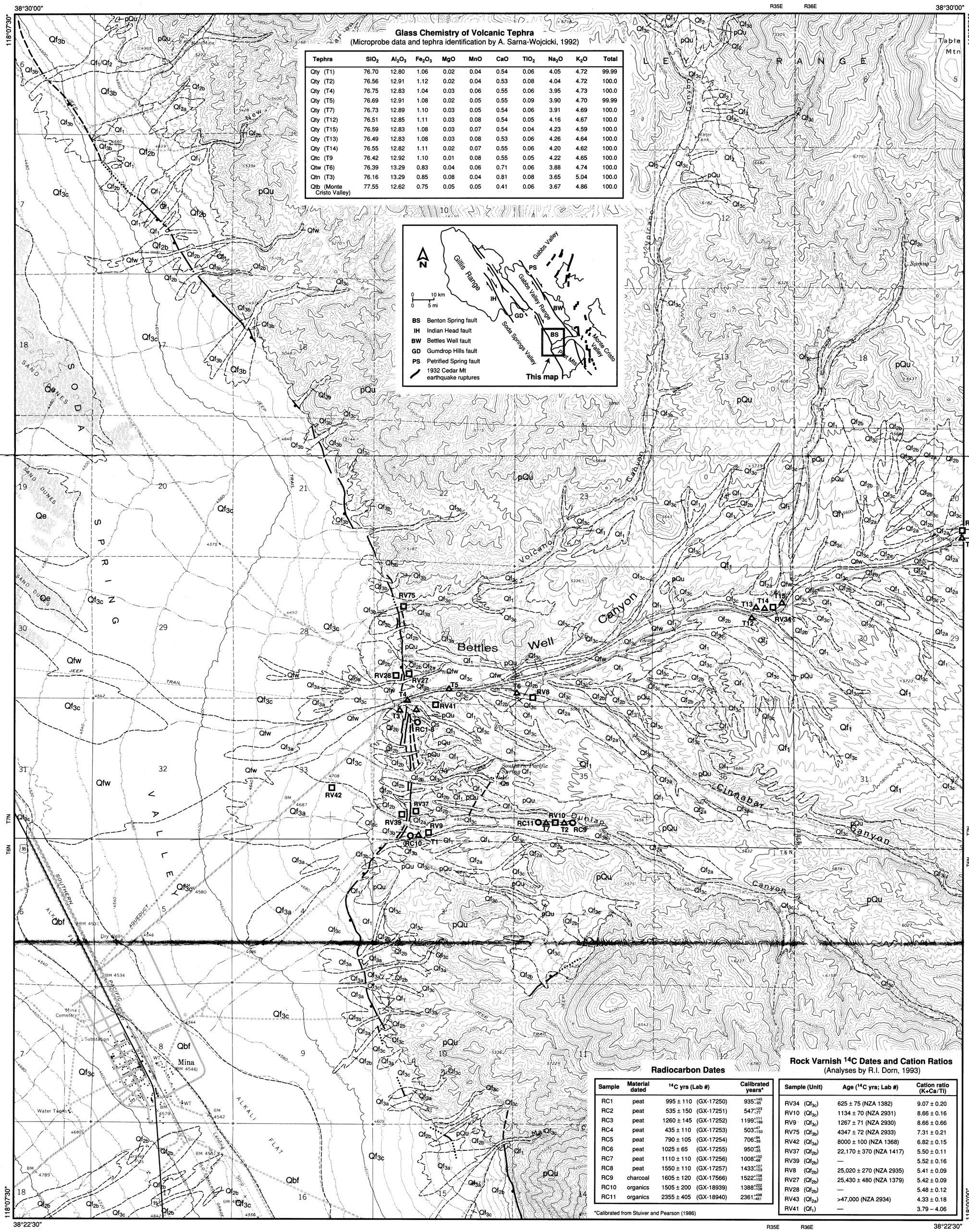

Tephra	SiO_2	Al_2O_3	Fe_2O_3	MgO	MnO	CaO	TiO_2	Na_2O	K_2O	Total
Qty (T1)	76.70	12.80	1.06	0.02	0.04	0.54	0.06	4.05	4.72	99.99
Qty (T2)	76.56	12.91	1.12	0.02	0.04	0.53	0.08	4.04	4.72	100.0
Qty (T4)	76.75	12.83	1.04	0.03	0.06	0.55	0.06	3.95	4.73	100.0
Qty (T5)	76.69	12.91	1.08	0.02	0.05	0.55	0.09	3.90	4.70	99.99
Qty (T7)	76.73	12.89	1.10	0.03	0.05	0.54	0.06	3.91	4.69	100.0
Qty (T12)	76.51	12.85	1.11	0.03	0.08	0.54	0.05	4.16	4.67	100.0
Qty (T15)	76.59	12.83	1.08	0.03	0.07	0.54	0.04	4.23	4.59	100.0
Qty (T13)	76.49	12.83	1.08	0.03	0.08	0.53	0.06	4.26	4.64	100.0
Qty (T14)	76.55	12.82	1.11	0.02	0.07	0.55	0.06	4.20	4.62	100.0
Qtc (T9	76.42	12.92	1.10	0.01	0.08	0.55	0.05	4.22	4.65	100.0
Qtw (T6)	76.39	13.29	0.83	0.04	0.06	0.71	0.06	3.88	4.74	100.0
Qtn (T3)	76.16	13.29	0.85	0.08	0.04	0.81	0.08	3.65	5.04	100.0
Qtb (Monte Cristo Valley)	77.55	12.62	0.75	0.05	0.05	0.41	0.06	3.67	4.86	100.0

Qfw **Modern active wash deposits** Very pale-brown to grayish-brown muddy, sandy gravel and gravelly sand; poorly to moderately stratified; uncemented. Includes numerous recent water-flood and debris-flow deposits radiating from mouths of canyons along the Gabbs Valley Range and Pilot Mountains.

Qe **Eolian sand deposits** Very pale-brown sand; well sorted; loose, uncemented. Includes sand sheets and inactive dunes of mid to late Holocene age.

Qbf **Basin-fill deposits** White to very pale-brown silty sand and sandy silt; moderately well stratified; poorly cemented. Unit is basin-floor (playa) facies of mid to late Holocene alluvial fan (**Qf_3**) deposits.

Qs **Spring deposits** Light-gray to black sandy silt; loose, uncemented. At mouth of Bettles Well Canyon, deposits consist of interbedded volcanic ash (**Qty**) and peat. Eight ^{14}C dates on the peat range from 435 to 1,550 yr BP (RC1 through RC8).

Qf_3 **Holocene fan-piedmont and wash terrace remnants** Composed dominantly of volcanic andesite, tuff, and basalt clasts with minor to moderate concentrations of limestone, sedimentary, and metamorphic clasts in units near the Pilot Mountains. **Qf_{3c}** Very pale-brown to grayish-brown muddy, sandy gravel to gravelly sand; poorly to moderately stratified; uncemented. Fresh-looking distributive bar-and-channel microtopography with discrete debris flows distinguishable on aerial photography. Unit forms bulk of the piedmont flanking the west side of the Gabbs Valley Range and Pilot Mountains. Soil varies from A-C profile with no visible horizonation to A-C profile with incipient to very weak B-horizon development; carbonate, if present, is weak stage I. Incipient desert pavement; weak to no rock varnish. Contains several chemically indistinguishable Mono Craters tephra (**Qty**) ranging in age between about 900 and 1950 yr BP. Three ^{14}C dates from charcoal and organics in deposits from Dunlap Canyon range between 1,505 and 2,355 yr BP (RC9, 10, 11). Rock varnish ^{14}C AMS dates from clasts overlying the tephra in Dunlap and Bettles Well Canyon (RV9, 10, 34) range between 625 and 1267 yr BP. **Qf_{3b}** Light-gray to grayish-brown muddy, sandy gravel to gravelly sand; poorly to moderately stratified; uncemented to slightly cemented. Surfaces exhibit distributive bar-and-channel microtopography slightly more subdued than **Qf_{3c}**. Soil is A-C profile typically with 5 cm Av and 30 cm Bk horizon (stage I coatings). Incipient to weak desert pavement; moderately dark rock varnish; moderately etched limestone clasts. A rock varnish ^{14}C AMS date of 4,347 yr BP was obtained from surface clasts at the mouth of Volcano Canyon (RV75). **Qf_{3a}** Light-gray to grayish-brown muddy, sandy gravel to gravelly sand; poorly to moderately stratified; slightly cemented. Relatively broad, flat, slightly dissected remnants stand only slightly topographically higher (<1 m) than younger **Qf_3** remnants; bar-and-channel microtopography has been subdued and smoothed. Soils are camborthids typically containing 7 cm Av, 15 cm Bw (10 YR), and 30 cm Bk (stage I-II) horizons. Moderately well developed desert pavement and rock varnish. Just east of quadrangle along Bettles Well Canyon, unit contains a Mono Craters tephra (**Qtc**; T9) estimated to be about 7.2 ka where dated at Crooked Meadows, California. A rock varnish ^{14}C AMS date of 8,000 yr BP was obtained from surface clasts near the mouth of Dunlap Canyon (RV42).

Qf_2 **Late Pleistocene fan-piedmont remnants** Forms prominent series of broad, flat surfaces inset slightly below (1-2 m) unit **Qf_1** in Bettles Well Canyon. Composed dominantly of volcanic andesite, tuff, and basalt clasts with minor to moderate concentrations of limestone, sedimentary, and metamorphic clasts in units near the Pilot Mountains. **Qf_{2b}** Light-brownish-gray to pale-brown muddy, sandy gravel to gravelly sand; poorly to moderately stratified; slightly to moderately cemented. Soils are haplargids typically with 7 cm Av, 25 cm Bt (7.5 YR), and 50-60 cm Bk (stage II-III) horizons. Well-developed desert pavement and dark rock varnish on broad, flat interfluves give unit distinctive aerial photographic appearance. Contains the Wilson Creek tephra (**Qtw**, T6; 36 ka) in a side-stream exposure along Bettles Well Canyon. Rock varnish ^{14}C AMS dates from clasts above ash and from surfaces at mouths of Bettles Well and Dunlap Canyons yielded ages ranging between 22 and 25 ka (RV27, 28, 37, 39). **Qf_{2a}** Light-brownish-gray to pale-brown muddy, sandy gravel to gravelly sand; poorly to moderately stratified; moderately to well cemented. Soils are haplargids and durargids with typically 7 cm Av, 7 to 10 cm Bt (7.5 YR), and 60 to 100 cm Bk or Bqkm (stage III-IV) horizons. Well-developed desert pavement and dark rock varnish on moderately dissected interfluvial remnants; remnants are geomorphically similar to **Qf_{2b}** and generally are only slightly topographically higher. The Mono Craters Negit Causeway tephra (**Qtn**, T3; 60-100 ka) occur in faulted paludal deposits within **Qf_{2a}** deposits at the mouth of Bettles Well Canyon and in **Qf_{2a}** gravels exposed in a roadcut along Bettles Well Canyon just off the quadrangle to the east. A rock varnish ^{14}C date from clasts overlying the tephra was infinite: >47,000 yr BP (RV43).

Qf_1 **Early to mid Pleistocene fan-piedmont remnants** A prominent series of high-level, well-dissected, digitate remnants which comprise the bulk of the fan-piedmont complex in Bettles Well Canyon. Along Dunlap and Cinnabar Canyons, unit lies directly on Tertiary sedimentary and volcanic rocks. Light-brownish-gray to brown muddy, sandy gravel to gravelly sand; poorly to moderately well stratified; well indurated to massively cemented. Soils are durargids with remnantal Bt horizons overlying strongly cemented Bqkm (stage IV) horizons in excess of 1 m thick. In Monte Cristo Valley to the east of the quadrangle, unit contains Bishop-Glass Mountain G tephra (**Qtb**, 0.73-1.0 Ma). Rock varnish cation ratios from clasts at mouth of Bettles Well Canyon indicate unit is >>47,000 yr BP (RV41).

pQu **Pre-Quaternary rocks, undivided** See companion map by Oldow and Dockery (1993).

Neotectonic History of the Benton Spring Fault

The Benton Spring fault is one of several prominent northwest-trending faults which comprise the central Walker Lane belt; the others include the Bettles Well, Indian Head, Petrified Spring, and Gumdrop Hills faults. These faults form a large right-slip fault system through and bounding the Gillis and Gabbs Valley Ranges and the Pilot Mountains, with the Benton Spring fault offsetting the Tertiary volcanic section as much as 8 km (Ekren and Byers, 1984). North- and northeast-trending conjugate faults in Monte Cristo and Gabbs Valleys ruptured during a large magnitude (M7.2) earthquake in 1932. Right-slip faulting of as much as 2 m associated with the earthquake was attributed to wrench fault tectonics of the Walker Lane belt by Gianella and Callaghan (1934).

The Benton Spring fault displays recurrent Quaternary offset in the Mina Quadrangle. At the mouths of Dunlap and Bettles Well Canyons, the late Wisconsin (>22-25 ka) **Qf_{2b}** fan-piedmont remnants are vertically offset as much as 3.8 m, and the older (60-100 ka) **Qf_{2a}** surfaces are vertically offset about 7.6 m. No geomorphic evidence of lateral offset (for example, offset stream channels) is visible within the faulted alluvium, and the component of Quaternary right slip is not [redacted] alluvial fault contact at the southern edge of the quadrangle, however, plunge 25 to 35° N and represent a horizontal to vertical slip ratio of between about 1.5:1 to 2:1. The most recent faulting event had a maximum vertical offset of about 1 m; it displaced **Qf_{3b}** deposits, but predated the deposition of **Qf_{3c}** deposits. Thus, the age of the most recent event is constrained between about 900 and 4,300 yr BP based on tephra and rock-varnish age control. One or more older events are preserved in the 3.8 m offset in the >22 to 25 ka **Qf_{3b}** deposits at Dunlap and Bettles Well Canyons, but additional study, including exploratory trenching, is necessary to resolve these older slip histories. Based on a 1.5:1 to 2:1 horizontal to vertical slip ratio, 6.6 to 9.0 m of net slip is estimated to have occurred in the last 22 to 25 ka, yielding a slip rate of about 0.26 to 0.41 mm/yr. Similarly, a slip rate of between 0.13 and 0.30 mm/yr is estimated from a 13.2 to 18.0 m net offset of **Qf_{2a}** deposits (60-100 ka).

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Radiocarbon Dates

Sample	Material dated	^{14}C yrs (Lab #)	Calibrated years*
RC1	peat	995 ± 110 (GX-17250)	935^{+145}_{-85}
RC2	peat	535 ± 150 (GX-17251)	547^{+123}_{-77}
RC3	peat	1260 ± 145 (GX-17252)	1199^{+111}_{-189}
RC4	peat	435 ± 110 (GX-17253)	503^{+47}_{-153}
RC5	peat	790 ± 105 (GX-17254)	706^{+94}_{-36}
RC6	peat	1025 ± 65 (GX-17255)	950^{+40}_{-95}
RC7	peat	1110 ± 110 (GX-17256)	1008^{+152}_{-58}
RC8	peat	1550 ± 110 (GX-17257)	1433^{+127}_{-103}
RC9	charcoal	1605 ± 120 (GX-17566)	1522^{+108}_{-152}
RC10	organics	1505 ± 200 (GX-18939)	1388^{+222}_{-128}
RC11	organics	2355 ± 405 (GX-18940)	2361^{+498}_{-461}

*Calibrated from Stuiver and Pearson (1986)

Rock Varnish ^{14}C Dates and Cation Ratios
(Analyses by R.I. Dorn, 1993)

Sample (Unit)	Age (^{14}C yrs; Lab #)	Cation ratio (K+Ca/Ti)
RV34 (Qf_{3c})	625 ± 75 (NZA 1382)	9.07 ± 0.20
RV10 (Qf_{3c})	1134 ± 70 (NZA 2931)	8.66 ± 0.16
RV9 (Qf_{3c})	1267 ± 71 (NZA 2930)	8.66 ± 0.66
RV75 (Qf_{3b})	4347 ± 72 (NZA 2933)	7.31 ± 0.21
RV42 (Qf_{3a})	8000 ± 100 (NZA 1368)	6.82 ± 0.15
RV37 (Qf_{2b})	22,170 ± 370 (NZA 1417)	5.50 ± 0.11
RV39 (Qf_{2b})	—	5.52 ± 0.16
RV8 (Qf_{2b})	25,020 ± 270 (NZA 2935)	5.41 ± 0.09
RV27 (Qf_{2b})	25,430 ± 480 (NZA 1379)	5.42 ± 0.09
RV28 (Qf_{2b})	—	5.48 ± 0.12
RV43 (Qf_{2a})	>47,000 (NZA 2934)	4.33 ± 0.18
RV41 (Qf_1)	—	3.79 – 4.06

QUATERNARY
- Holocene: Qfw; Qty; Qf_{3c}; Qf_{3b}; Qtc; Qf_{3a}
- Pleistocene: Qtw; Qf_{2b}; Qtn; Qf_{2a}; Qtb; Qf_1

Qe; Qbf; Qs; pQu

Contact Dashed where approximately located.

Quaternary fault Dashed where approximately located, dotted where inferred, ball on downthrown side.

RV9 Rock varnish sample

RC2 ^{14}C sample

T4 Tephra

QUATERNARY GEOLOGIC MAP OF THE MINA QUADRANGLE, NEVADA

John W. Bell

1995

Scale 1:24,000

0 0.5 1 kilometer

0 0.5 1 mile

0 1000 2000 3000 4000 5000 feet

CONTOUR INTERVAL 40 FEET
Supplemental contours at 20 feet

Base map: U.S. Geological Survey Mina 7.5' Quadrangle, 1967

Office review by:
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Alan Ramelli, NBMG
Jim Rigby, NBMG

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Nevada Bureau of Mines and Geology
University of Nevada, Mail Stop 178
Reno, Nevada 89557-0088