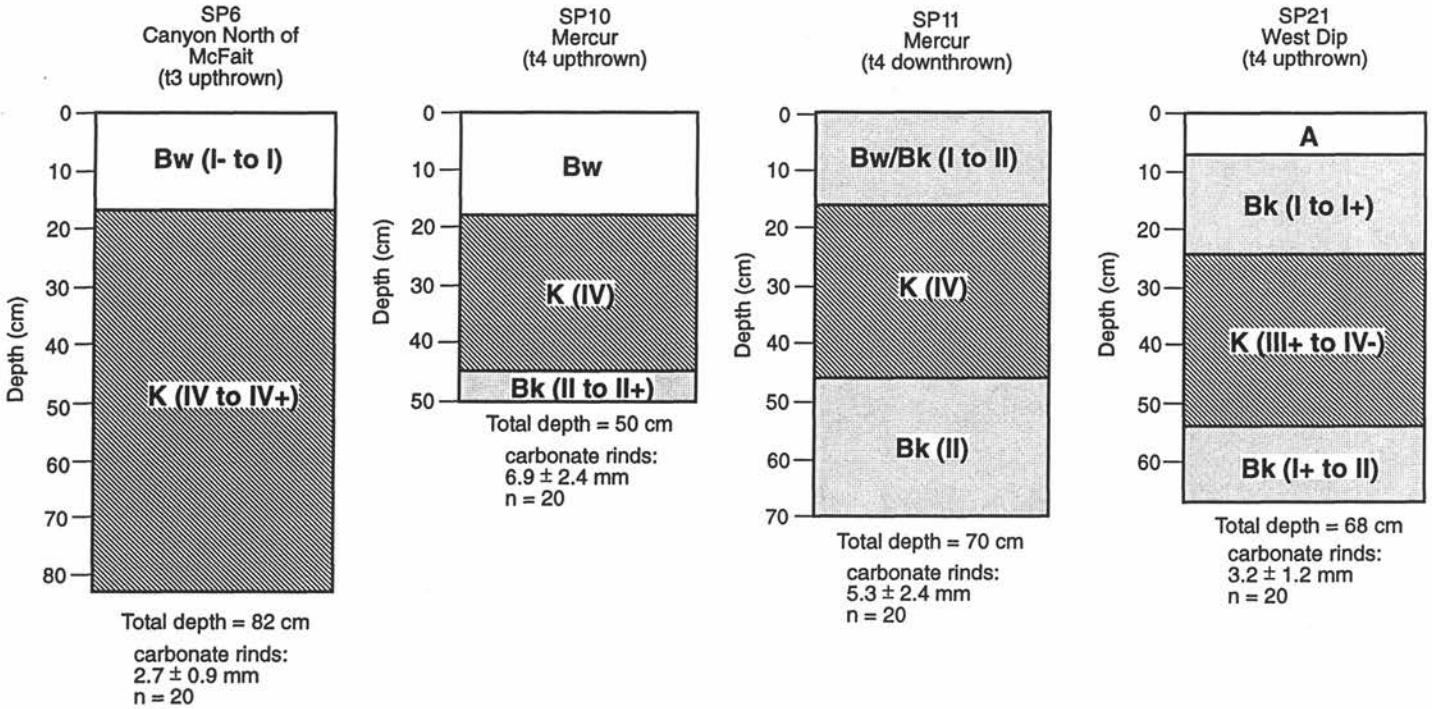


Project No. SK9714	SOMFZ NEHRP	LOGS OF SOIL PITS ON af2 SURFACES	Figure 3c
	URSG Woodward Clyde Federal Services		

SK9714-1000/060199/gos



Project No. SK9714	SOMFZ NEHRP	LOGS OF SOIL PITS ON t3 AND t4 SURFACES	Figure 3d
URSG Woodward Clyde Federal Services			

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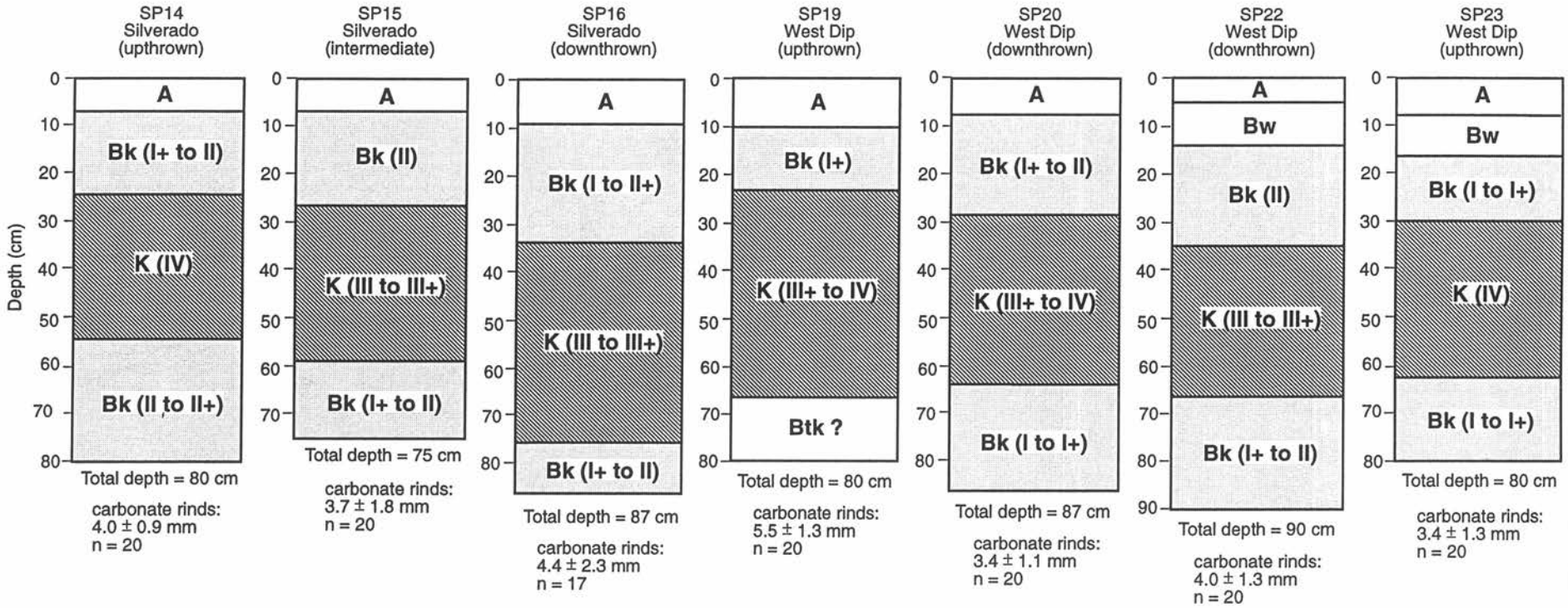

Project No. SK9714	SOMFZ NEHRP	LOGS OF SOIL PITS ON af4 SURFACES	Figure 3e
URSG Woodward Clyde Federal Services			

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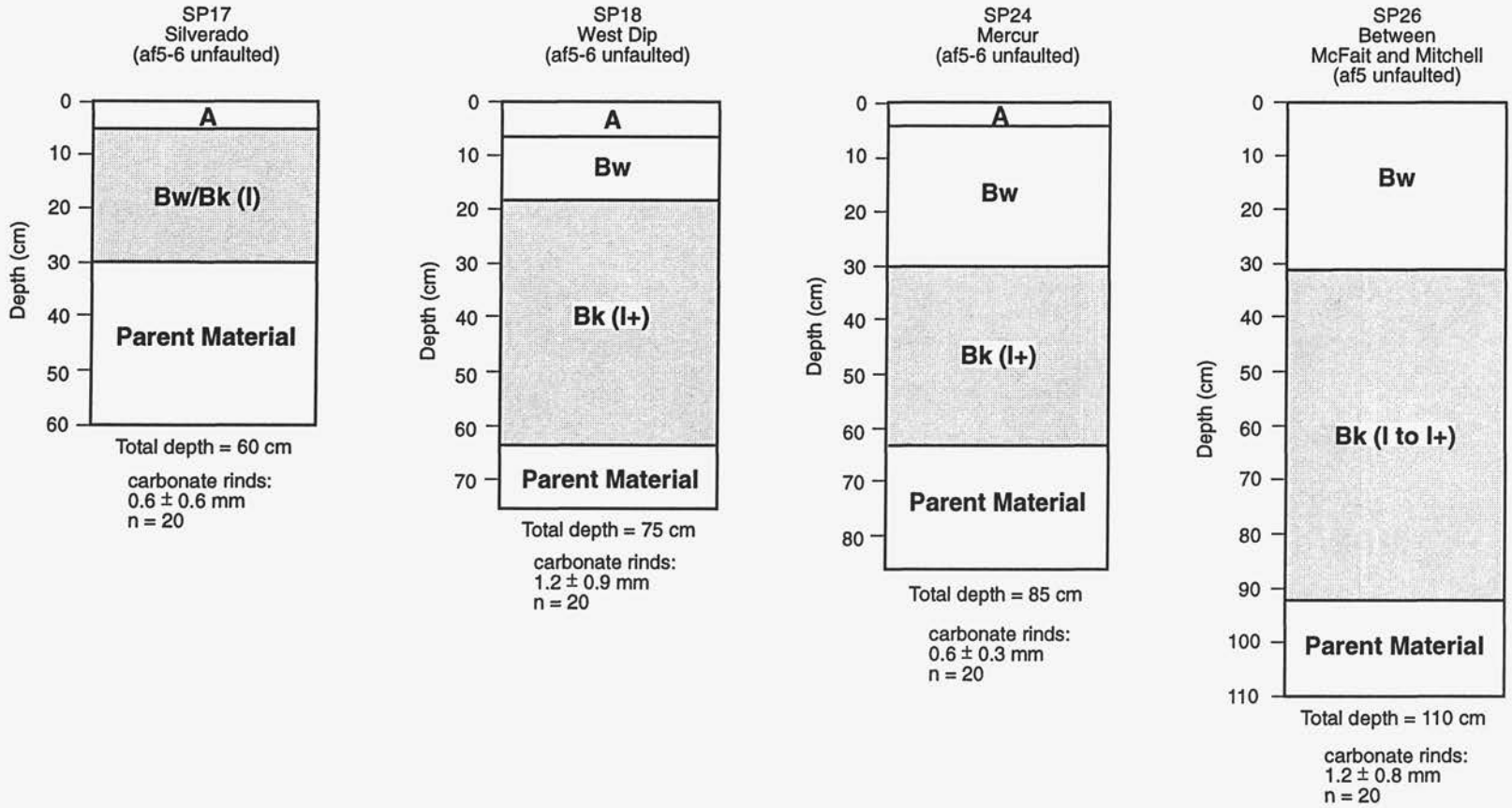

Project No. SK9714	SOMFZ NEHRP	LOGS OF SOIL PITS ON af5-6 SURFACES	Figure 3f
URSG Woodward Clyde Federal Services			

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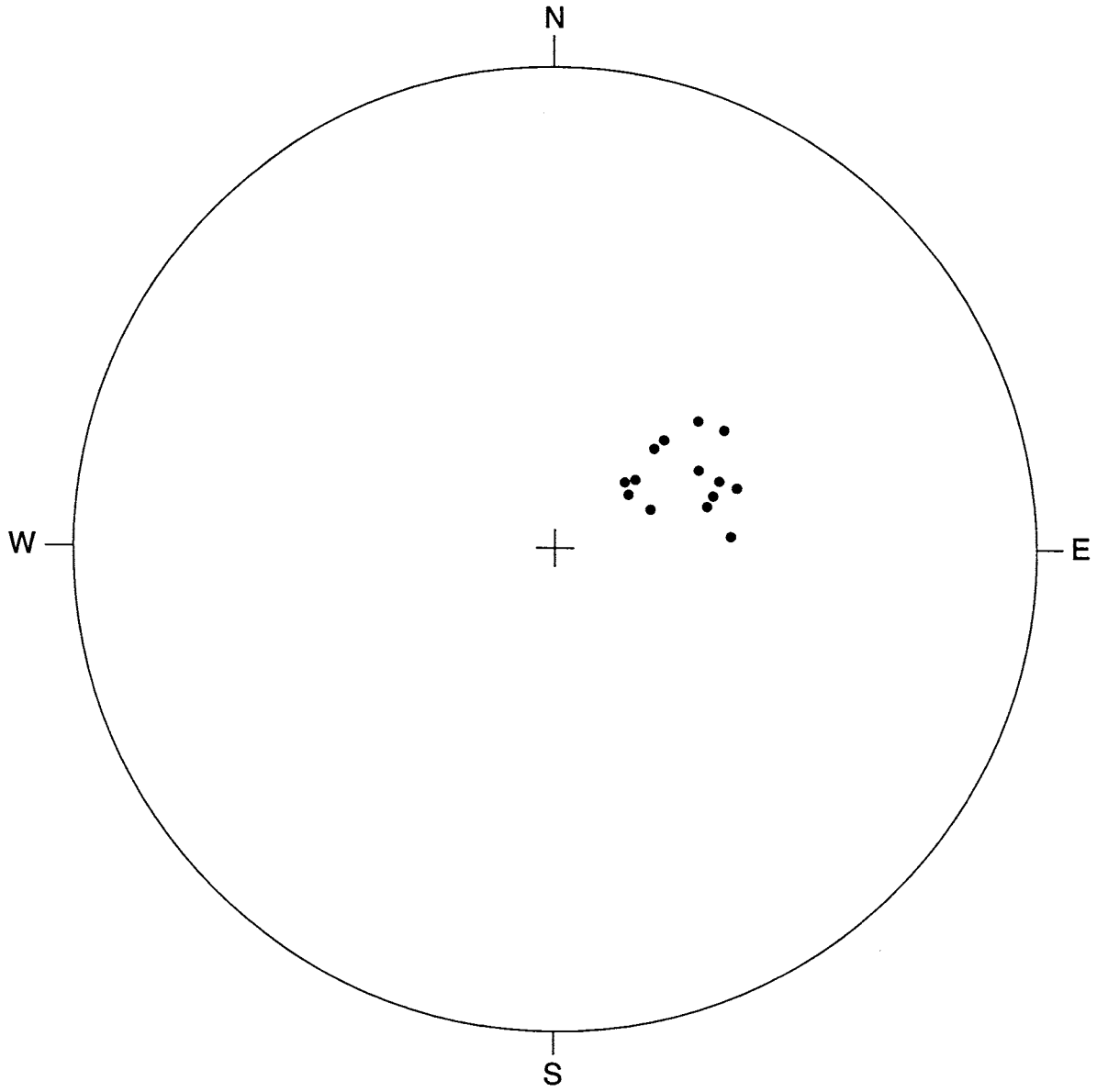
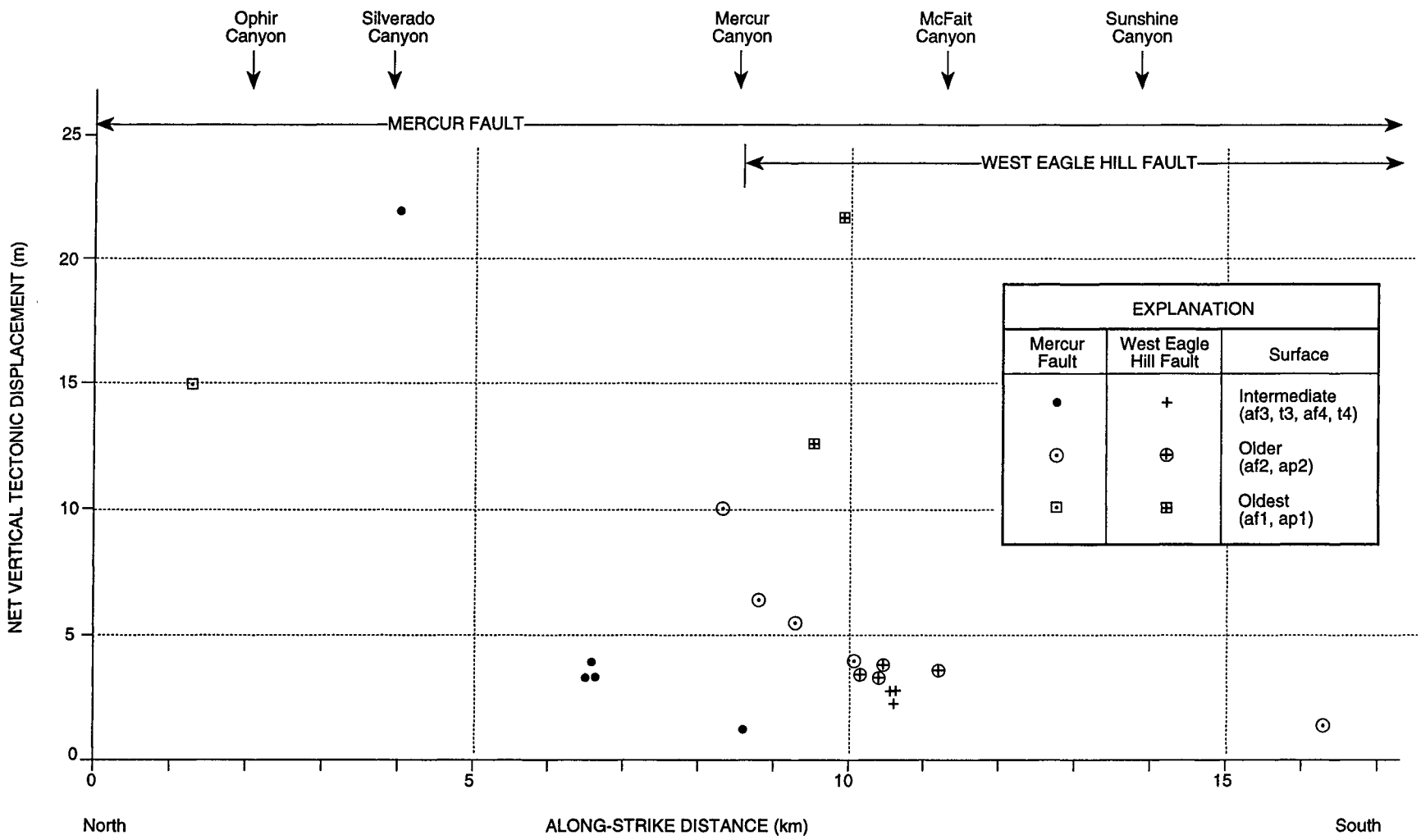


n = 14
Lower hemisphere projection

Project No. SK9714	SOMFZ NEHRP	STEREONET PLOT OF POLES TO BEDDING PLANES IN THE GREAT BLUE LIMESTONE	Figure 4
URSG Woodward Clyde Federal Services			

SK9714-1000/0060199/gos



Project No. SK9714	SOMFZ NEHRP	DISPLACEMENTS ALONG THE MERCUR AND WEST EAGLE HILL FAULT SCARPS	Figure 5
URSG Woodward Clyde Federal Services			

SK9714-1000/0060199/gos

APPENDIX A

Appendix A

Soil Pit Data

(See Figure 2 For Locations)

SOIL PIT DATA SHEET

Project: Mercur Fault - SK9714 **Initials:** SSO

7.5' Topo: Mercur **Date:** 9-10-97

Location: T6S R4W Sec 12 (SP1)

Surficial Map Unit: up 1 " upthrown side of MFHF (2 "Fingers" N. of McFait) 1/2 way bet/ Mercur & McFait

SURFACE

Slope and aspect: 4° To SW

Height above active drainage: ~20' to N 60' to S

Vegetation: Juniper + Sage, grass, prickly pear (+ bitterbrush, ...) 25-130%

Bar & swale topography: distinct subdued (none)

Degree of dissection: (none) moderate extensive

DEPOSITS

Texture: 5-10%-br 25%-cb 35 -gr 20 -sd 10%-si & cl

USCS: sandy cobbly gravel

Genetic: Stream gravel overlain by colluvium clast-supported

(debris flow, fluvial, channel, colluvium, sheetwash, eolian, etc.)

Other: Pediment surface - underlain by thick-bedded gray limestone (Mgb) bedding 30-35° 230°N/

SOIL

Horizons: A- Ø Bw- Ø Bt- Ø Bk- X K- X

Color (dry): 10YR 8/2 very pale brown (K) / 10YR 6/4 light yell. brown

Carbonate morphology (stage): 0-20 cm Bk, stage I+ / 20-65 cm K stage II+-III / 65-95 cm Bk stage II

Carbonate rind thicknesses (mm)/clast composition:

2.5	2-3.5	2.5-5	3-4.5	3-4.5	2-3.5	3.5-5	
1-3	2-3	2-4.5	2.5-5	2-3.5	2.5-4		
1.5	3-4	2-3.5	5-8	3-5	2-4.5		
1-1.5	1-2	2-6	2-4	2.5-3	3.5-3		
2	2-2	3.5	2-4	4-5.5	4-6		

Other: bedrock not encountered in pit, at least another m. down if not more

SP1

SOIL PIT DATA SHEET

Project: Mercur Fault - SK9714 **Initials:** SSO

7.5' Topo: Mercur **Date:** 9-10-97

Location: T6S R4W Sec 13 (SP2)

Surficial Map Unit: af2, downthrown side of WEHF (2 "Fingers" N of McFait Cyn) - ~ 1/2 way bet/ Mercur + McFait

SURFACE

Slope and aspect: 5° to SW (S45°W)

Height above active drainage: 25' (clc w/ abrsq)

Vegetation: Juniper (10%), sparse pinyon pine, sage, rabbitbush, prickly pear, grass

Bar & swale topography: distinct (for overlying young lobes of debris flows) subdued none (for older surface)

Degree of dissection: none moderate extensive

DEPOSITS

Texture: 10-15 -br 20 -cb 40 -gr 1 < -sd 10/5 -si & cl

USCS: sandy cobbly gravel

Genetic: stream alluvium (clasts [illegible] stratified, clasts well-imbricated)

(debris flow, fluvial, channel, colluvium, sheetwash, eolian, etc.)

Other: Surface same elevation as "finger" to S + almost (maybe 10' lower) as high as Mercur Cyn fan to N but higher than "finger" directly to N

SOIL

Horizons: A- Ø Bw- 0-20cm Bt- Ø Bk- 75-90cm (stage II) K- 20-75cm (up to stage [illegible])

Color (dry): K - 10YR 7/3 very pale brown / A - 10YR 6/4 light yellowish brown

Carbonate morphology (stage):

Carbonate rind thicknesses (mm)/clast composition:

6-8	Ls	6-7	Ls	2.5-4.5	1 <	2-4	Ls
7-8	"	5-8	Ls	3-5	qtzite	5-6	Ls
9	qtzite	5-7.5	Ls	5-6	Ls	6-8	Ls
20-25	1 <	3.5-4	Ls	5-7	Ls	5-6	Ls
9	Ls	4-6	1 <	5-7	Ls	6-7	Ls
4-5	qtzite	2.5-4	Ls				

Other: 90 cm deep [illegible] by boulder!

SP2

SOIL PIT DATA SHEET

Project: Mercur Fault - SK9714 **Initials:** AEG + SSO

7.5' Topo: Mercur TGS R4W Sec 24 **Date:** 9-11-97

Location: SP3 - upthrown side @ McFait Cyn

Surficial Map Unit: aP2

SURFACE

Slope and aspect: ~4°, S60°W

Height above active drainage: ~4 AEG (ft)

Vegetation: ~40% (0-5% juniper) - sage, grasses, cacti (prickly pear)

Bar & swale topography: distinct subdued none

Degree of dissection: none moderate extensive

DEPOSITS

Texture: 0-5%-br 20%-cb 50%-gr 20%-sd 5-10%-si & cl

USCS: Sandy Cobbly Gravel

Genetic: stream gravel overlying pediment

(debris flow, fluvial, channel, colluvium, sheetwash, eolian, etc.)

Other: Pit is ~75 cm deep, deposits are clast supported, gray limestone (Mgb) underlying deposit is striking 315°, dipping 35° SW

SOIL

Horizons: A- ∅ Bw- 0-17cm Bt- ∅ Bk-65-85cm (Stage I to II) K- 17-65 (Stage I to III)

Color (dry): K (17-57 cm) 10YR 7/3 (v. pale brown) / Bk at bottom 10YR 7/4 to 6/4 v. pale brown to light yellowish br

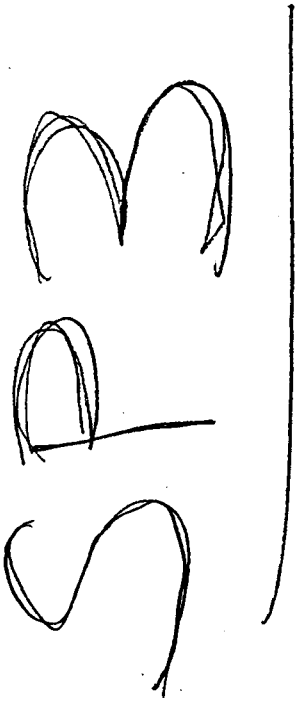
Carbonate morphology (stage):

Carbonate rind thicknesses (mm)/clast composition:

3-4	SS	1-1.5	lms	1-1.5	SS	1-2	lms	2-2.5	[illegible]
1-2	SS	2.5-3.5	lms	1-1.5	Qtzite	1.5-2	lms	3-4	Qt
lms	1.5-2	1.5-2	SS	1-1.5	lms	2-2.5	lms	1-1.5	[illegible]
1-2	lms	3	lms	1-1.5	lms	1-2	lms	1-2.5	[illegible]
2-3	lms	1.5-2	lms	1-2	SS	2.5	SS	1-1.5	[illegible]
3-4	lms	3	SS	1-1.5	lms	2-3	Qtzite		

Other: Didn't expose bedrock but it is exposed in drainage to S is about 1-1.5 m below surface (alluvium thickens toward [illegible] canyon [illegible])

Horizon	Depth	Stage	Dry Color



SOIL PIT DATA SHEET

Project: Mercur Fault - SK9714 **Initials:** SSO

7.5' Topo: Mercur **Date:** 9-11-97

Location: (SP4) T6S R4W sec 24, McFait Cyn

Surficial Map Unit: af2 on downthrown side of WEHF

SURFACE

Slope and aspect: 4 ~S60°W

Height above active drainage: ~3m

Vegetation: Scattered juniper, sage, prickly pear, grass, rabbitbr 10%

Bar & swale topography: distinct subdued (none)

Degree of dissection: none (moderate) locally (extensive) for surface in gen.

DEPOSITS

Texture: 5%-br 20%-cb 40%-gr 20%-sd 15%-si & cl

USCS: Sandy cobbly gravel

Genetic: stream gravels overlying pediment surface

(debris flow, fluvial, channel, colluvium, sheetwash, eolian, etc.) (clast supported well stratif well imbricated)

Other: Minimum thickness of alluvium ~3m (Bedrock exposed ~.2mi to SW on road)

SOIL see back

Horizons: A- ϕ Bw- Bt- ϕ Bk- K-

Color (dry):

Carbonate morphology (stage):

Carbonate rind thicknesses (mm)/clast composition:

2-4.5	Qzt	5-5.5	Qzt	4.5	LS	4.5-5	LS
2-4	Qzt	5.5-8	LS	3.5-4	LS	4-5	SS
4-6	Qzt	3-4	LS	2-5	LS	5-5.5	LS
6.5	LS	3.5-5	LS	2-4	LS	3-5.5	LS
4.5-5	Qzt	25-4.5	LS	4-4.5	Qzt	4-4.5	LS

Other: Better developed K horizon than in SP3 (stage IV laminar)

Soil Horizons

Horizon	Depth	Stage	Dry Color
BW/Bk	0-18	I-	
K-laminar	18-56	IV	10YR 8/1 - 8/2, white - v. pale brown
K	56-70	III	10 YR 8/3 - 7/3 v. pale brow[redacted]
BK	70-85	II	10 YR 6/4 Light yellowish brown

SOIL PIT DATA SHEET

Project: Mercur Fault - SK9714 **Initials:** SSO

7.5' Topo: Mercur T6S R4W Sec 24 **Date:** 9-11-97

Location: (SP5) Roadcut north of McFait

Surficial Map Unit: af2

SURFACE 6° overall to SW

Slope and aspect: 10° to S10°W local dissected inset

Height above active drainage: 60'

Vegetation: Juniper, Pinyon, sage

Bar & swale topography: distinct subdued (none)

Degree of dissection: none moderate (extensive)

DEPOSITS

Texture: 5-br 20-cb 35-40-gr 20-sd 15-20-si & cl

USCS: silty sandy cobbly gravel

Genetic: stream gravel

(debris flow, (fluvial), channel, colluvium, sheetwash, eolian, etc.)

Other: stratification dips ~5°-7° to SW

SOIL see back

Horizons: A- Bw- Bt- Bk- K-

Color (dry):

Carbonate morphology (stage):

Carbonate rind thicknesses (mm)/clast composition:

Other: Profile stripped - K thickness is minimum (cut not visible on 1987 photos - more recent)

Photos #20, 21 on Roll #2

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Soils

Horizon (top stripped)	Depth	Stage	Dry Color
K	0-35 cm	III	10YR 8/2 v. pale brown
K laminar	35-70 cm	IV	10YR 8/1 white
Bk	70-90	II-I	10YR 7/4 v. pale brown
Ck	90-103 m	—	10YR 6/ light yellow[redacted] brown

SOIL PIT DATA SHEET

Project: Mercur Fault - SK9714 **Initials:** AEG

7.5' Topo: Mercur T6S R4W sec 24 **Date:** 9-12-97

Location: SP6, First Canyon N. of McFault (upthrown side of P3)

Surficial Map Unit: t3 (younger than af2 & older than af5)

SURFACE

Slope and aspect: 4°, 255°

Height above active drainage: ~ 2 m

Vegetation: 40% coverage (0-5% juniper), sage, grasses, cactus

Bar & swale topography:	distinct	very subdued	none
Degree of dissection:	none	moderate	extensive

DEPOSITS

Texture: 0-5% -br 10% -cb 60% -gr 20% -sd 5-10% -si & cl

USCS: Sandy gravel

Genetic: Fluvial deposit overlying shallow limestone (Mgb) bedrock (Pediment)

(debris flow, fluvial, channel, colluvium, sheetwash, eolian, etc.)

Other: SP6 is ~82cm deep, bottoms in K horizon, very difficult digging. Pit did not expose bedrock, but bedrock is exposed ~2' below soil pit in road.

SOIL see back

Horizons:	A-	Bw-	Bt-	Bk-	K-
Color (dry):					
Carbonate morphology (stage):					

Carbonate rind thicknesses (mm)/clast composition:

3-4	Qtzite	1-1.5	Qtzite	1-1.5	Qtzite	2.5-3.5	lms
1.5-2.5	lms	1-1.5	lms	1.7-2.0	lms	1.5-2.5	Qtzite
2-3	lms	0.5-1.5	Qtzite	2-3	Qtzite	4-4.5	SS
2.7-3.1	Qtzite	1-2	lms	2-3.5	lms	0.5-1.0	lms
1-2.5	SS	2	Qtzite	2.5-3.0	lms	1.5-3.0	Qtzite

Other: Generally thin $CaCO_3$ rinds found, modern drainage immediately to the South appears to be aggrading.

Soils

Horizon	Depth	Stage	DRY COLOR
Bw	0-17cm	I- to I	10YR 6/3 pale brown
K	17 - 82cm	IV to IV+	10YR 8/2 to 7/2 very pale brown to light gray

SP6

SOIL PIT DATA SHEET

Project: Mercur Fault - SK9714 **Initials:** AEG, LMC, SSO

7.5' Topo: Mercur T6S R4W Sec 24 **Date:** 9-12-97

Location: SP7, 1st canyon North of McFait Cny

Surficial Map Unit: af2 (~~?~~ T3) on downthrown side of WEHF

SURFACE

Slope and aspect: 4°, S 55° W

Height above active drainage: ~1.62 m above drainage to S, ~1m below aggrading surface to ~2 m above drainage to

Vegetation: sage, rabbit-brush, prickly pear, grass

Bar & swale topography: distinct subdued none

Degree of dissection: none moderate extensive

some to the North

DEPOSITS

Texture: 10-15%-br 20%-cb 35%-gr 20-25%-sd 10-15%-si & cl

USCS: cobbly sandy gravel

Genetic: stream alluvium overlaying terrace (imbricated & stratified, clasts are slightly imbricated clast supported)

(debris flow, fluvial, channel, colluvium, sheetwash, eolian, etc.)

Other: Depth of Pit is ~90cm

N of active aggrading channel & S of active incising channel

SOIL SEE BACK

Horizons:	A-	Bw-	Bt-	Bk-	K-
Color (dry):					
Carbonate morphology (stage):					

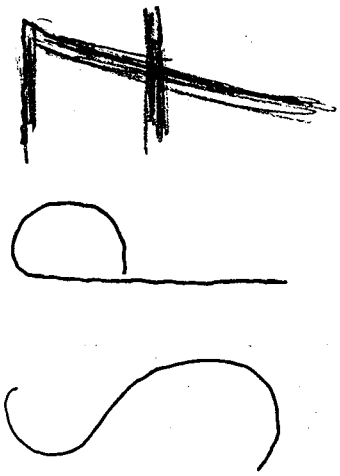
Carbonate rind thicknesses (mm)/clast composition:

1-1.5	lms	1-2.5	Qtzite	1-3	Qtzite	2.5-3.5	lms
1-2	lms	1-2	Qtzite	2	lms	1-1.5	Qtzite
2-3.5	Qtzite	2-2.5	lms	2	lms	1-1.5	Qtzite
1.5-2.5	Qtzite	1-2.5	Qtzite	2.5-3	lms	2-2.5	Qtzite
1-2	lms	1-2	lms	1-1.5	Qtzite	2	Qtzite

Other: Pit is N of road going up scarp

SOILS

Horizon	Depth	Stage	Color
Bw/Bk	0-18 cm		
K	18-80 cm	III+	10YR 8/2 v. pale brown
Bk	80+ cm	I to II	10YR 7/3 to 6/3 very pale brown to pale brown



SOIL PIT DATA SHEET

Project: Mercur Fault - SK9714 **Initials:** AEG & SSO & LMC

7.5' Topo: Mercur T6S R4W Sec24 **Date:** 9-12-97

Location: (SP8) on P4 (downthrown side) 1st Gyp N. of McFarlit

Surficial Map Unit: ~~Ts or~~ af2(?)(downthrown side WEH=)

(1.6m) over surface than SP9 on af2)

SURFACE

Slope and aspect: 6° S40°W of pit

Height above active drainage: 2m (to NNbut S. of road & S. of SP7) +/- to top of aggr. surf. to N

Vegetation: Sparse juniper (<5%) sage grass

Bar & swale topography: distinct subdued (none)

Degree of dissection: (none) locally moderate (extensive) overall

DEPOSITS

Texture: 5-10 -br 15 -cb 25-30 gr 25 -sd 20 -si & cl

USCS: silty sandy gravel

Genetic: Stream gravels (yea gravels stratified, dom. clast supported)

(debris flow, (fluvial), channel, colluvium, sheetwash, eolian, etc.)

Other: Finer grained (more fine fewer cobbles & coarse gravels) than SP6 SP7, & SP8 but still fluvial

SOIL see back

Horizons: A- Bw- Bt- Bk- K-

Color (dry):

Carbonate morphology (stage):

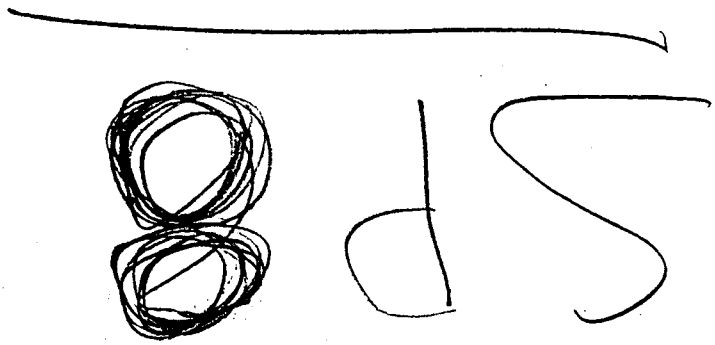
Carbonate rind thicknesses (mm)/clast composition:

1	Qtzite	4	Ls	1.5	Qtzite	2-2.5	Qtzite
2-4	Qtzite	4-5	qtzite	2	Qtzite	1-2	Ls
1-2.5	Qtzite	2.5	Ls	2-3	Qtzite	2-3	Ls
3-4	Qtzite	2.5-4	Qtzite	2-4	Ls	3-5.5	Qtzite
3-5	Qtzite	2	lms	1.5-2	Ls	2-4	Ls

Other: Pit refusal total - either LARGE boulder or possible shallow bedrock(?)

Soils

Horizon	Depth (cm)	Stage	Dry Color
0-15	Bw/Bk	Stage I-	—
15-30	K some burrows	Stage III-	10YR 6/4 light yellow brown
30-50	K	Stage IV (laminar bridging clasts)	7/R 8/2 v. pale brow.
50-75	K	Stage III	10 YR 7/3 v. Pale Brow



SOIL PIT DATA SHEET

Project: Mercur Fault - SK9714 **Initials:** SSO & AEG

7.5' Topo: Mercur T6S R4W sec 24 **Date:** 9.12.97

Location: SP9 on P5 (downthrown side) 1st cny North of McFait

Surficial Map Unit: ~~ts~~ afz(?) (downthrown side of WEHF)

SURFACE

Slope and aspect:

Height above active drainage:

Vegetation: juniper (5%), sage, rabbit brush, grass, prickly pear

Bar & swale topography: distinct subdued none

Degree of dissection: none moderate extensive

DEPOSITS

Texture: 5 -br 15 -cb 40 -gr 25 -sd 15 -si & cl

USCS: sandy gravel with cobbles

Genetic: stream alluvium (well stratified & imbricated, clast supported
(debris flow, fluvial, channel, colluvium, sheetwash, eolian, etc.) less cobbles than S7 & S6)

Other: ~70 cm pit is deep

SOIL SEE BACK

Horizons: A- Bw- Bt- Bk- K-

Color (dry):

Carbonate morphology (stage):

Carbonate rind thicknesses (mm)/clast composition:

2-3	LS	2-4	LS	1-2	LS	1-2	LS
3-5	Qzt	1.5-3	Qzt	1-3	Qzt	3.5	Qzt
2-4	Qzt	2	LS	2-5	Qzt	2-2.5	Qzt
2-5	LS	2-3	Qzt	2-3	LS	1.5-2.5	Qzt
2-4	Qzt	1-2	LS	1-2	Qzt	3-3.5	Qzt

Other:

SP 9

SOILS

Horizon	Depth (cm)	Stage	dry color
BW/BK	0 – 20		
K	20 - 60	III+	10 YR 8/3 - 8/2 v. pale brown
BK	60 - 70	II+	10YR 7/4 v. pale brown

SOIL PIT DATA SHEET

Project: Mercur Fault - SK9714 **Initials:** AEG + LHC

7.5' Topo: Ophir Quad **Date:** 9-15-97

Location: SP10 on P9 upthrown side, small inset terrace, south side Mercur Cyn drainage

Surficial Map Unit: t4

SURFACE

Slope and aspect: 2-3°, ~232°

Height above active drainage: ~ 6½ m

Vegetation: 40% (0-5% juniper), sage, grasses, cacti

Bar & swale topography: distinct subdued (none)

Degree of dissection: (none) moderate extensive

DEPOSITS

Texture: 0-5%-br 40%-cb 30%-gr 15%-sd 0-10%-si & cl

USCS: Sandy gravelly cobbles

Genetic: fluvial terrace gravels

(debris flow, fluvial, channel, colluvium, sheetwash, eolian, etc.)

Other:

SOIL See Back

Horizons: A- Bw- Bt- Bk- K-

Color (dry):

Carbonate morphology (stage):

Carbonate rind thicknesses (mm)/clast composition:

3-5	lms	2-8.5*	ss	5.5-8	lms	3-7*	lms
3-6	lms	2-5	lms	3-6	ss	2-8	lms
2-4.5	lms	3.5-5	lms	4-6	lms	14*	NP
2.5-4.5	lms	4.5-11*	lms	3-6	ss/(qtzite)	5-7.5	lms
4.5-6	NP	3.5-10*	ss	3-6	lms	3-4	lms

— only thickest part measured

Other: K horizon w/ lamination observed ∴ stage IV, digging fairly difficult thru K horizon

Soils

Horizon	Depth	Stage	Dry Color
Bw	0-18		
K	18-45	IV	7.5 YR 8/2 to 10YR 8/2 pinkish white to very pale brown
Bk	45-50	II to II+	10 YR 6/4 light yellowish brown

SP10

SOIL PIT DATA SHEET

Project: Mercur Fault - SK9714 **Initials:** LMC-AEG

7.5' Topo: Ophir **Date:** 9.15.97

Location: SP 11 on F9 downthrown side, small inset terrace south side Mercur Cyn drainage

Surficial Map Unit: t4

SURFACE

Slope and aspect: 2-3° ~230°

Height above active drainage: ~2 of AEG's eyeheights

Vegetation: 40%, junipers (0-2%), sage, grasses, cactii

Bar & swale topography: distinct subdued (none)

Degree of dissection: (none) moderate extensive

DEPOSITS

Texture: 5-10 -br 5-10 -cb ~~35-50~~ 10-15 -gr ~~20-25~~ 20-25 -sd 15-20 -si & cl

USCS: Silty sands gravel

Genetic: Fluvial terrace gravels

(debris flow, fluvial, channel, colluvium, sheetwash, eolian, etc.)

Other: Pit is ~70 cm deep

SOIL

Horizons: A- Bw- Bt- Bk- K-

Color (dry):

Carbonate morphology (stage):

Carbonate rind thicknesses (mm)/clast composition:

4-7	lms	3-5.5	lms	5-11	Qtzite	3-5	lms
1.5-5	Qtzite	3.5-5.5	lms	2-3	lms	1-3	Qtzite
2-5	lms	3.5-5.5	lms	2-3	Qtzite	3	lms
2.5-4.5	lms	3.5-5.5	Qtzite	2-3	lms	4-5.5	SS
3.5-6.5	lms	~2	lms	2.5-5	lms	6-11*	SJP

Other: Digging not as difficult as in SP10 [possible due to presence of tree roots (one 48 cm x 13 cm other 40 cm x 15 cm) ?]
[illegible] indicated at depth of [illegible]

SOILS

Horizon	Depth	Stage	Dry Color
Ea/Ek	0-17cm	I-2	—
K - laminations up to 2mm thick	17-47cm	IV	10YR 8/2 very pale brown
Ek	47-70cm	II	10YR 7/3 very pale brown

11dS

SOIL PIT DATA SHEET

Project: Mercur Fault - SK9714 **Initials:** AEG, LA

7.5' Topo: Ophir Quad **Date:** 9-16-97

Location: SP12 along profile P10 upthrown side south lobe Mercur Cyn fan

Surficial Map Unit: aF2

SURFACE

Slope and aspect: 2.5°, 224°

Height above active drainage: 16.2m above Mercur Cyn drainage, 2.4m above drainage imm. to S

Vegetation: 30% (0-5 juniper), sage grasses cacti

Bar & swale topography: distinct subdued (none)

Degree of dissection: none (moderate) extensive

DEPOSITS

Texture: 0-5%-br 10 -cb 40 -gr 30-35-sd 15-20-si & cl

USCS: sand & gravel with cobbles

Genetic: Fluvial gravel - alluvial fan

(debris flow, fluvial, channel, colluvium, sheetwash, eolian, etc.)

Other: Pit is 77 cm deep

SOIL See Back

Horizons: A- Bw- Bt- Bk- K-

Color (dry):

Carbonate morphology (stage):

Carbonate rind thicknesses (mm)/clast composition:

3.5 - 10	LS	2-4	LS	2-3	LS	3-5	LS
2.5 - 5	QZt	2.5-5	LS	2-3	LS	3-7	LS
3	QZt	2-3.5	LS	3-5	NP	3-5	LS
2.5-5	LS	2-7	LS	2-2.5	LS	5	LS
2-5	LS	2-3.5	LS	3-5	LS	3-5	LS

Other: No [illegible] K [illegible] elsewhere

Upper BK [illegible] Rinds are thinner than expected

Soils

Horizon	Depth	Stage	Dry Color
Bw/BK	0 - 24		
BK	24 - 40	II	10YR 6/4 - 5/4 light yellowish brown - [illegible]
K	40 - 69	III+ - IV- *	10YR 8/2 v. pale brown
BK	69 - 77	I+ - II+	10YR 7/4 - 6/4 v. pale brown - light yellowish brown

*faint discontinuous laminations SSD 12-29-97

SOIL PIT DATA SHEET

Project: Mercur Fault - SK9714 **Initials:** LMC AEG

7.5' Topo: Ophir **Date:** 9.16.97

Location: SP13 along profile P12 downthrown side, S. Mercur Fault Fan

Surficial Map Unit: aF2

SURFACE

Slope and aspect: 2° ~190°

Height above active drainage: 2.75 AEG heights

Vegetation: 40%, juniper (0%) sage, grasses, cacti

Bar & swale topography: distinct subdued none

Degree of dissection: none moderate small drainage at base of scarp extensive

DEPOSITS

Texture: 0-5 -br 10 -cb 35-40-gr 30-35-sd 15-20-si & cl

USCS: sandy gravel with cobbles

Genetic: fluvial gravel - alluvial fan

(debris flow, fluvial, channel, colluvium, sheetwash, eolian, etc.)

Other: Pit is ~70 cm deep

SOIL SEE BACK

Horizons: A- Bw- Bt- Bk- K-

Color (dry):

Carbonate morphology (stage):

Carbonate rind thicknesses (mm)/clast composition:

2-3.5	LS	3.5-4	Qzt	3-4	Qzt	3.5-14*	LS
1.5-2	Qzt	2-5	LS	2-5	LS	2-3	LS
2.5-6	LS	1.5-4	LS	2-3.5	LS	4-5.5	LS
2-2.5	LS	3-6.5*	LS	1-2	Qzt	4-5	LS
1.5	LS	1-2	LS	1-4.5	Qzt	2.5-6	LS

Other: 1mm or less thick lamination at top of K horizon, Bw/Bk is not as well developed as in SP12, K horizon is not as well developed as other stage III K horizons, found rind (no parent) on upthrown side of scarp with thickness of 11-17 mm

SOILS

HORIZON	DEPTH (cm)	STAGE	DRY COLOR
Bw/BK	0-20		
K	20-59	IV	10YR 8/2 - 8/3 v pale brown
BK	59-70	I-II	10YR 7/2 - 7/3 light grey - v. pale brown

SOIL PIT DATA SHEET

Project: Mercur Fault - SK9714 **Initials:** AEG & LMC

7.5' Topo: Ophir **Date:** 9.17.97

Location: SP14 on P13 on upthrown side of Eastern scarp – Silverado cyn

Surficial Map Unit: af4

SURFACE

Slope and aspect: 3-4°, 250°

Height above active drainage: ~80ft above drainage to N (from topo) (~ 5980' amsl)

Vegetation: 25-35% juniper & pinyon pine (95%) sage, grass, cactii

Bar & swale topography:	distinct	subdued	none
Degree of dissection:	none	moderate	extensive

DEPOSITS

Texture: 0-5 -br 5-10 -cb 45 -gr 35 -sd 10-15 -si & cl

USCS: sandy gravel

Genetic: fluvial terrace

(debris flow, fluvial, channel, colluvium, sheetwash, eolian, etc.)

Other: pit is 80cm deep, pit very similar to SP15

SOIL SEE BACK

Horizons:	A-	Bw-	Bt-	Bk-	K-
Color (dry):					
Carbonate morphology (stage):					

Carbonate rind thicknesses (mm)/clast composition:

2-5	Qzt	2-3	LS	2-4	LS	2-4	LS
2-4	LS	1-3	LS	2-4	LS	2-4	LS
2-4	Qzt	2-3	LS	1-4	calcite cobble	2-4	LS
1-2.5	LS	2-6	Qzt	2-4	LS	2-6	Qzt
2-4	LS	1-4	SS	2-3	Qzt	2-4	LS

Other: lower K boundary clear to gradational, 1-1.5mm thick laminar stew, K horizon & bottom BK clast supported, upper BK is matrix supported.

SOILS

Horizon	Depth (cm)	Stage	Dry Color
A	0-7		
BK	7-24	I+-II	
K	24-54	IV	10 YR 8/2-7/2 v. pale brown - light gray
BK	54-80	II-II+	10YR 7/3-6/3 v pale brown - pale brown

HdS

SOIL PIT DATA SHEET

Project: Mercur Fault - SK9714 **Initials:** AFG & LMC

7.5' Topo: Ophir **Date:** 9.17.97

Location: SP15 on P13; downthrown side of eastern scarp upthrown side of western scarp Silverado Cyn

Surficial Map Unit: af4

SURFACE

Slope and aspect: 2.5°, S70°W (~5935' amsl)

Height above active drainage: ~9m above drainage to S, ~60' above Silverado Cyn to North (from

Vegetation: 20-35% juniper & pinyon pine (95%) sage, grasses & cacti

Bar & swale topography: distinct subdued none

Degree of dissection: none moderate extensive

drainages to N&S

DEPOSITS

Texture: 5 -br 10-15 -cb 40 -gr 35-40 -sd 10 -si & cl

USCS: Sandy gravel with cobbles

Genetic:

(debris flow, fluvial, channel, colluvium, sheetwash, eolian, etc.)

Other: pit is 75 cm deep, pit very similar to SP14

SOIL SEE BACK

Horizons: A- Bw- Bt- Bk- K-

Color (dry):

Carbonate morphology (stage):

Carbonate rind thicknesses (mm)/clast composition:

1-2	lms	1-2	Qtzite	2-4	lms	3	lms
4-5	lms	2.5	lms	1.5-2	lms	2-3	lms
3-6	lms	2-3	lms	2	lms	3-5	Qtzite
4.5-6	lms	2	lms	2	lms	4-7	Qtzite
3-5	lms	2	lms	5-7	lms	2-2.5	Qtzite

Other: Abundant roots, largest is ~1 inch in diameter. Much of pit is clast supported but very close to being matrix supported & is in some places, pit very similar to SP14

SOIL

HORIZON	DEPTH	STAGE	DRY COLOR
A	0 - 7		
Bk	7 - 27	II	10YR 6/3 - 5/4 (*better of two) pale brown - yellowish brown
K	27 - 59	III - III+ No laminations observed	10YR 8/2 v. pale brown
Bk	59 - 75	I ± II	10YR 7/4 - 6/3 v. pale brown - pale brown

Gids

SOIL PIT DATA SHEET

Project: Mercur Fault - SK9714 **Initials:** AFG & LMC

7.5' Topo: Ophir **Date:** 9.17.97

Location: SP16 on P13, downthrown side of western scarp Silver Cyn

Surficial Map Unit: aff

SURFACE

Slope and aspect: 5° ~240°

Height above active drainage: 20-25' above Silverado Cyn (from topo) (~5840' ansl)

Vegetation: 30-35% juniper & pinyon pine (95%) sage, grasses, cactus

~lots of small drainages surround

Bar & swale topography: distinct subdued none

Degree of dissection: none moderate extensive

DEPOSITS

Texture: 0 -br 0-5 -cb 15-20-gr 30 -sd 50 -si & cl

USCS: sandy silt w/ gravel

Genetic: alluvium?, some rounded gravels seen

(debris flow, fluvial, channel, colluvium, sheetwash, eolian, etc.)

Other: Unit is fine grained & matrix supported. first ck to this point

Pit is 87cm deep

SOIL SEE BACK

Horizons: A- Bw- Bt- Bk- K-

Color (dry):

Carbonate morphology (stage):

Carbonate rind thicknesses (mm)/clast composition:

2-5	LS	2-4	LS	2	LS	2-3	LS
1-2	LS	4-6	LS	2-3	LS	4-5	LS
1-2	LS	1-2	LS	1-2	Qzt	5-8	NP
3	LS	3-6	LS	2	SS	3-6	NP
2-4	LS	1	LS	1	LS	6-9	NP

} found near small drain

Other: No laminar horizon observed, K horizon is mottled with brown (10YR 6/4 - light yellowish brown)

SOIL

HORIZON	DEPTH (cm)	STAGE	DRY COLOR
A	0-9		
BK	9-33	I-II upper½ II-II+ lower½	some is 10YR 5/4 yellowish brown 10YR 7/3-6/4 v. pale brown-light yellowish brown
K	33-77	III-III+	10YR 8/2-7/3 v. pale brown
BK	77-87	I-I+	10YR 6/4 light yellowish brown

9dS

SOIL PIT DATA SHEET

Project: Mercur Fault - SK9714 **Initials:** AEG & LMC

7.5' Topo: Ophir **Date:** 9.18.97

Location: SP17. young, unfaulted alluvium immediately South of Silverado Cy.

Surficial Map Unit: af5 or af6

SURFACE

Slope and aspect: 3-5° 245°

Height above active drainage: ~1m above drainage to south + north

Vegetation: 35-40% juniper (5%) sage, grasses, cacti

Bar & swale topography: distinct subdued none

Degree of dissection: none moderate extensive

DEPOSITS

Texture: 0 -br 5-10 -cb 45-50 -gr 25 -sd 25-30 si & cl

USCS: silty sandy gravel

Genetic: Fluvial gravel deposit (poss. some colluvium?)

(debris flow, fluvial, channel, colluvium, sheetwash, eolian, etc.)

Other: Pit is 90 cm deep, clasts angular to subrounded, Bw slightly more resistant than underlying parent material, clast supported

SOIL SEE BACK

Horizons:	A-	Bw-	Bt-	Bk-	K-
Color (dry):					
Carbonate morphology (stage):					

Carbonate rind thicknesses (mm)/clast composition:

0.2	LS	0.5-1	LS	0.5	LS	0.3-0.4	LS
0.1-1	LS	0.5	LS	0.7	LS	0.5	LS
0.4	LS	0.3-0.4	LS	0.2-0.3	LS	0.5	LS
0.2-0.5	LS	0.3	LS	0.5	LS	0.1-0.3	LS
0.5	LS	1.5-3	LS	0.5-1	LS	0.2	LS

Other: most of clasts have thin carbonate rinds on the bottoms.

SOIL

HORIZON	Depth	Stage	Dry color
A	0-5		
Bw/Bk* ← only b/c it has a slight amount of strength/structure	5-30	I	10YR 5/3 - 6/3 brown - pale brown very slightly lighter colored than parent material
Parent material	30-60	thin, disc. $CaCO_3$ coats	10YR 5/3 brown

Bk horizon thickness & development varies between walls - this is avg. 5-55 Bk I+ on E wall and 5-20 Bk stage I- on W wall - avg. (representative wall) is S wall

Eldo

SOIL PIT DATA SHEET

Project: Mercur Fault - SK9714 **Initials:** LMC, AEC

7.5' Topo: Ophir Quad **Date:** 9-18-97

Location: SP18 unfaulted, young surface near Rt73 at West Dip Gulch

Surficial Map Unit: af5-6

↳ pit on older, higher portion

SURFACE

Slope and aspect: 3-5°, 200°

Height above active drainage: ~50 ft above drainage on SE edge of fan (from topo)

Vegetation: 30-40% (0-5% juniper), sage, grasses, cacti

Bar & swale topography: distinct (on some other area of surface) < subdued (locally near pit) none

Degree of dissection: none moderate extensive

DEPOSITS

Texture: 0-5 -br 10 -cb 40-45-gr 20-25-sd 15-20 -si & cl

USCS: silty sandy gravel

Genetic: fluvial deposit (alluvial fan)

(debris flow, fluvial, channel, colluvium, sheetwash, eolian, etc.)

Other: stratification observed - coarse gravels (top) - pea gravels (middle) - coarse gravels (bottom)
Clast Supported but a lot of matrix

SOIL SEE OTHER SIDE

Horizons: A- Bw- Bt- Bk- K-

Color (dry):

Carbonate morphology (stage):

Carbonate rind thicknesses (mm)/clast composition:

1-1.5	LS	1-2	LS	0.5-1	LS	2-4	SS
0.5	LS	0.5-1	LS	0.5-1	LS	2	LS
0.5-1	LS	1.5-4	SS	0.5	LS	0.1-0.5	LS
1-3	LS	0.5	LS	0.5	LS	0.5	LS
1-2	LS	0.5	LS	0.2-0.5	LS	0.2-0.5	LS

Other: A horizon vesicular, granular, subtle platy texture (seen also @ Silverado Cyn + Mercur Cyn)

SOILS

HORIZONS	DEPTH	STAGE	DRY COLOR
A	0-7cm	—	10 YR 7/ to 10YR 7/3 light gray to v. pale brn.
Bw	7-19cm	—	10YR 6/3 to 6/4 pale brn to light yellowish brn.
Bk	19-64	I+ some coated some not	10YR 6/4 light yellowish brn.
Parent Mat.	64-75	—	10YR 6/4 to 5/4 light yellowish brn. to yellowish brn.

SP18

SOIL PIT DATA SHEET

Project: Mercur Fault - SK9714 **Initials:** LMC & AEG

7.5' Topo: Ophir **Date:** 18 Sept 1997

Location: SP19, along P14, north side of road going up West Dip Gulch (upthrown)

Surficial Map Unit: af 4

SURFACE

Slope and aspect: 5-6° 240°

Height above active drainage: ~3 AEG eyeheights

Vegetation: 30 (5% juniper) sage, grasses, few cacti

Bar & swale topography: distinct subdued none

Degree of dissection: none moderate extensive

→ only at base of scarp, upthrown surface not dissected

DEPOSITS

Texture: 0-5 -br 5-10 -cb 50-55-gr 30-35-sd 10-15 -si & cl

USCS: silty sandy gravel to sandy gravel

Genetic: fluvial deposit

(debris flow, fluvial, channel, colluvium, sheetwash, eolian, etc.)

Other: Pit is ~80 cm deep, stratified - coarse (top), pea gravel (bottom) Btk(?) is at bottom of section, mainly in the pea gravels.

SOIL SEE BACK

Horizons: A- Bw- Bt- Bk- K-

Color (dry):

Carbonate morphology (stage):

Carbonate rind thicknesses (mm)/clast composition:

6-9	lms	3-4.5	Qtzite	5-6	lms	3.5-7	lms
3.5-4	lms	6-7	lms	4-5	lms	3.5-4.5	Qtzite
4-6	lms	4-4.5	Qtzite	3.5-4	lms	2-5	lms
6	qtzite	4-6	lms	5-6	lms	5-6	lms
4-5	lms	4.5-6 (~1-1.5 mm)	lms	3	Qtzite	5	Qtzite

Other: laminations seen at top of K horizon but not extremely cemented; Btk horizon has lots of carbonate but clay film is seen (clay is coating grains). More strongly cemented K horizon seen outcropping near sides of surface.

SOIL

HORIZON	DEPTH	STAGE	DRY COLOR
A	0-10	—	
BK	10-23	I+	10YR 7/4 to 6/4 v. pale brn to light yellowish brn
K	23-67	IV*	10YR 8/2 v. pale brn
Btk(?) (poss. clay films observed)	67-80	—	10YR 7/3 to 6/3 v. pale brn to pale brn.

*III+ ? SSO 10-24-97
couldn't see laminations
but under wet freezing
conditions

Sp19

SOIL PIT DATA SHEET

Project: Mercur Fault - SK9714 **Initials:** AEG, LMC

7.5' Topo: Ophir **Date:** 19 Sept 1997

Location: SP20 along P14 north side of road going up West Dip Gulch (downtown)

Surficial Map Unit: aF4

SURFACE

Slope and aspect: 2-3°, S38°W

Height above active drainage: ~1.8m (from drainage to south)

Vegetation: 20-30% juniper (0-5%) sage grasses cacti

Bar & swale topography: distinct subdued (none)

Degree of dissection: (none) moderate extensive

DEPOSITS

Texture: 0-5 -br 10-15-cb 50-55-gr 15-20-sd 10-15-si & cl

USCS: silty sand gravel - sandy gravel

Genetic: Fluvial Deposit

(debris flow, fluvial, channel, colluvium, sheetwash, eolian, etc.)

Other: Pit is 87cm deep

SOIL

Horizons: A- Bw- Bt- Bk- K-

Color (dry):

Carbonate morphology (stage):

Carbonate rind thicknesses (mm)/clast composition:

1-3	LS	1-2	LS	1-1.5	QZT	2-3	LS
1-2.5	? shale or SS	4-5	LS	1-3	LS	2-6*	LS
2-4	LS	1-3	LS	1-2	LS	2-3	LS
2.5-4	LS	1-5*	LS	2-3	LS	2.5	LS
1.5-4	QZT	2.5-5	LS	1-3	LS	2-3	LS

Other: Laminations @ top of K-horizon, laminations are 0.1-3mm thick

SOILS

Horizon	Depth (cm)	Stage	Dry Color
A	0 - 8		
Bk	8 - 29	I+ - II	10 YR 6/4 light yellowish brown
K	29 - 64	IV*	10YR 8/2 - 7/2 v pale brown - light grey
Bk	64 - 87	I = I+	10YR 7/3 - 6/3 v pale brown - pale brown

* III+ (?) SSO 10-24-97
couldn't see laminations
under wet - freezing conditions

SP20

SOIL PIT DATA SHEET

Project: Mercur Fault - SK9714 **Initials:** LMC & AFG

7.5' Topo: Ophir **Date:** 9.19.97

Location: SP21 along P15 terrace on south side of road up W. Dip Gulch (upthrow

Surficial Map Unit: t4

SURFACE

Slope and aspect: 3° 225°

Height above active drainage: ~3.5 m above drainage to N, ~1.8m above drainage to

Vegetation: 30-35% juniper (0-5%) sage, grasses cactus

Bar & swale topography: distinct (<subdued) none

Degree of dissection: none (moderate) extensive

drainages to N & S

DEPOSITS

Texture: 5-10 -br 10-15 -cb 50 -gr 15-20-sd 10-15 -si & cl

USCS: sandy cobbly gravel

Genetic: Fluvial deposit

(debris flow, fluvial, channel, colluvium, sheetwash, eolian, etc.)

Other: pit is ~ 68 cm deep. More boulders in this pit than in most others. clast suppt'd

SOIL SEE BACK

Horizons: A- Bw- Bt- Bk- K-

Color (dry):

Carbonate morphology (stage):

Carbonate rind thicknesses (mm)/clast composition:

1.5-3	LS	1-3	LS	1.5-3	LS	1-2.5	LS
3	Qzt	2	LS	1-3	LS	1-5*	LS
4-6	SS	1-3	LS	1-2	LS	1-4.5	LS
2	LS	2	LS	1-1.5	LS	2-4	LS
1-3	LS	2-3	LS	2-4	LS	3-5	Qzt

Other: A horizon is very granular, very fine laminations (<0.5mm) seen in K horizon.

SOILS

HORIZON	DEPTH	STAGE	DRY COLOR
A	0-8	—	—
Bk	8-24	I - I+	10YR 7/4 to 6/4 v. pale brn to light yellowish brn
K	24-53	III+ - IV-	10YR 8/2 to 7/3 v. pale brn.
Bk	53-65	I+ - II	10YR 7/3 to 7/4 v. pale brn.

SP21

SOIL PIT DATA SHEET

Project: Mercur Fault - SK9714 **Initials:** AEG, LMC

7.5' Topo: OPhr **Date:** 9/20/97

Location: SP22 along P15 downthrown terrace south of road and West Dip Gulch

Surficial Map Unit: af4

SURFACE

Slope and aspect: 4°, 226

Height above active drainage:

Vegetation: 35-40% juniper (0-5%) sage grasses cactus

sage are taller here than on upthrown side

Bar & swale topography: distinct subdued none

Degree of dissection: none moderate extensive

small drainages on surface

DEPOSITS

Texture: 0-5 -br 5-10 -cb 50 -gr 30 -sd 5-10 -si & cl

USCS: sandy gravel

Genetic:

(debris flow, fluvial, channel, colluvium, sheetwash, eolian, etc.)

Other: Pit is 90 cm deep; matrix supported above K, clast supported below K; above K 20% gr 80% fines;

SOIL SEE OTHER SIDE

Horizons: A- Bw- Bt- Bk- K-

Color (dry):

Carbonate morphology (stage):

Carbonate rind thicknesses (mm)/clast composition:

1-3	LS	1-3.5	LS	2-3	LS	2-3	LS
2-3	SS	2-3	QZt	2-4	LS	2-4	LS
3-5	SS	2	LS	2-4	LS	4-5	LS
1-4	LS	2-3	LS	1-4	LS	2-3	LS
1-8*	LS	3-5	LS	4-6	LS	2-5	LS

Other: thicker deposits on top of K horizon

SOILS

Horizon	Depth (cm)	Stage	Dry Color
A	0 - 5	—	—
Bw	5 - 14	—	—
Bk	14 - 35	II	10YR 6/4 light yellowish brown
K	35 - 67	III - III+	10YR 8/2 - 7/3 v. pale brown
Bk	67 - 90	I+ - II	10YR 6/4 light yellowish brown (slightly damp)

SP22

SOIL PIT DATA SHEET

Project: Mercur Fault -.SK9714 **Initials:** AEG, LMC

7.5' Topo: Ophir **Date:** 20 Sept 1997

Location: SP23 along P16 upthrown side higher surface ~ 3.5m from E. end P16 West Dip Gulch

Surficial Map Unit: qf4

SURFACE

Slope and aspect: 6°, 216°

Height above active drainage: ~5.75m (to south) ~4m (to lower terrace to N)

Vegetation: 30-35% juniper (0-5%) sage grasses cactus

Bar & swale topography: distinct subdued none

Degree of dissection: none on surface moderate → drainages to S + N extensive

DEPOSITS

Texture: 0 -br 0-5 -cb 60 -gr 25 -sd 10-15 -si & cl

USCS: sandy gravel.

Genetic: Fluvial deposit capping bedrock

(debris flow, fluvial, channel, colluvium, sheetwash, eolian, etc.)

327
48 SW

Other: Pit is 80cm deep; Bedrock observed ~ 75' to the SE, strike 327° Dipping 48 SW. Alluvial cover estimated ~ 8' deep; deposits above K are matrix supported, below K are clast supported above K 10-20% gr 80-90% fines

SOIL

Horizons: A- Bw- Bt- Bk- K-

Color (dry):

Carbonate morphology (stage):

Carbonate rind thicknesses (mm)/clast composition:

2.5-5	LS	2-4	LS	2-3	LS	1-3	LS
1.5-3	LS	1-2	LS	2-5	LS	2-4	LS
1.5	LS	2-4	Qzt	1.5-3	LS	1-4	LS
1-2	LS	1-2	LS	1.5-4	LS	1-6*	LS
1-3	LS	1	LS	1-4	LS	2-5	LS

Other: Laminar K horizon observed laminations ~ 1-4mm thick K horizon seems to have an irregular boundary & thickness

SOILS

Horizon	Depth	Stage	Dry Color
A	0-8cm	–	–
Bw	8-17cm	–	–
Bk	17-30	I-I+	10YR 6/4 light yellowish brn.
K	30-62	IV	10YR 8/2 to 7/2 v. pale brn. to light gray
Bk	62-80	I-I+	10YR 6/4 light yellowish brown

SP23

SOIL PIT DATA SHEET

Project: Mercur Fault - SK9714 **Initials:** AEG

7.5' Topo: Ophir **Date:** 21 Sept 1997

Location: SP24 Young unfaulted surface just S of Mercur Cyn

Surficial Map Unit: aF5 or 6

SURFACE

Slope and aspect: 3-4° 225°

Height above active drainage: ~ 3.75 AEG ⇔ from drainage to North

Vegetation: 50 ~ 55 % (0% juniper), sage, grasses

Bar & swale topography: distinct (> subdued) none

Degree of dissection: (none) moderate extensive

DEPOSITS

Texture: 0% -br 0-5% -cb 55-60-gr 25-30 -sd 10-20-si & cl

USCS: silty sandy gravel

Genetic: fluvial deposits (alluvial fan)

(debris flow, fluvial, channel, colluvium, sheetwash, eolian, etc.)

Other: stratification observed - coarse (top) - pea gravels - sand/silt - coarse (bottom). Deposits are clast-supp't (except for the sand lense)

SOIL

Horizons: A- Bw- Bt- Bk- K-

Color (dry):

Carbonate morphology (stage):

Carbonate rind thicknesses (mm)/clast composition:

0.2	lms	0.6	lms	0.4	Qtzite	0.5-1.0	lms
0.5	Qtzite	0.2	lms	0.5	lms	0.5-1.0	Qtzite
0.5	lms	0.5	Qtzite	0.7	Qtzite	0.7	Qtzite
0.3-0.5	lms	0.5-1.0	Qtzite	0.5	Qtzite	0.5	lms
0.4	Qtzite	0.3	lms	1-1.5	lms	0.2	lms

Other: Unsure whether parent material was observed, boundary btwn Bw/Bk and Parent Material (P.M.) defined by P.M. possibly being a little "looser."

Soils

Horizon	Depth	Stage	Dry Color
A	0-4cm	—	—
Bw	4-30cm	—	—
Bw/Bk	30-63cm ?	I+	10YR 6/4
P.M.?	63-85cm ?		10YR 6/4 lglt yellowish brn

poss. slightly looser than Bk above

SPZH

SOIL PIT DATA SHEET

Project: Mercur Fault - SK9714 **Initials:** AEG

7.5' Topo: Ophir **Date:** 22 Sept 1997

Location: SP25

Surficial Map Unit: aFl along profile P17 upthrown side Ophir Cyn

SURFACE

Slope and aspect: 5°, 227°

Height above active drainage: ~2 AEG ⊗ above small drainage to N; ~130' above main (~58 ... Ophir Cyn. drainage (from topo.)

Vegetation: 20% (100% juniper + pine)

Bar & swale topography: distinct subdued (none)

Degree of dissection: none (>moderate) extensive

DEPOSITS

Texture: 0-5 -br 20 -cb 45 -gr 15 -sd 15-20 -si & cl ← slightly more si + cl than sand

USCS: silty sandy cobbly gravel

Genetic: Fluvial deposit

(debris flow, fluvial, channel, colluvium, sheetwash, eolian, etc.)

Other: Pit is ~ 90cm ~~deep~~ hit refusal on boulder

SOIL

SEE OTHER SIDE

Horizons: A- Bw- Bt- Bk- K-

Color (dry):

Carbonate morphology (stage):

Carbonate rind thicknesses (mm)/clast composition:

2-3	lms	5-6	lms	4	lms	4-7	lms
6.5-9	lms	2-4	lms	4-5	lms	1-2.5	lms
4-6.5	lms	5-6.5	lms	2-3	lms	5-6	volc?
5-7	lms	6-7	lms	2-4	lms	2-4	lms
2.5-4	lms	5-6	lms	3-4	lms	4	lms

Other: no laminations observed in K horizon, was weakly cemented (i.e. fairly easy to dig thru). Bk below seems to have a lot of carbonate thru out (whitish appearance)

SP25

SOILS

Horizon	Depth	Stage	Dry Color
A	0-8.5cm	—	still wet
Bw	8.5-18cm	—	still wet
Bk	18-34cm	I+ to II	10YR 7/3 to 6/3 v. pale brn. to pale brn.
K	34-45cm	III	10YR 8/2 to 7/2 v. pale brn to light gray
Bk	45-90	II+	10YR 6/3 v. pale brn.

SOIL PIT DATA SHEET

Project: Mercur Fault - SK9714 **Initials:** AEG

7.5' Topo: Mercur, Utah **Date:** 22 Sept 1997

Location: SP26 young, unfaulted surface, btwn Mitchell + McFait Cyns

Surficial Map Unit: af5 or af6

SURFACE

Slope and aspect: 4° 245°

Height above active drainage: ~ 1/2 AEG ⇒ above road

Vegetation: 60-70% (0% juniper) sage, some grass, some cacti

Bar & swale topography: distinct (>subdued) none

Degree of dissection: (none) moderate extensive

DEPOSITS

Texture: 0 -br 10 -cb 10 -gr 20-30-sd 50-60-si & cl

USCS: silty sand (mainly); top gravel is silty sandy gravel; bottom gravels sandy, silty gravel

Genetic: fluvial deposit ?

(debris flow, fluvial, channel, colluvium, sheetwash, eolian, etc.)

Other: Pit is 110cm deep, mostly fine grained sands + silts, w/gravels near top and at bottom. Possible parent material @ 92cm. Main silty/sandy body is ~70cm thick, no bedding (except coarse-fine-coarse) seen.

SOIL See other side

Horizons: A- Bw- Bt- Bk- K-

Color (dry):

Carbonate morphology (stage):

Carbonate rind thicknesses (mm)/clast composition:

1-1.5	lms	0.5-1.0	Qtzite	0.2	Qtzite	0.5-0.9	Qtzite
0.5	Qtzite	0.4-1.0	lms	2-3.5 ?!	lms	1-2.5	Qtzite
0.4	lms	0.7-1.0	lms	1-2	lms	1.0	lms
0.3-0.5	lms	0.5-1.5	lms	0.5-0.8	lms	1-1.3	Qtzite
1-1.5	Qtzite	0.4-1.0	Qtzite	0.5-1.0	Qtzite	0.3-0.5	lms

Other:

from where soils were measured (cm)

SOILS

Horizon	Depth	Stage	Dry Color
Bw? / Bk	0-31	I (to I+?)	— still wet
bottom ~7cm in gravel Bk	31-92	I to I+	10YR 6/4 light yellowish brn
Parent material? slightly looser than Bk above, also gravelly	92-110		10YR 6/4 to 5/4 light yellowish brn. to yellowish brn

SP26

SOIL PIT DATA SHEET

Project: Mercur Fault - SK9714 **Initials:** AEG

7.5' Topo: Ophir Cyn Quad **Date:** 25 Oct 1997

Location: Downthrown side, western scarp, pit located in profile P17 (SP27)

Surficial Map Unit: af5/ af1

SURFACE

Slope and aspect: ~ 3°, ~200°

Height above active drainage: ~1.5 m above drainage @ base of eastern scarp.

Vegetation: 30% (80% juniper) ? near areas of 100% sage + grasses

Bar & swale topography: distinct subdued → covered w/ 12" snow + drifts none

Degree of dissection: (> none) moderate ∴ hard to tell extensive

DEPOSITS

Texture: 0% -br 0-5% -cb 60-70 -gr 15-20 -sd 15 -si & cl

USCS: Silty sandy gravel

Genetic: Fluvial deposit

(debris flow, fluvial, channel, colluvium, sheetwash, eolian, etc.)

Other: Pit is ~110 cm from wet to frozen. matrix supp't from 0-37 cm, ∆ to clast supp't mix ~ 8-10 cm. Deposit ∴ ages are for 37-110 cm. No discontinuity seen in the soil/deposits which would indicate a buried surface, though obvious ↳ hard to see w/ all the snow blowing in... 20% ssd 20% gravels

SOIL

See back

Horizons: A- Bw- Bt- Bk- K-

Color (dry):

Carbonate morphology (stage):

Carbonate rind thicknesses (mm)/clast composition:

2-2.5	lms	1.5-2.0	lms	2-3	lms		
1.5-4.5	lms	1.5-3.0	lms				
2-5	lms	2.0-4.0	lms				
4	lms	4-7	lms				
2-3.5	lms	2-3	lms				

Other: V. cold + hard to find clast large enough to break to measure $CaCO_3$ rind. Is starting at 11 cm? none found on ground surface due to snow cover.

Kb	70 - 110 cm	IV	

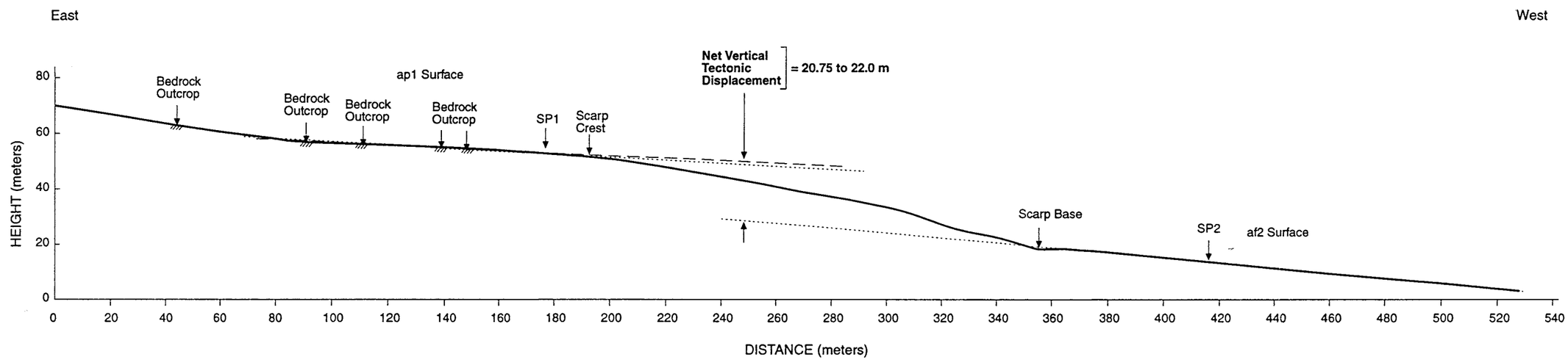
SP27

APPENDIX B

Appendix B

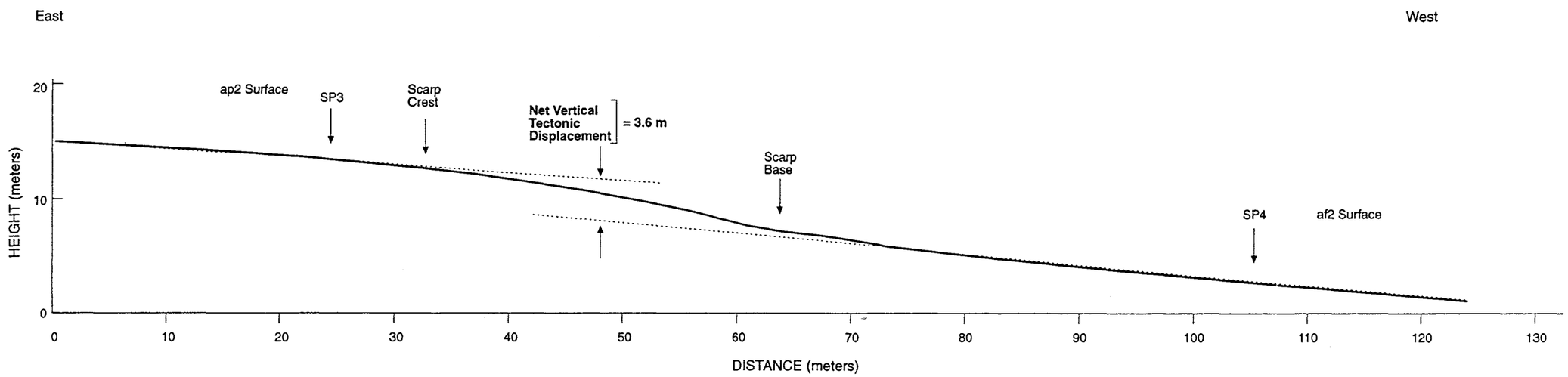
Scarp Profiles

(See Figure 2 For Locations)



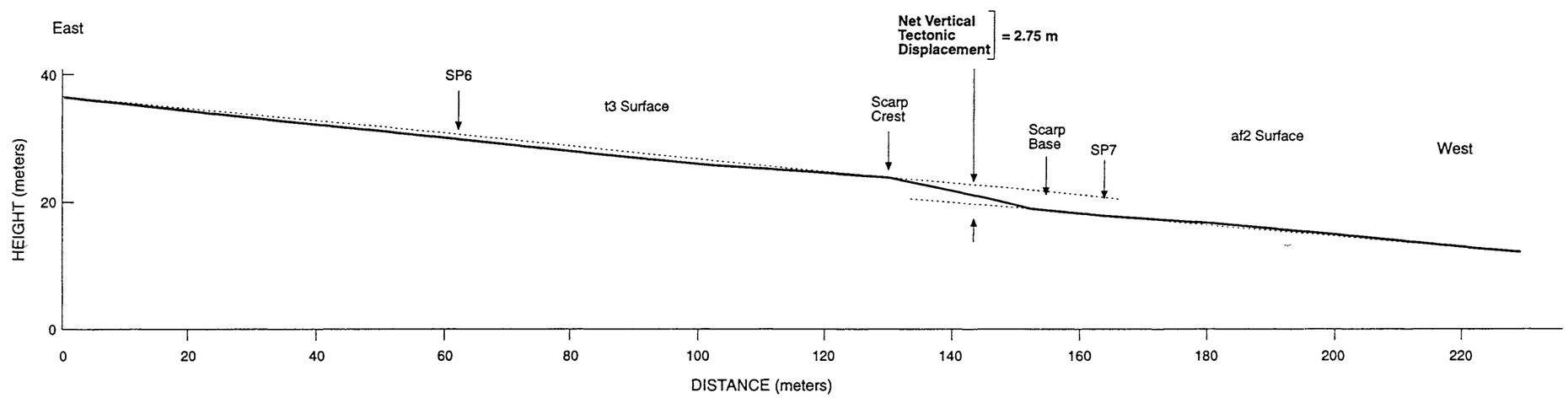
Project No. SK9714	SOMFZ NEHRP	PROFILE P1	Figure B-1
URSG Woodward Clyde Federal Services			

SK9714-1000/060199/gos



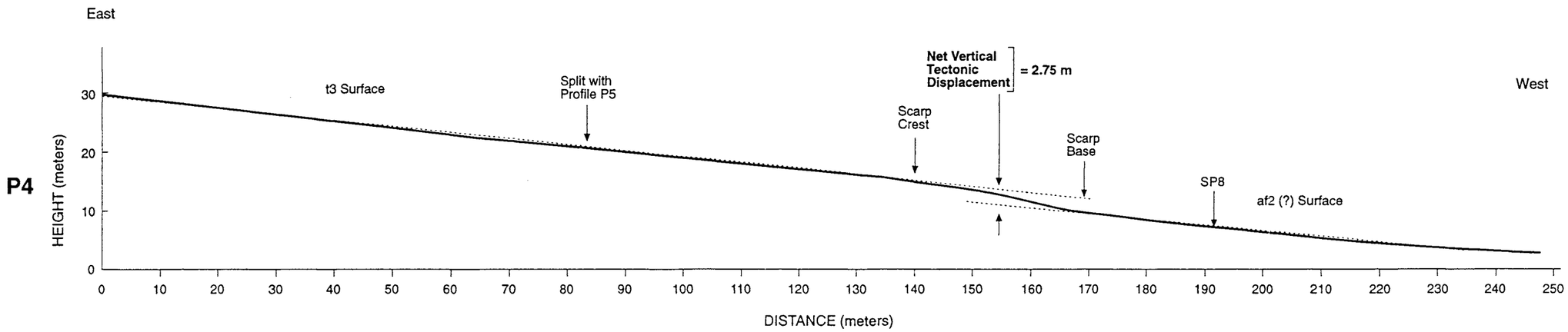
Project No. SK9714	SOMFZ NEHRP	PROFILE P2	Figure B-2
URSG Woodward Clyde Federal Services			

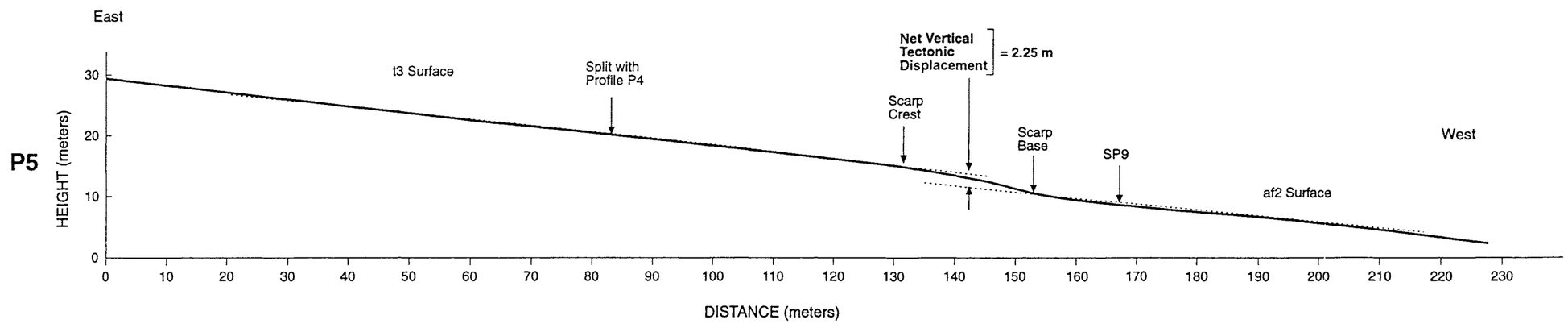
SK9714-1000/060199/gos



Project No. SK9714	SOMFZ NEHRP	PROFILE P3	Figure B-3
URSG Woodward Clyde Federal Services			

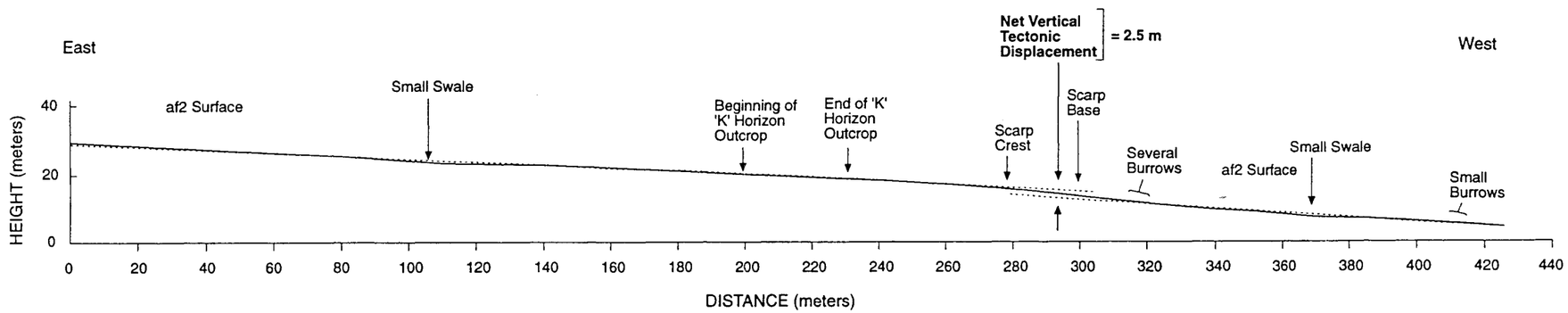
SK9714-1000/060199/gos





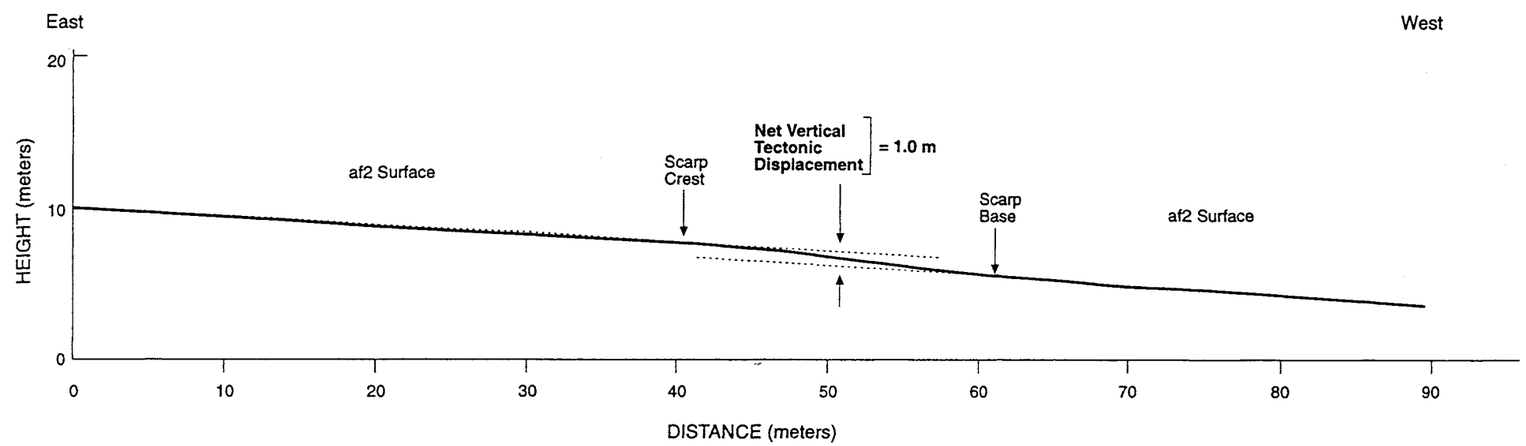
Project No. SK9714	SOMFZ NEHRP	PROFILES P4 AND P5	Figure B-4
	URSG Woodward Clyde Federal Services		

SK9714-1000/060199/gos



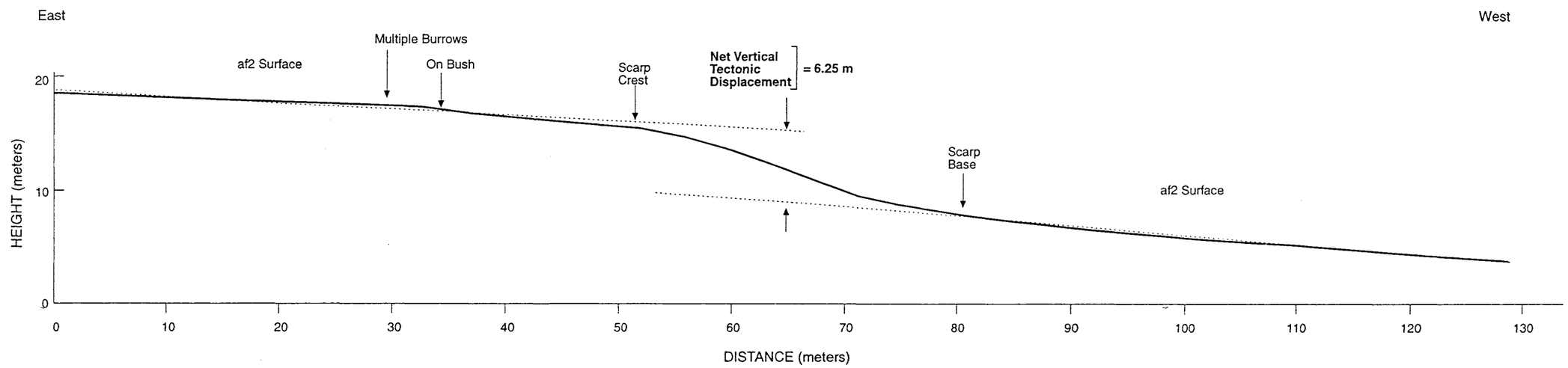
Project No. SK9714	SOMFZ NEHRP	PROFILE P6	Figure B-5
URSG Woodward Clyde Federal Services			

SK9714-1000/060199/gos



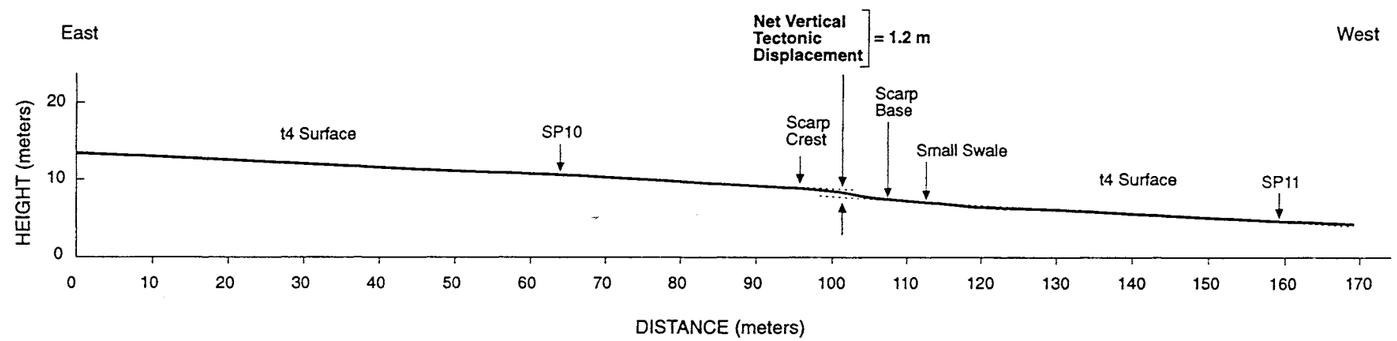
Project No. SK9714	SOMFZ NEHRP	PROFILE P7	Figure B-6
URSG Woodward Clyde Federal Services			

SK9714-1000/060199/gos



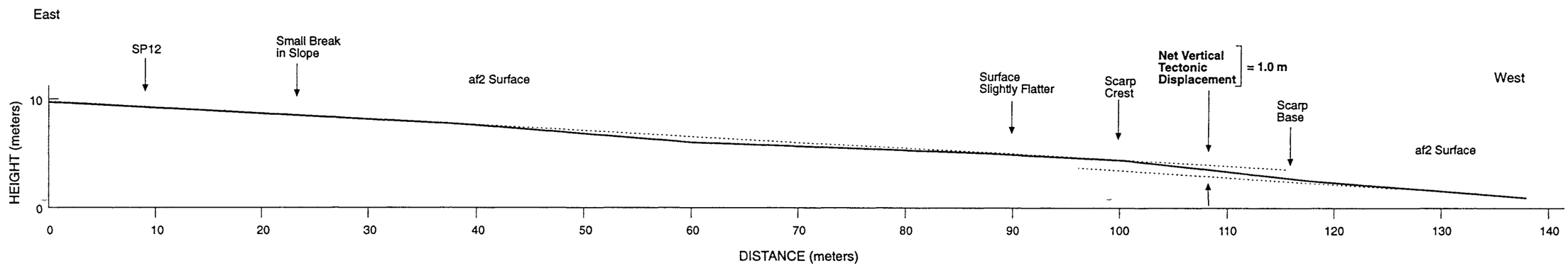
Project No. SK9714	SOMFZ NEHRP	PROFILE P8	Figure B-7
URSG Woodward Clyde Federal Services			

SK9714-1000/060199/gos



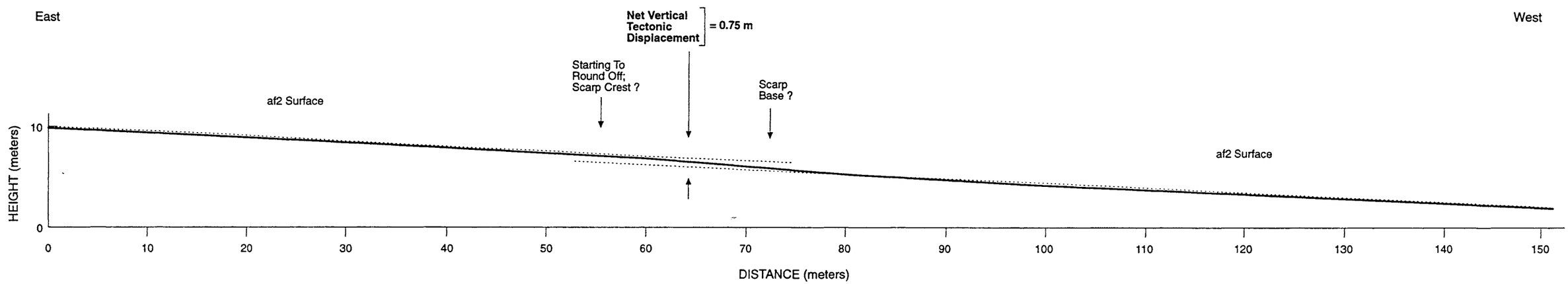
Project No. SK9714	SOMFZ NEHRP	PROFILE P9	Figure B-8
URSG Woodward Clyde Federal Services			

SK9714-1000/060199/gos



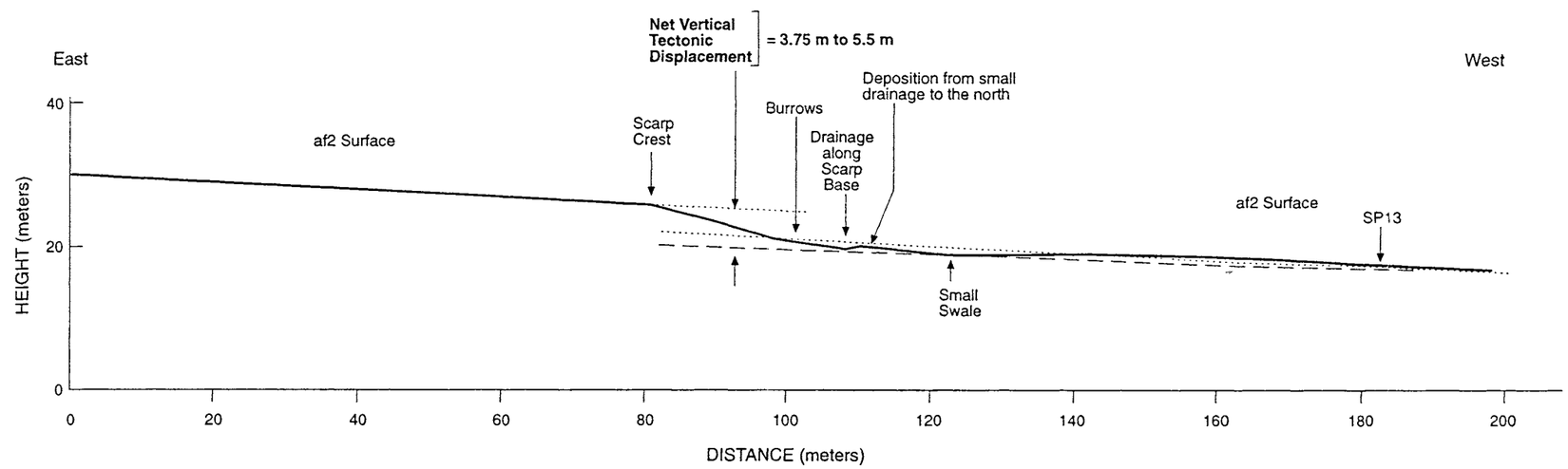
Project No. SK9714	SOMFZ NEHRP	PROFILE P10	Figure B-9
URSG Woodward Clyde Federal Services			

SK9714-1000/060199/gos



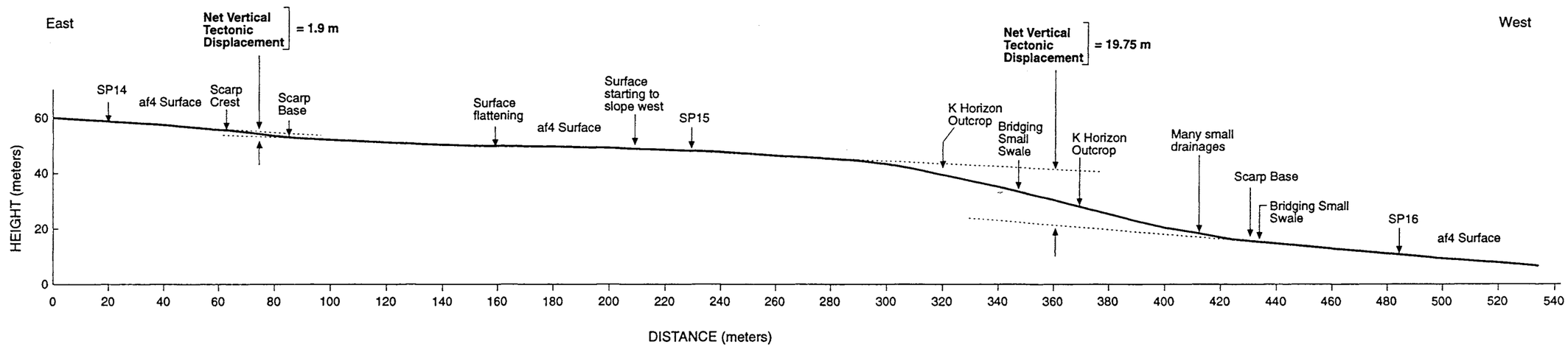
Project No. SK9714	SOMFZ NEHRP	PROFILE P11	Figure B-10
	URSG Woodward Clyde Federal Services		

SK9714-1000/060199/gos



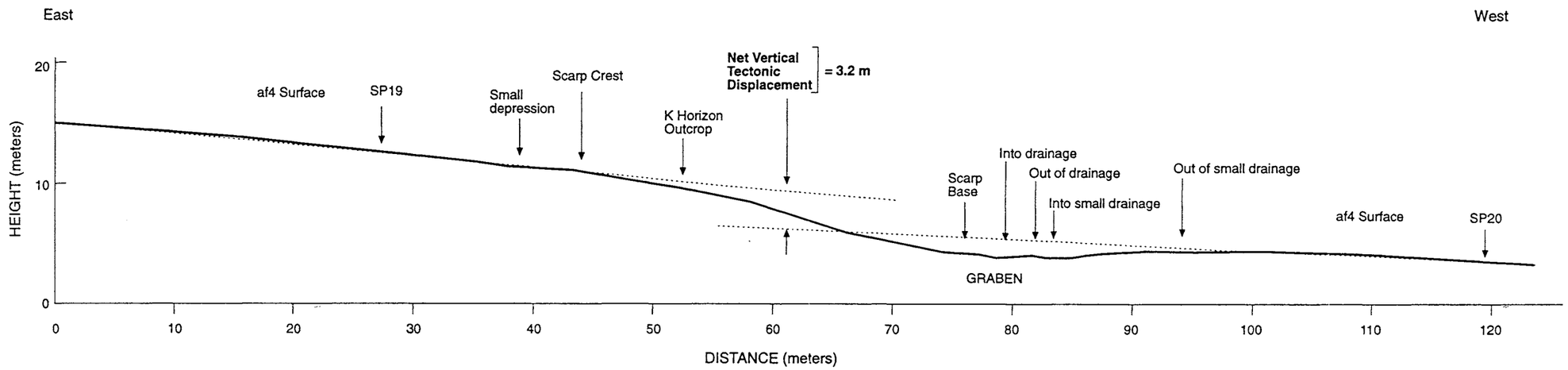
Project No. SK9714	SOMFZ NEHRP	PROFILE 12	Figure B-11
URSG Woodward Clyde Federal Services			

SK9714-1000/060199/gos



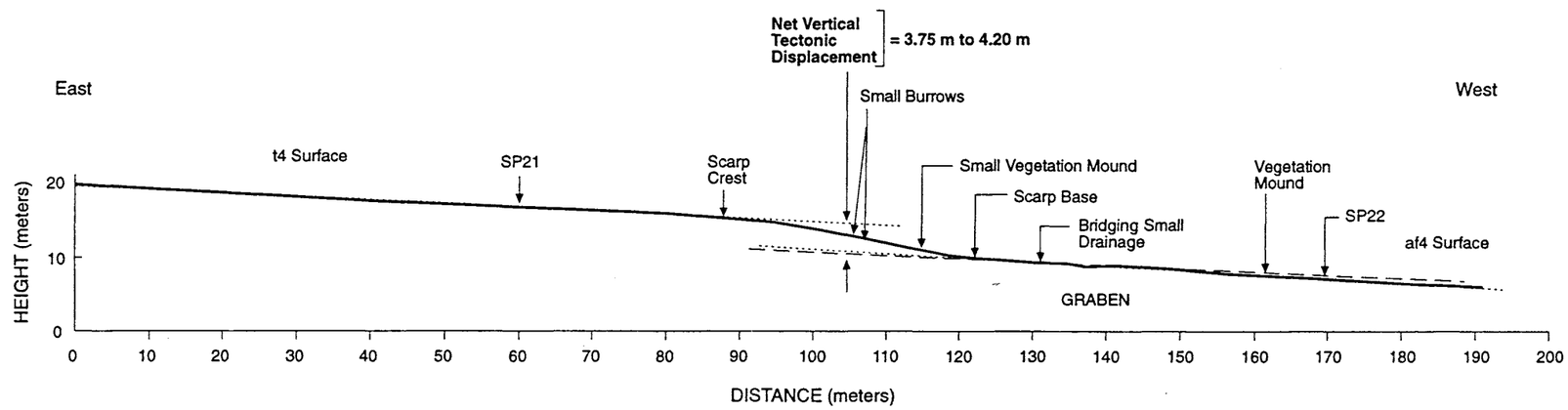
Project No. SK9714	SOMFZ NEHRP	PROFILE P13	Figure B-12
	Woodward-Clyde Federal Services		

SK9714-1000/060199/gos



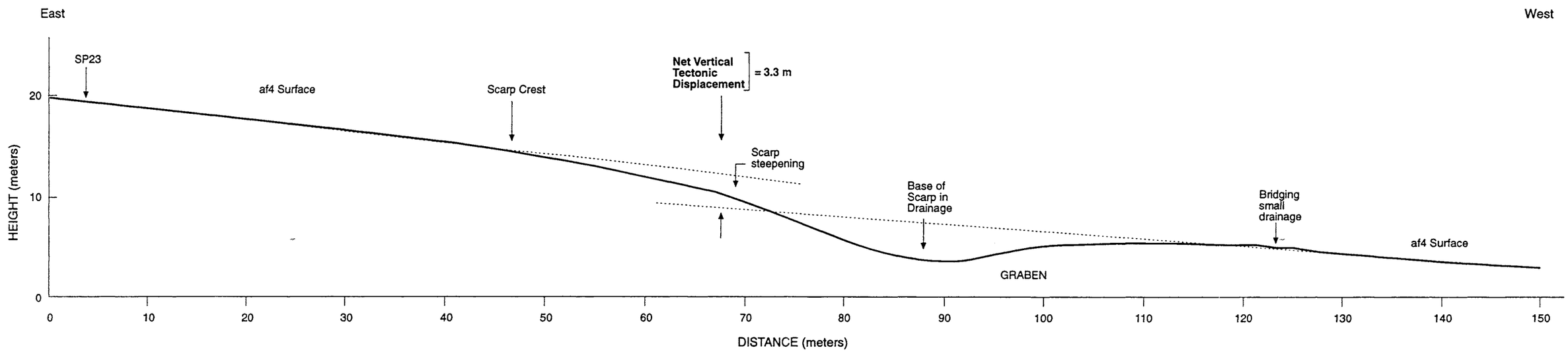
Project No. SK9714	SOMFZ NEHRP	PROFILE P14	Figure B-13
URSG Woodward Clyde Federal Services			

SK9714-1000/060199/gos



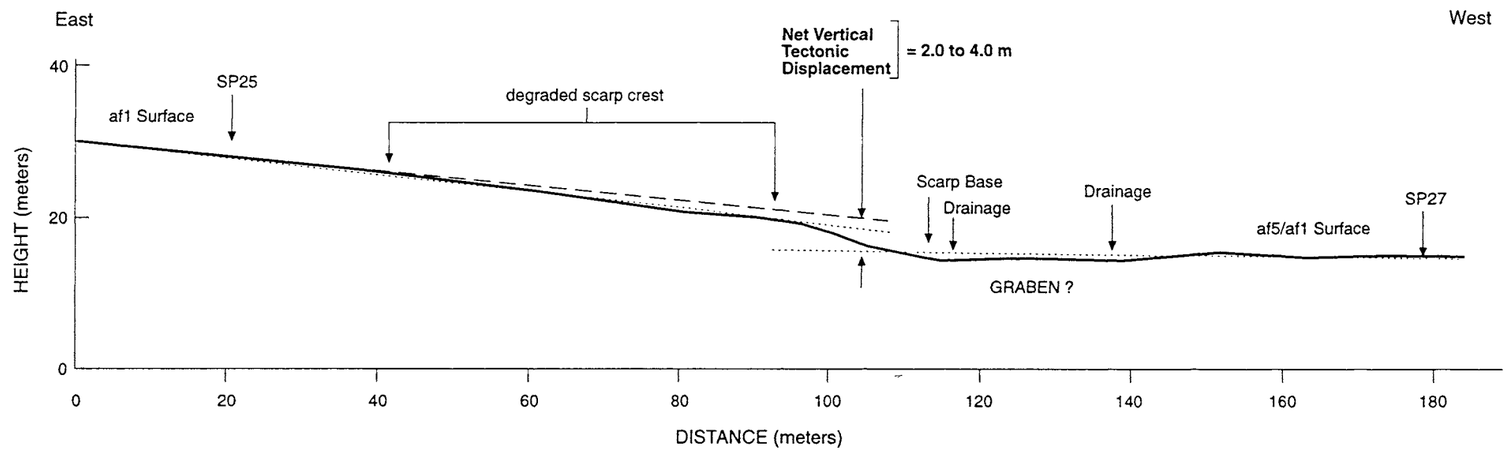
Project No. SK9714	SOMFZ NEHRP	PROFILE P15	Figure B-14
	URSG Woodward Clyde Federal Services		

SK9714-1000/060199/gos



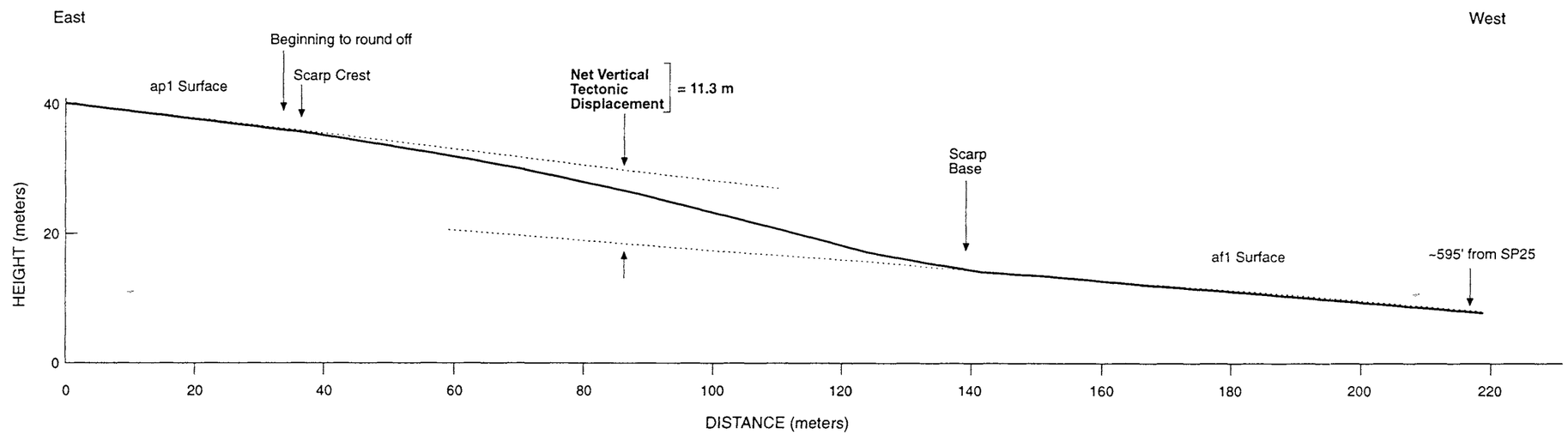
Project No. SK9714	SOMFZ NEHRP	PROFILE P16	Figure B-15
	URSG Woodward Clyde Federal Services		

SK9714-1000/060199/gos



Project No. SK9714	SOMFZ NEHRP	PROFILE P17	Figure B-16
URSG Woodward Clyde Federal Services			

SK9714-1000/060199/gos



Project No. SK9714	SOMFZ NEHRP	PROFILE P18	Figure B-17
URSG Woodward Clyde Federal Services			

SK9714-1000/060199/gos

APPENDIX C

Appendix C
Associated Publications

QUATERNARY BEHAVIOR ALONG THE SOUTHERN OQUIRRH FAULT ZONE, UTAH

OLIG, Susan S. and GORTON, Andrew E., Seismic Hazards Group, URS Greiner Woodward-Clyde Federal Services, 500 12th Street, Oakland, CA 94607 and CHADWELL, Lori, University of Utah, Department of Geology & Geophysics, 719 WBB, Salt Lake City, UT 84112

A series of en echelon down-to-the west normal faults, bound the western flank of the southern Oquirrh Mountains and comprise the southern Oquirrh Mountain fault zone (SOMFZ). These include the Mercur, West Eagle Hill, Soldier Canyon and Lakes of Kilarney faults, which extend a total length of 25 km, suggesting an expected maximum moment magnitude of 6.7 for the SOMFZ. Although these faults pose an earthquake threat to Salt Lake City, Provo, and the nation's chemical weapon cryofracture plant and storage facility at Tooele Army Depot, very little is known about their paleoseismicity, and what is known remains controversial, including issues about relations between faults and the timing of surface faulting events. Therefore, to better understand the Quaternary behavior and earthquake potential of the SOMFZ, we mapped Quaternary deposits, measured scarp profiles and excavated soil pits along the Mercur and West Eagle Hill faults where scarps on alluvium are best expressed. Based on various field parameters, we distinguished six different ages of stream and/or fan alluvium, two intermediate age terrace deposits, and older pediment surfaces that range in elevation from 6 m to over 25 m above active drainages. The oldest alluvium that appears unfaulted along both the Mercur and West Eagle Hill faults post-dates the Bonneville Shoreline and was deposited after 14.5 ka. In contrast, intermediate-age fans and terraces are the youngest deposits cut by the Mercur fault, and a slightly older terrace is the youngest unit offset by the West Eagle Hill fault. Soils are surprisingly well-developed on these intermediate-age deposits indicating a late Pleistocene age or older. Net vertical tectonic displacements of intermediate-age surfaces average 12 m along the Mercur fault and 2.6 m along the West Eagle Hill fault. Maximum displacements are 21.7 m and 2.8 m, respectively. Overall displacement patterns indicate that faulting has shifted basinward on the SOMFZ and most of the Quaternary offset is partitioned onto the Mercur fault. Although our mapping did not resolve the controversy over if the most recent surface rupture on the Mercur fault occurred post-Bonneville, we will report on an ongoing trench study of the timing and size of recent faulting events on the Mercur fault.

ABSTRACT SUBMITTED FOR THE 42ND ANNUAL MEETING OF THE ASSOCIATION OF ENGINEERING GEOLOGISTS, SEPTEMBER 26-29, 1999, SALT LAKE CITY UTAH