PRELIMINARY GEOLOGIC MAP OF MOST OF THE CHALK HILLS QUADRANGLE, STOREY COUNTY, NEVADA

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af **Recent excavations (Holocene)** Man-made excavations at an aggregate mine within the Washington Hill Rhyolite. May also include outcrops of Taa and Tsw.

Qa **Recent alluvium (Holocene)** Poorly sorted, subangular to subrounded unconsolidated silt, sand, and gravel (rarely boulders) along active, or recently active, washes; incised erosional channels and undifferentiated nearby over-bank flood deposits with some A-C soil development. Maximum thickness is ~6 m.

Qls **Landslide deposit (Holocene)** Poorly sorted, angular, silt to boulder unconsolidated slide deposit found only in NE1/4 of section 23, T18N, R21E. Indicated by headwall scarp. Maximum thickness is ~15 m.

Qly **Lacustrine deposit (Holocene)** Unconsolidated clay, silt, and sand of seasonal lakes with some A-C soil development. Maximum thickness is ~10 m. Deposits found in sections 34 and 27, T18N, R21E.

Qao, Qao_1, Qao_2, Qao_3 **Qao, Alluvium undifferentiated** Poorly sorted, unconsolidated, subangular silt, sand, pebble, cobble, and boulders of volcanic and sedimentary rocks; locally derived rocks of Tka, Tkd, Tkrd, Tlb, Tcmb, Tma, Twr, Qmb, and Tcl, Tct, Tsw, and Tcf form talus, small alluvial fans, and valley-fill deposits; locally has moderate development of A-C soil caliche crust in parts. Maximum thickness is ~10 m. Rare consolidated, thin-bedded brown, coarse, subangular, well-sorted, matrix-supported lithic arenite developed within Long Valley; incised by active washes (maximum thickness is ~1 m). **Qao_1, Alluvium of McClellan Peak Basalt** Poorly sorted, unconsolidated, subangular cobble and boulders of basalt derived from McClellan Peak Basalt (Qmb); predominantly forms a thin veneer above erosional surfaces on basalt or talus beneath Qmb outcrops. Maximum thickness is ~5 m. **Qao_2, Alluvium of Clark Mountain and Lousetown basalts** Poorly sorted, unconsolidated, subangular cobble and boulders of basalt derived from Lousetown (Tlb) and Clark Mountain (Tcmb) basalts. Predominantly forms as talus below basalt outcrops or as a thin veneer above erosional surfaces on basalts. Maximum thickness is ~10 m. **Qao_3, Alluvium of Washington Hill Rhyolite** Poorly sorted, unconsolidated, subangular cobble and boulders of rhyolite derived from Washington Hill Rhyolite (Twr). Forms as talus beneath rhyolite outcrops. Maximum thickness is ~5 m.

Qp **Pediment deposits (Holocene to lower Pleistocene)** Thin veneers of silt, sand, gravel, and rare boulders similar to recent and older alluvium deposits. Maximum thickness is <5 m; caps erosional surfaces developed on sedimentary rocks in the south-central part of the map area.

Qmb, Qlmb **Qmb, McClellan Peak Basalt (lower Pleistocene)** Medium gray to black, brown- to red-weathering, augite olivine basalt lava containing 10-15% phenocrysts; composed of 10-20% olivine (2-5% of olivine has iddingsite rims), 5-25% lath-shaped plagioclase, trace to 4% augite; porphyritic and vesicular in parts. Phenocrysts range up to 8 mm long. Abundant cinder and blocks crop out around a possible vent at Cinder Mountain (Rose 1969) along the eastern edge of the map area. Lavas flowed westward, filling topographic lows along Long Valley, and into the Truckee River canyon, ~12 km from Cinder Mountain. Qmb is locally columnar jointed within Long Valley. Maximum thickness of flows is ~5 m. A groundmass concentrate yielded an $^{40}Ar/^{39}Ar$ date of 1.44±0.01 Ma. **Qlmb, McClellan Peak intrusion** Small plug in east-central part of map area showing concentric foliations and standing ~25 m above surrounding flows; petrographically similar to flows.

Tlb, Tlib **Tlb, Lousetown Basalt (upper Miocene)** Medium to dark gray locally vesicular, olivine basalt and augite basaltic andesite lavas containing up to 35% phenocrysts. Phenocrysts include 10-25% laths of plagioclase, 2-8% olivine (3-10% of olivine altered to or exhibit rims of iddingsite), 3-8% augite, and trace hypersthene and hornblende. Phenocrysts range up to 4 mm long. Tlb weathers brown to red. Plugs and flows crop out within the Tertiary sedimentary rocks (Tct, Tcl). ~1.5 km east of the main flows, and cap ridges of Kate Peak volcanics in the southwest part of the map area. Maximum thickness is ~150 m. A groundmass concentrate yielded an $^{40}Ar/^{39}Ar$ date of 7.54±0.08 Ma. **Tilb, Lousetown Basalt intrusions** Intrusive olivine plugs of Lousetown Basalt. Plugs contain 2-6% phenocrysts of olivine, typically altered to iddingsite; commonly exhibits columnar jointing. A groundmass concentrate yielded an $^{40}Ar/^{39}Ar$ date of 7.57±0.45 Ma. A large plug, within the main body of the lavas, is petrograhically similar to flows but is distinct from the smaller olivine plugs. The large plug contains 5-10% plagioclase, 2-8% olivine (10-14% altered to iddingsite) and trace hornblende, hypersthene, and augite phenocrysts.

Tcmb **Basalt of Clark Mountain (upper Miocene)** Medium to dark gray, locally vesicular, glomeroporphyritic olivine basalt lavas containing up to 18% phenocrysts; including 8-10% laths of plagioclase (2-5% of plagioclase altered to sericite), 2-6% olivine (3-6% of olivine altered to or exhibit rims of iddingsite), 1-3% augite, and trace hypersthene and hornblende. Maximum phenocryst size is 2 mm. Tcmb weathers brown to red. Maximum thickness is 120 m. Flows may have originated from Clark Mountain. A groundmass concentrate yielded an $^{40}Ar/^{39}Ar$ date of 9.64±0.04 Ma.

Twr, Tsw **Twr, Washington Hill Rhyolite dome (middle to upper Miocene)** White to gray, flow-banded biotite rhyolite; commonly aphanitic with up to 5% phenocrysts consisting of 1-3% biotite, 1-2% plagioclase, and trace sanidine, hornblende, and orthopyroxene; also contains 1-2% spherulites. Actively mined for aggregate. Plagioclase and biotite have yielded K/Ar dates of 9.7 to 11.5 Ma (Silberman and others, 1979; and Vikre and others, 1988). **Tsw, Washington Hill tuffaceous sediments** Rhyolitic to lithic tuffs with thin to medium interbeds of cross-laminated lithic arenites, diatomite, and tuffaceous shales; concentrated around the Washington Hill rhyolite dome (Twr). Also includes poorly-sorted matrix-supported pebble to boulder conglomerate with subangular clasts up to 1.5 m. long and moderately sorted coarse lithic arenite with subangular clasts and tuff interbeds. Conglomerate clast composition is 60% Tka, 32% Tkd or Tkdi, and 8% Twr clasts. No basaltic or Tkva clasts were observed. Tsw is generally poorly exposed; best outcrops lie to the southwest of Twr outside the map area. Maximum thickness is 250 m.

Sedimentary rocks of the Chalk Hills (middle to upper Miocene)

Tcf, Tcl, Tct **Tcf, Chalk Hills fluvial sediments** Thin- to medium-bedded gray to tan, commonly cross-laminated, tuffaceous lithic arenites, with interbeds of medium-bedded, poorly sorted, matrix-supported, pebble conglomerate with subrounded clasts. Maximum clast size is 20 cm. Maximum thickness is ~200 m. **Tcl, Chalk Hills lacustrine sediments** Thin- to medium-bedded, rarely thick-bedded, light-gray to white diatomite with interbeds of thin- to medium-bedded, fine to coarse lithic tuffs and moderately sorted, matrix supported coarse-grained to pebble lithic arenites with subangular to subrounded clasts. Clastic dikes locally cut strata. Locally strata are deformed into outcrop-scale folds. Diatomites commonly contain abundant fossil flora and rare vertebrates suggesting an early Pliocene age (Axelrod, 1956, 1958, 1962; La Rivers, 1953); however, radiometric dates suggest a Miocene age. Maximum thickness is ~400 m. Biotite from an interbedded tuff yielded a K/Ar date of 12.3±0.5 Ma (biotite) (Stewart and others, 1994). **Tct, Chalk Hills tuffaceous sediments** White to gray, thin- to thick-bedded, in parts graded, locally dacitic, rhyolitic, and lithic tuffs; a cliff former (commonly cross-laminated); interbeds of: 1. medium- to thin-bedded, poorly sorted, matrix-supported, brown, tuffaceous cobble breccias; 2. thin-bedded, fissile diatomite; 3. thin-bedded; fine- to medium-grained pumiceous tuff; 4. poorly sorted, matrix-supported, tuffaceous pebble conglomerate and lithic arenites with subrounded to subangular clasts. Lithic tuffs contain rip-up clasts of diatomite and carbonaceous material. Parting lineations, cross-laminations, pebble imbrication, and mega-ripples suggest a predominant flow direction from the south. Probably originated primarily as debris flows and surge deposits. Maximum thickness is ~500 m. Biotite from pumiceous rhyolite tuff yielded a K/Ar date of 12.6±0.5 Ma (Silberman and McKee, 1972). From this study, a biotite yielded an $^{40}Ar/^{39}Ar$ date of 12.63±0.14 Ma.

Sedimentary rocks of the Chalk Hills were initially named Truckee Formation by Thompson (1956) based on Miocene age but later labeled Coal Valley Formation by Axelrod (1962) on the basis of predominant andesitic detritus. Age of the Chalk Hills tuffs suggests a temporal correlation and possible interfingering with the underlying Kate Peak volcanics. The Chalk Hills basin is a west tilted half graben developed in the hanging wall of the Comstock fault (Thompson, 1956). Tlb overlies the Chalk Hills sedimentary rocks in angular unconformably.

Tma **Mustang Andesite (upper Miocene)** Light to dark gray porphyritic hornblende andesite with 15-20% phenocrysts consisting of 10-15% plagioclase (2-4% of plagioclase altered to sericite), 5-10% hornblende (0-3% of hornblende altered to chlorite; 0-1% of hornblende altered to hematite or magnetite), 1-3% biotite (1-2% of biotite altered to chlorite), trace to 1% hypersthene, and trace oxyhornblende. Hornblende is commonly euhedral and up to 10 mm long. Weathers brown. Intrusions of Mustang Andesite were observed at Clark Mountain and exhibit similar geochemical signature to the flows (samples B and C). Maximum thickness is ~50 m. Previous studies reported K/Ar dates of 8.4 to 9.5 Ma for Tma (Morton and others, 1977,1980). A hornblende from this study yielded an $^{40}Ar/^{39}Ar$ date of 12.11 ± 0.06 Ma.

Tkd, Tkdi, Tka, Tkrd **Kate Peak Formation (middle Miocene) Tkd, Kate Peak dacite** Purplish to reddish, medium to light gray porphyritic hornblende-biotite dacite lavas; weathers red to brown; contains up to 20% phenocrysts of 2-5% hornblende, 2-4% biotite, 2-5% plagioclase, trace augite, trace to 3% oxyhornblende, trace to 1% hypersthene, and trace quartz. Biotite commonly forms euhedral books up to 6 mm in diameter. 3-8 % of plagioclase altered to sericite. 5-40% of biotite and hornblende exhibit hematite or titanomagnetite rims, hematite staining, or alteration to chlorite. Groundmass is generally finer grained than Tka but coarser grained than Tkrd. Biotite from a possible correlative unit at Kate Peak yielded a K/Ar date of 13.1±0.8 Ma (Silberman and McKee, 1972). A biotite from this study produced an $^{40}Ar/^{39}Ar$ date of 12.11 ± 0.04 Ma. Maximum thickness is ~300 m. Tkd locally contains thick lenses of clast-supported, moderately sorted, boulder breccias with clasts up to 50 cm long; breccias may have been rock avalanches. **Tkdi, Kate Peak dacite intrusions** Domes and dikes similar petrographically to Tkd; distinguished by porphyritic nature; contains large (<6 mm) phenocrysts of biotite, hornblende, and plagioclase and concentric flow-foliations. **Tka, Kate Peak andesite** Medium to dark gray hornblende andesite; weathers medium gray to red; typically contains ~20% phenocrysts (<5 mm in size) of 5-10% (rarely 15%) plagioclase, 3-8% hornblende, 2-3% augite, 0-3% biotite, 0-2% olivine, trace to 1% hypersthene, magnetite, and oxyhornblende. About 3-6% of biotite and hornblende show rims or alteration to titanomagnetite. Groundmass is generally coarser than Tkrd and Tkd. Flow banding typically dips less than 30°. Maximum thickness is ~700 m. Tka locally includes undifferentiated andesitic dikes and lenses of thick-bedded, clast-supported, moderatley sorted, boulder breccia with clasts up to 60 cm long. Breccia deposited as possible rock avalanches. **Tkrd, Kate Peak rhyodacite** Red to light gray rhyodacite lavas and intrusions; weathers red to brown; contains 10% phenocrysts commonly <2 mm long of 1-4% biotite, 1-3% hornblende, 1-5% plagioclase, and trace quartz and sanidine. 5-10% of hornblende and biotite are altered to or rimmed by titanomagnetite; locally includes black to gray flow-banded rhyolitic vitrophyre. Groundmass is generally finer than Tkd or Tka. Devitrified spherulites (<10 mm in diameter) are common. Flow banding typically dips steeply. Tkrd locally contains xenoliths, up to 40 cm in length, of andesite. Maximum thickness is ~500 m. Biotite from vitrophyre yielded a K/Ar date of 12.4±0.2 Ma (Silberman and McKee, 1972). Note: geochemical analysis shows rhyolite composition (see table below).

Kate Peak sedimentary rocks (middle Miocene)

Tks, Tkc **Tks, Kate Peak sedimentary rocks, undifferentiated** Poorly exposed, poorly indurated, gray to white, thin- to medium-bedded dacitic to andesitic tuff, diatomite, and tuffaceous sediments. This unit consists of thin lenses of sediment interbedded within Tkd and Tka, but Tks is more abundant to the east of the mapped area (Rose, 1969). Maximum thickness is ~10 m. **Tkc, Kate Peak conglomerate** Moderately to well sorted, matrix-supported, pebble to cobble conglomerate with subangular andesitic and dacitic clasts up to 1 m long. Commonly occurs at the base of, or is inter-bedded with, Tka. Tkc possibly originated as debris flows. Locally interbedded with cross-laminated dacitic to andesitic nonwelded tuffs that may have originated as surge deposits. Maximum thickness is ~25 m.

Tkva **Altered volcanics (middle Miocene)** White to orange hydrothermally altered rhyolite, dacite, and andesite; commonly propylitically altered containing pyrite, calcite, epidote, and clays. Bleached rocks show remnant hornblende, biotite, and plagioclase but are mostly oxidized with alunite and clay minerals remaining. Tkva is locally opalized (Whitebread, 1976). Tkva occurs primarily near the Washington Hill Rhyolite dome (Twr), but isolated altered rocks do crop out in the southeast part of the map area.

Contact Dashed where approximately located.

Fault Dashed where approximately located, dotted where concealed; queried where uncertain; ball on downthrown side.

Landslide scarp Ticks point downslope.

Inclined minor antiform Showing bearing and plunge of hingeline and dip of axial plane.

Syncline axial trace Showing plunge, dashed where approximately located, dotted where concealed.

Strike and dip of beds

Inclined

Calculated attitude of contact

Strike and dip of foliation in volcanic rocks or intrusions

Inclined

Sample location

Map Symbol	Sample #	Latitude N	Longitude W	Formation
A	(KS99-438)	39° 28' 09"	119° 34' 56"	Clark Mountain
B	(KS99-440)	39° 27' 51"	119° 33' 50"	Mustang
C†	(KS99-505)	39° 30' 10"	119° 33' 49"	Mustang
D	(KS99-447)	39° 28' 03"	119° 37' 15"	Washington Hill
E	(KS99-152)	39° 27' 27"	119° 35' 09"	McClellan Peak
F	(KS99-499)	39° 25' 17"	119° 30' 22"	McClellan Peak
G	(KS99-240)	39° 28' 03"	119° 35' 17"	Kate Peak
H	(KS99-470)	39° 22' 58"	119° 32' 18"	Kate Peak
I	(KS99-30)	39° 23' 06"	119° 35' 17"	Kate Peak
J	(KS99-304)	39° 23' 57"	119° 32' 47"	Kate Peak
K	(KS99-323)	39° 25' 10"	119° 31' 13"	Kate Peak
L	(KS99-307)	39° 23' 58"	119° 32' 39"	Kate Peak
M	(KS99-321)	39° 25' 10"	119° 31' 41"	Kate Peak
N	(KS99-2B)	39° 23' 41"	119° 34' 37"	Lousetown
O	(KS99-04)	39° 23' 20"	119° 32' 27"	Lousetown
P	(KS99-601)	39° 23' 51"	119° 37' 08"	Lousetown
Q	(KS99-602)	39° 23' 39"	119° 36' 30"	Lousetown
R††	(KS99-700)	39° 32' 02"	119° 38' 50"	Washington Hill

† Sample is located on the Patrick Quadrangle
†† Sample is located on the Vista Quadrangle

$^{40}Ar/^{39}Ar$ Radiometric Dates*

Map Symbol	Lithology	Material Dated	Apparent Age (Ma)
A	basalt	whole rock	9.64 ± 0.04
B	andesite	hornblende	12.11 ± 0.06
E	basalt	whole rock	1.44 ± 0.01
G	dacite	biotite	12.11 ± 0.04
N	basalt	whole rock	7.54 ± 0.08
O	basalt	whole rock	7.57 ± 0.45
S	tuff	hornblende	12.63 ± 0.14
T	andesite	plagioclase	12.13 ± 0.16
U	rhyodacite	hornblende	12.54 ± 0.21

* New Mexico Geochronological Research laboratory (NMGRL); Internal Report #: NMGRL-IR-118 and NMGRL-IR-117.

Geochemical Data*

Map Symbol	A	B	C†	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R††
Major Oxides (weight %)																		
SiO_2	55.41	56.68	57.00	77.00	50.12	48.32	63.00	60.34	60.58	60.61	59.27	73.02	69.96	52.09	54.78	52.99	52.66	77.24
TiO_2	1.14	1.10	1.09	0.10	1.68	1.91	0.67	0.88	0.92	0.90	1.05	0.26	0.52	0.78	1.08	0.81	0.78	0.08
Al_2O_3	17.91	17.85	17.76	13.30	16.58	16.19	17.24	16.53	17.27	16.86	16.84	14.36	15.59	18.17	18.64	18.41	18.05	13.20
FeO*	7.36	6.46	6.49	0.58	8.17	8.84	4.76	6.13	5.56	5.91	6.51	1.81	2.78	7.74	7.51	7.79	7.77	0.42
MnO	0.14	0.12	0.11	0.05	0.14	0.15	0.07	0.11	0.10	0.14	0.11	0.04	0.05	0.14	0.12	0.15	0.14	0.03
MgO	4.38	3.45	3.23	0.12	8.14	8.83	2.56	3.81	3.69	2.87	3.57	0.66	0.60	6.35	4.83	5.43	6.18	0.17
CaO	7.44	7.50	7.43	0.62	9.76	10.36	5.23	6.03	5.88	5.96	6.15	1.72	2.01	10.50	7.58	9.98	10.14	0.46
Na_2O	3.89	3.93	4.08	4.11	3.06	3.03	3.29	3.57	3.02	3.49	3.67	3.05	3.98	3.08	3.75	3.20	3.08	3.89
K_2O	1.79	2.37	2.30	4.09	1.78	1.77	2.95	2.25	2.72	2.93	2.45	5.01	4.40	0.96	1.39	1.05	1.00	4.49
P_2O_5	0.52	0.53	0.50	0.02	0.57	0.59	0.22	0.33	0.24	0.31	0.37	0.06	0.11	0.18	0.29	0.18	0.17	0.01
Total	98.48	99.33	99.38	99.78	99.48	99.49	98.71	100.48	99.46	99.63	99.82	98.96	99.06	100.19	99.76	100.25	100.25	100.29
Mg#	56.00	53.35	51.59	30.74	68.10	68.15	53.56	57.09	58.69	50.96	53.98	43.70	31.48	63.72	57.92	59.85	63.02	46.19
Trace Elements (ppm)																		
Sc	22	21	15	3	29	25	16	15	15	17	14	5	9	35	19	33	27	7
V	167	159	158	1	225	226	105	150	161	132	170	25	46	238	183	238	240	8
Cr	66	41	42	0.1	321	315	24	62	51	38	51	8	10	149	74	104	144	8
Ni	49	29	41	11	141	157	19	31	29	24	43	29	17	60	55	31	46	32
Cu	38	36	35	0.1	38	34	14	31	26	30	26	6	17	69	35	57	60	3
Zn	112	96	91	28	80	82	79	80	93	87	91	43	52	77	96	81	75	13
Ga	20	20	20	13	17	17	18	17	17	19	19	15	15	15	19	20	17	14
Rb	26	31	35	94	29	33	84	44	77	67	59	143	127	8	18	13	12	115
Sr	745	1326	1308	91	910	840	839	672	656	677	718	275	333	703	816	705	672	40
Y	24	21	23	11	21	22	20	20	20	24	24	17	22	16	20	17	17	12
Zr	187	180	177	60	177	171	172	127	180	168	165	149	227	72	108	79	75	47
Nb	12.2	16.4	15.8	10.7	27.8	33.0	6.6	7.5	8.2	8.0	7.6	9.6	11.1	4.2	6.2	5.1	4.3	11.4
Ba	979	876	930	1400	768	727	2013	903	928	1052	1287	1491	1332	480	775	507	573	594
La	14	31	28	12	33	34	38	25	20	19	13	21	34	19	23	10	14	16
Ce	46	85	72	31	87	77	54	54	42	62	51	60	57	31	39	18	31	27
Pb	14	9	6	24	5	6	16	10	17	20	12	26	26	5	9	5	8	20
Th	5	5	7	10	1	3	11	3	9	8	10	18	16	3	3	4	3	9

* All analyses by X-ray fluorescence at the Geoanalytical laboratory, Washington State University.
Major elements are normalized to 100% on a volatile-free basis; total is before normalization.
FeO* = total Fe expressed as FeO.
† Sample is located on the Patrick Quadrangle
†† Sample is located on the Vista Quadrangle

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

Base map: U.S. Geological Survey Chalk Hills 7.5' Quadrangle, 1982
Digital Raster Graphic (DRG)

Schematic Stratigraphic Column
Northern Chalk Hills

Schematic Stratigraphic Column
Southern Chalk Hills

Field work done by Ken Schwartz in 1999 and 2000.

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