Rb-Sr whole-rock isotopic ages of granitic piutons in the western part of the Tonopah 1 by 2° quadrangle, Nevada

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Rb-Sr WHOLE-ROCK ISOTOPIC AGES OF GRANITIC PLUTONS IN THE WESTERN PART OF THE TONOPAH 1° BY 2° QUADRANGLE, NEVADA

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Granitoids, ranging in composition from granite to diorite, form about 60 plutons in the western part of the Tonopah 1° by 2° quadrangle, Nevada (fig. 1; John, 1987). Previous investigations of isotopic ages of these rocks suggest that plutonic activity occurred from Triassic to middle Tertiary time (about 221 to 30 Ma; Speed and Armstrong, 1971; Silberman and others, 1975; Bonham and Garside, 1979; Kleinhampl and Ziony, 1985; Shawe and others, 1986, 1987; John and McKee, 1987; McKee and John, 1987). As part of the Tonopah CUSMAP (Conterminous United States Mineral Assessment Program) project and of regional Sr-isotope studies, the geology of the granitoids and hydrothermal alteration and mineralization associated with these rocks were systematically studied (John, 1987). During these projects, several granitic bodies and hydrothermal alteration products in granitic rocks were dated by either K-Ar or Rb-Sr methods. The K-Ar ages were reported by John and McKee (1987) and McKee and John (1987). In this paper we present Rb-Sr whole-rock ages for eight plutons in the Tonopah quadrangle. These plutons are the Illinois stock exposed north of Gabbs; the Crow Springs pluton at the southern end of the Royston Hills; the Fraziers Well pluton in the San Antonio Mountains north of Tonopah; the Lone Mountain pluton; the granite of Pipe Springs, and the Belmont and Round Mountain plutons that form the granite of Shoshone Mountain in the southern Toquima Range; and the main phase of the Ophir pluton on the east side of the Toiyabe Range (fig. 1).

SAMPLING TECHNIQUES

Samples of granitoids dated in this study are typical main phases of the plutons and cross-cutting aplite and pegmatite dikes. Samples from the granites of Pipe Springs and Shoshone Mountain and the Lone Mountain and Fraziers Well plutons were collected by A. C. Robinson, D. E. Lee, and R. W. Kistler and consist of one or more samples of the main phase of the pluton, one or more aplite or pegmatite dikes from a single outcrop, or as float ("FL" samples, table 1) at a single location (table 1). Samples of the Illinois stock and of the Crow Springs and Ophir plutons were collected by D. A. John or R. W. Kistler from five or more sites spread across the entire intrusion, and include felsic dikes from one or more sites (table 1).

ANALYTICAL METHODS

Sample preparation and Rb and Sr analyses were carried out in the U.S. Geological Survey laboratories, Menlo Park, California. Analyses of Rb and Sr concentration in the whole rock samples were by energy dispersive XRF. Estimated relative error at 2 sigma is 3 percent for concentrations greater than 60 ppm and 5 percent for concentrations between 20 and 60 ppm. Mineral Rb and Sr concentrations were by standard isotope dilution techniques. Strontium isotope ratios were determined by MAT 261, 90° sector mass spectrometer, with radius equivalent to 46 cm, using double rhenium filament mode of ionization, a thirteen specimen carousel, double collection, and fully automated mode of operation and data reduction. Replicate analyses of the Eimer and Amend $SrCO_3$ and NBS 987 $SrCO_3$ standards have $^{87}Sr/^{86}Sr$ of 0.70800 ± 3 and 0.71023 ± 3, respectively. All strontium isotopic ratios are normalized to a $^{86}Sr/^{88}Sr$ value of 0.1194. The decay constant of ^{87}Rb used is $\lambda_\beta = 1.42 \times 10^{-11} yr^{-1}$.

Analytical data are presented in table 2. Estimates of 2-sigma relative error for $^{87}Sr/^{86}Sr$ include total laboratory error. They correspond to Sr concentration and are based on replicate measurements of 10 powder splits each of nine samples ranging from 20 to 600 ppm Sr. $^{87}Sr/^{86}Sr$ values for a few samples collected by R. W. Kistler and D. E. Lee were obtained by single collection on an earlier mass spectrometer, and are assigned a 2-sigma relative error of 0.015.

Whole-rock isochrons are calculated using an adaptation (Ludwig, 1987) of the error-weighted least squares regression technique of York (1969). The regression model for the Illinois stock and the two sample locations in the Belmont pluton assumes all scatter is due to analytical error. Because our total laboratory analytical error, including sample powder inhomogeneity, is relatively low, the mean squares of the weighted deviates (M.S.W.D.) are large for most of the regressions. This indicates a modest to moderate geologic scatter in initial $^{87}Sr/^{86}Sr$. The regression model for the remaining isochrons assumes that scatter is due to analytical error plus a normally distributed error in initial $^{87}Sr/^{86}Sr$. The error in age and initial $^{87}Sr/^{86}Sr$ is one sigma for the Belmont pluton isochron of location 9 and two sigma for all other isochrons. Rb-Sr isochrons are plotted in figures 2 to 7.

GEOLOGICAL DESCRIPTION

ILLINOIS STOCK

The Illinois stock is the largest and oldest of four small plutons exposed in the southern Lodi Hills about 8 km north of Gabbs (loc. 1, fig. 1). It has been previously mapped and described by Vitaliano and others (1957) and John (1987). It is a coarse-grained, equigranular to sparsely porphyritic biotite granite that contains scattered potassium feldspar megacrysts as long as 3 cm and about 5 percent biotite. It is locally strongly foliated. Krueger and Schilling (1971) reported a biotite K-Ar age of 48.0 ± 2.0 Ma (all pre-1977 ages are recalculated using the new decay constants; Steiger and Jager, 1977).

We obtained a seven-point whole-rock Rb-Sr isochron age of 103.1 ± 4.5 Ma (fig. 2). We believe that this age is the emplacement age of the stock, and that the younger K-Ar age results from thermal resetting by middle to late Tertiary magmatism.

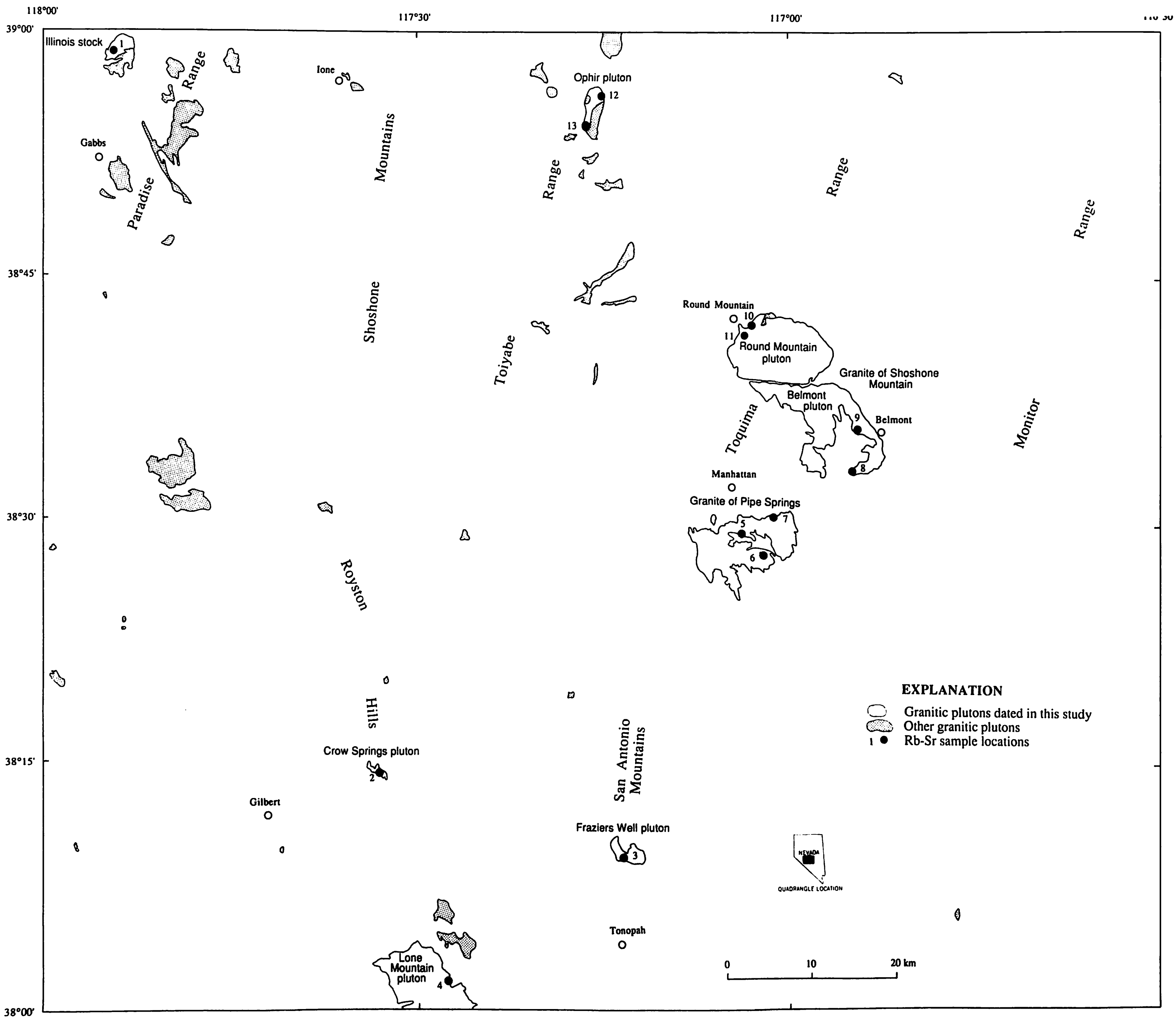

Figure 1. Location map showing sample localities and the distribution of plutonic rocks in the western part of the Tonopah 1° by 2° quadrangle.

SAMPLE DESCRIPTIONS

TABLE 1. Sample locations and descriptions.

Location (fig. 1)	Sample number	Latitude	Longitude	Sample description
1	82-DJ-14	38°58'44"N	117°54'18"W	main phase
1	82-DJ-23	38°58'45"	117°54'33"	aplite dike
1	82-DJ-28	38°58'32"	117°54'29"	main phase
1	84-DJ-2	38°58'45"	117°54'33"	main phase
1	84-DJ-4	38°59'07"	117°53'33"	main phase
1	84-DJ-5	38°59'07"	117°53'33"	2 m aplite pod
1	N2A-81[2]	38°57'20"	117°53'42"	main phase
2	82-DJ-114A	38°14'09"	117°32'33"	main phase
2	84-DJ-167	38°14'15"	117°32'35"	main phase
2	84-DJ-168	38°14'15"	117°32'35"	main phase
2	84-DJ-169	38°14'15"	117°32'35"	main phase
2	84-DJ-170	38°14'15"	117°32'35"	leucocratic dike
2	84-DJ-171	38°14'15"	117°32'35"	2 cm aplite dike
2	84-DJ-172	38°14'15"	117°32'35"	main phase
2	84-DJ-173	38°14'15"	117°32'35"	10 cm aplite/pegmatite dike
3	N2-83	38°09'15"	117°13'09"	main phase
3	N2A-83	38°09'15"	117°13'09"	pegmatite
3	N3-83	38°09'15"	117°13'18"	main phase
3	N3A-83	38°09'15"	117°13'18"	5 cm aplite dike
3	GR108[1]	38°09'05"	117°11'50"	main phase
3	GR107[1]	38°09'05"	117°12'10"	main phase
4	N1-83	38°01'18"	117°28'03"	main phase
4	N1A-83	38°01'18"	117°28'03"	6 cm aplite/pegmatite dike
4	N1B-83	38°01'18"	117°28'03"	15 cm aplite dike
4	N1FL-83	38°01'18"	117°28'03"	pegmatite
4	N1FLA-83	38°01'18"	117°28'03"	fine-grained, foliated phase
4	50-65[2]	38°01'37"	117°27'34"	porphyritic main phase
4	51-65[2]	38°01'28"	117°27'42"	porphyritic main phase
4	52-65[2]	38°01'28"	117°27'42"	equigranular main phase
5	N6-83	38°29'27"	117°04'21"	main phase
5	N6A-83	38°29'27"	117°04'21"	1 x 2 m aplite pod
5	N6B-83	38°29'27"	117°04'21"	main phase
5	N6C-83	38°29'27"	117°04'21"	30 cm pegmatite dike
5	N6D-83	38°29'27"	117°04'21"	40 cm aplite dike
6	N7-83	38°27'41"	117°01'39"	main phase
6	N7A-83	38°27'37"	117°01'21"	med.-gr. leucocratic phase
6	N7B-83	38°27'37"	117°01'21"	30 cm aplite dike
7	GR109[1]	38°30'30"	117°01'15"	main phase
7	GR110[1]	38°30'00"	117°01'05"	main phase
8	N4-83	38°33'23"	116°54'44"	main phase
8	N4A-83	38°33'23"	116°54'44"	aplite
8	N4B-83	38°33'23"	116°54'44"	aplite
9	N5-83	38°35'47"	116°54'05"	main phase
9	N5A-83	38°35'47"	116°54'05"	40 cm leucocratic dike
9	N5B-83	38°35'47"	116°54'05"	20 cm aplite dike
10	N8-83	38°41'49"	117°01'54"	main phase
10	N8A-83	38°41'49"	117°01'54"	30 cm aplite dike
10	N8FL-83	38°41'49"	117°01'54"	aplite
10	N8FLB-83	38°41'49"	117°01'54"	main phase
10	NV72-38[3]	unknown	unknown	main phase
11	45-65-3[2]	38°41'39"	117°03'34"	main phase
11	45-65-3PL[2]	38°41'39"	117°03'34"	plagioclase
11	45-65-3MU[2]	38°41'39"	117°03'34"	muscovite
11	45-65-4[2]	38°41'39"	117°03'34"	main phase
11	45-65-5[2]	38°41'39"	117°03'34"	main phase
12	82-DJ-227	38°56'12"	117°14'52"	main phase
12	82-DJ-227A	38°56'12"	117°14'52"	pegmatite dike
12	82-DJ-231	38°55'58"	117°15'17"	propylitized main phase
12	82-DJ-233	38°56'10"	117°15'39"	main phase
13	82-DJ-250	38°54'13"	117°15'47"	main phase
13	82-DJ-251	38°54'14"	117°15'53"	main phase
13	82-DJ-275	38°54'20"	117°16'15"	chloritized main phase

[1]Collected by D. E. Lee.
[2]Collected by R. W. Kistler.
[3]From Farmer and Depaolo (1983).

TABLE 2. Rb and Sr isotopic data and calculated ages and initial Sr ratios

Unit and location (fig. 1)	Sample number	Rb (ppm)	Sr (ppm)	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$	Percent Error	Age (Ma)	$(^{87}Sr/^{86}Sr)_i$
Illinois stock								
1	82-DJ-14	160	289	1.60	.70684	.005	103.1 ±4.5	0.70453 ±0.00011
1	82-DJ-23	341	22.7	43.7	.76797	.030		M.S.W.D. =0.786
1	82-DJ-28	161	282	1.65	.70699	.005		
1	84-DJ-2	155	238	1.88	.70733	.005		
1	84-DJ-4	123	215	1.66	.70695	.005		
1	84-DJ-5	216	353	1.77	.70710	.005		
1	N2A-81	201	214	2.71	.70851	.005		
Crow Springs pluton								
2	82-DJ-114A	168	575	.845	.70779	.005	198.5 ±5.0	0.70549 ±0.00046
2	84-DJ-167	185	587	.912	.70800	.005		M.S.W.D. =32.6
2	84-DJ-168	188	570	.954	.70803	.005		
2	84-DJ-169	191	535	1.03	.70839	.005		
2	84-DJ-170	285	174	4.75	.71939	.005		
2	84-DJ-171	242	415	1.69	.71002	.005		
2	84-DJ-172	176	621	.820	.70830	.005		
2	84-DJ-173	237	148	4.64	.71816	.005		
Fraziers Well pluton								
3	N2-83	132	780	.489	.70658	.005	188.7 ±24.3	0.70531 ±0.00034
3	N2FL-83	223	632	1.02	.70790	.005		M.S.W.D. =12.7
3	N3-83	140	819	.495	.70663	.005		
3	N3A-83	276	376	2.12	.71105	.005		
3	GR108	130	865	.435	.70637	.005		
3	GR107	120	712	.488	.70694	.015		
Lone Mountain pluton								
4	N1-83	137	734	.540	.70782	.005	85.3 ± 4.3	0.70709 ±0.00019
4	N1A-83	174	85.6	5.88	.71443	.007		M.S.W.D. =12.1
4	N1B-83	276	31.6	25.3	.73686	.017		
4	N1FL-83	280	264	3.07	.71088	.005		
4	N1FLA-83	139	781	.515	.70759	.005		
4	50-65	174	542	.929	.70810	.015		
4	51-65	182	709	.743	.70817	.015		
4	52-65	143	802	.516	.70756	.015		
Granite of Pipe Springs								
5	N6-83	100	766	.378	.70633	.005	80.2 ± 2.4	0.70588 ±0.00010
5	N6A-83	217	32.0	19.7	.72817	.017		M.S.W.D. =11.0
5	N6B-83	112	765	.424	.70640	.005		
5	N6C-83	218	56.1	11.3	.71925	.009		
5	N6D-83	117	205	1.65	.70781	.005		
6	N7-83	117	709	.477	.70636	.005		
6	N7A-83	225	105	6.20	.71298	.005		
6	N7B-83	184	81.4	6.54	.71311	.007		
7	GR109	120	735	.472	.70630	.005		
7	GR110	113	676	.484	.70653	.005		
Belmont pluton, granite of Shoshone Mountain								
8	N4-83	139	863	.466	.70685	.005	84.2 ± 2.3	0.70629 ±0.00012
8	N4A-83	243	70.0	10.1	.71831	.007		M.S.W.D. =0.30
8	N4B-83	175	56.7	8.94	.71710	.009		
9	N5-83	186	805	.668	.70795	.005	84.8 ± 4.4	0.70716 ±0.00009
9	N5A-83	176	302	1.69	.70927	.005		M.S.W.D. =8.05
9	N5B-83	178	137	3.76	.71158	.005		
Round Mountain pluton, granite of Shoshone Mountain								
10	N8-83	139	694	.579	.70724	.005	89.6 ± 3.3	0.70667 ±0.00027
10	N8A-83	202	153	3.82	.71104	.005		M.S.W.D. =22.2
10	N8FL-83	234	78.9	8.59	.71725	.007		
10	N8FLA-83	235	181	3.76	.71183	.005		
10	N8FLB-83	146	706	.598	.70733	.005		
10	NV72-38[3]	167	648	.744	.70756	.005		
11	45-65-3	177	570	.898	.70803	.015		
11	45-65-3P	155	632	.705	.70798	.015		
11	45-65-3M	730	117	18.1	.72990	.015		
11	45-65-4	188	183	2.97	.71040	.015		
11	45-65-6	477	219	6.30	.71468	.015		

continued

TABLE 2. Rb and Sr isotopic data and calculated ages and initial Sr ratios (continued)

Unit and location (fig. 1)	Sample number	Rb (ppm)	Sr (ppm)	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$	Percent Error	Age (Ma)	$(^{87}Sr/^{86}Sr)_i$
Ophir pluton, main phase								
12	82-DJ-227	141	536	.761	.70674	.005	89.1 ± 8.7	0.70563 ± 0.00045
12	82-DJ-227A	319	88.6	10.4	.71873	.006		M.S.W.D. = 149
12	82-DJ-231	105	483	.629	.70619	.005		
12	82-DJ-233	85.3	391	.631	.70662	.005		
13	82-DJ-250	142	366	1.12	.70683	.005		
13	82-DJ-251	146	523	.808	.70622	.005		
13	82-DJ-275	123	202	1.76	.70848	.005		

CROW SPRINGS AND FRAZIERS WELL PLUTONS

The Crow Springs pluton is a small intrusion exposed at the south end of the Royston Hills about 30 km northwest of Tonopah (loc. 2, fig. 1), and the Fraziers Well pluton is a slightly larger intrusion exposed about 8 km north of Tonopah in the San Antonio Mountains (loc. 3, fig. 1). As discussed by John and McKee (1987), these plutons have unusual compositions and textures that differ from most granitoids in the western Great Basin. They are medium- to coarse-grained, coarsely porphyritic hornblende-biotite quartz monzodiorites that contain scattered to abundant, pink to white potassium feldspar megacrysts as much as 5 cm long. They contain about 15–20 percent biotite + hornblende, but unlike most other megacryst-bearing granitoids, hornblende is about twice as abundant as biotite. A small intrusion exposed south of Gilbert also has similar texture and composition (fig. 1). Speed and Armstrong (1971) reported a hornblende K-Ar age of 206.3 ± 3.3 Ma for the Crow Springs pluton, and John and McKee (1987) reported a hornblende K-Ar age of 220.9 ± 6.6 Ma for the Fraziers Well pluton. Speed and Armstrong (1971) also reported a muscovite alteration age of about 198 Ma for the intrusion south of Gilbert.

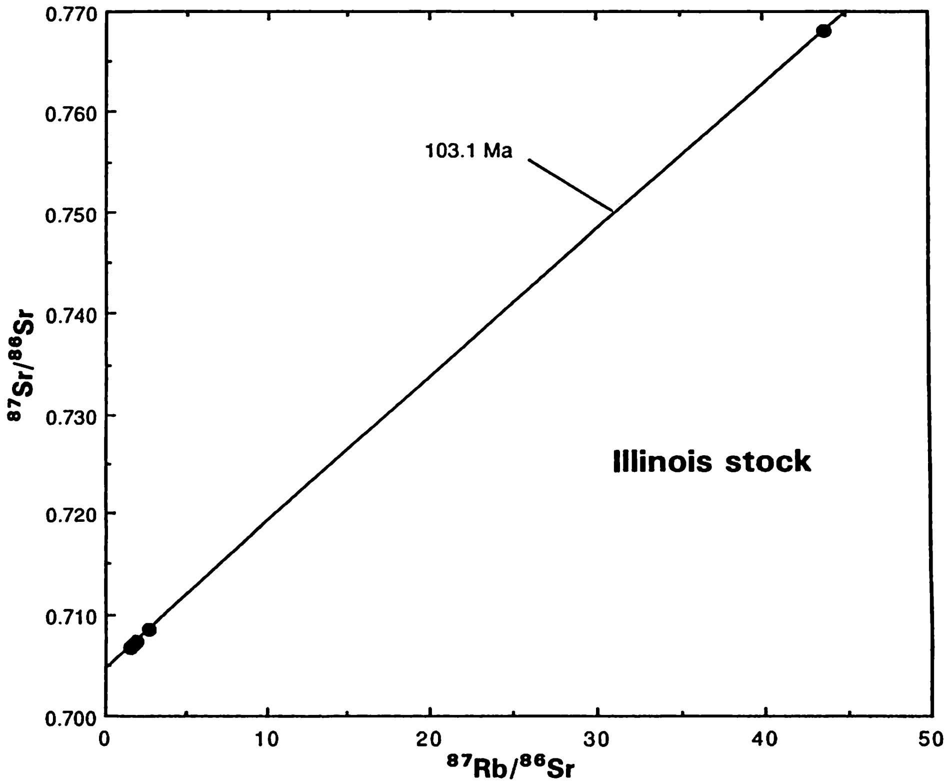

Figure 2. Strontium evolution diagram and whole-rock isochron for the Illinois stock.

We obtained an eight-point whole-rock Rb-Sr isochron of 198.5 ± 13.9 Ma for the Crow Springs pluton and a six-point whole-rock Rb-Sr isochron of 188.7 ± 24.3 Ma for the Fraziers Well pluton (fig. 3). These data can be combined into a 14-point isochron of 200.5 ± 10 Ma. These ages generally confirm the K-Ar ages of Speed and Armstrong (1971) and John and McKee (1987), although the Rb-Sr age of the Fraziers Well pluton is about 30 m.y. younger than the K-Ar age. This discrepancy may result from a relatively limited range in $^{87}Rb/^{86}Sr$ ratios, variation in initial $^{87}Sr/^{86}Sr$, or excess radiogenic Ar in the hornblende analyzed by John and McKee (1987). These age data do indicate that there were several compositionally and texturally distinctive plutons emplaced during Triassic or earliest Jurassic time in an east-west zone in the southwestern part of the Tonopah quadrangle.

LONE MOUNTAIN PLUTON

The Lone Mountain pluton is a large intrusion that forms the massif of Lone Mountain about 20 km west of Tonopah (loc. 4, fig. 1). It has been previously described by Albers and Stewart (1972), Bonham and Garside (1979), Maldonado (1984), and John (1987). It is a medium- to coarse-grained, locally porphyritic, leucocratic biotite granite. It locally contains trace amounts of garnet and primary(?) muscovite and scattered potassium feldspar megacrysts as much as 2 cm long. It has a pervasive weak to strong, northwest-trending, protoclastic or cataclastic foliation. Silberman and others (1975) reported three biotite K-Ar ages ranging from 67 to 71 Ma.

We obtained an eight-point whole-rock Rb-Sr isochron age of 85.3 ± 4.3 Ma (fig. 4). We believe that this age is probably the emplacement age of the Lone Mountain pluton, and that the younger K-Ar ages probably are cooling ages resulting from uplift or doming of the pluton and formation of the pervasive foliation. On the basis of magnetic and gravity data, D. B. Synder (written commun., 1983) suggested that the Lone Mountain pluton was domed by a more mafic intrusion that underlies the massif. Similar doming and metamorphsim has been suggested for large plutons in the southern Toquima Range by Shawe and others (1986).

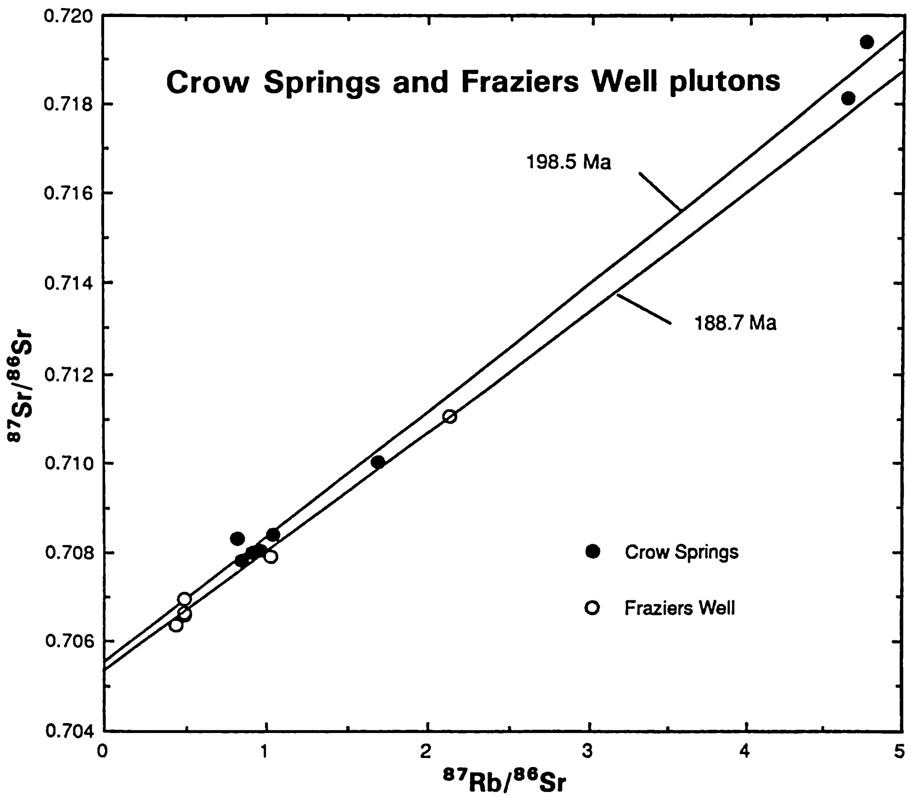

Figure 3. Strontium evolution diagram and whole-rock isochrons for the Fraziers Well and Crow Springs plutons.

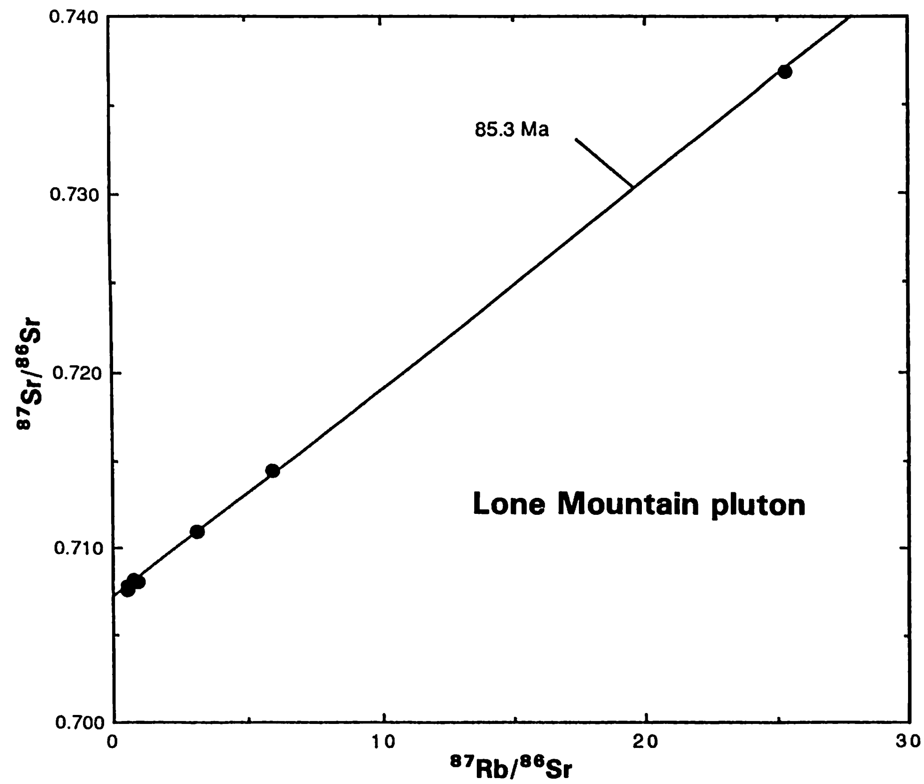

Figure 4. Strontium evolution diagram and whole-rock isochron for the Lone Mountain pluton.

GRANITE OF PIPE SPRINGS

The granite of Pipe Springs is a large pluton at the southern end of the Toquima Range (locs. 5 to 7, fig. 1). Descriptions of the pluton are given by Shawe (1981b), Shawe and others (1986), and John (1987). It is a coarse-grained, locally coarsely porphyritic, leucocratic biotite granite. It contains locally abundant potassium feldspar megacrysts as much as 6 cm long and is strongly foliated along its western margin. Shawe and others (1986) reported K-Ar ages of 75.0 ± 2.6 Ma (biotite) and 78.9 ± 1.8 Ma (muscovite), and a two-point Rb-Sr isochron age of 80.1 ± 1.0 Ma from a whole rock-biotite pair.

We obtained a ten-point whole-rock Rb-Sr isochron age of 80.2 ± 2.4 Ma (fig. 5). This age determination agrees well with the muscovite K-Ar and Rb-Sr data reported by Shawe and others (1986).

GRANITE OF SHOSHONE MOUNTAIN

The granite of Shoshone Mountain forms the largest exposure of granitic rocks in the Tonopah quadrangle (fig. 1). It consists of two intrusions, the Round Mountain and Belmont plutons, that are separated by a thin septum of Paleozoic rocks. Descriptions of the pluton include Ferguson (1921), Ferguson and Cathcart (1954), Ervine (1972), Shawe (1981a,b), Shawe and others (1986, 1987), and John (1987).

The Round Mountain pluton is a medium- to coarse-grained, equigranular, leucocratic biotite granite. It locally has an alaskitic core and contains trace amounts of muscovite. It has a strong cataclastic foliation along its western margin, and Shawe and others (1986) suggest that this foliation formed during doming and metamorphism of the intrusion about 80 Ma. Shawe and others (1986) reported K-Ar ages of 80.9 ± 2.8 Ma (biotite) and 80.2 ± 2.7 Ma (muscovite), which they interpret as metamorphic ages. They also reported an apparent emplacement age of 95 Ma based on Pb^{206}-U^{238} isotopes in monazite.

The Belmont pluton is a medium- to coarse-grained, locally coarsely porphyritic biotite granite. The outer part of the pluton contains potassium feldspar megacrysts as much as 8 cm long. The inner part of the pluton is a coarse-grained, nonporphyritic granite. Seven biotite and muscovite K-Ar ages range between 80 to 82 Ma (Krueger and Schilling, 1971; Silberman and McKee, 1971; Edwards and McLaughlin, 1972; Shawe and others, 1987).

We obtained separate whole-rock Rb-Sr isochrons for two locations in the Belmont pluton and one isochron for two locations in the Round Mountain pluton (locs. 8-11, fig. 1). Samples from the Round Mountain pluton collected just east of Round Mountain (locs. 10 and 11, fig. 1) yielded an eleven-point whole-rock and mineral isochron age of 89.6 ± 3.3 Ma (fig. 6). Samples from each of the two localities in the Belmont pluton (locs. 8 and 9, fig. 1) are internally consistent and yield three-point whole-rock isochron ages of 84.2 ± 2.3 and 84.8 ± 4.4 Ma (fig. 6). Samples from these two localities have significantly different initial $^{87}Sr/^{86}Sr$ ratios (table 2) that bracket the initial Sr ratio determined for the Round Mountain pluton (fig. 6). Variations in initial Sr ratios of similar magnitude are known for other large plutons in Nevada and in the Sierra Nevada batholith (Kistler and others, 1986; A. C. Robinson, unpub. data). We believe that the whole-rock isochrons determined from individual sample sites in the Belmont pluton yield reasonable estimates for the age of emplacement of the intrusion. Our data suggest that the granite of Shoshone Mountain was emplaced in two pulses about 90 and 84–85 Ma, and that the younger K-Ar ages determined for these intrusions may reflect doming and metamorphism as suggested by Shawe and others (1986, 1987).

OPHIR PLUTON

The Ophir pluton is a composite intrusion exposed along the east side of the Toiyabe Range near the north edge of the Tonopah quadrangle (locs. 12 and 13, fig. 1). The Ophir pluton is composed of at least four intrusions that vary in composition from two mica-garnet granite to diorite (John, 1987). The oldest and largest intrusion, the main phase, is a medium-grained, locally porphyritic biotite granodiorite. It has a strong, northwest-trending, protoclastic or cataclastic foliation and is locally recrystallized to an augen gneiss. The main phase of the Ophir pluton is previously undated, although muscovite alteration associated with tungsten mineralization at the north end of the pluton is about 68 Ma (F. G. Poole, written commun., 1986), and Speed and McKee (1974) report a biotite K-Ar age of 55.5 ± 1.5 Ma for a granodiorite porphyry that intrudes the south end of the main phase.

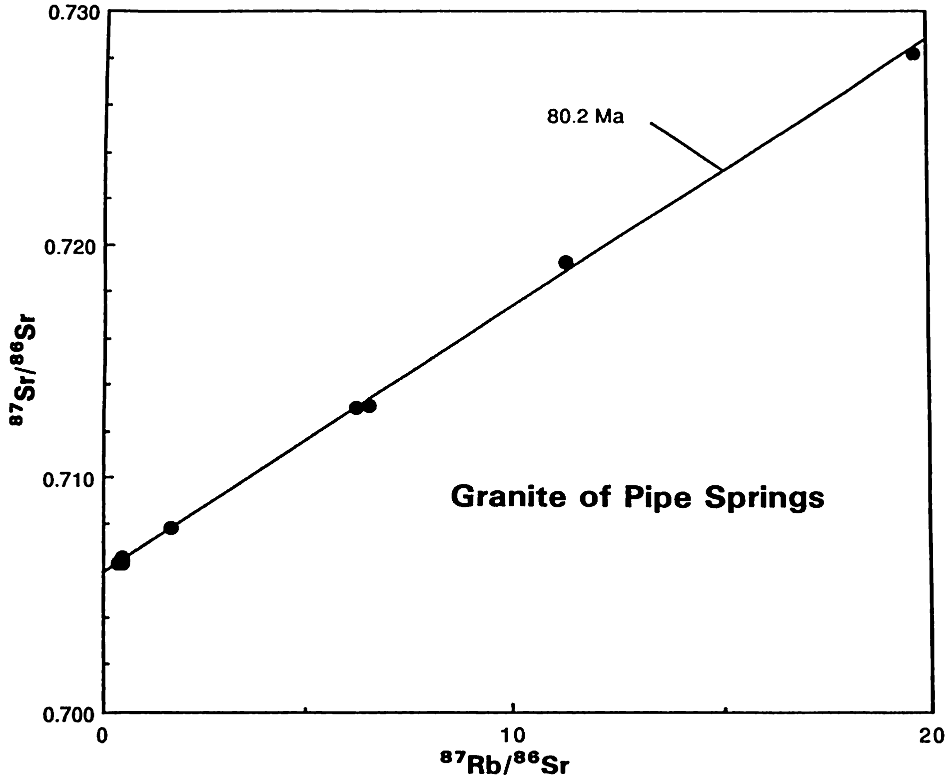

Figure 5. Strontium evolution diagram and whole-rock isochron for the granite of Pipe Springs.

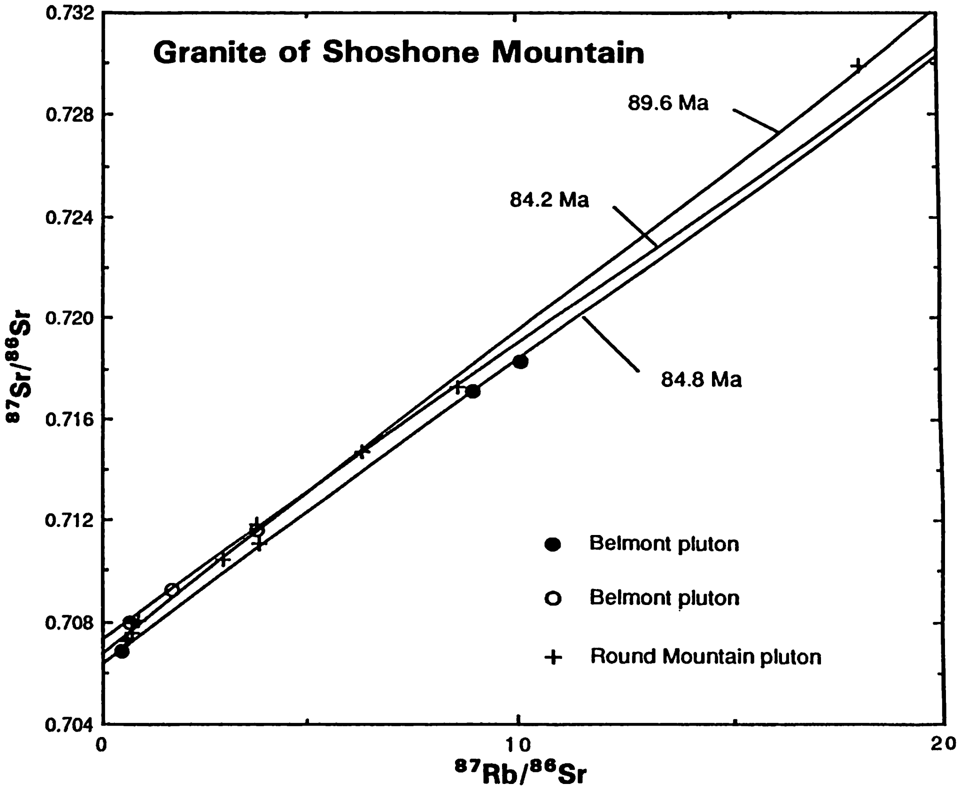

Figure 6. Strontium evolution diagram and whole-rock isochrons for the Round Mountain and Belmont plutons.

We obtained a seven-point whole-rock (including a pegmatite) isochron age of 89.1 ±8.7 Ma that we regard as a minimum emplacement age for the main phase of the pluton (fig. 7). The six whole-rock main phase samples without the pegmatite yield an age of 127.4 ±68 Ma. The scatter resulting in the large M.S.W.D. may reflect deformation, recrystallization, and hydrothermal alteration of the pluton and(or) variation in the initial Sr ratio. Deformation of the main phase may have occurred about 68 Ma, as the younger granodiorite phase dated at about 55 Ma is undeformed.

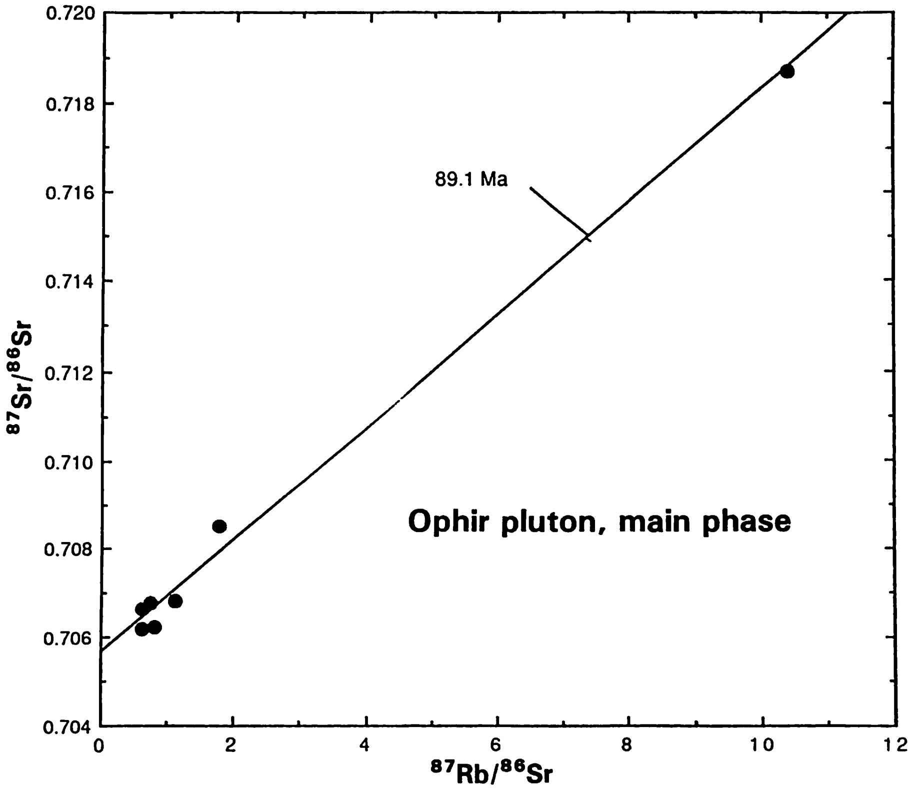

Figure 7. Strontium evolution diagram and whole-rock isochron for the main phase of the Ophir pluton.

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