plagioclase and euhedral augite. Small irregular grains of quartz are probably of hydrothermal origin. Pyroxene grains are rimmed with opaque oxides, and most of the plagioclase laths are veined by albite and replaced by irregular patches of calcite and abundant dusty saussurite.

HYDROTHERMAL ALTERATION OF THE IGNEOUS ROCK

The rock descriptions make it clear the hydrothermal alteration of the igneous rocks has been widespread in the Shoshone Range. The most intense alteration and mineralization occur near and in the breccia pipes and near concentrations of small dikes and plugs, particularly in the breccia pipes of Rocky, Pipe, and Horse Canyons, along the range front near the mouth of Lewis Canyon, in the Maysville Summit and Hilltop areas, and near Tenabo and Gold Acres. The main areas of relatively unaltered igneous rock are the Granite Mountain stock (although some of its satellitic dikes are altered) and the Tertiary volcanic rocks in the valleys of Harry and Cooks Creeks. Of approximately 400 thin sections, a representative sampling of the igneous rocks of the Shoshone Range, at least three-fourths show some alteration and one-half have been extensively recrystallized. The close areal correlation of alteration with the breccia pipes, dikes, and plugs indicates that much of the hydrothermal activity probably accompanied or closely followed the volcanic activity.

The hydrothermal solutions primarily added CO_2 and H_2O to the rocks. Calcite has partly replaced plagioclase, hornblende, and biotite in most of the altered rocks. In groundmasses it forms irregular blebs and patches. Most of the necessary CaO was released during alteration of the plagioclase. Some andesine crystals are extensively veined by albite and many have patches of residual albite and streaks and blebs of clay. Epidote, clinozoisite, sericite, and prehnite also commonly replace plagioclase. Hornblende and biotite have been altered to chlorite, magnetite, ilmenite, quartz, calcite, epidote, and in the case of biotite, to K-feldspar.

K-feldspar was little affected; most shows only a slight dusting of sericite. In some dikes containing large phenocrysts of K-feldspar, the surrounding matrix is highly altered, but the phenocrysts and the minerals enclosed in them are clear except for thin marginal zones of sericite, calcite, and chlorite. This suggests that the K-feldspar was remarkably stable despite the extensive alteration of the surrounding rock.

Hydrothermal solutions have also altered the Paleozoic sedimentary rocks. Normally dark cherts, argillites, and siliceous shales have been bleached to a white, light-gray, or creamy color except for much red iron staining along bedding planes and joints. Locally there are thin veins of quartz and small knots and scattered crystals of pyrite and pyrrhotite.

CHEMICAL COMPOSITION

The chemical compositions of representative Tertiary igneous rocks, both intrusive and extrusive, altered and unaltered, are given in table 7, and plotted in figure 26, showing the variation in the weight percentage of the principal oxides as silica content varies. Spectrographic analyses of minor elements are listed in grams per metric ton in table 8.

TABLE 7.—*Chemical analyses and norms of Tertiary igneous rocks, Mount Lewis and Crescent Valley quadrangles, Nevada*

[Analyses 4, 5, 6, 8, 9 by L. D. Trumbull; all others by L. N. Tarrant]

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
SiO_2	52.98	53.75	56.32	62.81	64.12	64.96	67.61	67.98	69.29	71.31	73.13	76.84	79.18	55.89
Al_2O_3	15.65	15.75	14.36	16.21	15.52	16.96	15.48	14.62	16.77	14.57	12.51	12.40	11.51	14.70
Fe_2O_3	2.39	2.20	.84	2.01	2.14	.88	.72	1.56	.56	1.50	.54	.31	.28	2.90
FeO	5.58	5.31	5.29	2.15	1.87	1.62	2.73	1.43	.49	.76	.18	.45	.24	7.37
MgO	4.93	5.62	7.64	2.78	1.78	3.18	1.73	.99	.65	.46	.20	.01	.07	3.98
CaO	7.70	6.85	5.91	4.68	2.56	4.42	3.65	2.83	3.03	2.12	1.57	.35	.10	7.39
Na_2O	3.06	3.58	1.94	2.78	4.69	3.29	3.14	3.67	3.90	3.50	1.74	3.93	.49	3.11
K_2O	2.50	2.28	2.74	2.59	3.13	.92	3.31	3.06	3.71	4.43	5.37	4.60	5.87	1.84
H_2O^- [1]	.42	.13	.29	.74	.39	.53	.13	.37	.15	.31	1.54	.14	.49	.48
H_2O^+ [1]	.89	2.00	3.01	2.20	1.61	2.53	.73	1.24	.65	.31	3.24	.38	1.17	.34
TiO_2	1.57	1.36	.58	.52	.50	.64	1.45	.41	.41	.33	.10	.04	.04	1.36
CO_2	1.34	.24	.55	.01	1.16	.02		1.15	.03	.00	.01	.20	.03	.02
P_2O_5	.57	.56	.15	.19	.17	.20	.16		.19	.13	.03	.01	.01	.46
S	.00	.02	.03	.01		.00	.01	.02	.02	.02	.01		.06	
MnO	.14	.12	.12	.09	.08	.03	.07	.06	.02	.05	.01	.02	.01	.16
BaO	.03	.07	.12	.06	.13	.06	.03	.11	.11	.07	.04	.08	.22	.03
F [1]				.03	.03			.05	.03					
Less O		.01	.02	+.01			.01	.03					.03	
Total	99.75	99.83	99.87	99.86	99.88	100.24	100.94	99.52	100.01	99.87	100.22	99.76	99.74	100.03

From Gilluly J. + Gates, O., 1965 Tectonics + Igneous Geology of the Northern Shoshone Range, Nevada USGS PP 465.

TABLE 7.—*Chemical analyses and norms of Tertiary igneous rocks, Mount Lewis and Crescent Valley quadrangles, Nevada*—Continued

[Analyses 4, 5, 6, 8, 9 by L. D. Trumbull; all others by L. N. Tarrant]

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
C.I.P.W. norms														
Q	3.18	2.70	8.46	21.78	16.50	27.90	24.90	27.18	25.38	29.40	38.88	35.10	53.34	9.36
or	15.01	13.34	16.12	15.57	18.35	5.56	19.46	18.35	21.68	26.13	31.69	27.24	35.03	10.56
ab	25.68	30.39	16.24	23.38	39.82	27.77	26.72	30.92	33.01	29.34	14.64	33.54	4.19	26.20
an	21.68	18.35	22.52	22.80	11.95	21.13	17.24	13.62	14.46	9.73	7.78	1.67	.56	20.85
wo	5.45	4.99	2.78		.12									6.61
en	12.30	14.10	19.10	7.00	4.50	8.00	4.30	2.50	1.60	1.10	.66			8.60
fs	5.94	5.68	8.05	1.58	1.06	1.06	3.83	.66				.66	.13	9.11
il	3.04	2.58	1.22	.91	.91	1.22	.76	.76	.76	.61	.15			2.58
mt	3.48	3.25	1.16	3.02	3.02	1.39	.93	2.32	.46	1.62	.46	.46	.46	4.18
hm									.32	.32	.16			
ap	1.34	1.34		.34	.34	.34	.34	.34	.34	.34				1.34
C				.31		2.86	.41	.41	1.12	.51	1.02	.31	4.08	
Niggli values														
qz	−3.8	−5.2	19.8	70	55.4	96.4	100.4	117.6	111.8	139.8	214	231.2	300	12.8
k	.35	.29	.48	.38	.30	.16	.41	.36	.38	.46	.67	.43	.89	.28

DESCRIPTION OF ANALYZED SAMPLES

1. Basalt from small knob near the mouth of Harry Creek, sec. 2, T. 28 N., R. 44 E.
2. Hornblende andesite from dike on Goat Ridge, sec. 28, T. 29 N., R. 45 E.
3. Pyroxene-quartz diorite porphyry from dike in Lewis Canyon, sec. 26, T. 30 N., R. 45 E.
4. Dacite tuff breccia, south end of Tertiary area in Indian Creek valley, sec. 17, T. 29 N., R. 46 E.
5. Dacite porphyry of the block agglomerate, highly altered and calcitized. Head of Dean Canyon, sec. 36, T. 29 N., R. 45 E.
6. Quartz diorite porphyry, slightly altered; sec. 3, T. 29 N., R. 46 E.
7. Granodiorite, porphyritic, from Granite Mountain stock, sec. 11, T. 29 N., R. 46 E.
8. Quartz latite breccia, slightly altered, from Mount Lewis; sec. 12, T. 29 N., R. 45 E.
9. Quartz latite porphyry from dike in Horse Canyon, sec. 4, T. 30 N., R. 45 E.
10. Quartz latite welded tuff, hilltop south of Mill Creek, sec. 6, T. 28 N., R. 45 E.
11. Rhyolite, from low hill north of mouth of Lewis Canyon, sec. 14, T. 30 N., R. 45 E.
12. Soda rhyolite, Pipe Canyon breccia pipe, sec. 34, T. 30 N., R. 45 E.
13. Rhyolite, plug on southeast flank of Mount Lewis; sec. 7, T. 29 N., R. 46 E.
14. Basaltic andesite, east of Slaven Canyon, sec. 7, T. 30 N., R. 47 E.

NOTE.—The variation diagram of figure 26 takes into consideration analyses 6 and 7, even though they represent rocks of an earlier cycle than most of the others; their general chemistry suggests close similarity of the magmas. Analysis 14 has been included in this diagram also, despite the probable considerably younger age of the rocks it represents. However, it seems chemically so different—in its relatively lower K_2O considering its silica content—as to suggest a different magma type as the source.

TABLE 8.—*Semiquantitative spectrographic analyses, in grams per metric ton, of trace elements of the intrusive and volcanic rocks of Miocene and Pliocene and earlier ages*

[Analyst, Paul R. Barnett. Localities given in table 7]

	1	2	3	4	5	6	7	8	9	10	11	12	13	Average igneous rock [1]
B	20			10						10			30	3
Ba	1,000	1,000	2,000	700	2,000	1,000	1,000	1,000	1,000	2,000	500	1,000	2,000	250
Be				1	1	1	1	1	1	2	1	1	4	2
Co	30	30	40	10	9	6	9	9						23
Cr	100	100	200	100	60	60	30	30	4	5	1	3	3	200
Cu	20	40	30	9	6	20	80	80	8	5	3	4	4	70
Ga	20	20	10	20	20	20	10	10	20	10	8	9	10	15
La	100	100		50	80		90	90	90	100				19.6
Nb	30			8	10	10	30	30	6	40	20	40	20	24
Ni	70	80	90*	20	5	10	7	7		3				80
Pb	20	20	50	20	20	5	30	30	20	30	30	50	30	16
Sc	30	20	30	20	20	20	10	10	6	6	3	4	2	5?
Sr	1,000	1,000	700	900	800	700	800	800	900	700	400	300	100	300
V	200	200	200	90	90	100	90	90	40	40	6			150
Y	60	60	40	40	40	30	40	40	20	40	20	30	10	7.4
Yb	4	4	3	2	3	3	3	3	1	3	2	4	2	2.7?
Zn	200	200												51
Zr	100	100	60	60	100	60	70	70	100	90	40	60	70	220

[1] Data from Green (1953, table 2).

Looked for but not found: Ag, As, Au, Bi, Cb, Cd, Ge, In, Mo, Pt, Sn, Ta, Th, Tl, U, W.