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Feldspars from hybrid granitoid rocks of the southern Snake Range, Nevada

by

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ABSTRACT

Chemical analyses are presented for alkali and plagioclase feldspars from hybrid granitoid rocks of the southern Snake Range, Nevada. Composition of these feldspars varies with rock chemistry much as one would expect in a series of "normal" differentiates. The alkali feldspars present in these rocks are maximum microcline microperthites, indicating that they formed at low temperatures, perhaps below 400° C. However, previously published data for biotites coexisting with these feldspars indicate crystallization temperatures in the range 735-780°C. The discrepancy in temperature is probably explained by difference in degree of sub-solidus equilibration for different mineral phases.

INTRODUCTION

Granitoid rocks of Jurassic age crop out a few kms north of the Mount Wheeler mine in the southern part of the Snake Range, about 80 km southeast of Ely, Nevada. The many well-defined differences in the chemistry and mineralogy of these granitoid rocks within an outcrop area of about 50 km^2 are considered by Lee and Van Loenen (1971) to have resulted mainly from assimilation of chemically distinct host rocks. This paper describes the feldspars present in these hybrid granitoid rocks. It is one of a series of papers on the systematic mineralogy and geochemistry of these igneous rocks. Lee and Van Loenen (1971) is a comprehensive field and laboratory study and includes a geologic map and sample locations. Sample numbers used in this paper are the same as in the comprehensive study, where rocks are numbered in order of increasing CaO content; that is, from most felsic to most mafic. The field numbers used in earlier papers are keyed to these sample numbers by Lee and Van Loenen (1971, p. 11).

The hybrid granitoid rocks from which these feldspars were recovered appear on the map as two separate and distinct bodies, one exposed in the Snake Creek-Williams Canyon area, the other in the Pole Canyon-Can Young Canyon area.

The influence of host rock on the chemistry and mineralogy of the igneous rocks of the southern Snake Range is most clearly shown in the Snake Creek-Williams Canyon area, where the intrusive is undeformed, probably has not been eroded to a depth of much more than 300 m, and is well exposed in contact with limestone, shale, and quartzite. Within a horizontal distance of 5 km the intrusive grades from a granodiorite (63

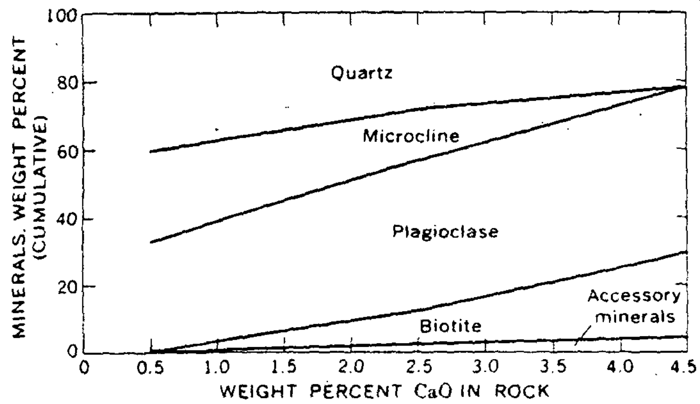

Figure 1.—General relations between CaO content and mineralogy, for granitoid rocks of the Snake Creek—Williams Canyon area. (From Lee and Van Loenen, 1971, fig. 11.)

percent SiO_2; 4.5 percent CaO) where the host rock is limestone to quartz monzonite (76 percent SiO_2, 0.5 percent CaO) where the host rock is quartzite. The amounts of feldspars present in these granitoid rocks are shown in figure 1.

The Pole Canyon-Can Young area intrusive is exposed almost entirely in contact with quartzite. This intrusive is distinguished in part by the presence of large muscovite phenocrysts, many of which contain euhedral crystals of biotite. Chemical differences in the rock from place to place are relatively small, with no systematic spatial distribution of values. We (Lee and Van Loenen, 1971, p. 5) attribute the distinctive nature of this intrusive to the assimilation of argillite.

Major elements were determined by chemical methods described by Peck (1964). Semiquantitative spectrographic results are based on their identity with geometric brackets whose boundaries are 1.2, 0.83, 0.56, 0.38, 0.26, 0.18, 0.12, and so forth and are reported arbitrarily as midpoints of these brackets, 1., 0.7, 0.5, 0.3, 0.2, 0.15, 0.1, respectively. The precision of a reported value is approximately one bracket at 68-percent, or two brackets at 95-percent confidence.

Maximum microcline microperthites

The feldspars were prepared for analysis by repeated centrifuging of -150 mesh material in heavy liquids, and by use of the Frantz isodynamic separator[1]. It was possible to obtain clean separates of the microcline microperthities by taking the material with a specific

[1]The use of trade names is for descriptive purposes only and does not neccessarily constitute endorsement by the U.S. Geological Survey.

gravity of less than 2.60, X-ray study showed that all of these are maximum microclines. Chemical analyses of the microcline microperthites gave somewhat low totals (table 1). This probably is due to the fact that each of these minerals contains 0.3-0.5 percent Ba (0.35-0.56 BaO) as shown by spectrographic analysis (table 1). BaO was not sought by the chemist, and the amounts present probably were lost during the gravimetric analyses (L. C. Peck, oral commun., 1970). In calculation of the ionic ratios (table 1), the spectrographic values for Ba (as equivalent BaO) were used. In the calculation of molecular percents, Ba^{++} is considered to substitute for K^{+}, and Mg^{++} is taken to be replacing Ca^{++} and calculated into the anorthite molecule.

The values calculated for the Z group (Si, Al, Fe^{+3}, Ti) on the basis of 32 oxygens are very close to the theoretical 16.00. The values for the X group (K, Na, Ca, Ba) are slightly low, but they compare favorably with the selected analyses of Deer and others (1963).

The Na_2O and CaO reported in the analyses (table 1) probably are in the plagioclase phases of the microperthites. Except in sample 66, all of these plagioclase phases are so dominantly sodic as to be albite, as is common in the plagioclase phases of microperthites (Deer and others, 1963, p. 34). In general the anorthite content of the plagioclase phase tends to be less in the microcline microperthites from the more felsic rocks (table 1), as might be expected.

Cain (1974) studied the rare-earth contents of samples 15, 22, 66, and 89 by means of neutron activation analysis. His work was done on splits of the same materials used for the major element analyses (table 1). Except for europium, Cain found the rare-earth contents of samples

Table 1.--Analytical data for microcline microperthites from the southern Snake Range, Nevada.

Sample Number---- [1]89	15	22	55	66	67
Weight percent of CaO in rock-	0.98	1.5	1.8	2.5	3.1	3.2
Weight percent of SiO_2 in rock	72.3	73.4	73.2	71.5	70.3	71.1
Chemical analyses of microcline microperthites (weight percent) Elaine L. Munson Brandt, Analyst						
SiO_2	64.89	64.71	64.87	65.26	65.36	64.59
Al_2O_3	18.74	18.50	18.60	18.47	18.41	18.63
[2] Fe_2O_3	.08	.11	.10	.10	.12	.10
MgO	.00	.04	.01	.00	.03	.01
CaO	.22	.02	.12	.25	.39	.16
Na_2O	1.42	1.19	1.39	1.58	1.49	1.16
K_2O	14.14	14.83	14.42	13.76	13.69	4.65
TiO_2	.00	.01	.01	.01	.01	.01
TOTAL--------	99.49	99.41	99.52	99.43	99.50	99.30
Semiquantitative spectrographic analyses (weight percent). Robert E. Mays, Analyst						
Ba	0.3	0.3	0.5	0.5	0.5	0.5
Ga	.002	.002	.002	.0015	.0015	.002
Mn	.0005	.001	.0003	.0002	.0003	.0003
Pb	.015	.01	.01	.007	.007	.007
Sr	.07	.03	.03	.03	.03	.03
Numbers of ions on the basis of 32 (O)						
Si	11.950	11.963	11.954	11.995	12.001	11.939
Al	4.067	4.031	4.040	4.001	3.984	4.059
Fe^{+3}	.011	.015	.014	.014	.017	.014
Ti	.000	.001	.001	.001	.001	.001
Mg	.000	.011	.003	.000	.008	.003
Na	.507	.427	.497	.563	.531	.416
Ca	.043	.004	.024	.049	.077	.032
K	3.322	3.497	3.390	3.226	3.207	3.454
Ba	.025	.025	.040	.040	.040	.041
Z	16.03	16.01	16.01	16.01	16.00	16.01
X	3.90	3.96	3.95	3.88	3.86	3.95
Molecular Percents						
Orthoclase	85.9	89.1	86.8	84.2	84.1	88.6
Albite	13.0	10.8	12.6	14.5	13.7	10.5
Anorthite	1.1	.1	.6	1.3	2.2	0.9

[1] Sample 89 is from the Pole Canyon-Can Young Canyon area. All other samples are from the Snake Creek-Williams Canyon area.

[2] Total iron as Fe_2O_3.

Table 2.--Analytical data for oligoclase-andesine from the southern Snake Range, Nevada.

Sample Number----	1/89	15	22	55	66	67	78
Weight percent of CaO in rock-	0.98	1.5	1.8	2.5	3.1	3.2	3.9
Weight percent of SiO_2 in rock	72.3	73.4	73.2	71.5	70.3	71.1	66.3
Chemical analyses of oligoclase and andesine (weight percent) Elaine L. Munson Brandt, Analyst.							
SiO_2	63.57	63.29	63.30	62.49	59.75	62.79	61.58
Al_2O_3	22.91	23.09	22.96	23.65	25.40	23.16	24.42
Fe_2O_3			.16		.18		.16
FeO	2/ .12	2/ .20	.10	2/ .23	.10	2/ .25	.08
MgO	.00	.04	.02	.00	.04	.00	.04
CaO	3.56	3.63	3.96	4.30	6.38	4.51	4.84
Na_2O	9.25	9.09	9.17	8.88	7.57	8.92	8.62
K_2O	.57	.64	.31	.43	.54	.33	.24
TiO_2	.02	.02	.02	.02	.04	.04	.02
TOTAL------	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Semiquantitative spectr ographic analyses (weight percent) Robert E. Mays, analyst.							
Ba	0.007	0.02	0.015	0.015	0.015	0.015	0.015
Be	.0005	.0005	.0005	.0002	.0002	.0002	.0003
Ga	.0015	.001	.001	.0007	.0007	.0007	.001
Mn	.0003	.001	.0007	.0003	.0003	.0003	.002
Sr	.015	.02	.015	.01	.015	.02	.03
V	0	.001	0	0	0	0	0
Numbers of ions on the bases of 32(0).							
Si	11.243	11.202	11.187	11.075	10.662	11.121	10.926
Al	4.775	4.808	4.776	4.941	5.342	4.832	5.105
Fe^{+3}			.021		.023		.021
Fe^{+2}	2/ .016	2/ .025	.015	2/ .030	.011	2/ .032	.012
Ti	.002	.002	.002	.002	.005	.005	.002
Mg	.000	.011	.001	.000	.011	.000	.011
Na	3.172	3.128	3.142	3.046	2.617	3.114	2.965
Ca	.675	.692	.754	.820	1.233	.856	.920
K	.128	.149	.070	.098	.129	.074	.053
Z	16.04	16.04	16.00	16.05	16.04	15.99	16.07
X	3.98	3.98	3.97	3.96	3.99	4.04	3.95
Molecular percents							
Orthoclase	3.2	3.7	1.8	2.5	3.2	1.8	1.3
Albite	79.8	78.6	79.2	76.8	65.6	77.0	75.1
Anorthite	17.0	17.7	19.0	20.7	31.2	21.2	23.6

1/ Sample 89 is from the Pole Canyon-Can Young Canyon area. All other samples are from the Snake Creek-Williams Canyon area.
2/ Total iron as Fe_2O_3.

15, 22, and 89 to be extremely low. Indeed, he was unable even to detect the presence of any of the heavier (than europium) rare earths. For limits of detection and a detailed discussion of the rare-earth contents of these microcline microperthites see Cain (1974).

Plagioclases

X-ray work showed that all of the plagioclase feldspars included in this study are in the low structural state. We were unable to eliminate quartz from any of the plagioclase feldspars prepared for analysis, and each of the 6 analyses (table 2) has been adjusted to total 100.00 on a quartz-free basis. Five are oligoclase and one is andesine. Except for sample 66 the anorthite content of these plagioclases increases systematically going toward the more mafic parts of the Snake Creek-Williams Canyon exposure. In a general way the amounts of maximum microcline ("orthoclase") solid solution in the plagioclase phases tend to decrease going toward the more mafic parts of the exposure.

Cain (1974) studied in rare-earth contents of all of the plagioclases in table 2 by means of neutron activation analyses, and again his work was done on splits of the same materials used for major element analyses. He found that the lighter rare-earth elements are present in larger amounts than the heavier rare-earth elements in these plagioclases, and that all of these plagioclases show a large positive europeum anomaly. In a detailed discussion Cain (1974) concluded that these plagioclases probably crystallized from a liquid phase with a lower rare-earth content than is observed in the whole rocks.

CONCLUSION

The work of T. L. Wright (written commun., 1979) indicated that maximum microclines such as those described here should form near or below 400° C. However, application of the various "geologic thermometers" to data on these hybrid granitoid rocks give some very different results. The magnetites and ilmenites coexisting with these feldspars suggest temperatures between 500 and 600°C (Lee and Van Loenen, 1979), whereas the coexisting biotites indicate temperatures in the range 735 to 780°C (Lee and Van Loenen, 1970, fig. 8). This lack of agreement among the indicated temperatures of formation is probably explained by differences in degree of sub-solidus equilibration for different mineral phases.

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