Text and references for Nevada Bureau of Mines and Geology Map 134

STRATIGRAPHIC AND STRUCTURAL FRAMEWORK OF THE NELSON SW QUADRANGLE

CLARK COUNTY, NEVADA

by

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INTRODUCTION

The Nelson SW Quadrangle contains excellent exposures of early to middle Miocene volcanic and sedimentary rocks, the upper part of the ~16.6 Ma Searchlight pluton, and the northernmost part of the Searchlight gold-silver-copper-lead mining district. The Miocene section rests nonconformably on Early Proterozoic gneiss. The Tertiary strata are generally moderately to steeply tilted and cut by complex arrays of northerly striking normal faults. In addition, these strata are deformed into a broad syncline in the northern part of the quadrangle. The normal faulting, tilting, and folding were induced by large-magnitude middle Miocene extension. Essentially undeformed, flat-lying late Miocene to Quaternary alluvial-fan deposits rest in angular unconformity on the tilted Miocene strata.

The purpose of this report is to describe the stratigraphic and structural framework of the Nelson SW Quadrangle, placing it in context with the evolution of the Colorado River extensional corridor. Stratigraphic and structural relations, as well as $^{40}Ar/^{39}Ar$ geochronology, are utilized to bracket the timing of extension. More detailed accounts of the geology of the Highland Range can be found in Davis (1984), Olson (1996), and Faulds and others (2002).

GEOLOGIC SETTING

The Nelson SW Quadrangle includes the southern parts of both the Highland Range and Eldorado Valley, as well as the northeastern fringe of Piute Valley in Clark County, Nevada. The quadrangle lies directly north of Searchlight, Nevada, and includes the northernmost part of the Searchlight mining district. Elevations range from about 900 m (~2,952 feet) along the north-central margin of the quadrangle to 1,331 m (~4,366 feet) in the south-central part.

The entire quadrangle lies within the western part of the highly extended northern Colorado River extensional corridor (fig. 1), which is bounded by the unextended Colorado Plateau to the east, relatively unextended Spring Range to the west, and right-lateral Las Vegas Valley shear zone and left-lateral Lake Mead fault zone to the north (Howard and John, 1987; Weber and Smith, 1987; Faulds and others, 1990). Magmatism and extension migrated northward through the corridor in early to middle Miocene time (Faulds and others, 1999). Voluminous outpourings of volcanic rock occurred just prior to and during extension. Thus, the corridor is dominated by panels of tilted fault blocks containing thick sections of Miocene volcanic rock and associated clastic sediments (e.g., Anderson, 1971; Turner and Glazner, 1990; Duebendorfer and Wallin, 1991; Faulds and others, 1995; Duebendorfer and Sharp, 1998; Gans and Bohrson, 1998; Miller and others, 1998b). The Miocene section generally rests directly on Proterozoic gneiss and granite.

The northern part of the corridor consists of two domains of oppositely dipping normal faults and associated tilt block domains. West-tilted fault blocks and east-dipping normal faults dominate in the south, whereas east-tilted fault blocks and west-dipping normal faults prevail in the north. These domains are referred to as the Whipple and Lake Mead domains, respectively (e.g., Spencer and Reynolds, 1989). The Black Mountains accommodation zone separates the two domains and spans nearly the entire extensional corridor (fig. 1). This accommodation zone is a 5- to 15-km-wide, east-northeast-trending belt of overlapping, oppositely dipping normal faults (Faulds and others, 1990) and is characterized by a series of extensional anticlines and synclines (Faulds and others, 2002). The Highland Range contains the westernmost anticline and syncline within the accommodation zone (fig. 1). The extensional syncline is best exposed in the Nelson SW Quadrangle.

PREVIOUS WORK

Early studies of the Highland Range and vicinity were restricted to geologic reconnaissance (Spur, 1903; Ransome, 1907, 1923; Hewett, 1956; Longwell and others, 1965; Bingler and Bonham, 1973) and investigations of mineralization in the Searchlight mining district (Callaghan, 1939; Longwell and others, 1965; Bown, 1977). Anderson (1971, 1977, 1978) was the first to carry out detailed geologic mapping in the region and describe large-magnitude extension within the corridor. On the basis of K/Ar dating of variably tilted volcanic rocks in growth-fault basins, the major episode of extension was constrained to middle Miocene time (Anderson and others, 1972). Anderson (1971) also provided some of the first detailed descriptions of regionally extensive volcanic units, including the Patsy Mine Volcanics, tuff of Bridge Spring, and Mount Davis Volcanics. These units have since become important time-stratigraphic markers throughout the northern Colorado River extensional corridor.

Several recent studies have focused on the Tertiary strata and structure of the Highland Range. Davis (1984) mapped an area directly west of the Nelson SW Quadrangle, analyzed Tertiary strata within the central Highland Range, and concluded that the broad northwest-trending anticline in that area was related to extensional processes. Detailed geologic mapping and stratigraphic and structural analyses were later conducted in the southern Highland Range by Olson (1996), Faulds and Bell (1999), Olson and others (1999), and Faulds and others (2002). Olson (1996) first recognized the northeast-trending syncline in the northern part of the Nelson SW Quadrangle. In addition, paleomagnetic and geochronologic investigations were carried out throughout the Highland Range (Faulds and Olson, 1997; Olson and others, 1999). On the basis of detailed geologic mapping of the Nelson SW Quadrangle, more comprehensive stratigraphic and structural analyses, and $^{40}Ar/^{39}Ar$ geochronology, Faulds and others (2002) documented the timing of deformation and three-dimensional geometry, age, and origin of the folds in the Highland Range. This work

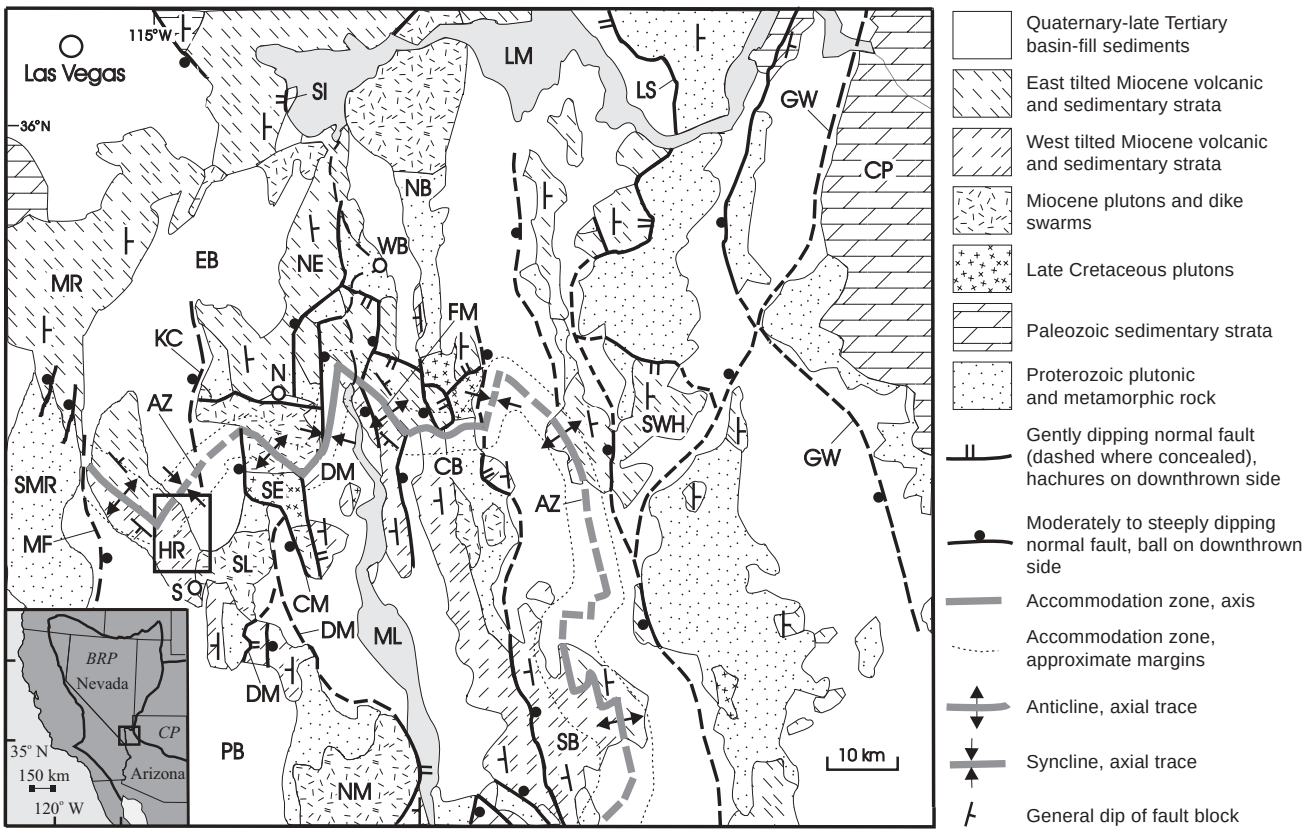

Figure 1. Generalized geologic map of the northern Colorado River extensional corridor. The box surrounds the Nelson SW Quadrangle. The margins of the accommodation zone correspond to the belt of overlap between multiple, east- and west-dipping normal faults of the Lake Mead and Whipple domains, respectively, and/or the area in which tilts begin decreasing appreciably toward the axis of the zone. The axis of the accommodation zone (AZ) marks the area in which tilt directions reverse and corresponds, in many cases, to the axial traces of the anticlines and synclines that comprise much of the zone. BRP, Basin and Range province (insert); CB, central Black Mountains; CM, Copper Mountain fault; CP, Colorado Plateau; DM, Dupont Mountain fault zone; EB, Eldorado basin; FM, Fire Mountain anticline; GW, Grand Wash fault zone; HR, Highland Range; KC, Keyhole Canyon fault; LM, Lake Mead; LS, Lakeside Mine-Salt Spring Wash fault; MF, McCullough Range fault; ML, Lake Mohave; MR, McCullough Range; N, Nelson, Nevada; NB, northern Black Mountains; NE, northern Eldorado Mountains; NM, Newberry Mountains; PB, Piute basin; SB, southern Black Mountains; S, Searchlight, Nevada; SE, southern Eldorado Mountains; SI, Saddle Island fault; SL, Searchlight pluton; SMR, southern McCullough Range; SWH, southern White Hills; WB, Willow Beach.

bracketed extension in the southern Highland Range between ~16.2 and 11 Ma and showed that the folds were produced by tilting of fault blocks in opposite directions in a belt of overlapping, oppositely dipping normal faults.

STRATIGRAPHIC FRAMEWORK

Alluvial-fan deposits of Eldorado and Piute Valleys

Essentially flat-lying, undeformed late Miocene to Quaternary alluvial-fan deposits unconformably overlie tilted Miocene strata, Early Proterozoic gneiss, and/or the ~16.6 Ma Searchlight pluton primarily within and along the margins of the Eldorado and Piute basins. Alluvial-fan deposits are mapped as allostratigraphic units differentiated on the basis of surface morphology, degree of pedogenic soil development, and inset topographic relations. These deposits are dominantly coarse-grained alluvium forming broad fan-piedmont complexes derived from the surrounding bedrock terrain of the Eldorado Mountains and the Highland and McCullough Ranges. Clast lithologies are dominantly volcanic in the western part of Eldorado Valley and in the northern part of Piute Valley. Clasts of granite become dominant toward the east in the eastern part of Eldorado Valley, where alluvium is partially derived from the ~16.6 Ma Searchlight pluton in the Eldorado Mountains. Clasts of gneiss become more abundant to the west in Piute Valley, where the alluvium is partly derived from Early Proterozoic gneiss of the southern McCullough Range.

Tertiary Strata

Thick sections of early to middle Miocene volcanic rock dominate the Highland Range. The Miocene section ranges up to 3.5 km in thickness and rests directly on Early Proterozoic gneiss and amphibolite. Correlation of volcanic units and determination of the timing of tilting were facilitated by the acquisition of ten $^{40}Ar/^{39}Ar$ dates within the quadrangle (figs. 2 and 3; table 1). In addition, 11 geochemical analyses of volcanic units were obtained (table 2).

In ascending order, the Tertiary stratigraphy in the quadrangle consists of: (1) an early Miocene nonconformity and thin (< 60 m) poorly exposed, basal sequence of arkosic conglomerate (Tca) and the 18.5 Ma Peach Springs Tuff (Tp) (cf., Glazner and others, 1986; Nielson and others, 1990), which crop out only in the southeasternmost part of the area (fig. 5); (2) a 1.5-km-thick sequence of 18.5 to 16.3 Ma trachydacite and trachyandesite lavas (Thld and Thla); (3) as much as 1 km of 16.3–16.0 Ma rhyolite flows and tuffaceous strata (Thr and Tht); (4) up to 1,200 m of 16.0 to 15.2 Ma basaltic trachyandesite flows (Thb); (5) 16.0 to 15.2 Ma megabreccia of probable rock avalanche origin (Tlu, Tlx, Tlb, and Tld) and volcaniclastic conglomerate and sandstone (Tsc) that locally exceeds 200 m in thickness; (6) up to 300 m of the 15.2 Ma tuff of Bridge Spring (Tb) and 15.0 Ma tuff of Mount Davis (Tdt), locally separated by thin rock avalanche deposits and conglomerate (Tbc); and (7) as much as 500 m of middle to late Miocene conglomerate, sandstone, and rock avalanche deposits (Tc and Tcbb) (fig. 3). The granitic Searchlight pluton (Bachl and others, 2001) invades the lower sequence of intermediate lavas in the southeasternmost part of the quadrangle (cross section B–B´). Tilts are essentially conformable in the lower sequence of trachydacite and trachyandesite lavas but progressively decrease up-section from ~80° in the lowermost part of the overlying rhyolite unit to less than 15° in the capping conglomerate (fig. 4).

The 18.5 to 16.3 Ma sequence of trachydacite and trachyandesite lavas (e.g., Thld and Thla), 16.3 to 16.0 Ma felsic volcanic sequence (Thr and Tht), and overlying 16.0 to 15.2 Ma basaltic trachyandesite lavas (Thb) are informally referred to as the volcanics of the Highland Range, because much of this section may be derived from sources either within or proximal to the Highland Range. Thld and Thla may correlate with the volcanics of Dixie Queen Mine in the central Black Mountains (Faulds and others, 1995), as evidenced by similar compositions and nearly identical ages. The upper, middle, and upper part of the lower Patsy Mine Volcanics in the northern Eldorado Mountains (e.g., Anderson and others, 1972) are temporally correlative with Thr, Tht, and Thb. However, the felsic sequence (middle member of Patsy Mine Volcanics) in the northern Eldorado Mountains is 15.5 to 15.2 Ma (Darvall, 1991), significantly younger than the 16.3 to 16.0 Ma Thr and Tht in the Nelson SW Quadrangle. Thus, the felsic sequences in the northern Eldorado Mountains and southern Highland Range were presumably derived from separate volcanic centers.

Coarsely porphyritic dacite and andesite domes, which may be sources for some of the Thld and Thla lavas, crop out directly south of the Nelson SW Quadrangle above the roof of the Searchlight pluton. Proximity of the domes, pluton roof, and thick sections of Thla-Thld lavas implies a genetic link between the pluton and lower part of the volcanics of the Highland Range.

The 16.3 to 16.0 Ma felsic volcanic sequence rests conformably on the trachydacite-trachyandesite section. Its lower part consists primarily of rhyolite lava (Thr), whereas the upper portion is dominated by nonwelded tuffs and tuffaceous sedimentary rocks (Tht). Vitrophyric rhyolitic lavas within Thr have locally been mined for perlite within the southwestern part of the quadrangle. The felsic sequence pinches out northwestward near the hinge zone of the northeast-trending syncline (cross section A–A´), where it interfingers with and gives way to a thick pile of basaltic trachyandesite lavas in the central Highland Range (fig. 2). The relatively thick sequence (~1 km) of rhyolite lavas and associated tuffs in the southwestern part of the quadrangle indicates a nearby source. Likely vent areas (presumably rhyolite dome complexes) may be buried beneath Quaternary alluvium in the southern part of Eldorado Valley and/or lie directly south of the quadrangle west of the town of Searchlight near a series of apparent intermediate to felsic domes.

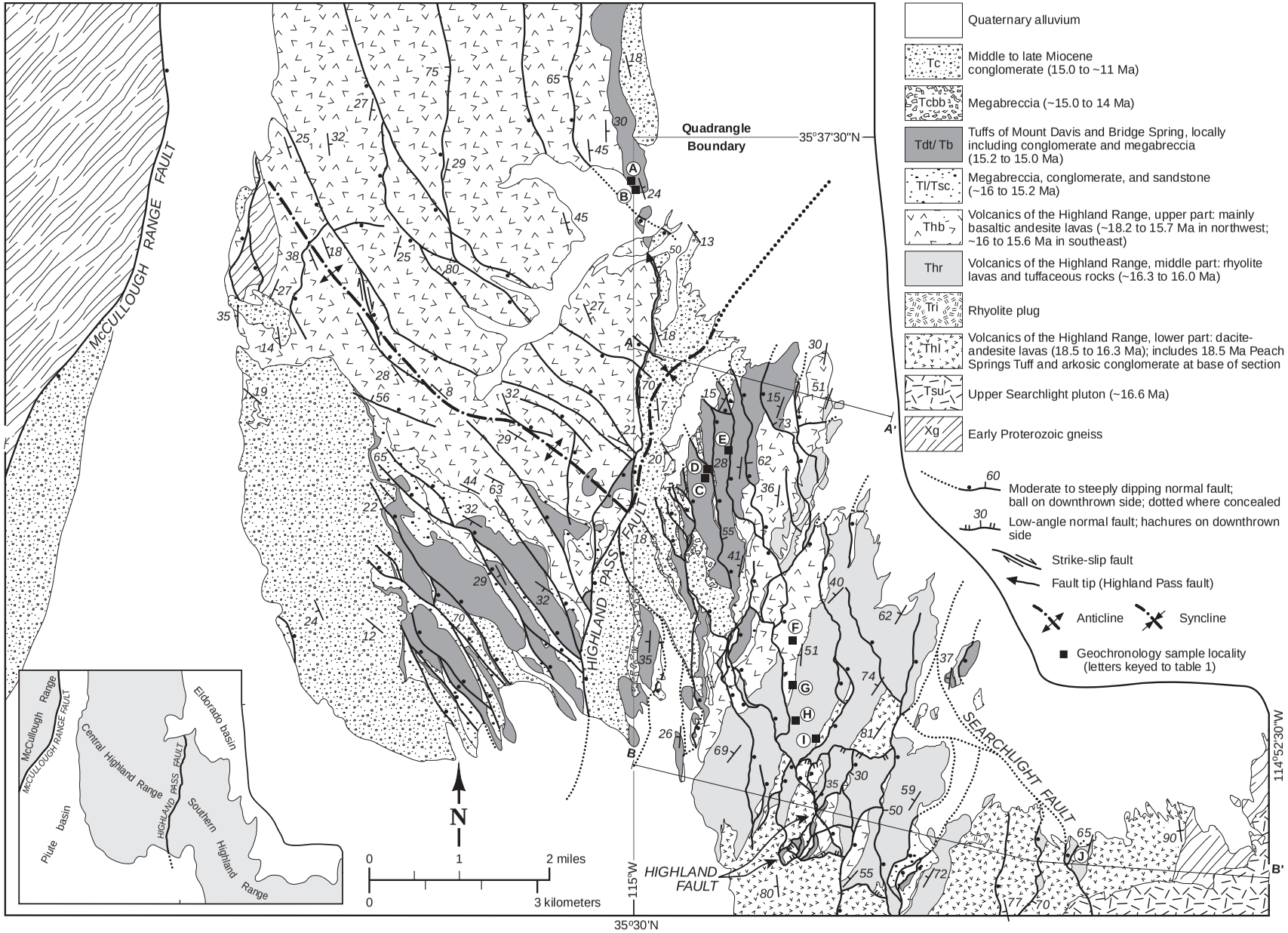

Figure 2. Generalized geologic map of the central and southeastern Highland Range, Nevada (from Faulds and Bell, 1999; Davis, 1984; modified slightly from Faulds and others, 2002). See map for descriptions of units. Circled letters indicate $^{40}Ar/^{39}Ar$ sample locations in the Nelson SW Quadrangle (see table 1).

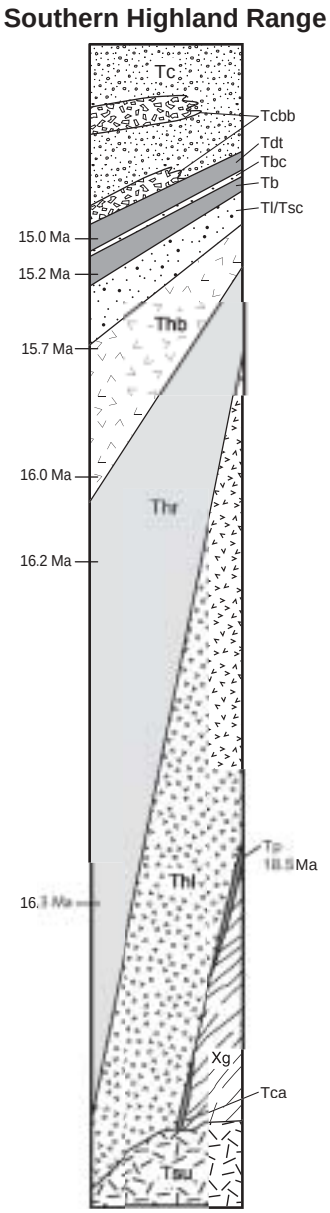

Figure 3. Generalized stratigraphic column showing approximate tilts and relative unit thicknesses for Miocene strata in the southeastern Highland Range. Patterns and labels are the same as in figure 2 or on the map.

Table 1. $^{40}Ar/^{39}Ar$ Isotopic Age Determinations, Nelson SW Quadrangle, Nevada

	Sample	Location	Latitude	Longitude	Dip	Unit	Material	Age (Ma)	Source
A	JF-94-82	CH-AE	35°37'02"	114°59'57"	24°E	Tdt	sd	15.01±0.03	1
B	JF-96-45	CH-AE	35°36'58"	114°59'58"	28°E	Tb	sd	15.21±0.04	2
C	JF-96-41	SHR	35°34'12"	114°59'09"	35°W	Tdt	sd	15.00±0.04	2
D	JF-96-42	SHR	35°34'17"	114°59'07"	45°W	Tb	sd	15.26±0.04	2
E	JF-96-44	SHR	35°34'28"	114°58'53"	40°W	Tb	sd	15.22±0.04	2
F	JF-94-64	SHR	35°32'39"	114°58'10"	45°W	Thb	gm	15.66±0.08	1
G	JF-94-63	SHR	35°32'11"	114°58'09"	60°W	Thb	gm	15.98±0.05	1
H	JF-94-62	SHR	35°31'43"	114°58'04"	75°W	Thr	bt	16.21±0.17	1
I	JF-94-61	SHR	35°31'29"	114°57'49"	75°W	Thr	bt	16.26±0.15	1
J	JF-99-477	SHR	35°30'38"	114°54'41"	65°W	Thr	sd	16.08±0.16	1

Notes: Samples correspond to letters showing location on figure 2. See Faulds and others (2002) for detailed discussion and analytical data. Location: CH-AE, central Highland Range, east limb of anticline; SHR, southeastern Highland Range. Unit: Tdt, tuff of Mount Davis; Tb, tuff of Bridge Spring; Thb, basaltic trachyandesite lava, volcanics of the Highland Range; Thr, rhyolite lava, volcanics of the Highland Range. Material: bt, biotite; gm, groundmass concentrate; sd, sanidine. Sources: 1. U.S. Geological Survey, Denver: Weighted mean or plateau ages from resistance-furnace, incremental-heating age spectra. 2. New Mexico Geochronology Research Laboratory: Weighted-mean ages from single-crystal laser-fusion analyses.

Table 2. Geochemical Data, Nelson SW Quadrangle, Highland Range, Nevada

Sample #	JF-94-61	JF-94-62	JF-94-63	JF-94-64	JF-99-83	JF-99-89	JF-99-141	JF-99-151	JF-99-235	JF-99-252	JF-99-265
Latitude	35°31'29"	35°31'43"	35°32'11"	35°32'39"	35°31'04"	35°31'27"	35°30'00"	35°30'04"	35°31'52"	35°32'36"	35°33'58"
Longitude	114°57'49"	114°58'04"	114°58'09"	114°58'10"	114°55'56"	114°56'04"	114°55'40"	114°58'20"	114°57'16"	114°57'03"	114°57'33"
Age (Ma)	16.26	16.21	15.98	15.66							
Map Unit	Thr	Thr	Thb	Thb	Thla	Thld	Thla	Thld	Thlb	Thrd	Thrd
Weight %											
SiO_2	67.41	69.72	57.94	57.23	62.50	63.56	63.61	63.08	60.16	65.16	68.05
TiO_2	0.591	0.395	1.154	1.180	0.849	0.811	0.820	0.831	1.189	0.824	0.733
Al_2O_3	15.69	15.18	15.63	15.95	16.46	16.74	16.45	15.51	15.10	14.82	14.55
FeO*	2.58	1.47	4.86	5.20	4.85	3.88	4.16	4.38	4.50	4.11	3.43
MnO	0.074	0.089	0.094	0.097	0.074	0.058	0.063	0.042	0.059	0.082	0.065
MgO	0.91	0.46	4.86	4.70	3.18	2.24	2.92	3.09	3.70	2.96	1.54
CaO	2.16	1.16	6.40	7.05	4.26	3.78	4.26	4.33	5.43	4.21	3.25
Na_2O	4.30	4.49	3.79	4.01	3.73	2.91	3.66	3.70	3.39	3.68	3.70
K_2O	4.87	5.51	3.94	3.40	3.72	5.67	3.70	4.61	5.64	3.85	4.37
P_2O_5	0.163	0.047	0.688	0.616	0.378	0.351	0.351	0.437	0.83	0.299	0.313
Total	98.75	98.52	99.34	99.43	98.73	98.95	98.79	99.42	99.27	99.19	99.48
Trace Elements (ppm)											
Sc	4	5	19	15	7	14	8	9	10	11	7
V	42	10	134	140	127	67	86	71	117	82	78
Cr	15	1	140	142	56	43	50	103	124	62	63
Ni	11	10	92	87	61	50	56	102	125	59	54
Cu	8	5	34	37	20	20	25	23	42	34	24
Zn	62	63	79	76	76	62	73	63	82	56	47
Ga	19	18	19	21	22	23	19	19	20	19	19
Rb	144.8	205.0	92.9	68.9	82	114	80	105	115	104	129
Sr	452	131	1188	1182	1066	963	942	1138	1337	600	578
Y	24.93	32.01	23.78	23.70	19	18	19	21	22	22	24
Zr	346	404	316	300	276	305	266	314	459	238	259
Nb	26.78	34.47	20.95	20.58	14.2	18.1	14.0	16.9	21.8	21.4	24.7
Cs	2.75	5.78	2.07	1.00							
Ba	1412	1250	1522	1399	1580	1455	1367	1806	1997	801	807
La	70.44	89.24	83.70	73.38	72	90	51	100	100	62	78
Ce	128.20	163.29	154.68	138.73	114	140	118	145	170	120	129
Pr	13.57	17.04	17.20	15.81							
Nd	48.36	61.02	66.70	62.37							
Sm	7.96	10.06	12.28	11.24							
Eu	1.86	2.00	3.02	2.81							
Gd	5.37	6.81	7.81	7.32							
Tb	0.82	1.05	1.03	1.00							
Dy	4.52	5.86	4.99	4.92							
Ho	0.86	1.13	0.86	0.87							
Er	2.33	3.09	2.12	2.14							
Tm	0.33	0.43	0.28	0.29							
Yb	2.12	2.84	1.69	1.69							
Lu	0.34	0.44	0.25	0.25							
Hf	8.03	10.20	7.83	7.09							
Ta	1.53	1.87	1.06	1.07							
Pb	23.40	27.54	17.90	17.74	24	25	22	22	18	19	18
Th	10.73	13.53	10.99	10.87	12	16	10	14	14	16	18
U	2.22	2.70	2.55	2.48							

Isotopic Compositions	
$^{143}Nd/^{144}Nd$	0.51214
$^{87}Sr/^{86}Sr$	0.7104
εNd	-9.63
$^{206}Pb/^{204}Pb$	17.806
$^{207}Pb/^{204}Pb$	15.538
$^{208}Pb/^{204}Pb$	38.441

Major and trace element data were analyzed at the GeoAnalytical Laboratory at Washington State University. Trace elements were measured by XRF (x-ray fluorescence), except samples 94-61, 94-62, 94-63, and 94-64. For these samples, Rb, Y, Nb, Cs, Ba, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Hf, Ta, Pb, Th, and U were analyzed on an ICP-mass spectrometer. Isotopic compositions were completed at the University of Kansas. See geologic map for descriptions of units.

The overlying sequence of 16.0 to 15.2 Ma basaltic trachyandesite lavas (Thb) thickens from about 35 m to 1,200 m northwestward across the Nelson SW Quadrangle. Thb continues to thicken northwestward toward a possible source in the central Highland Range, about 2 to 5 km to the west of the northwest margin of the quadrangle (Faulds, 1999, p. 31; Feuerbach and others, 1999). Basaltic andesite intrusions appear to be common in this area and may represent the vent of a small stratovolcano.

Rock avalanche deposits (Tlu) and/or a thin sequence of conglomerate (Tsc) locally overlie the basaltic andesite lavas. The rock avalanche deposits include megabreccia of Proterozoic gneiss (Tlx), early to middle Miocene trachydacite (Tld), and early to middle Miocene basaltic trachyandesite (Tlb). Clasts of Proterozoic rocks are common in the conglomerate. In the west near the Highland Pass fault, the clasts and megabreccia of gneiss resemble exposed basement in the southern McCullough Range, whereas to the east near the Searchlight fault such detritus more closely matches basement lithologies exposed in the southern Eldorado Mountains.

The 15.2 Ma tuff of Bridge Spring (Tb) crops out across the entire southeastern Highland Range. Tb rests directly on either the volcanics of the Highland Range or the megabreccia-conglomerate sequence. It thickens westward in the west-tilted half graben in the hanging wall of the Highland Pass fault and toward the hinge zone of the syncline (cross section A–A´). Thin sequences of rock avalanche deposits or bouldery, matrix-supported conglomerate, of probable debris flow origin, are commonly found between the tuff of Bridge Spring and tuff of Mount Davis (Tdt). Similar to Tb, Tdt also thickens westward within both the west-tilted hanging wall of the Highland Pass fault and toward the synclinal hinge zone (cross section B–B´). In the southernmost part of the range, Tdt is absent, but this may be a consequence of erosion, because Miocene sections younger than 15.2 Ma are missing.

The capping sequence of conglomerate and sandstone (Tc) conformably overlies the tuff of Mount Davis and has the same general distribution as the tuffs of Mount Davis and Bridge Spring. These sedimentary rocks are thickest near the east-dipping Highland Pass fault (cross sections A–A´ and B–B´, fig. 2) and, to a large extent, represent growth-fault sediments deposited in a half graben in the hanging wall of that fault. Clasts of Early Proterozoic gneiss are common in the conglomerate and increase in abundance and size to the west, suggesting a primary source in the crystalline terrane of the southern McCullough Range (fig. 2). This conglomerate probably correlates with a relatively thick capping conglomerate sequence to the west of the quadrangle, which lies on the west limb of the anticline and appears to coarsen westward toward the McCullough Range fault. The capping Miocene conglomerate within the quadrangle is therefore interpreted as the more distal part of a fanglomerate sheet shed from the southern McCullough Range.

The ~16.0 to 12.8 Ma sedimentary deposits within the Nelson SW Quadrangle also record the tectonic and erosional denudation of uplifted footwall blocks in the southern Eldorado Mountains and southern McCullough Range (Faulds and others, 2002). Megabreccias composed of both Proterozoic gneiss and early Miocene intermediate to mafic lavas lie: (1) between the 16.0 to 15.7 Ma upper part of the volcanics of the Highland Range and 15.2 Ma tuff of Bridge Spring; (2) between the tuffs of Bridge Spring and Mount Davis; and (3) within the lower part of the 15.0

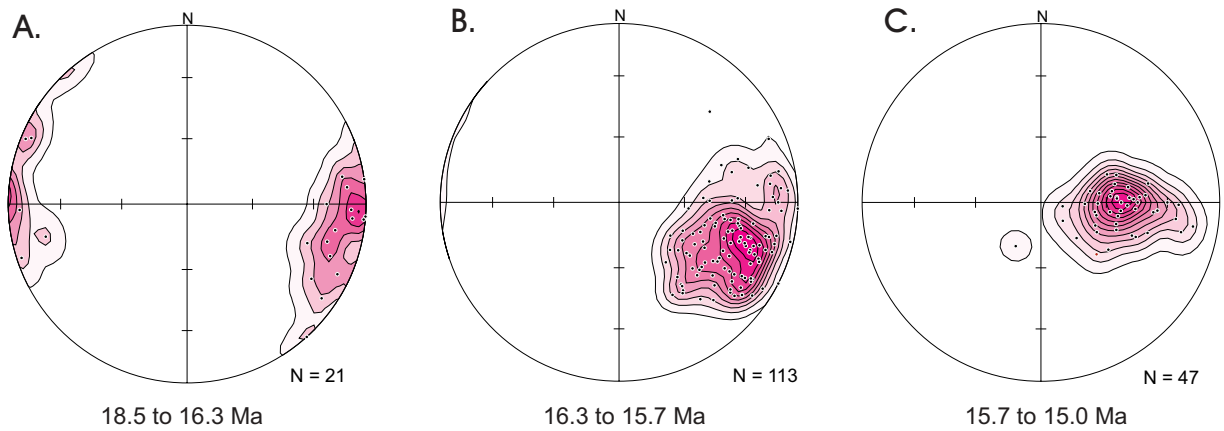

Figure 4. Lower-hemisphere equal-area stereographic projections of poles to layering and bedding in Miocene rocks of the southeastern Highland Range showing a progressive, up-section decrease in dip (from Faulds and others, 2002). These density contour plots indicate the percent of data per 1% area. N, number of measurements (shown as dots). A. 18.5 to 16.3 Ma lower part of the volcanics of the Highland Range. Mean orientation of layering and bedding is N3°E, 85°NW. Contour intervals are at 0, 2, 4, 6, 8, and 10% per 1% area. B. 16.3 to 15.7 Ma strata (mainly volcanics of the Highland Range). Mean orientation is N16°E, 63°NW. Contour intervals are at 0, 2, 4, 6, 8, 10, 12, 14, and 16% per 1% area. C. 15.7 to 15.0 Ma strata (mainly tuffs of Bridge Spring and Mount Davis). Mean orientation is 0°, 38°W. Contour intervals are at 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, and 22% per 1% area.

to 12.8 Ma conglomerate (fig. 3). Thus, the megabreccias began accumulating sometime after about 16.0 Ma and are probably as young as about 14.5 Ma. The megabreccias are rock-avalanche deposits that represent ancient landslides derived, at least in part, from steep coeval fault scarps. The rock avalanches may have been triggered by earthquakes. The Proterozoic detritus in both the megabreccias and conglomerate of similar age suggests that the basement rocks of the southern McCullough Range and southern Eldorado Mountains were uplifted and exposed in the footwalls of major normal faults about 16.0 Ma, which coincides with the most rapid rates of tilting (see discussion below). All of these sedimentary units are synextensional deposits that accumulated in discrete half grabens and locally constitute portions of the fold limbs.

Regional Ash Flows

The 15.2 Ma tuff of Bridge Spring and 15.0 Ma tuff of Mount Davis are two distinct regionally extensive ash-flow tuffs that blanketed much of the Highland Range and surrounding region. The tuff of Bridge Spring was first described by Anderson (1971) in the northern Eldorado Mountains. It extends from the White Hills on the east (Cascadden, 1991) to the McCullough Range on the west (Morikawa, 1994) and from the northernmost Eldorado Mountains (Anderson, 1971; Gans and others, 1994) southward to the southern Black Mountains. The tuff of Mount Davis, first described by Faulds (1995) in the Lake Mohave area, stretches from the White Hills westward to the Highland Range and between the latitudes of Willow Beach, Arizona, and Searchlight, Nevada (fig. 1). Although multiple cooling units were noted in the tuff of Bridge Spring, several previous studies failed to recognize the tuff of Mount Davis (Bingler and Bonham, 1973; Davis, 1984; Cascadden, 1991; Morikawa, 1994; Olson, 1996). This is not surprising, because the tuff of Mount Davis commonly rests directly on (fig. 5), and is compositionally similar to, the tuff of Bridge Spring. Thus, the tuff of Mount Davis has commonly been mistaken for an upper cooling unit within the tuff of Bridge Spring.

The two tuffs can, however, be distinguished by their age, subtle differences in phenocryst assemblages, and in some areas by intervening sequences of conglomerate, megabreccia, and/or mafic lavas. In the Nelson SW Quadrangle, for example, a thin sequence of megabreccia, of presumed rock-avalanche origin (cf., Yarnold and Lombard, 1989), and conglomerate commonly separates the tuffs of Mount Davis and Bridge Spring (fig. 3). In addition, $^{40}Ar/^{39}Ar$ geochronology indicates a statistically significant age difference between the two tuffs (fig. 6). In contrast to the tuff of Mount Davis, the tuff of Bridge Spring has ubiquitous sphene (sphene is rare in the tuff of Mount Davis), generally fewer phenocrysts, less abundant biotite and plagioclase, and typically finer-grained sanidine. Although both tuffs have reverse polarity, the declination of their respective paleomagnetic reference directions differs by about 20° and is statistically significant at the 95% confidence level (Faulds and Olson, 1997). The maximum thickness of the tuff of Bridge Spring (~200 m) exceeds that of the tuff of Mount Davis (~100 m), but in many areas of the Highland Range the tuffs have similar thicknesses.

The tuff of Bridge Spring may have been derived from a caldera in the northern part of the Eldorado basin (fig. 1; Gans and others, 1994). The source of the tuff of Mount Davis is unknown, but similarities in age, composition, and distribution suggest that both tuffs may have been erupted from the same cauldron.

Figure 5. Tuff of Mount Davis (Tdt) overlying tuff of Bridge Spring (Tb) in the northwest part of the Nelson SW Quadrangle. $^{40}Ar/^{39}Ar$ samples A and B were collected here. A thin paleosol separates the two tuffs in this area. The tuffs overlie basaltic andesite lavas (Thb).

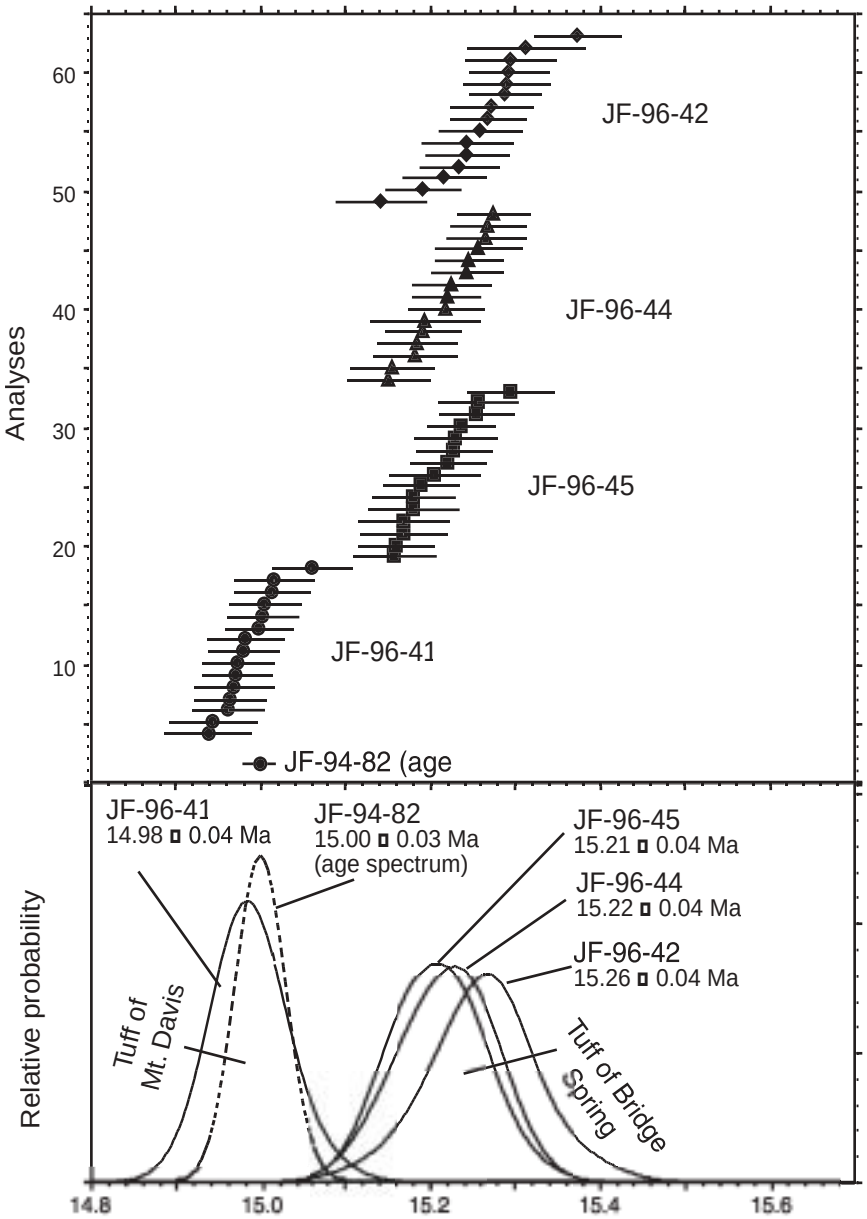

Figure 6. Age-probability distribution diagram (ideogram) combining incremental-heating and laser-fusion data from sanidine separates of the 15.0 Ma tuff of Mount Davis and the 15.2 Ma tuff of Bridge Spring (from Faulds and others, 2002). These data were obtained by Bill McIntosh and are discussed in detail in Faulds and others (2002).

STRUCTURAL FRAMEWORK

Miocene extension produced the major physiographic features within and near the Nelson SW Quadrangle, including the Highland Range and Piute and Eldorado basins. The southeastern part of the Highland Range constitutes the upper part of a large, steeply west-tilted fault block, the bulk of which resides in the neighboring southern Eldorado Mountains (fig. 1). This fault block exposes a crustal section that approaches 15 km in thickness and includes the 10+ km thick, ~16.6 Ma Searchlight pluton in the southern Eldorado Mountains and at least 3 km of volcanic strata in the southeastern Highland Range. The block is tilted nearly 90° and therefore reveals one of the thickest exposed cross sections of upper crust within the Colorado River extensional corridor. Although broken by several major east-dipping normal faults in the southeastern Highland Range (e.g., Highland and Searchlight faults), this block is essentially bounded by the east-dipping McCullough Range fault on the west and the gently east-dipping Dupont Mountain fault on the east (fig. 1). The McCullough Range fault probably links southward with a breakaway fault, described by Spencer (1985), that separates highly extended crust in the Colorado River extensional corridor from much less extended terrane to the west. Spencer (1985) surmised that the breakaway fault is part of a major east-dipping detachment system related to uplift and tectonic denudation of several metamorphic core complexes (e.g., Davis and others, 1980; Howard and John, 1987; Davis and Lister, 1988; Yin and Dunn, 1992; John and Foster, 1993; Campbell

and John, 1996). The Dupont Mountain fault also continues southward and appears to connect with major east-dipping detachment faults on the east flanks of the Sacramento and Chemehuevi Mountains. Both the Dupont Mountain and McCullough Range faults terminate northward in the Black Mountains accommodation zone (fig. 1). Within the Nelson SW Quadrangle, west tilts in the southeast Highland Range give way to east tilts to the northwest across the northeast-trending syncline. Accordingly, the large west-tilted fault block of the southern Eldorado Mountains and southeastern Highland Range terminates at the syncline.

The Piute basin is a west-tilted half graben developed primarily in the hanging wall of the east-dipping McCullough Range fault (fig. 2). It narrows and terminates northward as the McCullough Range fault loses displacement toward the accommodation zone. Only the northeasternmost part of the Piute basin lies within the Nelson SW Quadrangle. This portion of the basin also lies in the hanging wall of the Highland Pass fault, which projects southward into the eastern part of the Piute basin. Thus, the Piute basin probably includes several smaller west-tilted subbasins that have been filled with sediment. Both the Highland Pass and McCullough Range faults are covered by flat-lying late Tertiary to Quaternary sediments within the Piute basin.

The southern part of the Eldorado basin makes up the northeastern half of the Nelson SW Quadrangle. The Eldorado basin is a large composite basin that includes both east- and west-tilted subbasins. The southernmost part of the basin is largely composed of west-tilted subbasins in the hanging walls of major east-dipping normal faults, such as the Searchlight and Highland faults (see cross section A–A´). In contrast, two major west-dipping normal faults, the Keyhole Canyon and Copper Mountain faults, bound the central and southern Eldorado basin on the east (Faulds and others, 2002). The Keyhole Canyon fault borders a large steeply east-tilted fault block in the northern Eldorado Mountains on the west and the central part of the Eldorado basin on the east (fig. 1). It probably continues southward into the southern Eldorado basin about 10 km east of the northern and central Highland Range. The west-dipping Copper Mountain fault, which may link to the north with the Keyhole Canyon fault, bounds the uplifted crystalline terrane of the central and southern Eldorado Mountains on the west. It is locally exposed on the west flank of the central Eldorado Mountains and to the south near Copper Mountain. Displacement on the Copper Mountain fault appears to decrease significantly southward as it steps eastward through the crystalline terrane of the southern Eldorado Mountains and becomes a major antithetic west-dipping normal fault in the northern Whipple domain (fig. 1). The Keyhole Canyon and Copper Mountain faults are part of the west-dipping normal-fault system in the northern Eldorado Mountains that accommodated large-magnitude thin-skinned extension (see Anderson, 1971; Darvall, 1991). East-tilted half grabens probably reside in the hanging walls of these faults in the central part of the Eldorado basin, where the faults may have accommodated several kilometers of displacement. Similar to the Piute basin, all major faults in the southern Eldorado basin are onlapped by flat-lying late Tertiary to Quaternary sediments.

No major Quaternary faults have been identified in the Nelson SW Quadrangle or nearby parts of the Highland Range and Eldorado and Piute basins. None of the major normal faults in the area (e.g., Searchlight, Highland Pass faults) cut Quaternary deposits. A relatively conspicuous north-northeast-trending scarp in late Tertiary to Quaternary alluvial basin fill in the north-central part of the quadrangle (SW¼ section 10 and NW¼ section 15, T27S, R63E) appears to have an erosional origin. One minor north-striking fault may cut early Pleistocene alluvial fan deposits in the north-central part of the quadrangle (SW¼ section 16, T27S, R63E), but the exposed trace of this fault is only about 1 km in length.

Geometry and Kinematics of Faults

The southeastern Highland Range is dominated by north- to north-northwest-striking, gently to steeply east-dipping normal faults. Offset on most faults is less than 500 m, but the Highland Pass, Highland, and Searchlight faults all accommodated several kilometers of normal displacement (cross section B–B´). The Searchlight fault is a major moderately to steeply east-dipping normal fault zone that bounds much of the southern Highland Range on the east and continues southward into the Searchlight mining district. South of the Nelson SW Quadrangle, the trace of the fault is covered by Quaternary alluvium, but it probably lies about 0.5 km east of the town of Searchlight. Displacement on the fault is about 3 km near U.S. Highway 95, but probably increases to both the north and south of that area. The Searchlight fault is probably responsible for truncation and significant down-to-the-east offset of orebodies in the Searchlight mining district. The hanging wall of the fault is poorly exposed but partly comprises both the southern end of the Eldorado basin and northeastern part of the Piute basin. The Highland Pass fault is a moderately to steeply east-dipping normal fault exposed primarily just west of the quadrangle (fig. 2, cross section A–A´). At least 3 to 4 km of normal displacement along this fault produced a west-tilted half graben in its hanging wall. This half graben merges northward with the west-dipping eastern limb of the syncline.

Good kinematic indicators, such as rough facets and Riedel shears (cf., Angelier and others, 1985), are sparse within the quadrangle but generally indicate dominantly normal slip. Normal separation of stratigraphic units is ubiquitous. The strike of the faults and dominance of normal slip are generally compatible with an approximately east-trending regional extension direction. However, kinematic indicators on several faults suggest an episode of north-northeast directed extension in some areas (e.g., faults in sections 36 and 13, T27S, R63E).

Faults on the eastern, west-dipping limb of the syncline strike northerly and dip moderately to steeply eastward. Both east- and west-dipping normal faults are found near the hingeline of the syncline (cross section A–A´).

Crosscutting relationships between the oppositely dipping normal-fault sets are generally ambiguous. Reverse faults were not observed in the Nelson SW Quadrangle. However, a few minor oblique slip (dextral-normal and sinistral-normal), west-northwest-striking faults were observed on the east-dipping, western limb of the syncline.

Both listric and anti-listric (i.e., dip increases with depth) geometries are inferred for many faults within the Nelson SW Quadrangle. Where tilts of hanging walls are less than that of footwalls, anti-listric geometries are interpreted. Listric geometries are inferred in cases where hanging walls are tilted more steeply than footwalls, which is especially common near the hinge zone of the syncline (cross section A–A´). In much of the quadrangle, similar magnitudes of tilting characterize the hanging walls and footwalls of individual faults, suggesting a planar geometry. Slightly curved, concave-upward geometries (i.e., slightly listric) are inferred, however, for many of these faults (cross section B–B´), because they were probably active during deposition of synextensional strata. In such cases, concave-upward geometries would result from the upward propagation of individual faults at steep dips as deeper, older segments were progressively rotated to shallower dips through domino-like block tilting (Faulds and others, 2002).

The Highland fault (formerly the Joshua Tree fault of Faulds, 1999) is a major gently east-dipping normal fault that cuts steeply west-tilted strata in the southwestern part of the quadrangle. This fault is cut by more steeply dipping normal faults (cross section B–B´). These relations suggest that the Highland fault originally developed at a relatively steep dip and was rotated to its present shallow dip by domino-like block tilting (cf., Proffett, 1977). However, several minor steeply dipping faults appear to sole into the gently dipping Highland fault (cross section B–B´), suggesting that it accommodated some slip at a gentle dip.

It is noteworthy that fault-bedding intersection angles (as measured downward from bedding to the fault) commonly approach and, in many cases, exceed 90°. This implies that (a) most of the faults formed at steep dips, some approaching 90°, and/or (b) many of the faults developed after significant tilting had already occurred.

Syncline

The syncline separating the southeastern and central parts of the Highland Range has a north to northeast-trending hingeline that plunges gently south near its southern end and gently northeast farther north. Directly west of the Nelson SW Quadrangle, the syncline ends to the southwest at the intersection with the anticline (fig. 2). The east limb of the syncline corresponds to the upper part of the large aforementioned west-tilted faulted block that comprises much of the southern Eldorado Mountains and southeastern Highland Range. Only the southwestern part of the syncline is exposed. It is defined by gently tilted middle to late Miocene conglomerate within the hinge zone and oppositely tilted ridges of the tuffs of Mount Davis and Bridge Spring on the limbs (cross section B–B´). The syncline is as an open, asymmetric to symmetric, steeply inclined, subhorizontal, parallel fold (cross section A–A´) (cf., Fleuty, 1964; Ramsay, 1967). The interlimb angle is about 100° to 125° at exposed levels. The steep east dip of the west limb of the syncline decreases to the north; accordingly, the syncline becomes more symmetric to the northeast. The syncline projects northeastward into the southern part of the Eldorado basin, where it is buried by Quaternary alluvium, and probably links northward (possibly in a complex fashion) with an anticline in the central Eldorado Mountains (fig. 1). The anomalous steep dips of east-tilted strata near the juncture of the anticline and syncline are related to normal drag along the northern terminus of the east-dipping Highland Pass fault (cross section A–A´).

Several features indicate that the syncline within the Nelson SW Quadrangle reflects extensional strain. For example, the west-dipping eastern limb of the syncline is a half graben in the hanging wall of the east-dipping Highland Pass and related faults (cross section A–A´). The east-dipping limb appears to be related to east-tilted half grabens developed in the hanging wall of a west-dipping normal-fault system that bounds the Eldorado basin on the east (e.g., Keyhole Canyon and Copper Mountain faults). $^{40}Ar/^{39}Ar$ data indicate that the folding was synchronous with extension in the southern part of the quadrangle (see discussion below) and occurred ~16.5 to 11 Ma. Furthermore, normal faults dominate the entire area, and no major reverse faults were observed. The syncline is therefore interpreted as a fault-related extensional fold produced by the partial, along-strike overlap of oppositely dipping normal-fault systems and attendant tilt-block domains. It formed between overlapping outwardly dipping listric faults, as adjacent fault blocks were tilted toward one another. The syncline significantly affected depositional patterns, with synextensional units (e.g., Tb, Tdt, and Tc) thickening toward the hinge.

SEARCHLIGHT MINING DISTRICT

The Searchlight mining district was discovered in 1897 and has a recorded production of about $7 million (approximately $78 million in 2002 dollars) primarily between 1902 and 1953 (see discussion in Longwell and others, 1965). The district has yielded over 246,000 ounces of gold, 352,000 ounces of silver, 750,000 pounds of copper, and 1.3 million pounds of lead. Ore deposits of the Searchlight district occur as fissure veins that typically consist of quartz-cemented breccias. Adularization, silicification of wall rock, and base-metal sulfides accompany the quartz veins in these breccias in the south, whereas lamellar calcite and traces of sulfides are found in the north (Longwell and others, 1965). The base-metals-deficient veins found in the northern part of the district may be of a lower temperature type, thus representing a shallower level of exposure in the hydrothermal system. The ore is largely oxidized, with principal past production from veins with lead carbonate mineralization.

Most of the production in the Searchlight mining district has been south of the Nelson SW Quadrangle, chiefly from the footwall of the east-dipping Searchlight fault zone within or directly adjacent to the roof of the Searchlight pluton. The Quartette Mine, 1.2 km south of Searchlight, has been the largest producer in the district, accounting for 64% of the recorded gold (Longwell and others, 1965). The workings of the Quartette Mine occur along a large vein that strikes N70°W and dips ~50° south. Easterly striking calcite and quartz veins and rhyolite dikes are common in the region and are probably associated with mild north-south extension in early Miocene time (Faulds and others, 2001). Many of these east-striking dikes and veins cut the ~16.6 Ma Searchlight pluton. Mineralization in the district has also been related to subhorizontal dikes, as exemplified in the Blossom Mine 0.8 km south of the Nelson SW Quadrangle (Longwell and others, 1965). Most of these subhorizontal dikes have probably been tilted ~90° and may be genetically related to the Searchlight pluton. Most of the orebodies are probably offset by the Searchlight fault zone. Offset eastward extensions of some of the orebodies are probably buried beneath alluvium in the hanging wall of the Searchlight fault zone.

The Searchlight mining district appears to be genetically related to the ~16.6 Ma Searchlight pluton. The zone of alteration associated with the district appears to form a halo around the upper hypabyssal parts of the pluton. The pluton and surrounding volcanic units are all tilted 50–90° to the west. Most of the mineralization is confined to the Searchlight pluton and lower sequence of trachydacite and trachyandesite lavas in the volcanics of the Highland Range. It is therefore inferred that the mineralization predates most of the tilting and east-west extension. Thus, the Searchlight mining district may provide a cross-sectional view of a large, epithermal mineralized system. The presence of large-magnitude west tilting must be taken into account in future exploration efforts within the district.

Several moderately to steeply dipping, east- to east-northeast-striking calcite and quartz veins crop out along the southern margin of the Nelson SW Quadrangle within the northern part of the Searchlight mining district, but none are known to have produced significant amounts of gold or silver. However, the thick sequence of 16.3 to 16.0 Ma rhyolite lavas within the quadrangle is similar in age and composition to deposits that host a large epithermal gold deposit in the Castle Mountains (e.g., Capps and Moore, 1997; Hart Mountain Mine) located approximately 20 km southwest of the quadrangle.

PALEOMAGNETIC DATA

A total of 147 paleomagnetic samples at 19 sites were collected and analyzed from the Nelson SW Quadrangle to evaluate the role of vertical axis rotation in the development of extensional folds within the Black Mountains accommodation zone. Samples were collected with a portable field drill and subjected to alternating field or thermal demagnetization. Characteristic remanent magnetization directions were isolated using a modified form of principal component analysis (Kirschvink, 1980). Of the 19 sites collected from the quadrangle, 4 were from the tuff of Bridge Spring and 15 from the tuff of Mount Davis. These data are reported in table 3.

A reference direction was established for the regionally extensive 15.2 Ma tuff of Bridge Spring (9 sites, Declination =199°, Inclination=-47°, α_{95}= 5.7°) in the unrotated terrain of the northern Eldorado Mountains (Faulds and Olson, 1997). In the Nelson SW Quadrangle, the tilt-corrected data from 4 sites in the tuff of Bridge Spring (Declination=199.3°, Inclination=-46.6°, α_{95}=15.9°) overlap the reference direction for the tuff of Bridge Spring at the 95% confidence level. This indicates that no discernible vertical-axis rotations have occurred in the Nelson SW Quadrangle since 15.2 Ma. Assuming that vertical-axis rotations are negligible in the quadrangle, the group site mean of tilt-corrected data suggests that the tuff of Mount Davis has a reference direction with a declination of 172.3° and inclination of -39.3° (α_{95}= 4.5°).

TIMING OF DEFORMATION

The onset of major east-west extension was determined by dating the youngest, most steeply tilted unit, above which significant tilt fanning began. Peak extension probably corresponds to the highest rate of tilting. An upper limit of extension was constrained by dating the youngest, most gently tilted strata and by regional relations.

In the southeastern Highland Range, average west tilts progressively decrease up-section from 85° in the 18.5 to 16.3 Ma lower part of the Highland Range volcanics, to 63° in the 16.3 to 15.7 Ma rhyolites and basaltic trachyandesites of the Highland Range volcanics, and to 38° in the 15.2 to 15.0 Ma tuffs of Bridge Spring and Mount Davis (fig. 4). The youngest most steeply tilted unit was found in Thr and yielded an $^{40}Ar/^{39}Ar$ date on biotite of 16.21±0.17 Ma (table 1). This signifies the approximate onset of tilting and extension. Peak extension occurred between 16.2 and 16.0 Ma, as evidenced by tilting rates during this period of approximately 75°/Ma. About 50% of the tilting in the southeast Highland Range occurred between 16.2 and 15.0 Ma, prior to deposition of the tuff of Mount Davis. The onset and peak episode of extension in the Highland Range, as well as tilting of the large west-tilted fault block in the southern Eldorado Mountains and Highland Range, appears to have immediately followed emplacement of the 10+km thick, ~16.6 Ma Searchlight pluton (Faulds and others, 1998).

An upper age limit for extension in the Nelson SW Quadrangle cannot be well defined. The conglomerate and sandstone of the Highland Range (Tc) forms the uppermost syntectonic unit. Although this unit locally contains tuffaceous material (Tct), most of the interbedded tephras are reworked and cannot be radiometrically dated. Glass geochemistry correlation techniques (i.e., tephrochronology) were not attempted. Nonetheless, stratigraphic relations to both the east and north suggest that extension within the

quadrangle was waning by 12.8 Ma and had probably ceased by about 11 Ma. Gently tilted (~10–15°) 12.79±0.22 Ma basalt lavas crop out in the northeast part of the Highland Range (Faulds and others, 2002). Gently tilted basalt flows in the Lake Mohave area (fig. 1) have also yielded 12.8 to 13.0 Ma $^{40}Ar/^{39}Ar$ dates (Faulds and others, 1995). In the Lake Mohave area directly to the east, 11.3 to 11.6 Ma strata are flat-lying to very gently tilted (<5°) and therefore postdate any appreciable extension (Faulds and others, 1995; Faulds, 1996).

CONCLUSIONS

Typical of the northern Colorado River extensional corridor, the Nelson SW Quadrangle contains a thick (>3 km) section of Miocene volcanic and subordinate clastic sedimentary rocks. The Miocene section ranges from 18.5 Ma to about 13 Ma and rests directly on Early Proterozoic gneiss. The early Miocene nonconformity is poorly exposed in the southeast part of the quadrangle. The ~16.6 Ma Searchlight pluton intrudes the lower part of the Miocene section.

The structural framework of the Nelson SW Quadrangle is dominated by extensional strain features that reflect large-magnitude middle Miocene east-west extension. Miocene volcanic and sedimentary strata are generally moderately to steeply west-tilted and cut by numerous east-dipping normal faults. Extension began about 16.2 Ma and had probably ceased by about 11 Ma. Tilts progressively decrease up-section from about 80° in 16.2 Ma rhyolites to less than 20° in a 15 to ~13 Ma capping conglomerate. The ~16.6 Ma Searchlight pluton was probably emplaced just prior to the onset of regional east-west extension. The Searchlight mining district extends into the southern part of the Nelson SW Quadrangle and is characterized by easterly striking dikes and veins, which probably reflect mild north-south early Miocene extension. The mineralization may be related to the Searchlight pluton. The southern part of the quadrangle contains the upper part of a large steeply west-tilted fault block that extends eastward into the southern Eldorado Mountains. This fault block exposes a crustal section that approaches 15 km in thickness. It terminates northward in the northern part of the quadrangle in an extensional syncline, produced by the along-strike overlap of outwardly dipping listric normal faults. Essentially undeformed, flat-lying Quaternary sediments of the Eldorado and Piute basins onlap the tilted and faulted Miocene rocks. One minor northerly striking fault may cut early Pleistocene deposits within the quadrangle.

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Table 3. Paleomagnetic Data, Nelson SW Quadrangle, Highland Range

Site	Unit	Location	D	I	k	α_{95}	N/N_0	Strike, Dip	C
HS1	Tdt	AWW	198.3	-31.5	158	4.42	8/8	0, 35 W	175, -36
HS2	Tdt	SWE	198.1	-35.1	1089	1.68	8/8	27, 27 NW	183, -28
HS3	Tdt	SWE	193.8	-38.2	540	2.39	8/8	16, 31 NW	172, -31
HS4	Tdt	SWE	195.7	-42.0	1321	1.52	8/8	14, 32 NW	170, -36
HS5	Tdt	SWE	192.8	-37.6	125	6.01	6/7	6, 28 NW	172, -36
HS6	Tdt	SWE	184.0	-43.1	531	2.24	9/9	349, 16 SW	169, -46
HS7	Tdt	SWE	177.7	-47.7	125	5.41	7/7	40, 20 NW	167, -33
HS8	Tdt	SWE	174.1	-48.6	200	3.65	9/9	29, 18 NW	162, -37
HS9	Tdt	SWE	177.7	-43.5	672	2.59	6/7	8, 21 NW	161, -36
HS10	Tdt	SWE	177.0	-44.9	361	3.18	7/7	9, 14 NW	165, -41
HS20	Tdt	AEE	154.8	-39.3	967	1.94	7/7	342, 24 NE	175, -38
HS38	Tdt	AEE	156.4	-47.5	1262	1.56	8/8	347, 27 NE	186, -46
HS39	Tb	AEE	147.8	-43.8	87	9.89	4/8	348, 65 NE	206, -32
HS40	Tdt	AEE	142.9	-9.6	279	3.32	8/8	13, 61 SE	174, -48
HS41	Tdt	AEE	146.1	-12.3	105	5.42	8/8	14, 74 SE	195, -49
HS42	Tdt	AEE	144.0	-42.5	395	2.79	8/8	334, 20 NE	163, -43
HS43	Tb	AEE	163.0	-55.8	407	2.75	8/8	325, 26 NE	189, -42
HS51	Tb	AEE	168.8	-58.4	290	3.26	8/8	355, 28 E	209, -51
HS52	Tb	SWE	231.0	-35.5	554	2.36	8/8	358, 41 SW	191, -60

Location designations are for west-tilted west limb of the anticline (AWW), east-tilted east limb of the anticline (AEE) (also east-tilted western limb of the syncline), and west-tilted east limb of the syncline (SWE). Tb, Tuff of Bridge Spring (shaded); Tdt, Tuff of Mt. Davis. D=Declination; I=Inclination; k=precision parameter (Fisher, 1953); α_{95}=half apical angle of 95% cone of confidence; N/N_0=number of samples averaged versus number of samples analyzed; strike and dip=attitude of compaction foliation in ash-flow tuff; C=declination and inclination corrected for tilting. The reference direction for the tuff of Bridge Spring, as established in the northern Eldorado Mountains, has a declination and inclination of 199° and 47°, respectively, with an α_{95}=5.7°.

County, Nevada: U.S. Geological Survey Geologic Quadrangle Map GQ-1394, scale 1:62,500.

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