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# PRELIMINARY EVALUATION OF THE BARE MOUNTAIN FAULT ZONE, TARANTULA CANYON, NYE COUNTY, NEVADA

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ENCLOSURE I

# PRELIMINARY EVALUATION OF THE BARE MOUNTAIN FAULT ZONE, TARANTULA CANYON, NYE COUNTY, NEVADA

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## ABSTRACT

Surficial geologic mapping, topographic profiles of fault scarps, and trench exposures of strata of Quaternary age indicate that the late Quaternary rate of faulting on the Bare Mountain fault is low, and the age of the most recent surface-faulting event may be significantly older than previously reported. At Tarantula Canyon, geologic mapping indicates that a fault scarp is present on an older, middle to late Pleistocene fan. Younger, late Pleistocene to Holocene age fans are not displaced. Topographic profiles measured across the scarp suggest that this scarp is very old, possibly 100,000 years. Preliminary interpretation of exposures in a trench excavated across the fault scarp also suggests that the most recent surface faulting event is no younger than late Pleistocene. A fluvial gravel with a strongly developed carbonate soil (stage IV-IV+) is vertically displaced approximately 1.5 meters by a single surface-rupturing event. The degree of soil profile development in the overlying, unfaulted colluvium, and the degree of post-

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faulting calcic horizon development in the faulted fluvial gravel and along the fault surface provide evidence indicating that this faulting event occurred early in the late Pleistocene.

On the basis of the apparent age of the most recent faulting event, age of the deposits displaced, and the amount of displacement observed from the single event in the Tarantula Canyon trench, the slip rate for the Bare Mountain fault appears to be about 0.015 millimeters per year or less and the recurrence interval for surface faulting events appears to be at least 100,000 years.

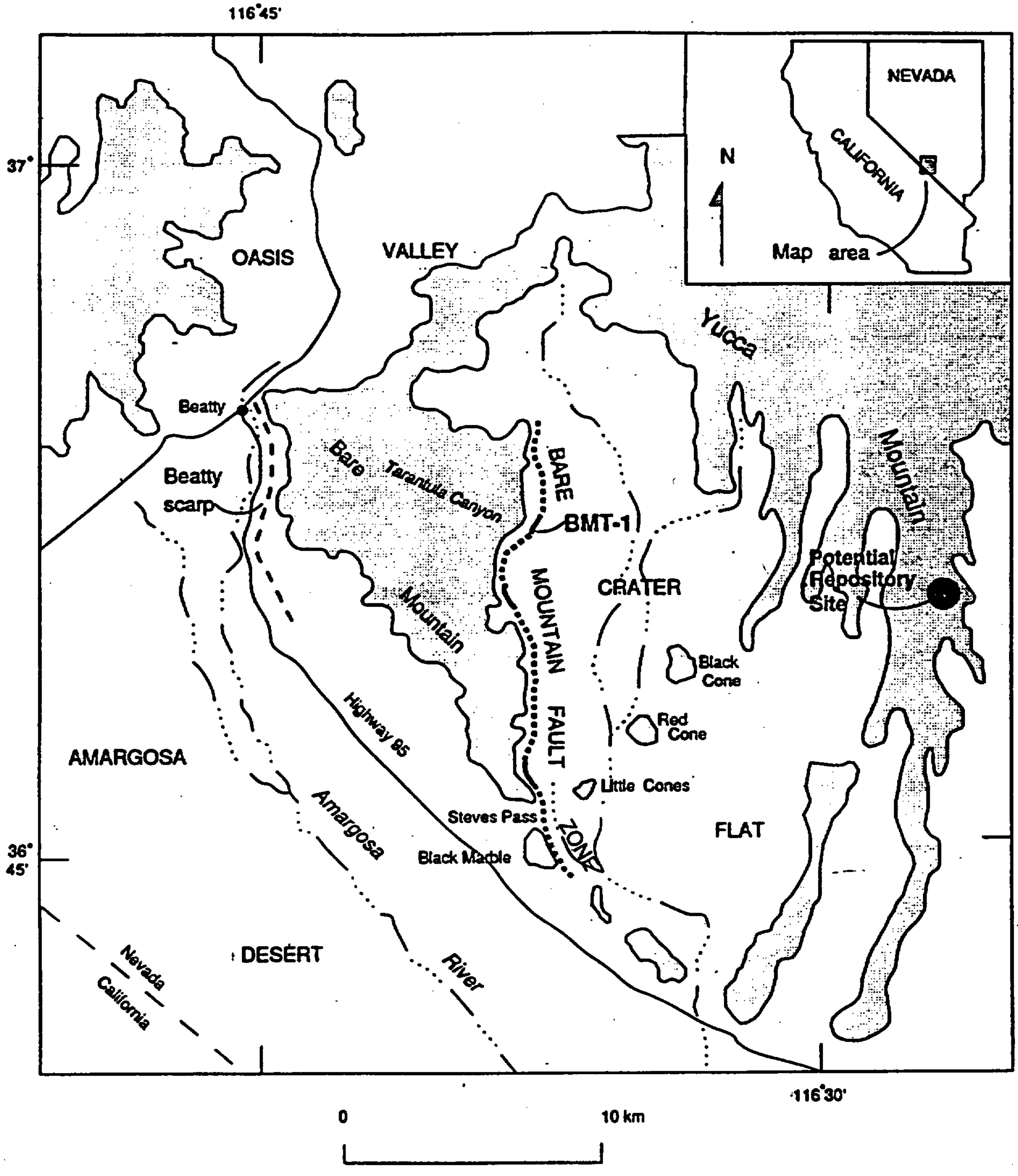
## INTRODUCTION

The Bare Mountain fault zone lies along the east side of Bare Mountain in Nye County, Nevada, approximately 15 km west of the potential nuclear waste repository at Yucca Mountain (fig. 1). Because of its proximity and the belief that this fault could be a potential source for significant future ground motions at the repository site, this fault zone was identified for detailed analysis in the Yucca Mountain Site Characterization Plan (U.S. Department of Energy, 1988).

FIGURE 1.--NEAR HERE

Cornwall and Kleinhampl (1961) were the first to recognize the presence of a major

Figure 1. Map showing the location of the Bare Mountain fault zone.




EXPLANATION

Fault scarps in younger (upper Pleistocene?) deposits, fault dotted where concealed

**BMT-1** Tarantula Canyon site

range-bounding structure along the east side of Bare Mountain. They also inferred Quaternary activity on this fault owing to the sharp, relatively straight range front and the small, relatively undissected alluvial fans along the east side of the range. Swadley and others (1984) were the first to refer to this structure as the Bare Mountain fault zone. Later mapping by Swadley and Parrish (1988) shows the range-front fault cutting early Pleistocene deposits but being buried by younger, early to middle Pleistocene, deposits. In contrast, Reheis (1988) and Monsen and others (1992) indicate that deposits as young as Holocene are faulted at several locations along the range. The reconnaissance work by Reheis (1988) specifically addressed the Quaternary faulting history along the eastern side of Bare Mountain. Surficial mapping and observations made in several mine exploration pits led Reheis (1988, p. 105) to report that there is abundant evidence for recurrent Quaternary activity along the eastern side of Bare Mountain. This paper takes exception to the earlier conclusions of Reheis (1988). It concludes that at the Tarantula Canyon site on the Bare Mountain fault zone, the late Quaternary rate of faulting is very low, and the age of the most recent surface faulting event is older than previously reported.

Acknowledgments

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## DETAILED STUDIES AT TARANTULA CANYON

Detailed study of the Bare Mountain fault zone began in 1993. Work has consisted of analysis of aerial photographs, surficial geologic mapping, profiling of suspected fault scarps, description of soil development on geomorphic surfaces at several locations, and analysis of geologic relationships exposed in one trench and one large test pit excavated across the trace of the fault zone. Most of this work has been concentrated in the Tarantula Canyon area. In the following sections, preliminary results from the studies at Tarantula Canyon are presented.

### Mapping

The Bare Mountain fault zone extends from about 5 km north of Tarantula Canyon to the southeastern end of Black Marble, a distance of approximately 17 km (fig. 1). Low-sun-angle (afternoon sun), 1:12,000 scale, vertical aerial photographs, flown by the State of Nevada in 1987, were analyzed in conjunction with field work to identify possible tectonic features, verify previous mapping, and further delineate Quaternary unit characteristics and contacts. Stratigraphic units defined by geomorphic surfaces and possible tectonic features (scarps and lineaments) identified on the aerial photographs and by previous workers were field checked, and preliminary criteria for the subdivision of these stratigraphic units along the range front were established; the basic criteria used were desert pavement and desert varnish development, soils, and topographic position.

The preliminary subdivision of surficial deposits and geomorphic surfaces is shown in table 1. All of the characteristics are readily observable in the field and easily recognized on aerial photographs. These characteristics are similar to those described by Hoover and others (1981), Swadley and others (1984), and Taylor (1986) for the surficial deposits in the region. Numeric ages have been obtained for geomorphic surfaces in the Amargosa Desert and Crater Flat areas (Peterson and others, 1995). Surface characteristics, soil development, and other relative age criteria were examined at these sites in order to further evaluate our age assignments for the Quaternary units along Bare Mountain.

**TABLE 1.--NEAR HERE**

Results of mapping for this study suggest no evidence of Holocene movement on the Bare Mountain fault zone. In addition, surficial evidence for late Quaternary faulting on the Bare Mountain fault zone continuing to the southeast into the Amargosa Desert does not exist. For most of its 17 km length, the Bare Mountain fault zone is marked by a linear contact between alluvium and resistant bedrock. In prospect pits, particularly along the northern part of the range, the fault contact is characterized by abundant and usually sheared carbonate material in alluvium and colluvium of unknown age. Along most of the range, however, the fault typically is concealed by young alluvial fan deposits and colluvium; only in a few areas is displacement of late Quaternary deposits readily recognized. Alluvium estimated to be late to middle Pleistocene in age is broken by what appear to be fault scarps at only three locations along the range front (shown as solid line segments in figure 1). The length of these scarps is 100 to 400 m and the height is 0.5 to 2 m. At several other locations, possible scarps or lineaments are present on middle or early Pleistocene deposits or at what appears to be the contact (fault line scarp?) between older and younger surficial deposits. At or near several localities where late Pleistocene or Holocene activity has been previously reported, deposits that appear to be older than those reported to be faulted apparently are not displaced.

The Tarantula Canyon site is the only location along the Bare Mountain range front where a fault scarp crosses a relatively flat Q2 alluvial fan (fig. 2; see table 1 for generalized unit descriptions, characteristics, and possible ages). The scarp is about 110 m long and up to 2.4 m high and is located above the projection of a carbonate-cemented shear or fault zone on the south side of the wash that was described by Reheis (1988). No scarp is present north of Tarantula Canyon wash apparently because the fault is buried by a slightly younger Q2 or an older Q3 deposit (mapped as Q3? on figure 2). South of Tarantula Canyon wash, the fault is buried by Q4 (early to middle Holocene) and Q3 deposits (late Pleistocene?; fig. 2). The fan with the fault scarp was mapped in this study as a Q2 fan (middle to late Pleistocene). However, in the area of the scarp and adjacent to the range front, the Q2 fan is buried by a thin veneer (< 50 cm) of younger alluvial, colluvial, and eolian material. This veneer is probably equivalent to Q4 deposits and probably is no older than latest Pleistocene.

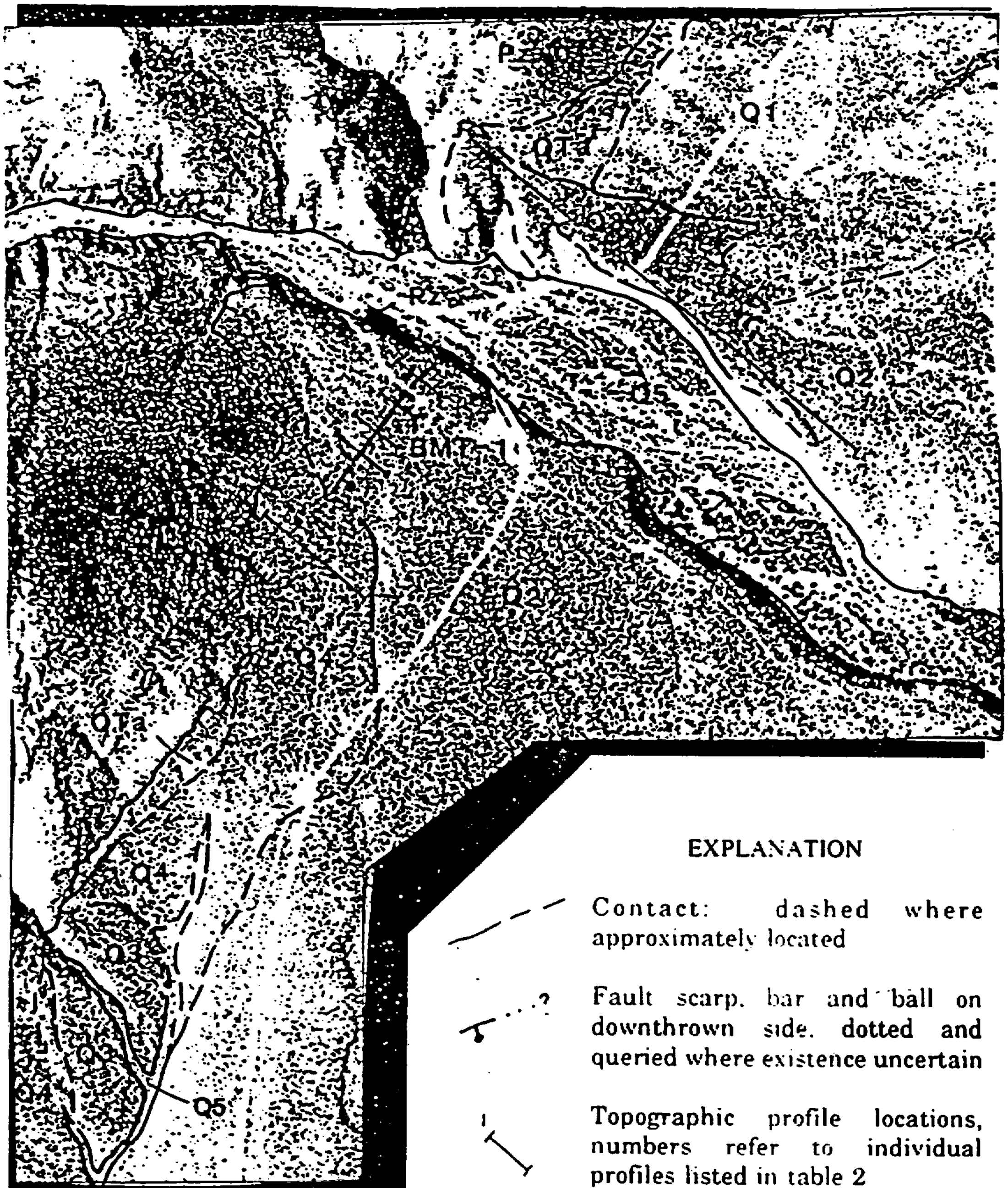
FIGURE 2.--NEAR HERE

## Scarp Profiles

To estimate the age of the fault scarp at Tarantula Canyon, topographic profiles were measured across the scarp. Topographic profiling has been widely used in the western United States to approximate the ages of fault scarps (Wallace, 1977, 1980; Bucknam and Anderson, 1979; Nash, 1980, 1984; Machette and Personius, 1984). The method is based on the assumption that a scarp developed in unconsolidated materials (regardless of its origin) will degrade in a relatively predictable manner. Nash (1986) provides a good review of the technique.

Nine profiles were measured at the mouth of Tarantula Canyon (fig. 2). On the south side of the wash, seven profiles (1-7) were measured across the scarp on the Q2 surface. Further south, one profile (8) was measured on a Q4 surface across a photo-lineament that trends south along strike of the scarp. On the north side of the wash one 220-m-long profile (9) was measured across the projection of the fault zone and scarp from the south side of the wash. Three of the scarp profiles (1, 3, and 5) were measured using a tape, stadia rod, and hand level; the remaining profiles (2, 4, and 6 to 9) were measured using an electronic surveying instrument (total station). A topographic profile

Figure 2. Surficial geologic map of the Tarantula Canyon site.




Base from enlarged low-sun-angle aerial photograph taken in 1987 (State of Nevada. Yucca Mountain Low Sun Angle Project. Photo 4-1a-10)

0 100m

EXPLANATION

Contact: dashed where approximately located

? Fault scarp. bar and ball on downthrown side. dotted and queried where existence uncertain

1 Topographic profile locations, numbers refer to individual profiles listed in table 2

BMT-1 Trench locations

Pz Paleozoic bedrock

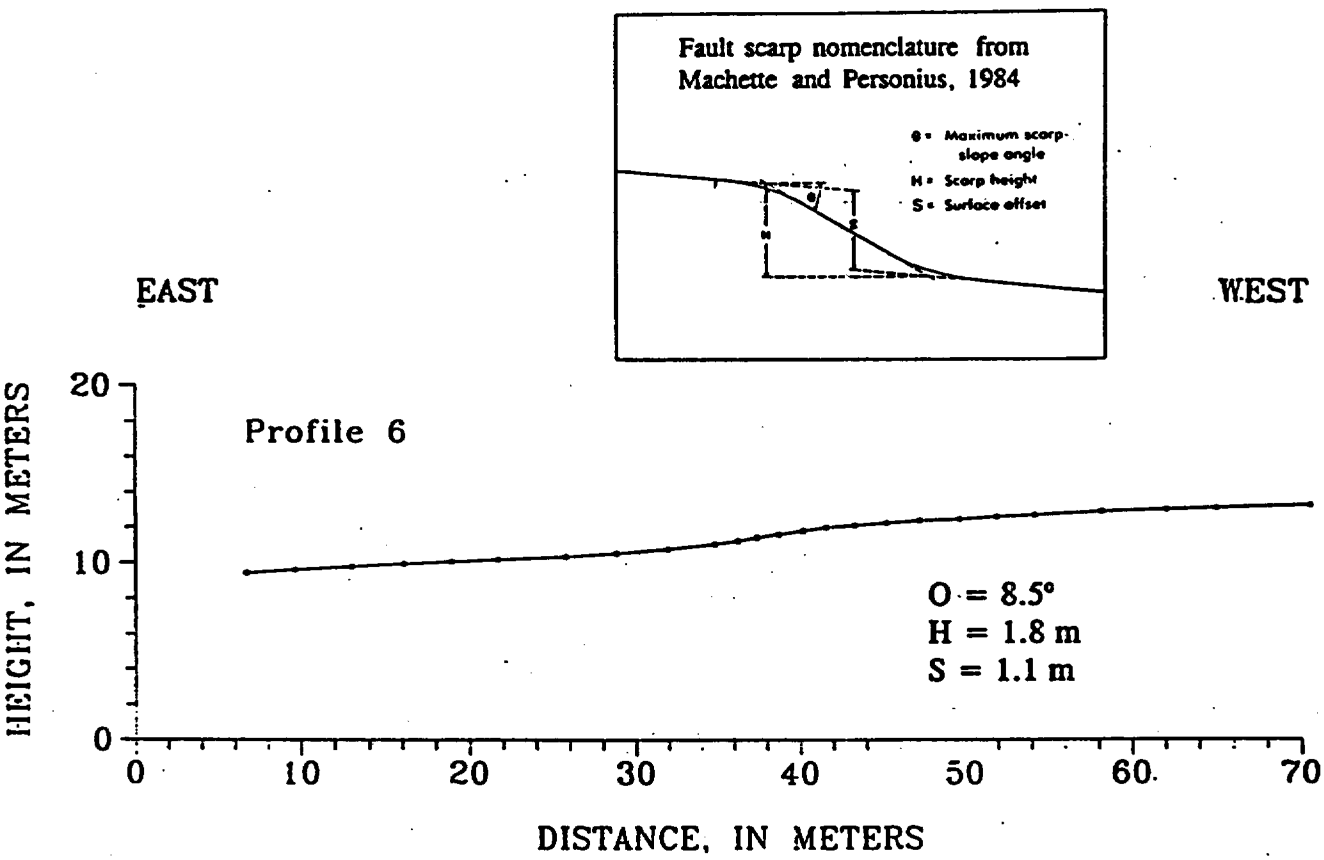
Q1 Surficial units, numbered oldest (Q1) to youngest (Q5). See table 1 for generalized unit descriptions, characteristics, and possible ages across the Bare Mountain fault zone at site 6 is shown in figure 3. An average of seven measurements were made to construct profiles 1, 3, and 5 (56-84 m long) while an average of 25 measurements per profile were made for profiles 2, 4, 6, and 7 (69-85 m long). Measurements of scarp height, surface offset, and maximum scarp-slope angle were then derived from computer-generated plots of these profiles and are listed in table 2. The scarp heights of profiles measured on the Q2 surface (profiles 1-7) range from 1.1 to 2.4 m, surface offsets range from 0.4 to 1.9 m, and maximum scarp-slope angles range from 5.5 to 10 degrees. The absence of compound scarps or obvious bevels in the profiles suggests that the Tarantula Canyon scarp formed during a single event. No scarp is discernible in the profiles measured across the photo-lineament south of Tarantula Canyon or across the projection of the fault and scarp north of the wash (profiles 8 and 9). Both of these profiles were measured on surfaces younger than the Q2 surface containing the scarp.

TABLE 2.--NEAR HERE

FIGURE 3.--NEAR HERE

Maximum scarp-slope angles and scarp heights for profiles across the Bare Mountain fault zone at Tarantula Canyon are plotted, along with those for profiles measured across the Beatty scarp on the west side of Bare Mountain by Anderson (this volume), in figure 4. The age of the Beatty scarp is relatively well constrained by radiocarbon ages

Figure 3. Topographic profile (Profile 6) across the Bare Mountain fault zone at Tarantula Canyon. Location of profile shown on figure 2.



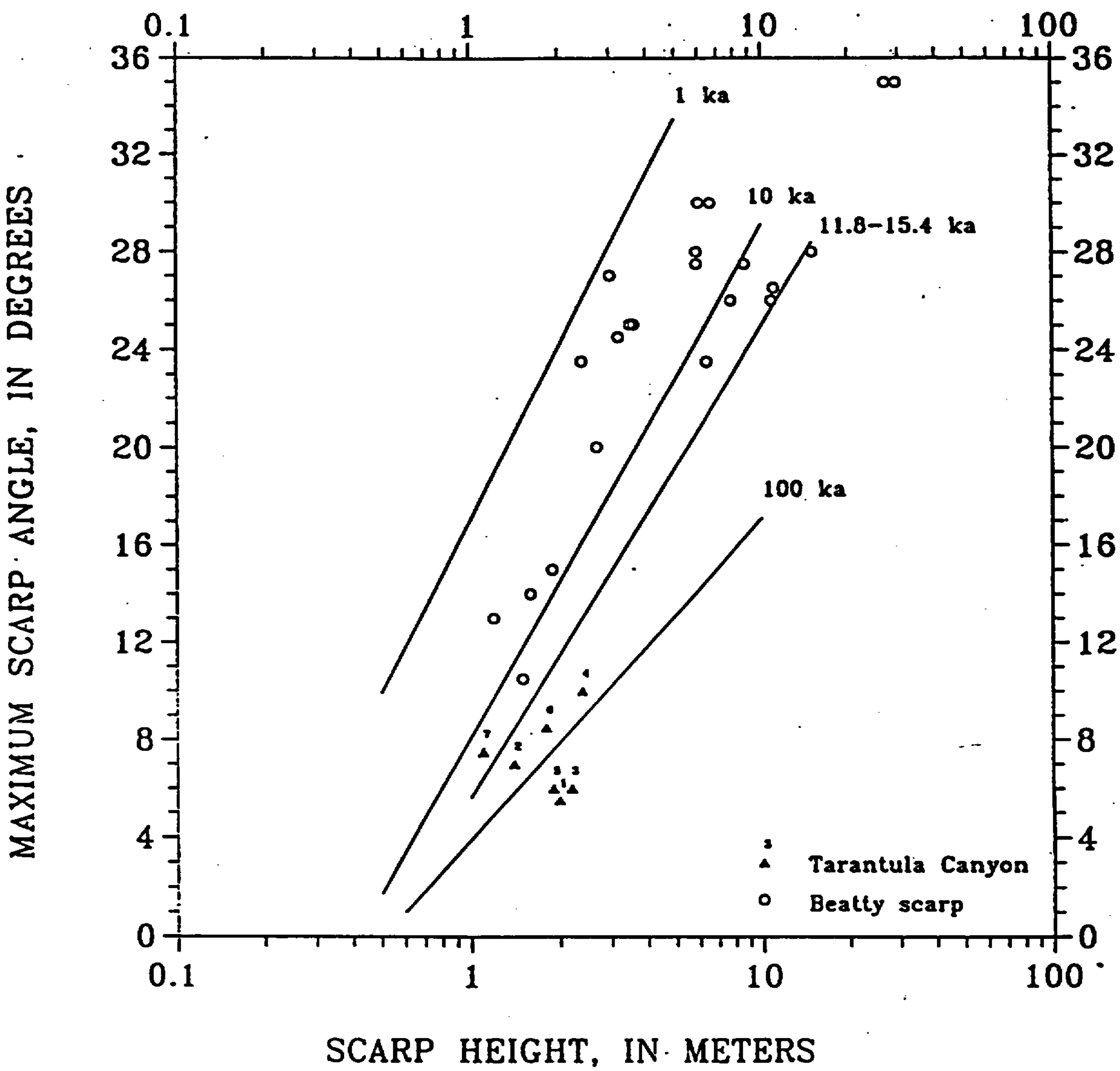
Fault scarp nomenclature from
Machette and Personius, 1984
θ = Maximum scarp-slope angle
H = Scarp height
S = Surface offset
EAST
WEST
Profile 6
O = 8.5°
H = 1.8 m
S = 1.1 m
HEIGHT, IN METERS
DISTANCE, IN METERS
0
10
20
30
40
50
60
70

between 8,300 and 10,000 years (Swadley and others, 1988; Anderson, this volume).

FIGURE 4.--NEAR HERE

The Tarantula Canyon scarp profile data also were compared to a series of regressions developed by Bucknam and Anderson (1979) for scarps of known age in the Great Basin Province (fig. 4). Data derived from the three profiles measured manually (1, 3, and 5) cluster together and plot lower on the graph than do the profiles measured electronically with the total station, even though profiles 1, 3, and 5 were measured along essentially identical transects as profiles 2, 4, and 6, respectively [the Bucknam and Anderson (1979) profiles were measured manually]. This suggests that profiles measured by hand result in profiles with lower maximum scarp-slope angles than do profiles measured by instrument. It is believed that the data collected manually, owing to the fewer number of data points and the greater distance between measurements, produces profiles that are artificially smoothed. Regardless of the slight differences in the scarp data, the Tarantula Canyon scarps are clearly much older than the Beatty scarp based on their dramatically lower maximum scarp-slope angles. In addition, a comparison of the scarp heights and maximum scarp-slope angles for the Tarantula Canyon scarp to the data for the Panguitch fault scarps in southwestern Utah reported by Bucknam and Anderson (1979) suggests that the Tarantula Canyon fault scarp may be about 100,000 years old.

Figure 4. Plot of scarp height versus maximum scarp-slope angle for profiles measured across the Bare Mountain fault zone at Tarantula Canyon (table 2) and the Beatty scarp (Anderson, this volume), compared to regression lines for scarps of known age in the Basin and Range (modified from Bucknam and Anderson, 1979).



MAXIMUM SCARP ANGLE, IN DEGREES
SCARP HEIGHT, IN METERS
0.1
1
10
100
0
4
8
12
16
20
24
28
32
36
1 ka
10 ka
11.8–15.4 ka
100 ka
Tarantula Canyon
Beatty scarp

Trench BMT-1

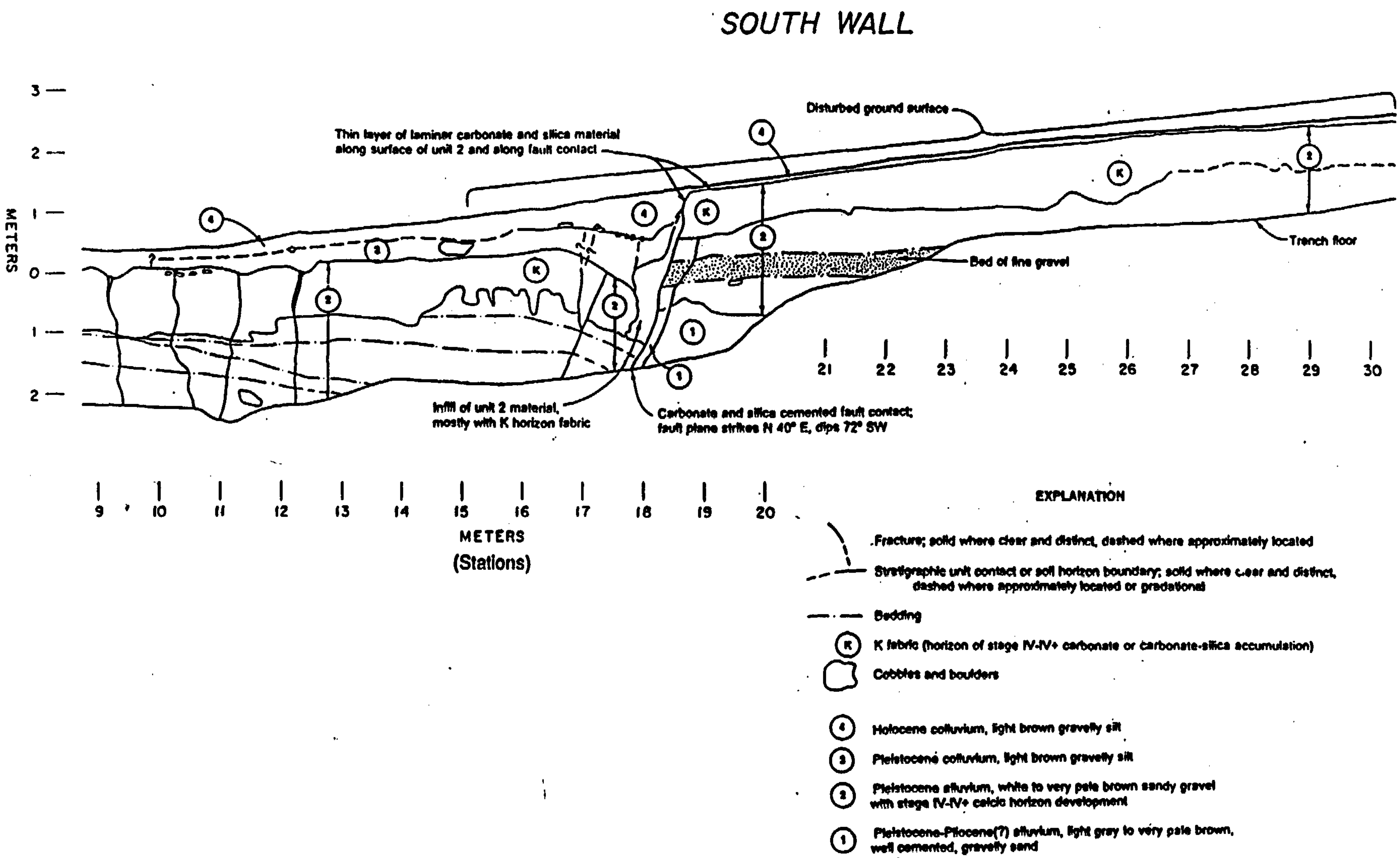
In September 1993, a 43-m-long trench (BMT-1) was excavated across the scarp at Tarantula Canyon (fig. 1 and 2). A portion of the trench log for BMT-1 is presented in figure 5.

FIGURE 5.--NEAR HERE

Unit 1, the lowermost unit recognized, is known to be present only in the west-central portion of the trench (the top of unit 1 may be present in the floor of the trench at station 11). This fairly resistant sandstone and conglomerate unit is probably equivalent to the QTa unit of Swadley and Parrish (1988), based on its degree of induration and relationship to overlying units. A clear unconformity separates unit 1 from unit 2.

Unit 2 is a crudely stratified sandy gravel. A well-developed calcic horizon (stage IV-IV+), 0.7-1.5 m thick, is present in the upper part of this unit (fig. 5; soil profile nomenclature from Birkeland, 1984). Unit 3, a gravelly silt, is preserved only in the eastern part of the trench (between stations 9 and 18), and it appears to be the argillic horizon (Bt) associated with the calcic horizon formed in unit 2. While unit 2 is a fluvial gravel deposited on the Tarantula Canyon alluvial fan, unit 3 consists of both finer grained fluvial deposits and eolian material that was deposited following abandonment and stabilization of the fan surface. Although differing from each other both texturally

Figure 5. Portion of trench log for south wall of BMT-1, Tarantula Canyon site.


SOUTH WALL
METERS
3
2
1
0
1
2
Disturbed ground surface
Thin layer of laminar carbonate and silica material along surface of unit 2 and along fault contact
Trench floor
Bed of fine gravel
Infill of unit 2 material, mostly with K horizon fabric
Carbonate and silica cemented fault contact; fault plane strikes N 40° E, dips 72° SW
21 22 23 24 25 26 27 28 29 30
9 10 11 12 13 14 15 16 17 18 19 20
METERS
(Stations)
EXPLANATION
Fracture; solid where clear and distinct, dashed where approximately located
Stratigraphic unit contact or soil horizon boundary; solid where clear and distinct, dashed where approximately located or gradational
Bedding
K fabric (horizon of stage IV-IV+ carbonate or carbonate-silica accumulation)
Cobbles and boulders
Holocene colluvium, light brown gravelly silt
Pleistocene colluvium, light brown gravelly silt
Pleistocene alluvium, white to very pale brown sandy gravel with stage IV-IV+ calcic horizon development
Pleistocene-Pliocene(?) alluvium, light gray to very pale brown, well cemented, gravelly sand

and by their mode of deposition, units 2 and 3 appear genetically related by soil development suggesting that their ages are similar.

Trench units 2 and 3 are considered the equivalent of map unit Q2, and the well-developed pedogenic carbonate (stage IV-IV+) present in the upper part of trench unit 2 suggests some antiquity for these deposits (Bull, 1991, chap. 2). As map unit Q2 is probably equivalent to unit Q2c of Swadley and others (1984), which has an estimated age of 270-800 ka, or to the Early Black Cones unit of Peterson and others (1995), which has an estimated age of >159->201 ka (table 1), these age estimates apply also to trench units 2 and 3. Thus, trench units 2 and 3 are at least 100,000 years old, and probably much older.

The uppermost and youngest unit in the trench, unit 4, is a massive, gravelly silt considered the equivalent of map unit Q2. An archeological survey of the trench site prior to excavation recovered artifacts reportedly 7,000 years old from this unit (Paul Buck, Desert Research Institute, oral commun., 1993). Based on the degree of soil profile development (no textural B horizon, stage I-II carbonate morphology), the maximum age for trench unit 4 is probably latest Pleistocene.

A prominent fault is exposed in the trench between stations 18 and 19, coincident with the base of the surface scarp (fig. 5). The fault clearly displaces trench units 1, 2, and 3. Although unit 4 thickens east of the fault on the south wall of BMT-1, it appears to be unfaulted. The thickening appears to be the result of pre-unit 4 erosion at the base of the fault scarp. The interpretation that unit 3 is the argillic (Bt) horizon associated with unit 2 is supported by the presence of shearing extending into unit 3 from unit 2, which in turn is overlain by unsheared unit 4. Unit 3 also thickens where it overlies the fissure fill (unit 2?) adjacent to the fault (station 18) and is present only in the eastern part of the trench where unit 2 has been backtilted. No buried soil horizons, stone lines, texturally different infill units, or colluvial wedges are present that would indicate multiple displacements of unit 2 and 3. The fissure fill composed of unit 2 material suggests only a single surface-faulting event. Backtilting and fissure filling like that observed between stations 9 and 13 are features commonly observed in trench exposures across Quaternary normal faults and are associated with historic normal faulting earthquakes in the Basin and Range (Nelson, 1992; McCalpin and others, 1994). Vertical separation across unit 2 also is uniform across the fault without progressive increase downward in the trench. These observations indicate that the Tarantula Canyon site has experienced only one surface-rupturing event since deposition of units 2 and 3.

The backtilting of units 2 and 3 on the hanging wall is particularly pronounced between stations 16 and 18, but is present in the trench eastward to at least station 5 (not shown in figure 5). To compensate for the backtilting, vertical separation resulting from the faulting event was measured by projecting the nearly flat surface of the calcic horizon from both ends of the trench to the fault. Total vertical separation of unit 2 across the fault is 1.5 m. No indications of lateral or oblique slip were observed in the trench. Slickensides with near-vertical rakes on bedrock and on silica-carbonate cemented material along the fault at other locations along the Bare Mountain fault zone indicate that past displacement on the fault has been nearly pure normal.

## DISCUSSION

Although study of the Bare Mountain fault zone is still in progress, several conclusions can be drawn from the work conducted to date. Unit 4 is the only unfaulted deposit in trench BMT-1. Therefore, the age of this unit provides the minimum age of the most recent faulting event at Tarantula Canyon. However, evidence both within the trench and from surrounding geologic relationships indicates that the age of this faulting event is much greater than the probable maximum age of unit 4 (latest Pleistocene). First, a distinct laminar carbonate layer, 0.5-1.5cm thick, is present at the contact between units 2 and 4 on the footwall block (stations 18-30+ in figure 5). This laminar carbonate layer seemingly postdates the most recent faulting event as it drapes the 72°-dipping fault plane, coating cobbles and pebbles along the fault surface, and extends nearly to the bottom of the trench, becoming thinner with depth. The carbonate layer retains its laminar character and is not brecciated, fractured, or striated as would be expected if the layer had been faulted. This laminar carbonate is not present between trench stations 8 and 18 where unit 2 has been backtilted and where unit 3 is preserved. A similar carbonate layer occurs in the eastern part of the trench up to station 8 and alternately truncates and infills fractures in unit 2. The fractures generally occur only in the hanging wall and are believed to be the result of the faulting event that offset unit 2, backtilted units 2 and 3, and produced the scarp. Thus, it appears that development of the 0.5- to 1.5-cm-thick laminar carbonate layer, followed by deposition of unit 4, more precisely constrains the age of faulting and suggests an age of at least several tens of thousands of years.

An additional line of evidence that supports an age of some antiquity for the faulting event is the topographic profiles of the scarp. As discussed previously, the profile data indicate that the scarp at Tarantula Canyon is significantly older than the Beatty scarp and could have an age of about 100 ka. Also, no bevels or compound scarps are present on the scarp profiles, and surface offsets measured from the profiles at the trench site (table 2) are consistent with the separation of strata measured in the trench and indicate only one surface-rupturing event.

Finally, the deposit mapped north of Tarantula Canyon Wash (Q3? in figure 2) is a small alluvial fan that originated from a side drainage and was deposited on the Q2 alluvium. This Q3? deposit postdates the surface-faulting event exposed in the trench and expressed by the fault scarp, as no fault scarp is present on the ground or in the topographic profile (profile 9) across this surface. The alluvial fan deposit that buries the fault has a well-developed soil with argillic and stage II+ carbonate horizons, suggesting it is at least several tens of thousands of years old, certainly much older than trench unit 4.

## EARTHQUAKE HAZARD

Generally, estimates of fault-slip rates and recurrence intervals are based on evidence for more than a single faulting event. However, the age of displaced deposits and the amount of slip exhibited at the Tarantula Canyon site do provide some age constraints on the late Quaternary activity of the Bare Mountain fault zone. Assuming a minimum age of 100 ka for trench unit 2 and given the vertical separation of 1.5 m, a late Quaternary slip rate of 0.015 mm/yr for the Bare Mountain fault zone at Tarantula Canyon is estimated. Considering that unit 2 is probably much older than 100 ka, a slip rate much less than 0.015 mm/yr is possible. Likewise, if one accepts that unit 2 is at least 100,000 years old and has been faulted only once, then the recurrence interval for surface-rupturing earthquakes on the Bare Mountain fault zone could be on the order of 100,000 years or more.

Fracturing of unit 1, which is truncated by unit 2, suggests an earlier, pre-unit 2 faulting event or events. In addition, stratigraphic relationships of the carbonate deposits filling some fractures in unit 2 suggest the possibility that unit 2 may have been fractured either before or after the 1.5-m surface-faulting event. If a fracturing event or events occurred, no measurable displacement has been noted. Thus, if an earthquake other than the 1.5-m surface-rupturing event occurred on the Bare Mountain fault and produced some of the fractures in unit 2, the magnitude of that earthquake was below the threshold of surface rupture. In the Basin and Range Province, this threshold is believed to be about $M_w$ 6.5 (dePolo, 1994). From the work of dePolo and Wells and Coppersmith (1994), it follows that the earthquake magnitude for the event that produced the 1.5 m of displacement was probably greater than $M_w$ 6.5.

## CONCLUSIONS

On the basis of work to date, clear evidence of Holocene or latest Pleistocene faulting along the Bare Mountain fault zone is not present. The activity rate of the Bare Mountain fault zone appears to be very low, about 0.015 mm/yr, and the age of the most recent surface-faulting event is significantly older than previously thought. Topographic profile data suggest that the scarp associated with the most recent faulting event at Tarantula Canyon could be about 100,000 years old. The fault scarp profiles and preliminary results from the trench also indicate that a single surface-faulting event, characterized by approximately 1.5 m of displacement, has occurred at the Tarantula Canyon site in the late Quaternary.

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Table 1. Surface characteristics utilized for the preliminary subdivision of surficial deposits and geomorphic surfaces along the Bare Mountain fault zone along with estimated age [The characteristics listed in this table may not depict the age of underlying deposits or reflect sedimentological properties related to its depositional history]

| Unit | Age | Soil | Pavement | Desert Varnish | Topography |
|---|---|---|---|---|---|
| Q5 | Historic-Late Holocene | May have weak A/C profile; $A_v$ < 1 cm thick | Generally absent; local incipient packing and horizontal orientation of clasts | None | High-relief bar and swale |
| Q4 | Holocene-Late Pleistocene | Thin $A_v$ horizon (several cm thick) | Poorly packed | Weakly developed on quartzite clasts | Bar and swale is distinct but subdued; bars are coarser grained than adjacent swales. |
| Q3 | Late to Mid-Pleistocene | Moderately developed $A_v$ horizon (5-10 cm thick) | Moderately to well packed on bars | Moderately developed on quartzite clasts | Bar and swale subdued; transition between bars and swales diffuse |
| Q2 | Mid- Pleistocene | Well developed $A_v$ horizon (< 10 cm thick) | Moderately to well packed pavement; $CaCO_3$ rinds and fragments common on surface clasts | Well developed on surface clasts | Little or no evidence of bar and swale |
| Q1 | Mid-to Early Pleistocene | $A_v$ horizon may or may not be present depending on topographic position | Moderately to well packed; pavement is being degraded; underlying petro-calcic horizon is locally exposed | Moderately to well developed on some surface clasts; sometimes lacking | Surface is dissected; small rills and drainages common |
| QTa | Pleistocene-Pliocene | Gravel completely cemented with carbonate or silica, or both; in places veneered by younger unconsolidated deposits | None | None | No original surfaces preserved |

Table 2. Bare Mountain fault zone profile data, Tarantula Canyon site

[Scarp height, surface offset, and maximum scarp angle measured from computer generated plots of the profiles. Profiles 1, 3, and 5 measured with hand level and stadia rod, other profiles measured with electronic surveying instrument (total station). No scarp observable in profiles 8 and 9. Profile 3 measured along axis of trench BMT-1 before excavation. Profile 4 measured immediately south of BMT-1. See figure 2 for approximate profile locations]

| Profile | Scarp height (meters) | Surface offset (meters) | Maximum scarp-slope angle (degrees) |
|---|---|---|---|
| 1 | 1.9 | 1.5 | 6.0 |
| 2 | 1.4 | 0.9 | 7.0 |
| 3 | 2.2 | 1.5 | 6.0 |
| 4 | 2.4 | 1.9 | 10.0 |
| 5 | 2.0 | 1.6 | 5.5 |
| 6 | 1.8 | 1.1 | 8.5 |
| 7 | 1.1 | 0.4 | 7.5 |
| 8 | - | - | - |
| 9 | - | - | - |