Chapter 6

Results of Paleoseismic Investigations on the Ghost Dance Fault

By Emily M. Taylor, Christopher M. Menges, and David C. Buesch

Contents

Abstract

The Ghost Dance Fault is a north-striking, steeply west dipping normal fault that lies close to and partly intersects the proposed repository site for the storage of high-level radioactive wastes at Yucca Mountain. The fault, which is as much as 7 km long, is expressed as a complex zone of subparallel and branching strands that narrows and decreases in cumulative offset northward. Topographic profiles across bedrock traces of the fault have none of the pronounced steps or scarps typical of Quaternary surface ruptures elsewhere in the Yucca Mountain area.

Six trenches were excavated in Quaternary deposits that overlie bedrock projections of the Ghost Dance Fault—one on Whale Back Ridge, one at the base of Antler Ridge, three in Split Wash, and one in Drill Hole Wash. Three of these trenches exposed fractured bedrock, which in places is draped and (or) infilled by secondary carbonate and opaline silica ranging in age from 10±0.1 to 392±29 ka (U-series analysis). The origin of a single fracture in the dense carbonate and opaline silica deposit in the trench on Whale Back Ridge is problematic. With the possible exception of this fracture, no evidence of Quaternary movement was observed on the Ghost Dance Fault.

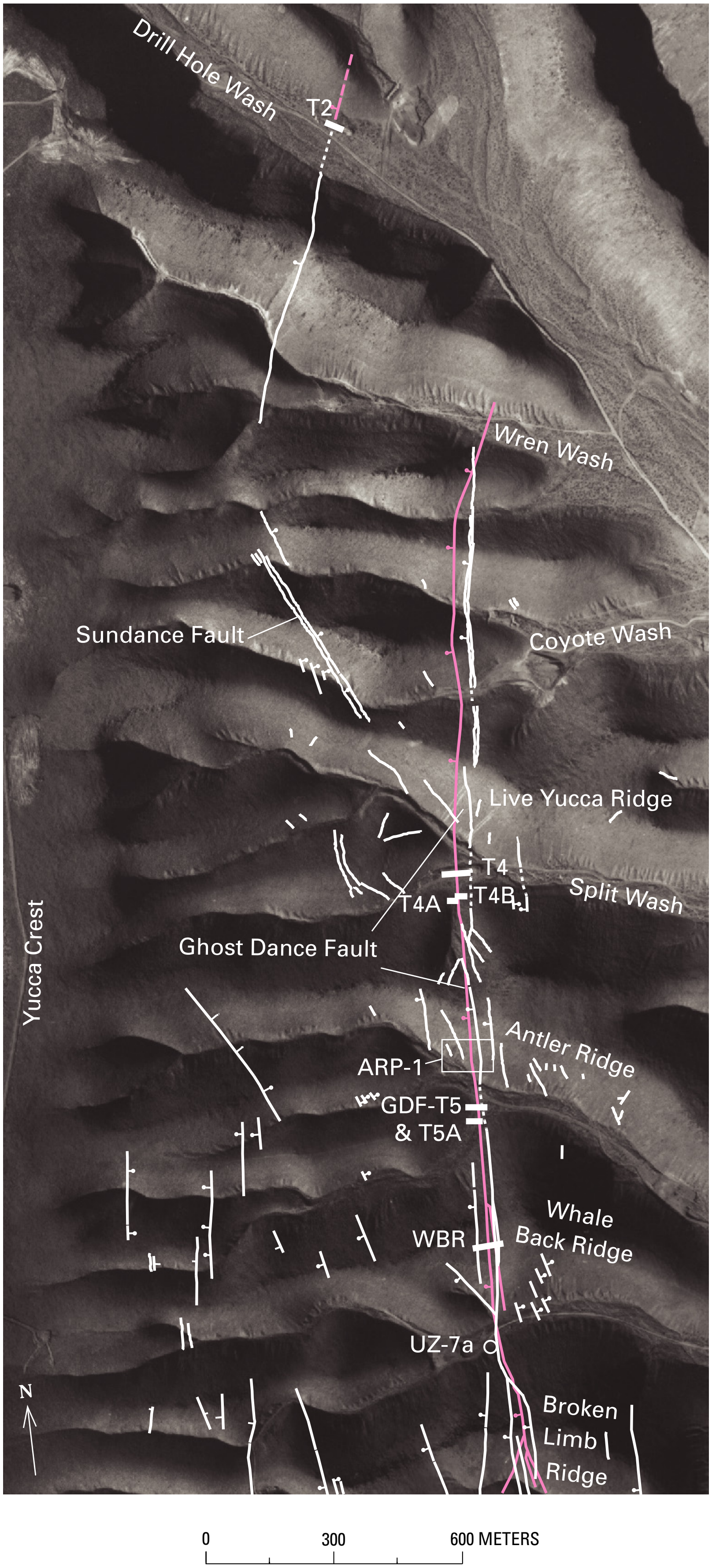
Introduction

This chapter summarizes the results of investigations of possible seismic hazards associated with the Ghost Dance Fault, a north-striking fault that lies close to, and partly intersects, the proposed repository site for the storage of high-level radioactive wastes at Yucca Mountain (figs. 1, 2; Day and others, 1998b). We emphasize the geologic relations exposed in trenches excavated in Quaternary deposits that overlie projections of the fault (figs. 2, 21). One or both walls of these trenches were mapped in detail to define the physical stratigraphy and the soils developed on the Quaternary deposits and to determine whether these deposits were faulted. For the purposes of this report, we describe the trenches on Whale Back Ridge (trench WBR), in Split Wash (trenches T4, T4A), and in Drill Hole Wash (trench T2).

Detailed logs of mapped trench walls were prepared by using a total-station theodolite. Stratigraphic units were described, and samples were collected for laboratory analysis of particle-size distribution, secondary-carbonate content, and pH. The soil nomenclature used to describe the soils and surficial deposits conforms to that of Birkeland (1984). Color names for bedrock and lithologic units are those on the Munsell Soil Color Chart (Munsell Color Co., Inc., 1992). Samples were also collected for U-series analysis of opaline silica and of pedogenic carbonate where material was available for study.

Other methods used to assess Quaternary activity on the Ghost Dance Fault include (1) a comparative analysis of the geomorphic expression of the fault, relative to the northern section of the Solitario Canyon Fault (fig. 2; see chap. 7); (2) exposure dating of the faultline escarpment formed along the fault; (3) descriptive analysis of fault characteristics in outcrop; and (4) analog studies of total bedrock displacements relative to other faults at Yucca Mountain. Though less direct than trenching investigations, these techniques provide useful information regarding possible Quaternary displacements.

The Sundance Fault, a small auxiliary fault that trends northwest across the northern part of the proposed repository site from near the Ghost Dance Fault trace (Potter and others,



EXPLANATION

Faults—Dashed where approximate, dotted where concealed, bar and ball on down-thrown side; white, Day, and others (1998b); red, Scott and Bonk (1984)

Drill hole

Trench

Figure 21. East slope of Yucca Mountain, southwestern Nevada (figs. 1, 2), showing locations of topographic features, Ghost Dance and Sundance Fault traces, and trenches. Fault traces modified from maps of Scott and Bonk (1984) and Day and others (1998b).

1999), was not trenched. The Sundance Fault, which is exposed in bedrock for about 750 m, was examined at the surface in conjunction with a detailed study of the Ghost Dance Fault, but no evidence was observed to indicate Quaternary activity. The Sundance Fault is briefly discussed in chapter 3.

Characteristics of the Ghost Dance Fault

Geomorphic Expression

The Ghost Dance Fault zone cuts transversely across a series of bedrock ridges (fig. 21) created by incision of central Yucca Mountain by the eastward-draining tributaries of Fortymile Wash (fig. 2). The fault zone traverses bedrock across narrow to broadly rounded ridgecrests and side slopes thinly mantled with colluvium (fig. 22) but is buried beneath colluvial and alluvial fill in the narrow floors of the intervening washes.

Little geomorphic expression of the Ghost Dance Fault zone is evident. Both the main fault trace and ancillary faults are exposed discontinuously on hillslopes in subdued bedrock outcrops interspersed among rubbly colluvial talus and scree. Only small segments of the fault zone are expressed as linear gullies, topographic steps or scarps, or saddles or other topographic depressions that would produce recognizable lineaments on aerial photographs. No scarps or other geomorphic expressions of the fault were observed in the valley floors. For these reasons, the Ghost Dance Fault must be located by careful geologic mapping of displaced lithologic contacts or aligned outcrops of brecciated rock cemented by white secondary carbonate.

On ridgecrests, the Ghost Dance Fault generally is near the base of west-sloping 5- to 15-m-high bedrock scarps that commonly reflect displacements of resistant bedrock units within the Miocene Tiva Canyon Tuff across the fault zone. Although such features superficially resemble large composite fault scarps, careful examination indicated that they are more likely faultline scarps formed primarily by differential erosion of bedrock units with varying degrees of resistance to weathering which are juxtaposed along the fault. Topographic profiles across the escarpments indicate broadly concave to linear forms with no pronounced steps or scarps that would reflect late Quaternary displacement.

Four slope profiles were measured across the Ghost Dance Fault—two on Whale Back Ridge, one on Antler Ridge, and one across the buried fault trace exposed at trench

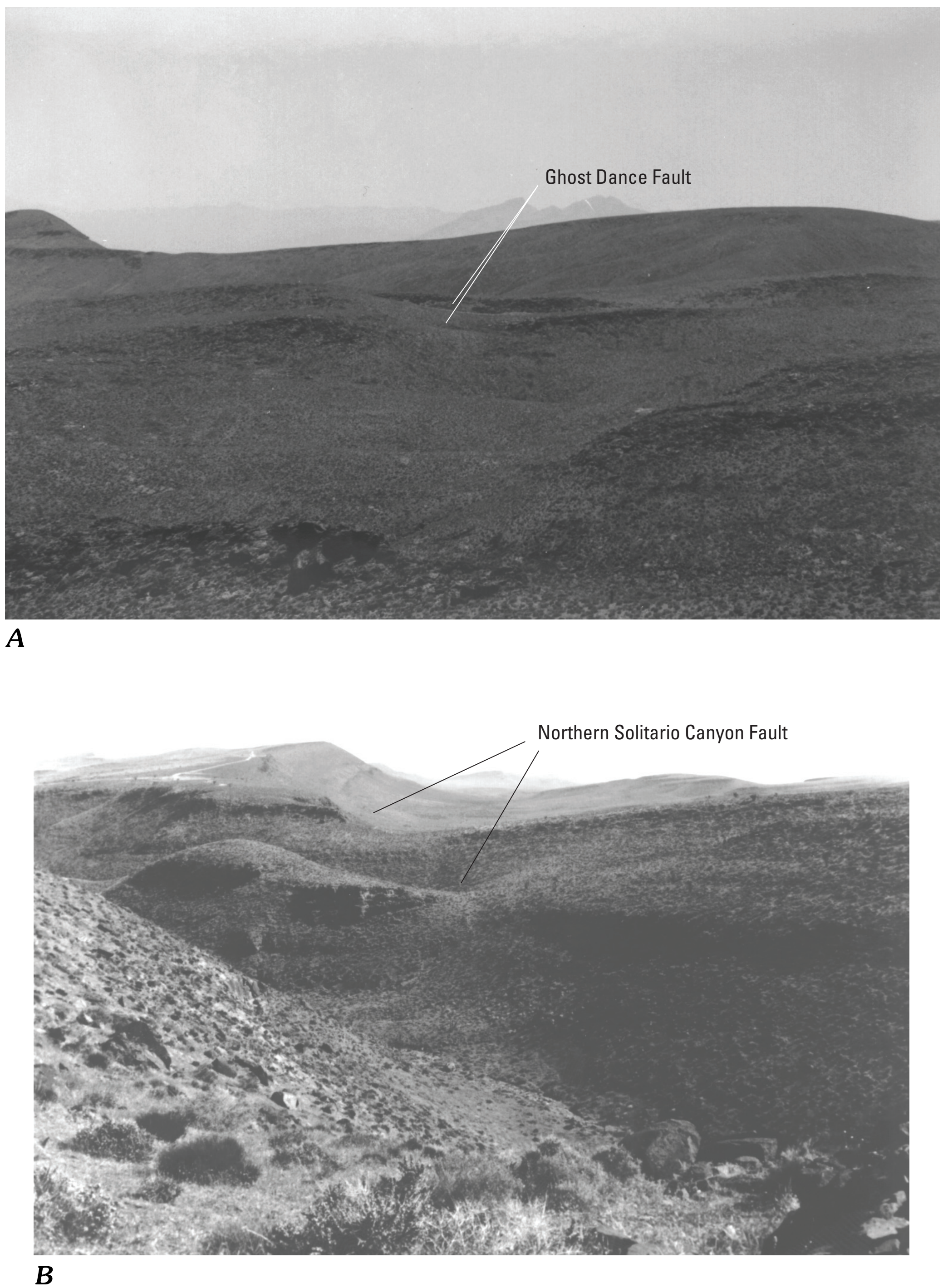


Figure 22. Ghost Dance and Northern Solitario Canyon Faults along slopes of Yucca Mountain, southwestern Nevada (figs. 1, 2, 21). *A*, Ghost Dance Fault exposed in Whale Back and Antler Ridges (in middle distance). Note poor physiographic expression of fault on sideslopes and gently sloping, west-facing faultline escarpments on ridgecrests. *B*, Northern Solitario Canyon Fault at northwest corner of Yucca Mountain. Fault is marked by conspicuous notches in saddles on ridgecrests and by lineaments or gullies on canyon walls.

T4 in Split Wash (figs. 21, 23, 24). Bedrock units were sampled along the Whale Back and Antler Ridge profiles for analyses of the cosmogenic radionuclides ^{10}Be and ^{26}Al that could be used to infer surface-erosion rates, and to estimate the minimum duration of burial by fault-scarp colluvium (fig. 24). Preliminary analytical data provided by C.D. Harrington (oral commun., 1995) indicate that erosion has been minimal and that the surface has been stable for at least 700–1,100 k.y. The whole-rock cosmogenic-^{10}Be estimated ages of samples collected at various localities along the Whale Back Ridge and Antler Ridge profiles are noted in figure 24. These estimated ages are uncorrected for erosion and so are only

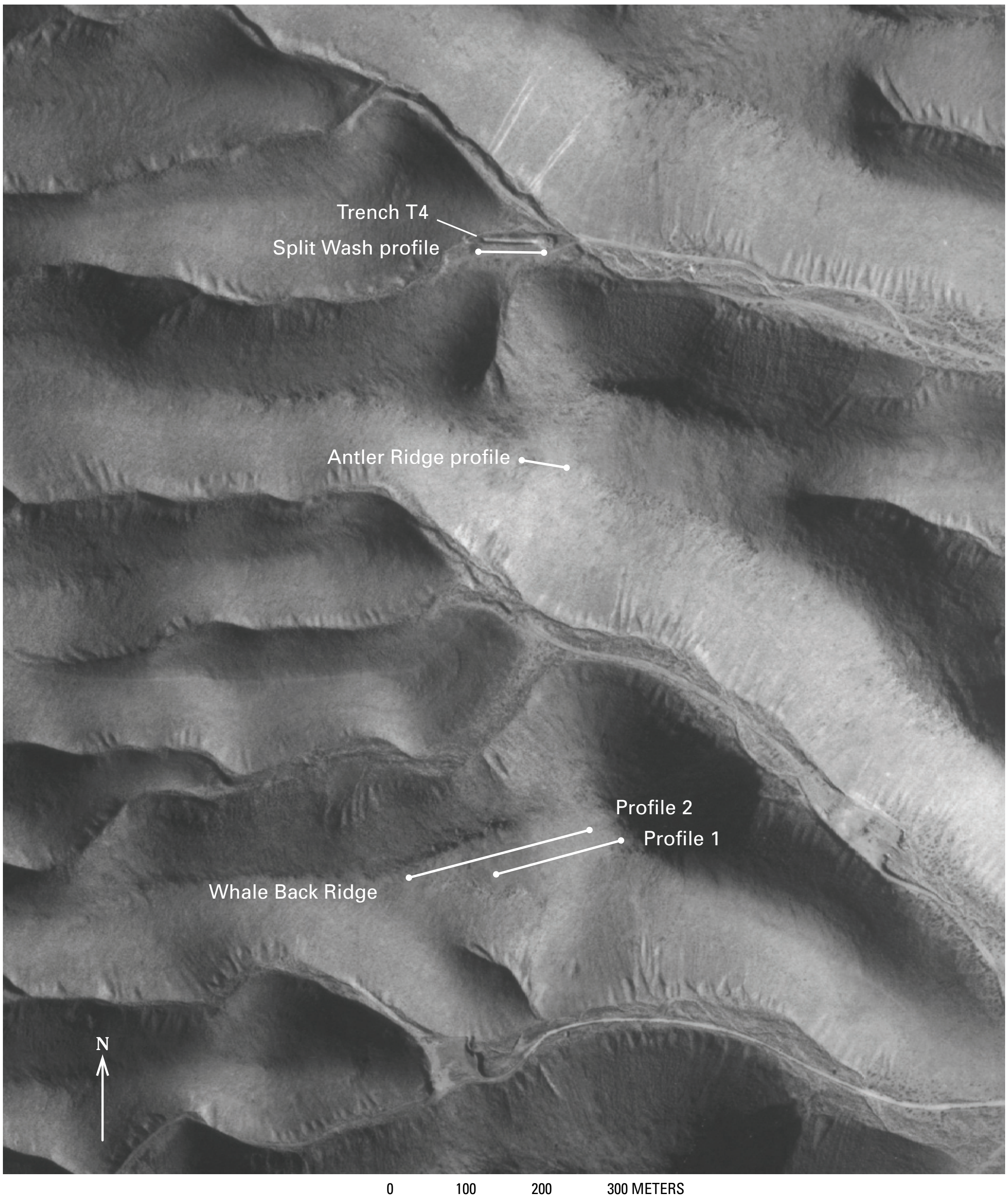


Figure 23. Whale Back and Antler Ridges in Split Wash along slopes of Yucca Mountain, southwestern Nevada (figs. 1, 2, 21), showing locations of topographic profiles across the Ghost Dance Fault.

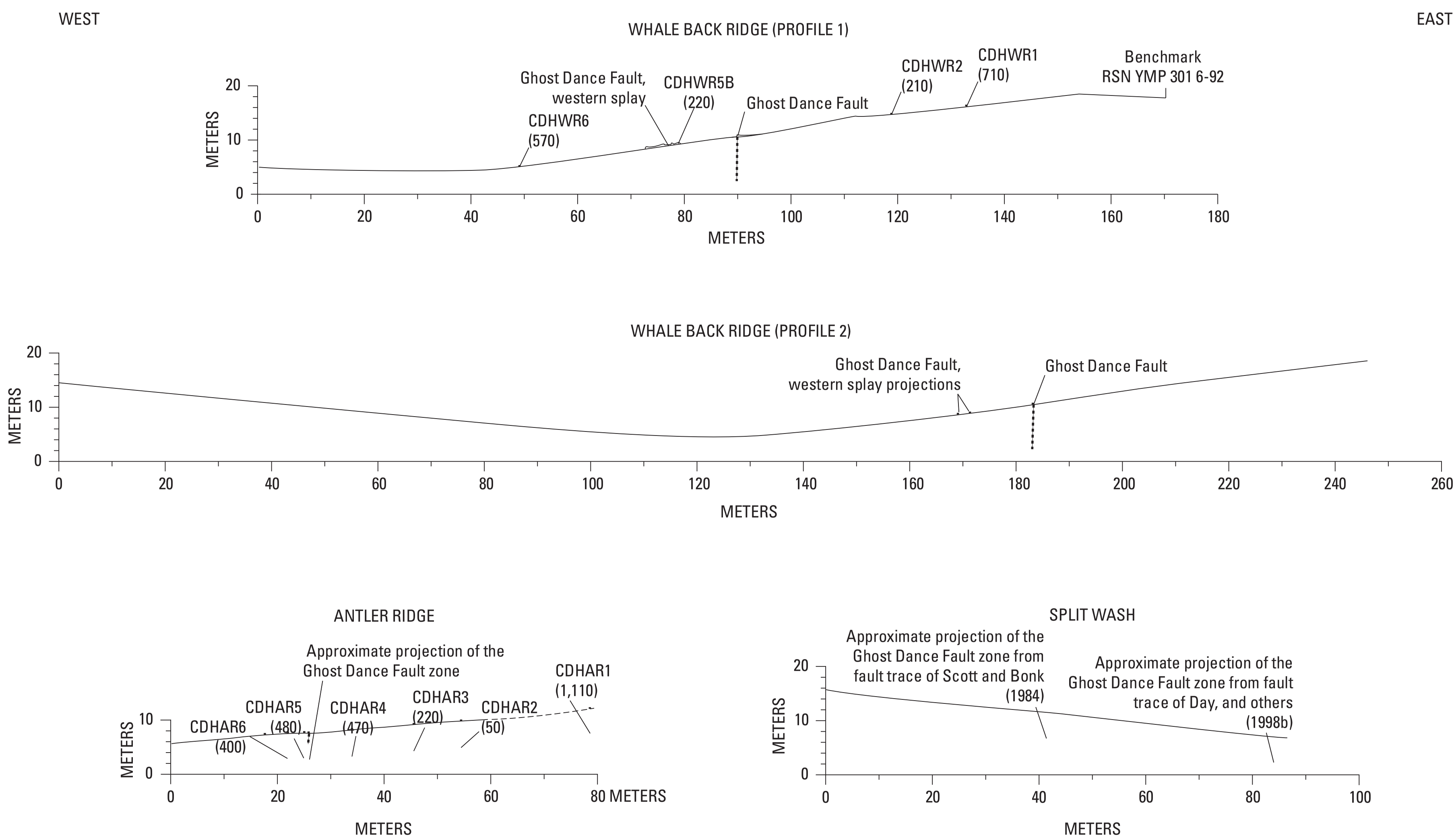


Figure 24. Topographic profiles (see fig. 23) across the Ghost Dance Fault on Whale Back and Antler Ridges and in Split Wash along slopes of Yucca Mountain, southwestern Nevada (figs. 1, 2, 21), showing locations of bedrock samples (arrows) collected for determination of whole-rock cosmogenic ^{10}Be estimated ages (numbers in parentheses, in thousands of years).

minimum limiting ages. The production rate (of ^{10}Be atoms in the rock) used in the analyses, normalized for sea level and high latitude, is 5.8 atoms/g per year, with an uncertainty of ±25 percent.

The Ghost Dance Fault varies in its position with respect to the top or bottom of the scarp faces. On Whaleback Ridge, for example, the fault is in about the middle of the scarp face, whereas on Antler Ridge it is near the base, indicating that appreciable erosion of the scarp has taken place since middle Miocene time. Also, the lowest elevations on ridgecrests generally do not correspond to the Ghost Dance Fault zone but, instead, are in saddles to the west of the fault zone where erosion has breached resistant bedrock units capping ridgecrests on the downthrown block. This relation likewise indicates erosional modification of an old fault-generated dissected landscape dating from middle Miocene time.

The slight geomorphic expression of the Ghost Dance fault as described above contrasts sharply with that of other faults in the Yucca Mountain area (for example, the nearby Solitario Canyon Fault; see chap. 7) that have undergone repeated late Quaternary displacements indicating little, if any, Quaternary activity on the Ghost Dance Fault. As discussed below, the fault also displays no evidence of displacement of any of the Quaternary deposits exposed above the fault zone in trench excavations.

A

B

Figure 25. Exposures of the Ghost Dance Fault in the Yucca Mountain area, southwestern Nevada (figs. 1, 2, 21). *A*, Ghost Dance Fault zone in a cleared bedrock exposure at Antler Ridge; main fault zone is defined by carbonate-cemented breccia below hammer. *B*, Main strand of the Ghost Dance Fault exposed in south wall of drillhole UZ–7a pad; east (left) side of fault zone is carbonate cemented, in contrast to loose breccia zone on west (right) side below gully.

Outcrop Characteristics

The Ghost Dance Fault is well exposed in an artificially cleared hillslope exposure of bedrock at the base of Antler Ridge (fig. 23), where the fault is characterized by a 0.5- to 2-m-wide zone of carbonate-cemented rock breccia cut by a dense network of north- to northwest-trending fractures (fig. 25*A*). Some of the rock fragments appear to be colluvial in origin, but at least some brecciation probably is related to fault deformation. This breccia zone is tightly cemented by carbonate, and some of the rock fragments are supported by a carbonate matrix. The breccia lacks a strong planar-shear fabric and commonly displays no strong preferential orientation subparallel to the fault. Only a few thin (<5 cm wide) planar laminae of carbonate or opaline silica are along the main fault traces. Similar types of oriented cemented breccia are also observed in most natural exposures of the Ghost Dance Fault.

The southern section of the Ghost Dance Fault is well exposed in a 60-m-wide zone in the artificially cleared southern wall of the drill-hole UZ–7a pad, which is located in the valley between Whale Back and Broken Limb Ridges (fig. 25*B*). The fault zone there contains a primary subvertical fault at the eastern margin of the zone and a secondary steeply east dipping fault 42 m to the west. Highly fractured and broken rocks in the hanging wall have been subdivided into four zones on the basis of the pattern and density of fractures (S. Williams-Stroud, written commun., 1995). The main fault zone contains a 2- to 4-m-wide zone of brecciated rock in a fine-grained matrix. The western part of this brecciated zone, near the footwall, is cemented by accumulations of secondary carbonate and silica that thin and weaken downsection through the exposure (fig. 25*B*). Unoriented fault breccia is loose and uncemented in a narrow zone at the east margin of the main fault zone; the absence of cementation there may reflect the position of a gully above the fault, which may direct infiltration and cause carbonate to be flushed through this part of the zone. Coarse carbonate laminae impart a local subvertical-planar fabric in the cemented part of the fault zone.

Fault Characteristics in Trench Exposures

Trench on Whale Back Ridge

The trench on Whale Back Ridge (WBR, figs. 2, 21), which was excavated across the main Ghost Dance Fault trace, exposes Quaternary slopewash colluvium and fine-grained eolian deposits overlying the Tiva Canyon Tuff (pl. 4). The exposed section of the main fault (sta. 13 m, fig. 26) displays some of the largest offsets of bedrock units; the strike and dip of the fault are N. 10° W. and 83° SW., respectively. The moderately welded nonlithophysal subzone of the crystal-rich member of the Tiva Canyon Tuff is locally brecciated (stas. 13.5–27 m). Clasts in this breccia, some as much as 1 m in diameter, are rotated to dips of 10°–30° E. The matrix consists of comminuted rock fragments from the moderately welded, nonlithophysal subzone. Although minor mixing of clasts from different bedrock units occurs within this subzone, the breccia is essentially monolithologic. Adjacent to the Ghost Dance Fault is a narrow (<1 m wide) brecciated zone that contains blocks from the upper part of the nonlithophysal crystal-transition subzone or the lower part of the mixed-pumice subzone. The breccia probably represents clasts stranded along adjacent fault slices.

Two faults (stas. 25, 27 m, fig. 26) form the west boundary of the main brecciated zone associated with the main Ghost Dance Fault zone (fig. 26). The first fault (sta. 25 m), which strikes N. 3° E. and dips 85° SE., separates a relatively unbroken, but largely covered, block of tuff of the moderately welded, nonlithophysal subzone of the crystal-rich member of the Tiva Canyon Tuff on the east from brecciated rocks of the same subzone on the west. The second fault (sta. 27 m), which strikes N. 18° W. and dips steeply west, locally has associated fractures that dip about 65° NW. This fault separates brecciated rocks of the moderately welded, nonlithophysal subzone on the east from partially fractured rocks of the vitric, densely welded subzone on the west.

Most of the trench floor (stas. 30–70 m, fig. 26) is covered by excavated spoil material, but numerous fractures, many filled with secondary carbonate, are exposed. Although no well-developed fracture pattern is evident in this part of the trench, many fractures strike from N. 5° E. to N. 25° W. Some fractures (sta. 68 m) were tentatively identified by Day and others (1998b) as representing one of the western strands of the Ghost Dance Fault zone.

Lithostratigraphic relations within the Tiva Canyon Tuff (pl. 4) are well established by detailed stratigraphic studies

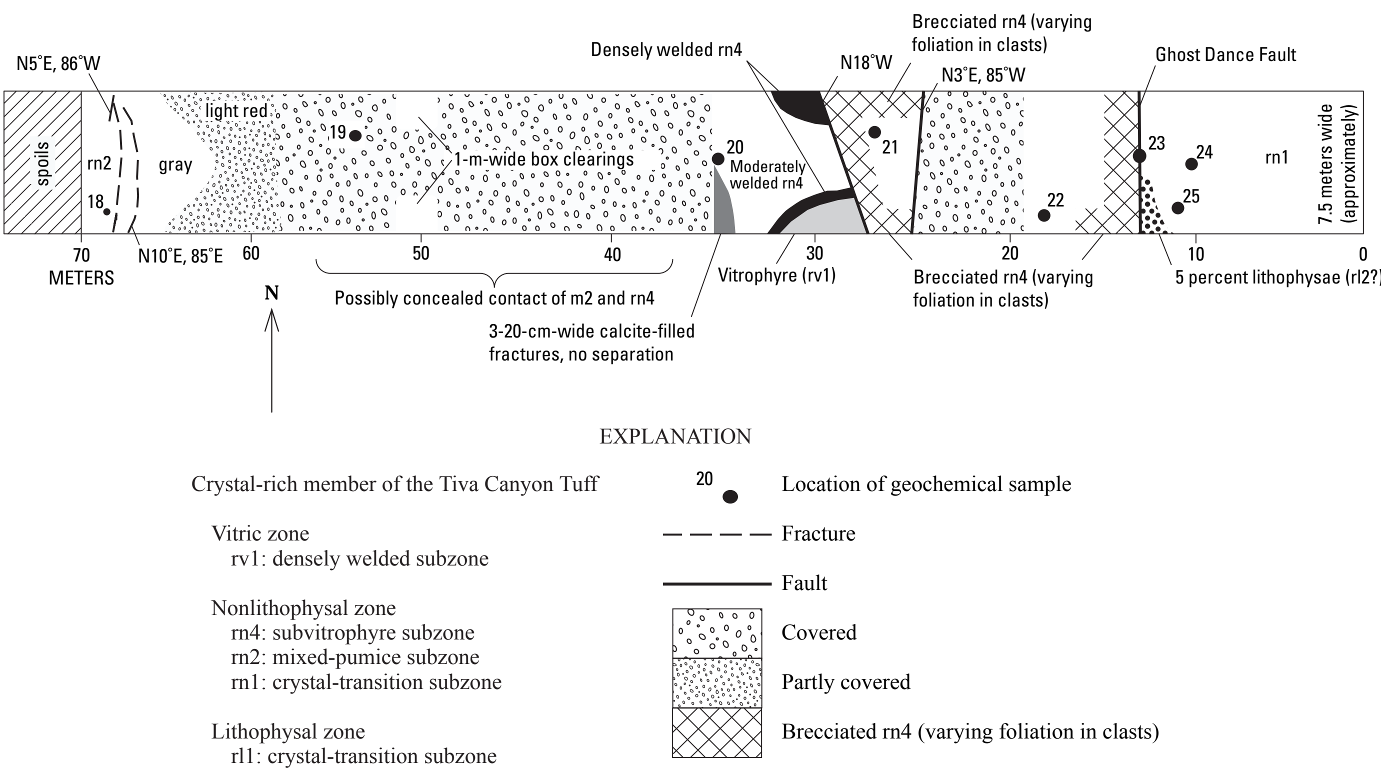


Figure 26. Simplified cross section showing lithostratigraphy and structural features in trench WBR across the Ghost Dance Fault in the Yucca Mountain area, southwestern Nevada (figs. 1, 2, 21).

(for example, Buesch and others, 1996), geologic mapping (for example, Day and others, 1998 a, b), and petrographic and geochemical studies (Peterman and Futa, 1996). Strata of the upper crystal-rich member of the formation, represented by parts of the vitric, nonlithophysal, and lithophysal zones (some of which are faulted out) that are exposed in the trench (see figs. 26, 27; table 13), dip 8°–11° E. The Ghost Dance Fault juxtaposes slightly broken rocks of the nonlithophysal and lithophysal crystal-transition subzones (units rn1 and rl1, respectively, fig. 27) with brecciated rocks of the moderately welded, nonlithophysal subzone (rn4), but the stratigraphic separation is difficult to measure directly because rocks in the hanging wall do not correlate with those in the footwall. However, one means for closely estimating the fault offset is by chemical analyses of the bedrock units involved, based on comparisons with analytical data from a measured surface sec-

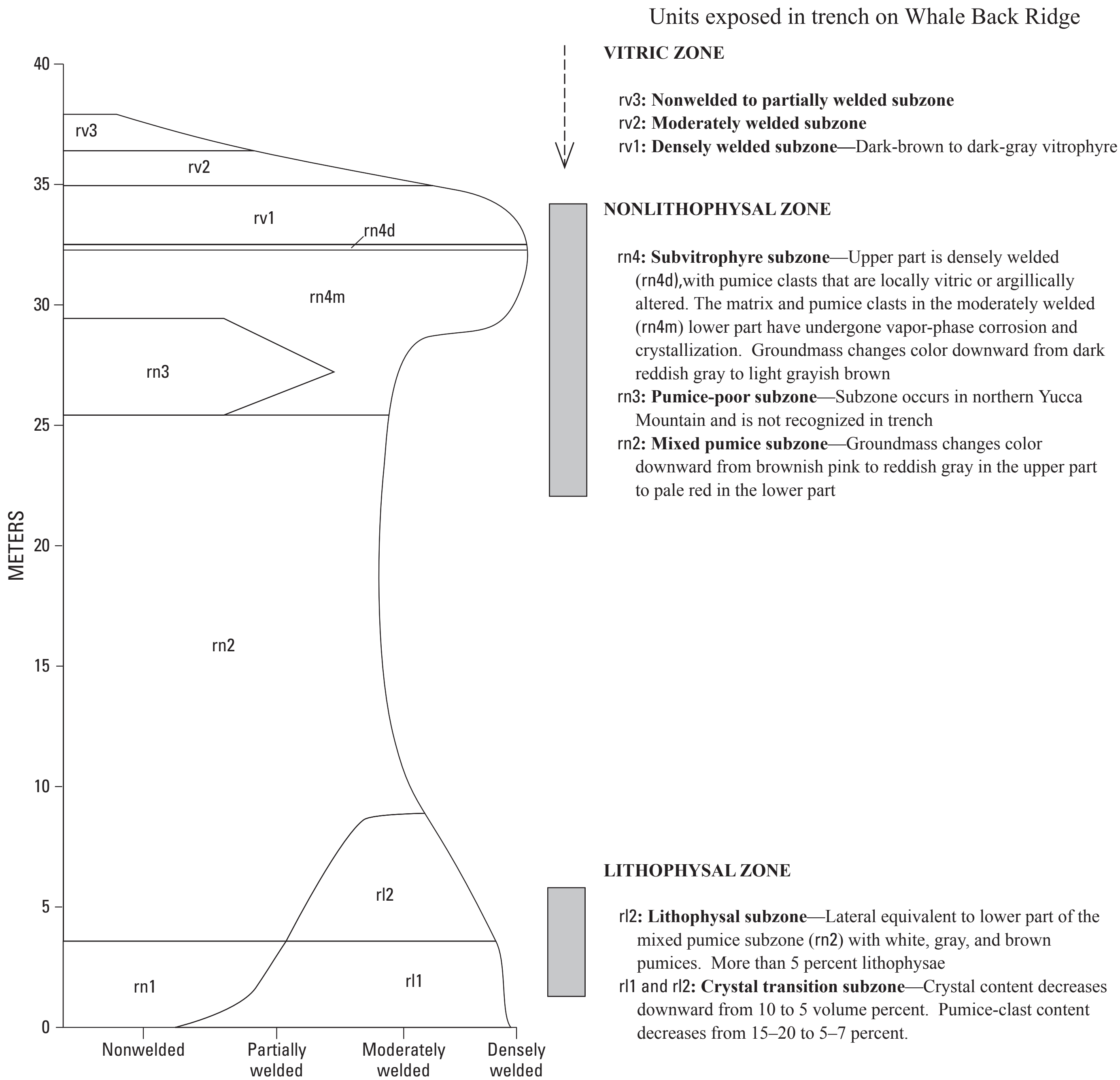


Figure 27. Generalized stratigraphic column of crystal-rich member of the Tiva Canyon Tuff in the Yucca Mountain area, southwestern Nevada (figs. 1, 2).

tion 200 m east of trench WBR (figs. 2, 21) and from borehole NRG#3 (approx 2.5 km northeast of the trench, fig. 8) that show systematic changes in cation concentrations with stratigraphic position, especially within the crystal-rich member of the Tiva Canyon Tuff (Peterman and Futa, 1996).

For the present study, several bedrock units were sampled from both the footwall and hanging-wall blocks of the Ghost Dance Fault in trench WBR (fig. 26), and analyzed for Ti and Zr contents (two of several elements useful for the purpose of correlation). The data from all three sources (measured surface section, borehole NRG#3, and trench WBR) were then plotted for comparison (figs. 28, 29). Analytical data used for determining the stratigraphic positions of the faulted units in trench WBR were from (1) sample 20 (fig. 26), located in the hanging-wall block about 1 m below the vitrophyre in the densely welded subzone (unit rv1, figs. 26, 27); and (2) sample 25,

Table 13. Lithostratigraphic features in bedrock units of the Tiva Canyon Tuff exposed in trench WBR across the Ghost Dance Fault in the Yucca Mountain area, southwestern Nevada.

[See figures 1 and 2 for locations. Nomenclature of Buesch and others (1996); colors from Munsell Soil Color Charts (Munsell Color Co., Inc., 1992). Units: rn1/rl1, crystal-transition zone of nonlithophysal zone; rn2, mixed-pumice subzone of nonlithophysal zone; rn4m, moderately welded lower part of subvitrophyre subzone of nonlithophysal zone; rn4d, densely welded upper part of subvitrophyre subzone of nonlithophysal zone; rv1, densely welded subzone of vitric zone. Central, feature observed in central part of trench (2N, 2S, pl. 4); east, feature observed in eastern part of trench (3N, 3S, pl. 4). n.o., none observed]

Feature	Unit of the Tiva Canyon Tuff				
	rn1/rl1	rn2	rn4m	rn4d	rv1
Phenocryst content (vol pct):					
Feldspar	5–7	8–12	10–12	12–15	12–15
Biotite	<1	<<1	<1–2	1	0
Pyroxene	n.o.	n.o.	Trace	Rare	Trace
Matrix/groundmass:					
Vitric/devitrified	Devitrified	Devitrified	Devitrified (incipiently devitrified below uppermost 1 m).	Devitrified	Vitric.
Color	5R 6/2	5R 6/1.5	7.5R 6/2 (upper part), 5YR 7/3 (lower part)	5R 5/1	N3
Zone of welding	Dense	Moderate	Moderate	Dense	Dense.
Macroscopic whole-rock porosity (pct).	<5	5	15–25	5	0
Lithophysae	Rare in rn1, 5 vol pct in rl1	0	0	0	0
Pumice clasts:					
Content (vol pct)	10–20	15–20	10–20	3–5	3–5
Vitric/devitrified	Devitrified	Devitrified	Devitrified	Vitric/ devitrified.	Vitric.
Color	N7	6–8% 5YR 5/3, 6–8% N7, 3–4% N3	N7–5YR 7/1, N3–5YR 3/1, 10YR 7/4–4/3, 10R 4/3	N7	N6
Maximum size (width× height) (cm).	15.5×3.0	11.2×3.0	29.5×8.5 (central), 2.8×1.0 (east)	3.5×2.6	6.7×2.9
Average maximum diameter (cm).[1]	8.8	7.3	12.1 (central), 2.6 (east)	3.0	4.4
Aspect ratio[2]	3.6–5.4	2.4–3.7	1.6–5.0 (central), 2.8–6.5 (east)	1.3–4.2	2.0–3.7
Vapor-phase corrosion	Partly	Partly	Partly	Partly	n.o.
Spherulite development	n.o.	n.o.	Trace of spherulitic intergrowths.	n.o.	Rare.
Lithic clasts:					
Content (vol pct)	None in rn1, rare in rl1	Trace	1–2	Rare	2–3
Vitric/devitrified	Devitrified	Devitrified	Devitrified	Devitrified	Devitrified.
Color	5YR 6/3	N5	N5	N7	10YR 4/2
Size (cm)	<4	<5	<5	<2	<1

[1]Average length of five largest pumice clasts. (Locally, fewer than five clasts were measured.)
[2]Ratio of longest axis to shortest axis of largest pumice clast.

located in the footwall block in the crystal-transition subzone (rn1). With respect to Ti content and comparisons with the measured surface section, sample 20 is projected to station 122.5 m and sample 25 to station 92.5 m, indicating a separation of 30 m (fig. 28). Comparison of Zr contents between the trench samples and the measured surface section show a separation of 26 m (118.5 m for sample 20 and 92.5 m for sample 25, fig. 29). The apparent difference in separation (30 versus 26 m) probably relates to uncertainties in extrapolation of the data. If the analytical results are projected to the curves for borehole NRG#3, the stratigraphic separations indicated by the Ti and Zr contents are 33 and 34 m, respectively (figs. 28,

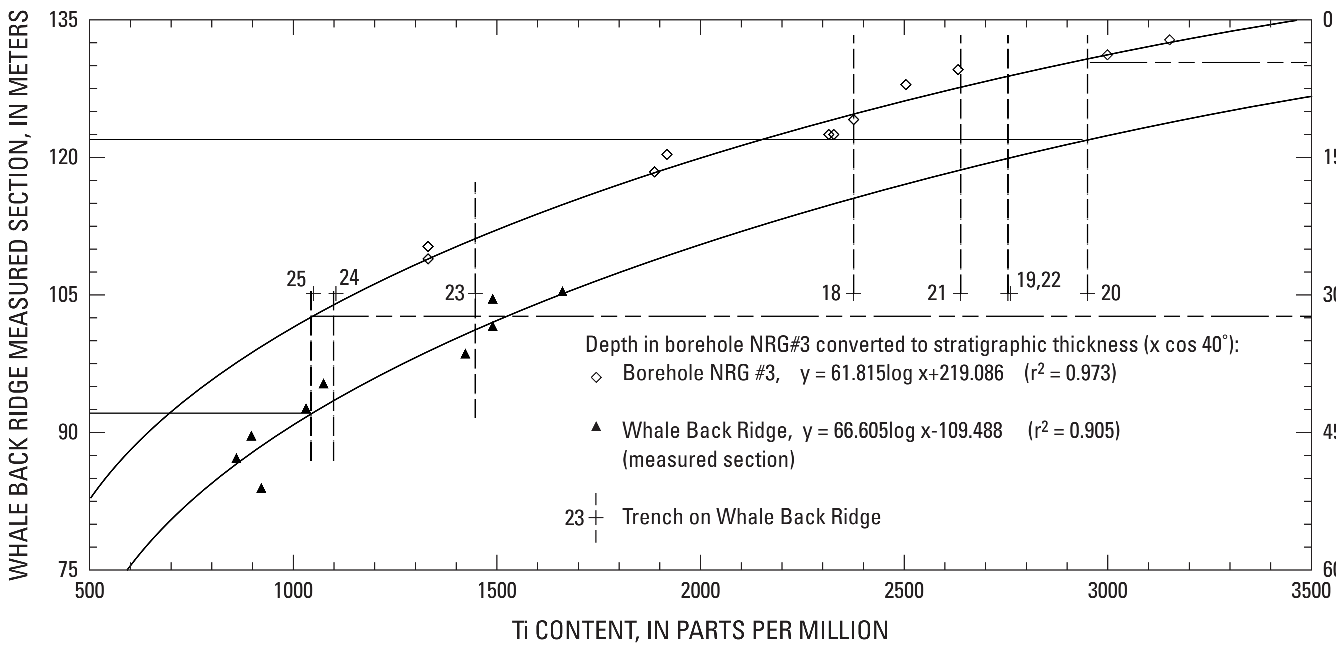


Figure 28. Ti contents in samples of Tiva Canyon Tuff collected from outcrops on Whale Back Ridge, core from borehole NRG#1, and exposures in trench WBR across the Ghost Dance Fault in the Yucca Mountain area, southwestern Nevada (figs. 1, 2, 21).

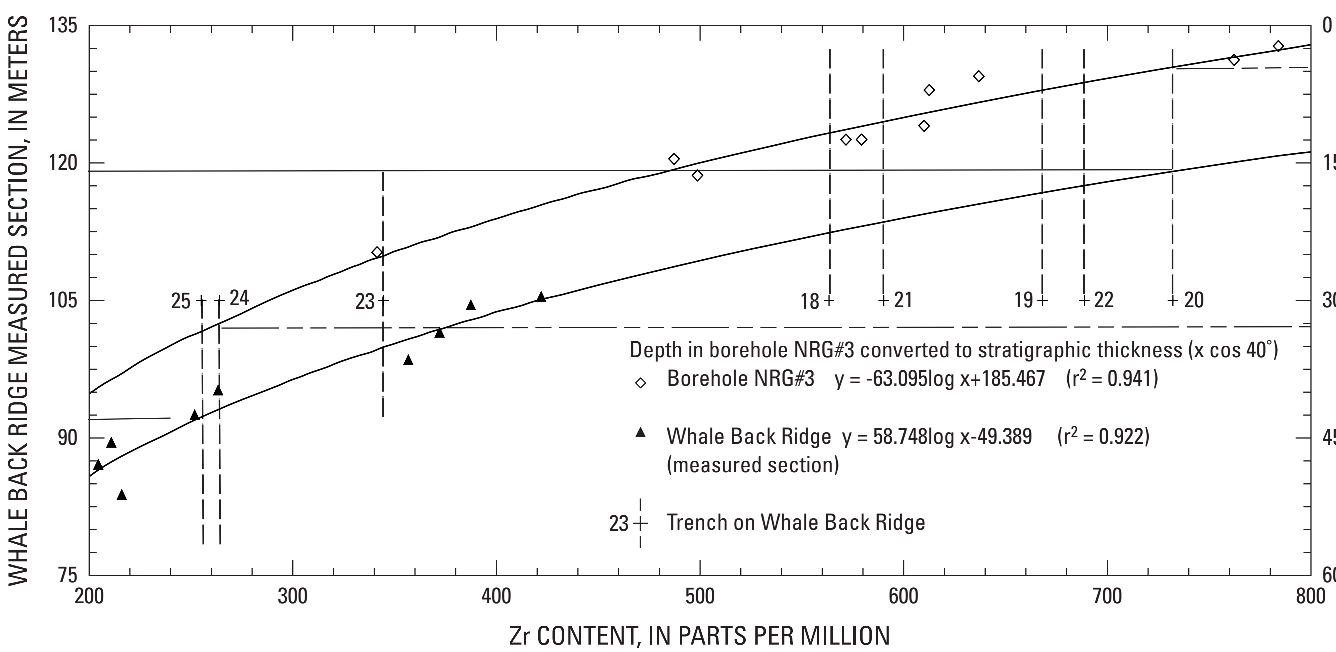


Figure 29. Zr contents in samples of Tiva Canyon Tuff collected from outcrops on Whale Back Ridge, core from borehole NRG#1, and exposures in trench WBR across the Ghost Dance Fault in the Yucca Mountain area, southwestern Nevada (figs. 1, 2, 21).

29). On the basis of surface geologic mapping, Day and others (1998b) showed 27 m of down-to-the-west displacement on the Ghost Dance Fault at this site.

In trench WBR, uppermost Pleistocene to lower Holocene slopewash colluvium and fine-grained eolian deposits (unit 1, Av+Bw, pl. 4) overlie faulted and fractured bedrock of the Tiva Canyon Tuff (table 14). In some places, the bedrock is draped with secondary carbonate and opaline silica (unit 2, 2Kqm); in other places (exposure segments 2N, 2S, pl. 4), the colluvium is separated from the dense carbonate and opaline silica that drapes the bedrock by a laminar carbonate (unit 2, 2K) of pedogenic origin. No offset of either the slopewash colluvium

Key to unit and soil descriptions for tables 14, 16, 18, and 19.

[See table 3 for soil-horizon terminology; prefixed numbers refer to differentiated soil horizons with increasing depth, and numbers within or following these designations refer to further differentiation of properties within an individual soil horizon]

Soil-horizon boundary

Distinctness		*Topography*	
va	very abrupt	s	smooth
a	abrupt	w	wavy
c	clear	i	irregular
g	gradual	b	broken
d	diffuse		

Soil texture

co	coarse	S	sand	SCL	sandy clay loam
f	fine	LS	loamy sand	CL	clay loam
vf	very fine	SL	sandy loam	SiCL	silty clay loam
		L	loam	SC	sandy clay
		SiL	silt loam	C	clay
		Si	silt	SiC	silty clay

Soil structure

Grade		*Size*		*Type*	
m	massive	vf	very fine (very thin)	gr	granular
sg	single grained	f	fine (thin)	pl	platy
1	weak	m	medium	pr	prismatic
2	moderate	co	coarse (thick)	cpr	columnar
3	strong	vco	very coarse (very thick)	abk	angular blocky
				sbk	subangular blocky

Note: If two structures, listed as primary (1°) and secondary (2°).

Soil consistence

Dry		*Moist*		*Wet*	
lo	loose	lo	loose	so, po	nonsticky or nonplastic
so	soft	vfr	very friable	ss, ps	slightly sticky or slightly plastic
sh	slightly hard	fr	friable	s, p	sticky or plastic
h	hard	fi	firm	vs, vp	very sticky or very plastic
vh	very hard	vfi	very firm		
eh	extremely hard	efi	extremely firm		

Clay films

Frequency		*Thickness*		*Morphology*	
vf	very few	n	thin	pf	ped-face coating
1	few	mk	moderately thick	br	bridging grains
2	common	k	thick	po	pore linings
3	many			gr	gravel coats

$CaCO_3$ effervescence on matrix		**Grain size**	
0	none in matrix	bd	boulders (>26 cm)
diss	disseminated	cb	cobbles (6–26 cm)
e	slightly; bubbles are readily observed	pb	pebbles (4–60 mm)
es	strongly; bubbles form a low foam	gr	gravel (2–4 mm)
ev	violently; thick foam “jumps” up		

Table 14. Quaternary stratigraphy exposed in trench WBR across the Ghost Dance Fault in the Yucca Mountain area, southwestern Nevada.

[See figures 1 and 2 for locations]

Lithologic unit, soil horizon, boundary (sample)	Depth or thickness (cm)	Dry color (<2 mm and/or ped face)	Moist color (<2 mm and/or ped face)	Texture	Structure	Soil consistence (dry, moist, wet)	Clay films	Secondary carbonate (gravel and disseminated)	Gravel content (volume percent)	Parent material and lithology	Miscellaneous (roots, pores, SiO_2, oxidation, concretions, salts)
1, Av+Bw; g, w	10–50	10YR 7/3	10YR 4/3	SCL	2 f-m sbk	sh; s, p	0	e0	10–15 bd cb gr, few pb, bd ≤51 cm	Eolian fines, slopewash, nonsorted, angular clasts, nonbedded, nonimbricated, matrix supported.	Dominated by eolian fines; reworked clasts with carbonate rinds present.
2, 2K; a, w	20–55	10YR 8/O	10YR 8/2	?	vco pl, 2° m	eh; so, po	0	IV, ev	5–10 cb pb gr	Nonsorted, angular clasts, nonbedded, nonimbricated, matrix supported.	Erosional unconformity; horizon is weathered from horizon below.
2, 2Kqm; c, s; (U-series samples 110494 GDF1–1 through GDF1–3)	15–40	10YR 8/2	10YR 7/3	?	m	eh; so, po	0	e	5–7 bd cb pb gr, bd ≤54 cm	Slopewash colluvium, angular clasts, nonimbricated, matrix supported.	Ubiquitous dense secondary carbonate and opaline silica precipitated on bedrock near surface.
(U-series sample 110494–4)	– –	– –	– –	– –	– –	– –	– –	– –	– –	Secondary carbonate with interspersed opaline silica, rind on clast in fault breccia.	Infiltrated fines and secondary carbonate in breccia.
(U-series sample 110494–5)	– –	– –	– –	– –	– –	– –	– –	– –	– –	Disseminated carbonate matrix within fault zone.	– – –

Table 15. Numerical ages of deposits in trenches T2, T4A, and WBR across the Ghost Dance Fault in the Yucca Mountain area, southwestern Nevada.

[See figures 1 and 2 for locations. All samples, U-series analyses by J.B. Paces; error limits, ±2σ. Do., ditto]

Trench	Sample	Unit and material sampled	Estimated age (ka)
T2 (pl. 7)	HD 1717	2, clast rind ------------------------------------	88±12, 95±12
	HD 1718	2, rhizolith--------------------------------------	67±2, 68±1
	HD 1719	2, opaline silica laminae----------------------	20±2, 25±1
T4A (pl. 6)	HD 1829	3, densely cemented fluvial gravel-----------	45±0.5, 50±1
	HD 1830	Opaline silica in bedrock---------------------	132±7, 253±13, 265±12
WBR (pl. 4)	HD 1831	Opaline silica in fractured bedrock----------	22±1, 23±1, 37±2
	HD 1721	Kqm soil horizon draping bedrock----------	43±1, 53±0.5, 81±2, 83±2
	HD 1722	do ---	10±0.1, 17±6

(unit 1, Av+Bw) or the laminar carbonate cap (unit 2, 2K) was observed across the main Ghost Dance Fault trace (pl. 4). One discontinuous fracture, however, was noted in the lower densely cemented unit (unit 2, 2Kqm), but the fracture does not extend upward into the weathered laminar K soil horizon (see exposure segment 2S, pl. 4). This well-cemented unit draping the bedrock, which was sampled above the main Ghost Dance Fault trace, yielded estimated U-series ages of 10±0.1 to 83±2 ka (exposure segment 3S, pl. 4; samples HD 1722, HD 1721, table 15). If the rocks (unit 2, 2Kqm) dated above the fault (exposure segment 3S) are correlative in time to the fractured rocks west of the sample locality (exposure segment 2S), then the event that fractured the dense laminar horizon must have occurred at least 82 ka. The fracture may have resulted from a seismic event on one or more other faults in adjacent areas, but not from movement on the Ghost Dance Fault.

Trench T4

Trench T4 (pl. 5; figs. 2, 21) was excavated in surficial deposits in Split Wash to intersect the bedrock projection of the Ghost Dance Fault trace, although current mapping does not extend the Sundance Fault southward of Split Wash (fig. 21; Day and others, 1998b). Trench T4 was originally excavated in the early 1980s as part of the preliminary fault studies by Swadley and others (1984); it was then deepened in 1994 in an attempt to expose the bedrock fault, but no bedrock was reached (see pl. 5).

Trench T4 exposes alluvium deposited in the main drainage of Split Wash (tables 16, 17). The sequence is composed of 2-m-thick layers of poorly to well sorted, nonimbricated to weakly imbricated gravel separated by erosional unconformities. Bedding is poor to well formed in places, and the gravel is typically clast to matrix supported. The proportion of gravel was visually estimated to range from 40 volume percent at the surface to as much as 80 volume percent at depth (table 16). The gravel content is uniform through the entire depth of the profile, averaging about 70 weight percent; the remaining 30 weight percent is dominated by fine sand to coarse silt—fractions that are characteristic of eolian additions. Fine-grained eolian material is commonly concentrated at the top of the layers.

Soils are young and minimally developed in the deposits exposed in trench T4; minor accumulations of secondary carbonate (2–3 weight percent) are near the ground surface, and no evidence of clay translocation was observed. Soil horizons were identified primarily on the basis of color and structure. The physical and chemical characteristics of the soils in trench T4 are typical of the upper Pleistocene to lower Holocene soils (possibly correlative with unit Qa5; see chap. 2) that are present throughout the Yucca Mountain area (figs. 1, 2), but no numerical ages were determined.

Bedding in the alluvial deposits extends without offset across projections of the Ghost Dance and Sundance Faults. No fractures or other evidence of displacement was observed. Layers are continuous—no vertical fractures, rotated clasts, offset bedding, vertical laminae, or any other features indicative of Quaternary fault activity were observed in trench T4 (pl. 5).

Trench T4A

Trench T4A (pl. 6; figs. 2, 21), located 50 m south of trench T4 on the projection of the main Ghost Dance Fault trace (fig. 21), was excavated to expose Quaternary deposits above faulted or fractured bedrock. Fractured bedrock of the Tiva Canyon Tuff is exposed in the bottom and lower walls toward the west end of the trench (see pl. 6); these fractures are probably within the hanging wall west of the main fault trace. Secondary carbonate, derived from eolian additions and inplace processes, has infilled the fractured bedrock. In some places the carbonate appears to line vertical fractures, and in other places it appears to form a continuous layer over vertical fractures. No evidence of fracturing was observed in the Quaternary deposits that bury bedrock.

Three lithologic units, separated by erosional unconformities, are exposed in trench T4A (pl. 6; table 18). The youngest unit (1), exposed in the west end of the trench, is a mixture of slopewash colluvium and fine-grained eolian material that includes two soil horizons (A+Bk, Bk). The uppermost soil horizon (A+Bk), exposed at the surface, has an anomalous clay content of 10 volume percent with no evidence of translocation, which probably indicates reworking from older soils that had formed farther upslope.

Unit 2, the thickest of the three lithologic units (pl. 6), consists of moderately well sorted, angular to subangular, nonbedded, poorly imbricated, clast- to matrix-supported gravel; the proportion of gravel clasts generally increases with depth in the deposit, which includes five soil horizons (table 18), defined on the basis of color and texture. No numerical ages were determined on samples from either unit 1 or 2 in trench T4A; both units exhibit characteristics that are interpreted to be correlative with surficial unit Qa5 (see chap. 2).

Unit 3 (pl. 6), which drapes the fractured bedrock, is composed of nonbedded slopewash deposits containing 15 to 20 volume percent of unsorted to moderately well sorted, angular to subangular clasts that increase in size downward. The unit is characterized by a well-developed soil (Bt) horizon that contains abundant translocated or alluvial clay (max 50 volume percent) above a second soil (K) horizon that contains abundant secondary carbonate (max 20 volume percent); both components indicate a soil that is considerably older than the soils in units 1 and 2. Two U-series ages, on samples of dense opaline silica laminae in the 3K soil horizon that was developed on and near bedrock, of 45±0.5 and 50±1 ka (sample HD 1829, table 15), provide a minimum estimated age for the deposit and indicate a probable correlation with surficial unit Qa3 of the standard Yucca Mountain Quaternary sequence (see chap. 2; fig. 3).

Horizontal and vertical laminae within fractured bedrock of the Tiva Canyon Tuff (R+K soil horizon, table 18) were also sampled for U-series analysis. U-series estimated ages on three horizontally oriented samples of opaline silica are 22±1,

Table 16. Quaternary stratigraphy exposed in trench T4 across the Ghost Dance Fault in Split Wash in the Yucca Mountain area, southwestern Nevada.

[See figures 1 and 2 for locations, and table 17 for additional lithologic data. Colors from Munsell Soil Color Charts (Munsell Color Co., Inc., 1992). Do., ditto]

Lithologic unit, soil horizon, boundary (*sample)	Depth or thickness (cm)	Dry color (<2 mm and/or ped face)	Moist color (<2 mm and/or ped face)	Texture	Structure (primary and secondary)	Consistence (dry, moist, wet)	Clay films	Secondary carbonate (gravel and disseminated)	Gravel content (volume percent)	Parent material and lithology	Miscellaneous (roots, pores, SiO_2, oxidation, concretions, salts)
1T, A+Bw; c, s (*unit 1 A+Bw)	– –	10YR 6/3	10YR 4/3	LS	f-co sbk, 2° sg	so-sh; so, po	0	0	40–50 pb gr	Moderately well sorted, nonbedded, nonimbricated, matrix supported.	Coarsens and thickens upslope. Unit is characterized by infiltrated eolian fines. Boulder train intersected in center of trench. Stratigraphic unit Qa5.
2T, 2Bk1; c, s (*unit 2–1 2Bk)	– –	10YR 6/3	10YR 3.5/3	LL	sg, 2° 1f sbk	so; vss, po	0	I+ diss, ev	50 cb pb gr	Poorly sorted, nonbedded, nonimbricated, matrix supported.	Decreasing carbonate and silt contents with depth, unit thins upslope.
2T, 2Bk2; g, s (*unit 2–2 2Bk2)	– –	10YR 6.5/3	10YR 4/3	SL	sg	lo; so, po	0	I– patchy coats, diss, ev	70 clasts ≤15 cm, very few ≤30 cm, cb pb gr	Nonbedded, weakly imbricated, matrix supported.	SiO_2 stage 1. In center of trench, this horizon is in contact with unit 3.
2T, 2Bk3; a, s (erosional contact) (*unit 2–3 2Bk3)	– –	10YR 6/3	10YR 4/3	SL	sg	lo; so, po	0	I– patchy coats, diss, ev	75 pb gr, clasts ≤15 cm	Moderately well to well sorted, lenses of well sorted pb, gr at base, weakly bedded, well imbricated toward base where clast supported, matrix to clast supported.	– – –
3T, 3Btkwb; c, s (*unit 3–1 3Btkwb)	– –	10YR 6/3	10YR 4/3	SL	1–2 vf-f sbk	h; so, po	0	I patchy coats, diss, ev	80 clasts ≤7 cm, pb gr	Poorly to moderately well sorted, nonbedded, nonimbricated, matrix supported.	Unit Qa4. Horizon pinches in and out and is present only in places.
3T, 3Bkw1b; a, s (*unit 3–2 3Ckn)	– –	10YR 6.5/3	10YR 4/3	SL	sg	lo; vss, po	0	I– patchy scaly carbonate and SiO_2, diss, e	80 clasts ≤32 cm, pb cb gr, few bd	Poorly to well sorted, well bedded in places, well imbricated in places, matrix supported, clast supported in coarser beds.	Characterized by distinct and well-preserved stratigraphic layering by moderately well sorted coarse- and fine-grained lenses. Unit 3 pinches out just west of middle of trench.
3T, 3Bkw2b; a, s (not sampled)	– –	10YR 6.5/3	10YR 4/3	SL	sg	lo; so, po	0	I– patchy	80 clasts ≤15 cm, pb cb gr	Poorly to well sorted, well bedded, well imbricated, matrix supported.	– – –
4T, 4Bkwlb; c, s (*unit 4–1 4Bkwlb)	– –	10YR 6.5/4	10YR 4/3	SL	sg	lo; so, po	0	I– patchy and powdery, diss, e	60 clasts ≤15 cm, few ≤22 cm pb cb gr	Poorly sorted, nonbedded, nonimbricated, matrix supported, clast supported in coarser layers.	– – –
4T, 4Bkw2b; a, s (*unit 4–2 4Bkw2b)	– –	10YR 6.5/4	10YR 4/3	SL	sg	lo; vss, po	0	I– scaly and patchy, diss, e. $CaCO_3$ stage I on clast where unit is <1 m below surface at west end.	80 pb cb gr, few bd clasts ≤33 cm	Moderately well bedded, imbricated in lenses, moderately well sorted.	Unit characterized by stratigraphic layering of coarse- and fine-grained beds.
5T, 5Bkwb (*unit 5)	– –	10YR 7/3	10YR 4/3	SL	1 vf-f sbk, 2° sg	lo; so, po	0	diss, e	70 pb gr, clasts ≤13 cm	Moderately well sorted, nonbedded, nonimbricated, matrix supported.	– – –

Table 16. Quaternary stratigraphy exposed in trench T4 across the Ghost Dance Fault in Split Wash in the Yucca Mountain area, southwestern Nevada—Continued

Lithologic unit, soil horizon, boundary (*sample)	Depth or thickness (cm)	Dry color (<2 mm and/or ped face)	Moist color (<2 mm and/ or ped face)	Texture	Structure (primary and secondary)	Consistence (dry, moist, wet)	Clay films	Secondary carbonate (gravel and disseminated)	Gravel content (volume percent)	Parent material and lithology	Miscellaneous (roots, pores, SiO_2, oxidation, concretions, salts)
Trench deepened and widened—units tentatively correlated											
4B (top of bottom) 4Bkw1b; c, s (*unit 1B–1)	– –	10YR 6.5/4	10YR 3/4	SL	sg	lo; ss, ps	0	I– patchy diss, e	70 cb pb gr	Moderately well sorted, poorly bedded, nonimbricated, matrix-clast supported.	– – –
4B, 4Bkw2b; g, s (unit 1b–2)	– –	10YR 7/4	10YR 3/3	SL	sg	lo; so, po	0	I+ diss, ev 1° reworked carbonate on clasts	60 cb pb gr, few bd	do -----------	– – –
4B, 4Bkw3b; g, s (unit 1B–3)	– –	10YR 7/4	10YR 3.5/4	SL	sg	lo; so, vps	0	I, diss, e 1° reworked carbonate on clasts	60 cb pb gr	do -----------	– – –
4B, 4Bkw4b; a, s (unit 1B–4)	– –	10YR 7/4	10YR 4/3	SL	sg	lo; so, po	0	I– patchy diss, e	75 pb cb gr	do -----------	– – –
5B, 5Cn; a, s (erosional contact) (*unit 2B)	– –	10YR 5/4	10YR 3.5/3	SL	sg	lo; vss, po	0	0	80 pb cb gr	Well sorted, moderately well bedded, moderately imbricated, matrix-clast supported.	Fining-upward sequence repeated in layers within unit 5B.
6B, 6Cn; (*unit 3B)	Bottom of trench	10YR 6/4	10YR 4/3	SL–L	sg	lo; ss, ps	0	0	60 pb cb gr, few bd	Moderately well bedded, moderately well sorted, nonimbricated.	– – –

23±1, and 37±2 ka (sample HD 1831, table 15), and on three vertically oriented samples are 132±7, 253±13, and 265±12 ka (sample HD 1830). The vertically oriented laminae could represent the timing of opening of a fracture in the bedrock, and the early onset of filling of the fracture with fine material and the precipitation of secondary carbonate and opaline silica. Although the origin of the fractures cannot be determined, clearly no offset of the Quaternary material that overlies the fractured bedrock is evident. An alternative explanation for the estimated ages of the fracture fill would involve exhumation of the bedrock and deposition of the soil currently at the bedrock interface. The cycle of stripping and deposition of alluvium is a common phenomena in the Yucca Mountain area. Here, carbonate infilling of preexisting fractures occurs where the bedrock was for some unknown period of time out of the zone of carbonate accumulation, and so the fractures could considerably antedate carbonate deposition. The range in the estimated ages (20–200 ka) of morphologically similar laminae supports an interpretation that the youngest material may be a replacement product and not primary to the deposit; however, these questions remain unresolved.

Trench T2

Trench T2 (pl. 7; figs. 2, 21), located in Drill Hole Wash on the projection of a parallel left-stepping fault west of the Ghost Dance Fault (fig. 21), is entirely in Quaternary gravelly alluvium derived from the main drainage and so is not deep enough to expose bedrock. The gravel is moderately well sorted, nonbedded, and imbricated in silt-free lenses. Two lithologic units separated by an erosional unconformity are represented in the trench walls (table 19). Unit 1 includes two soil horizons: a surface (A+Bw) horizon that is dominated by fine-grained eolian material, grading downward into a gravel matrix (Bk) horizon. Features characteristic of soil maturity are absent, and less than 1 weight percent of secondary carbonate is present. In their physical and chemical characteristics, these soils resemble the upper Pleistocene to lower Holocene soils (unit Qa5, tables 2–4; see chap. 2) that are present throughout the Yucca Mountain area (figs. 1, 2), although they could also be as young as middle to late Holocene (unit Qa6). Unit 2 preserves well-developed soils characterized by secondary accumulations of clay and carbonate. U-series estimated ages are 20±2 and 25±1 ka (sample HD 1719, table 15) on opaline silica laminae in the 2Kb soil horizon and 88±12 to 95±12 ka (sample HD 1717) on rinds from the underside of a clast. An analysis of a rhizolith from this soil horizon resulted in U-series estimated ages of 67±2 and 68±1 ka (sample HD 1718).

As in other trenches excavated across projections of the Ghost Dance and associated faults, no evidence of faulting or fracturing of the Quaternary deposits was observed in trench T2.

Table 17. Particle-size distribution, carbonate content, and pH in soils exposed in trenches T2, T4, and T4A across the Ghost Dance Fault in the Yucca Mountain area, southwestern Nevada.

[See figures 1 and 2 for locations. Gravel, sand, silt, clay, and $CaCO_3$ contents in weight percent. See table 3 for soil-horizon terminology; prefixed numbers refer to differentiated soil horizons with increasing depth, and numbers within or following these designations refer to further differentiation of properties within an individual soil horizon]

Sample	Gravel	Sand					Silt			Clay		Total			$CaCO_3$	pH
		vco	co	m	f	vf	co	m+f	vf	co+m	f	Sand	Silt	Clay		
Trench T2																
tr2 A+Bw	56.43	4.85	4.53	4.81	30.91	21.61	15.16	8.14	2.34	4.07	4.32	65.99	25.64	8.38	0.25	9.00
tr2 Bk	68.13	15.10	8.55	7.61	31.47	19.87	7.90	3.42	2.54	1.56	1.95	82.60	13.86	3.51	.69	8.70
tr2 2Btkb	59.69	13.29	6.59	4.58	17.21	10.01	5.75	11.34	9.86	15.20	6.16	51.68	26.95	21.36	1.84	8.20
tr2 2Kb	80.96	12.16	11.62	11.80	31.70	15.51	7.49	1.80	2.78	1.80	3.33	82.79	12.07	5.13	27.07	8.40
tr2 2Bkb	71.82	22.21	14.38	10.26	29.26	15.13	4.38	1.53	.99	.55	1.31	91.24	6.89	1.86	7.33	8.35
Trench T4B (top)																
tr4–T A+Bw	52.50	6.36	4.11	4.67	35.02	25.37	10.14	4.98	2.62	3.23	3.50	75.53	17.74	6.73	0.53	9.00
tr4–T 2Bkl	65.53	7.97	5.76	6.19	36.47	19.96	11.93	4.42	1.88	1.88	3.53	76.35	18.23	5.41	2.58	8.50
tr4–T 2Bk2	71.83	14.21	7.87	7.32	32.69	17.33	10.09	4.91	1.99	.93	2.66	79.42	17.00	3.59	3.01	8.05
tr4–T 2Bk3	78.94	16.95	9.98	8.71	33.52	14.36	7.65	3.16	1.98	.79	2.90	83.52	12.79	3.69	2.00	7.85
tr4–T 3Btkwb	73.69	11.97	7.59	8.08	30.13	17.38	11.99	7.85	1.96	.55	2.51	75.15	21.80	3.05	2.61	8.00
tr4–T 3Bkwlb	65.33	19.52	12.00	9.06	27.01	11.47	8.02	6.27	2.77	1.75	2.12	79.06	17.06	3.87	.93	8.00
tr4–T 4Bkwlb	66.57	14.56	11.10	10.42	32.93	12.22	8.43	5.06	1.26	1.48	2.53	81.23	14.75	4.00	1.07	8.20
tr4–T 4Bkw2b	68.36	5.85	5.14	7.75	43.69	20.20	5.32	5.67	1.97	1.04	3.36	82.63	12.96	4.40	.83	8.50
tr4–T 5Bkwb	66.97	5.89	5.89	8.58	37.83	17.67	10.82	4.23	3.11	2.12	3.86	75.86	18.16	5.97	.58	7.90
Trench T4B (bottom)																
tr4–B 4Bkwlb	66.96	8.14	6.85	7.38	29.45	16.69	11.75	1.17	3.06	3.41	6.11	68.51	15.97	9.52	0.78	7.95
tr4–B 4Bkw2b	70.69	11.36	7.61	7.27	36.71	13.52	9.88	5.29	2.35	1.76	4.23	76.47	17.52	6.00	1.71	7.95
tr4–B 4Bkw3b	63.52	9.69	6.19	6.19	29.91	17.64	12.51	6.69	2.41	3.51	5.27	69.62	21.62	8.78	.81	8.05
tr4–B 4Bkw4b	75.18	13.65	7.57	7.10	32.04	13.73	9.13	5.96	3.29	1.95	5.60	74.09	18.38	7.55	.50	8.10
tr4–B 5Cn	75.58	4.31	2.84	3.48	28.97	15.83	15.15	11.70	5.13	5.68	6.95	55.43	31.98	12.59	.37	8.10
tr4–B 6Cn	67.71	8.20	5.80	5.71	23.78	14.78	13.07	11.47	4.80	5.87	6.83	58.27	29.34	12.70	.43	8.10
Trench T4A																
tr4a A+Bk	52.77	1.54	1.35	2.39	26.03	17.38	13.88	10.65	2.26	9.96	14.85	48.69	26.79	24.54	0.15	8.25
tr4a Bk	42.04	3.35	1.85	2.28	20.18	15.48	12.23	9.26	6.61	10.25	18.51	43.14	28.10	28.76	1.12	7.98
tr4a A+Bkw	36.68	5.66	2.44	3.02	31.13	23.43	10.68	5.83	4.21	4.21	9.94	65.68	20.72	14.15	.33	7.80
tr4a Bkl	40.97	5.53	3.90	4.55	36.98	21.16	8.26	6.54	3.10	2.07	7.91	72.12	17.89	9.98	1.70	8.06
tr4a Bk2	19.65	4.12	4.69	5.88	34.30	21.71	10.69	7.93	3.10	1.38	6.21	70.70	21.72	7.59	2.09	7.92
tr4a Bk3	36.72	8.42	5.76	7.11	36.34	15.98	7.50	2.28	5.87	2.28	8.48	73.59	15.65	10.76	2.23	7.89
tr4a Bk4	18.73	13.12	8.62	7.90	32.04	13.98	6.58	3.95	3.62	3.29	6.90	75.66	14.14	10.19	.38	8.35
tr4a 3Bt	31.89	3.43	1.92	1.83	15.26	11.23	6.26	6.63	3.96	3.32	46.43	33.67	16.58	49.75	18.08	8.48
tr4a 3K	25.63	8.43	6.30	6.15	25.73	14.61	6.46	6.82	5.03	6.46	14.00	61.22	18.31	20.46	7.57	8.14
tr4a R+3K	35.46	5.65	4.40	4.95	26.23	18.03	9.14	9.52	7.23	5.33	9.52	59.26	25.88	14.85	33.64	8.30

Table 18. Quaternary stratigraphy exposed in trench T4A across the Ghost Dance Fault in Split Wash in the Yucca Mountain area, southwestern Nevada.

[See figures 1 and 2 for locations, and table 17 for additional lithologic data. Colors from Munsell Soil Color Charts (Munsell Color Co., Inc., 1992). Do., ditto]

Lithologic unit, soil horizon, boundary (*sample)	Depth or thickness range (cm)	Dry color (<2 mm and/or ped face)	Moist color (<2 mm and/or ped face)	Texture	Structure (primary and secondary)	Consistence (dry, moist, wet)	Clay films	Secondary carbonate (gravel and disseminated)	Gravel content (volume percent)	Parent material and lithology	Miscellaneous (roots, pores, SiO_2, oxidation, concretions, salts)
1, A+Bk; c,s (*1.1)	30–60	10YR 6/4	10YR 4/3	LS to SiL	1 f abk, 2° 1 f sbk	so; vss, po	0	I–, patchy, e0	35 pb gr, few cb ≤8 cm	Slopewash, nonsorted, angular clasts, nonbedded, nonimbricated, matrix supported.	Exposed only at west end of trench, incised into unit 2, stratigraphic unit Qa5.
1, Bk; c,s grades into unit 2 (*1.2)	5–25	7.5YR 7/4	7.5YR 4/4	SiL to L	2 m sbk , 2° 2f sbk	h; ss, po	0	I–, patchy, es	40 pb gr, few cb ≤8 cm	do --------------	Very close in age to surface horizon of unit 2; same unit(?) coarsens downslope.
2, A+Bkw; c,s (*2.1)	20–55	10YR 6/3	10YR 3/4	SiL	1 m sbk, 2° sg	so; vss, ps	0	Patchy filaments on underside of clasts	30 pb gr, few clasts ≤6 cm	Slopewash/eolian deposits, nonsorted, angular clasts, nonbedded, nonimbricated, matrix supported.	– –
2, Bk1; g,s (*2.2)	50–60	10YR 5.5/3	10YR 4/3	SL	sg	lo; so po	0	II, ev	50 cb pb gr, ≤23 cm	Alluvium, moderately well sorted, subangular, nonbedded, poorly imbricated, matrix supported.	Dominated by eolian fines.
2, Bk2; g,s (*2.3)	40–80	10YR 6/3	10YR 3/4	LS	sg	lo; so po	0	I, ev	50 cb pb gr, few ≤20 cm	do --------------	Dominated by infiltrated fines (eolian).
2, Bk3; g,s (*2.4)	30–75	10YR 6.5/3	10YR 4/3	SL	sg	lo; so po	0	I, ev	70 pb gr, few cb and bd ≤38 cm	Alluvium, moderately well sorted, subangular, nonbedded, poorly imbricated, matrix and clast supported.	– –
2, Bk4; a,s (*2.5)	40–50	10YR 7/3	10YR 3/4	SL	sg	lo, so, po	0	I–, ev	80 pb gr, few cb bd ≤38 cm, coarser lenses toward base	do --------------	– –
3, 3Bt; c,s (3Bt+R also) (*3.1)	40–50	7.5YR 6/4	7.5YR 4.5/4	SiL	2–3 m-co sbk, 2° 3 f abk	vh; ss, ps-p	0	filaments on pf, I–, ev	15 pb gr, ≤5 cm	Slopewash, moderately well sorted, subangular clasts, nonbedded, nonimbricated, matrix supported.	Mn stains on pf.
3, 3K or 3K+R; a,s (*4–1) (U-series sample 1829	30–40	10YR 8/3	10YR 5/4	SL	m, 2° 1 co abk	eh; so, po	0	III continuous stringers, lenses of ooids ≤1 cm	20 pb gr, few clasts ≤10 cm	Slopewash, nonsorted, angular clasts, nonbedded, nonimbricated, matrix supported.	Unit grades into R.
R and R+K (*4–2) (U-series samples HD 1830, HD 1831	– –	– –	– –	– –	– –	– –	– –	– –	– –	Fractured bedrock of the Tiva Canyon Tuff.	– –

Table 19. Quaternary stratigraphy exposed in trench T2 across the Ghost Dance Fault in Drill Hole Wash in the Yucca Mountain area, southwestern Nevada.

[See figures 1 and 2 for locations, and table 17 for additional lithologic data. Colors from Munsell Soil Color Charts (Munsell Color Co., Inc., 1992)]

Lithologic unit, soil horizon, boundary (*sample)	Depth or thickness (cm)	Dry color (<2 mm and/or ped face)	Moist color (<2 mm and/or ped face)	Texture	Structure (primary and secondary)	Consistence (dry, moist, wet)	Clay films	Secondary carbonate (gravel and disseminated)	Gravel content (volume percent)	Parent material and lithology	Miscellaneous (roots, pores, SiO_2, oxidation, concretions, salts)
1, A+Bw (*unit 1 A+Bw)	– –	10YR 7/4	10YR 3/3	L	1f-m sbk	so; so, po	0	0	50 pb cb	Moderately well sorted, nonbedded, imbricated in silt-free lenses.	Characterized by infiltrated eolian silt; unit Q5 or Q6(?).
1, Bk; a, s (erosional contact) (*unit 1 Bk)	– –	10YR 7/3	10YR 4/4	SL	1f-m sbk, 2° sg	so; so, po	0	I, diss, ew	90 pb cb	do---------------	Unit Q5 or Q6(?).
2, 2Btkb (*unit 2, Btk)	– –	7.5YR 6/4.5	7.5YR 5/4	LL	2–3 f-co sbk	h; s, ps	2 mk po	I– on 10–20% of clasts, diss, ev	30 pb cb	Moderately well sorted, nonbedded to moderately well bedded toward base of exposure.	Unit Q3
2, 2Kb (*unit 2, K) (U-series samples 110494–GDF2–1 through 110494–GDF2–3)	– –	7.5YR 8/0	7.5YR 8/0	SL?	3 f-co abk, plates preserved in places	eh	0	III–IV, diss, ev, lenses of ooids	~50 pb cb	do -------------	Unit Q3.
2, 2Bkb (2Btkb in places) (*unit 2, B1) (U-series sample 110494–GDF2–4)	– –	10YR 8/2	10YR 5/3	LS	sg	lo; so, po	0	II, lenses of III controlled by changes in gravel texture diss, ev	90 pb cb, very few bd	Clast-supported gravel.	Silica- and carbonate-cemented layers separated by matrix-supported gravel, some tonguing, unit Q3.