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GEOCHEMICAL DATA OF ALKALINE IGNEOUS ROCKS AND CARBONATITES, POTASH SULPHUR SPRINGS IGNEOUS COMPLEX, ARKANSAS

by

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Introduction

The Potash Sulphur Springs Igneous Complex is one of several alkaline igneous rock and carbonatite occurrences in the Southern Midcontinent of the United States. The complex is located in Garland County, Arkansas (W½, Sec. 17 and E½, Sec. 18, TS3, R18W), about 10 km west of the Magnet Cove Complex (Fig. 1). The surface exposure of the complex is about 2.6 km^2.

Rock types that comprise the Potash Sulphur Springs Igneous Complex include a variety of nepheline syenites, pulaskite, melteigite, ijolite, malignite, carbonatites, and lamprophyre dikes. Recent geochemical and mineralogical studies include those of Howard (1974), Heathcote (1987), and Heathcote and McCormick (1989). References to earlier studies are included in these recent reports. Geochronological studies indicate an age of 100 Ma for the complex (Zartman and Howard, 1987; Eby 1987). Vanadium mineralization occurs at the contacts between igneous rocks and thermally metamorphosed sedimentary country rocks (Heathcote and Owens, 1981). Two such areas of mineralization were mined for V by Union Carbide Corporation (Hollingsworth, 1973).

This report presents whole-rock geochemical analyses of 21 samples from drill core M162 and from 15 outcrop samples. The drill core is curated by the Arkansas Geological Commission in the Norman F. Williams Well Sample Repository, Little Rock, Arkansas. The drill core was obtained by Union Carbide Corporation as part of their mineral exploration program. The total depth of the core was 560 feet. The outcrop samples were collected by the authors and Malcolm Ross (USGS, Scientist Emeritus) and Donald R. Owens (U. Arkansas, Little Rock).

Analytical Methods

All whole-rock analyses were obtained by USGS personnel. Analytical methods have been previously documented (Flohr and Howard, 1995). The method used for each element is noted in Tables 1 and 2. Detailed descriptions of the techniques are given by Baedecker (1987) and references therein. Polished thin sections were also examined using the petrographic microscope and limited X-ray powder diffraction data were obtained on several samples.

Rock Types

Drill core M162. The M162 drill core (Fig. 1) is dominated by calcite carbonatites and lithologies referred to as hybrid rocks herein. Hybrid rocks correspond to the hybrid C_2 alvikites described by Heathcote and McCormick (1989) as the product of mixing between carbonatite (C_1 sovite) and ijolite magmas. No effort to further classify the carbonatites and hybrid rocks (Table 1) following the scheme of Heathcote and McCormick (1987) was made, as their classification was largely based on the compositions of phlogopites in these rocks. We note, however, that sample M162-456 (Table 1) probably corresponds to Heathcote and McCormick's ferriphlogopite sovite (with included clasts of ijolite), based on the optical characteristics of the phlogopite and high bulk Fe content of the rock. Ijolites and syenites are subordinate lithologies in the drill core. Both alkali syenites (pulaskite, leucopulaskite) and nepheline syenites appear to be represented, but are commonly altered, making accurate classification difficult. Relative high concentrations of CO_2 and CaO in the altered syenites (samples M162-167.5, - 345, -

492.5; Table 1) reflect the presence of calcite veins and development of minor calcite in the groundmass of these rocks.

Outcrop samples. Outcrops are uncommon in the Potash Sulphur Springs Igneous Complex. Lithologies exposed in outcrops (Fig. 1) include carbonatites, syenites (including pulaskite, leucopulaskite, feldspathoidal syenite, malignite, nordsjöite, and naujaite), mafic rocks of the melteigite-ijolite series (including fasinite), and lamprophyre dikes. Wollastonite rock and an aegirine-wollastonite-miserite-rich rock (sample PSS-5, tentatively identified as a fenite) occur in the contact zone of the complex. Whole-rock analyses of outcrop samples are presented in Table 2.

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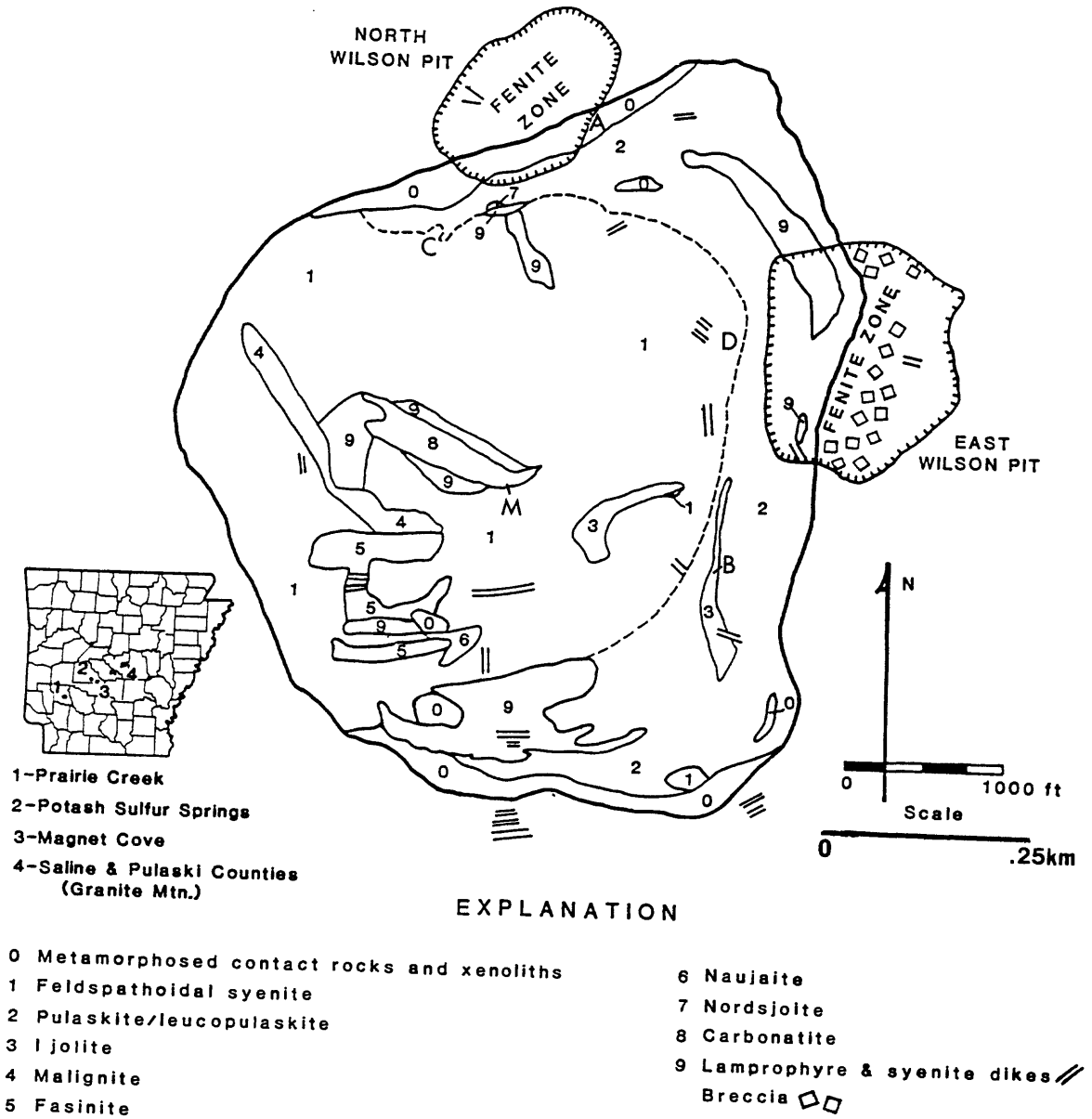

Figure 1. Geologic map of the Potash Sulphur Springs Igneous Complex, Garland County, Arkansas, from Zartman and Howard (1987) as modified from Howard (1974). Index map shows the location of the complex, in addition to several other alkaline rock occurrences. The North Wilson pit and the East Wilson pit are areas of V mineralization mined by Union Carbide Corporation. The dashed line indicates a gradational contact. Locations of samples collected from outcrops are indicated by capital letters: A (east edge of the North Wilson pit) - PSS-2, -3, -4, -5; B (outcrops exposed in diversion ditch along dirt road) - PSS-6, -7, -8, -9; C (northern syenite exposure and associated lamprophyre dikes) - PSS-10, -11B; D (along ridge overlooking divergence ditch) - PSS-12, -13, -14, -15, -16. 'M', within the central unit of carbonatite, indicates the approximate location of drill core M162.

Table 1. Geochemical data of M162 drill core samples, Potash Sulphur Springs Igneous Complex, Arkansas

[Sample - number following core number (M162) is depth in feet; Lab No. - USGS laboratory sample number; pct - percent; WDXRF - wavelength-dispersive X-ray fluorescence spectrometry; calc. - calculated; col. titra. colorimetric titration; SIE - selective ion electrode; comb./IR - combustion/IR spectroscopy; coul. titra. - coulometric titration; diff. - by difference (H_2O^+ is the difference between total H_2O determined coulometrically by Karl Fischer titration and H_2O^-); wt. loss - H_2O^- determined by weight loss of a 1-g sample after heating for 1hr. at 110°C); INAA - instrumental neutron activation analysis; LOI - loss on ignition; 925°C - LOI determined after heating sample to 925°C; EDXRF - energy-dispersive X-ray fluorescence; ICP-AES - inductively coupled plasma-atomic emission spectrometry; ppm - parts per million; ppb - parts per billion; -- - not analyzed; alt. - altered; neph. - nepheline]

		Sample	M162-16.5	M162-35.5	M162-100.5	M162-108.5	M162-125	M162-136.5	M162-137
		Lab No.	W-257430	W-257431	W-257432	W-257433	W-257434	W-257435	W-257436
		Rock type	hybrid	hybrid	carbonatite	hybrid	hybrid	hybrid	carbonatite
SiO_2	pct	WDXRF	28.5	42.0	13.9	44.8	29.5	36.1	8.42
TiO_2	pct	WDXRF	1.80	1.32	0.98	0.16	1.78	4.29	0.60
Al_2O_3	pct	WDXRF	7.15	11.9	4.52	5.07	7.72	9.54	2.53
Fe_2O_3	pct	calc.	3.65	3.53	1.80	2.50	3.37	5.49	1.89
FeO	pct	col. titra	4.00	3.53	5.02	1.62	4.46	6.40	3.76
MnO	pct	WDXRF	0.51	0.38	0.34	0.64	0.53	0.32	0.28
MgO	pct	WDXRF	4.33	4.25	4.67	1.65	4.04	8.34	3.02
CaO	pct	WDXRF	23.2	12.4	34.0	31.7	22.8	15.5	41.0
Na_2O	pct	WDXRF	3.65	5.68	1.25	2.82	3.99	3.27	0.2
K_2O	pct	WDXRF	3.17	4.80	2.67	1.73	2.73	3.65	1.87
P_2O_5	pct	WDXRF	1.08	0.52	2.01	1.34	1.12	0.98	2.29
F^-	pct	SIE	0.63	0.34	0.68	0.12	0.45	0.38	0.4
Cl^-	pct	SIE	0.030	0.119	0.012	0.025	0.094	0.115	0.003
Total S	pct	comb./IR	1.11	1.04	0.97	0.34	1.08	0.40	0.26
CO_2	pct	coul. titra.	15.4	6.11	25.8	4.05	13.6	3.12	30.4
H_2O^+	pct	diff.	0.90	1.01	0.89	0.52	0.97	1.21	0.78
H_2O^-	pct	wt. loss	0.10	0.14	0.06	0.09	0.13	0.13	0.21
-F≡oxy	pct	calc.	0.27	0.14	0.29	0.05	0.19	0.16	0.17
-Cl≡oxy	pct	calc.	0.007	0.027	0.003	0.006	0.021	0.026	0.001
-S≡oxy	pct	calc.	0.56	0.52	0.49	0.17	0.54	0.20	0.13
Sum	pct	calc.	100.0	99.8	100.3	99.4	99.1	99.6	98.2
LOI	pct	925°C	13.7	5.01	23.3	3.87	12.4	2.97	30.6
Na	pct	INAA	2.74	4.27	1.004	2.26	3.17	2.46	0.174
K	pct	INAA	2.60	4.0	2.35	1.36	1.63	3.2	1.66
Ca	pct	INAA	15.2	8.4	24.8	22.5	17.2	11.6	27.8
Fe	pct	INAA	5.80	5.28	5.71	3.28	6.26	8.99	4.52
V	ppm	ICP	760	523	299	502	816	605	306
Li	ppm	ICP	61	18	26	<5	32	18	10
Ba	ppm	EDXRF	2100	2100	1400	730	2000	1100	980

Table 1. Geochemical data of M162 drill core samples - Continued

	Sample	M162-16.5	M162-35.5	M162-100.5	M162-108.5	M162-125	M162-136.5	M162-137
Cu ..... ppm ..	EDXRF	33	42	54	30	42	83	26
Ni ..... ppm ..	EDXRF	30	41	21	18	32	68	14
Zn ..... ppm ..	EDXRF ...	225	260	144	68	245	180	104
Sc ..... ppm ..	INAA	14.49	7.95	4.59	5.21	14.59	30.12	1.66
Cr ..... ppm ..	INAA	162	253.1	16.6	20.5	138.9	175	6.3
Co ..... ppm ..	INAA	21.2	17.7	27.1	14.69	22.4	42.0	9.94
Ni ..... ppm ..	INAA	<60	67	26	28	47	66	<13
Zn ..... ppm ..	INAA	215	226	136	81.0	258	153	119
As ..... ppm ..	INAA	5.6	3.5	2.9	2.5	7.6	1.6	2.40
Rb ..... ppm ..	INAA	89	107	103.1	33.6	98.2	122	77.9
Sr ..... ppm ..	INAA	5040	2480	6280	1870	5510	1160	7990
Zr ..... ppm ..	INAA	276	202	220	85	365	400	131
Mo ..... ppm ..	INAA	<4	3	<1	<1	<4	<8	<1
Sb ..... ppm ..	INAA	0.40	0.34	<0.1	0.27	0.377	0.141	0.078
Cs ..... ppm ..	INAA	2.49	1.52	1.72	0.60	3.10	1.50	1.21
Ba ..... ppm ..	INAA	2080	2080	1450	737	2080	1090	980
La ..... ppm ..	INAA	174	60.5	210	83.7	181	107	196
Ce ..... ppm ..	INAA	231	78.7	269	115.9	241	198	251
Nd ..... ppm ..	INAA	71.6	24.1	77.0	37.0	72.4	78.8	74.1
Sm ..... ppm ..	INAA	12.5	3.91	12.45	6.04	12.95	15.2	12.03
Eu ..... ppm ..	INAA	3.14	0.973	3.43	1.58	3.45	3.76	3.17
Tb ..... ppm ..	INAA	1.14	0.310	1.26	0.697	1.34	1.22	1.23
Ho ..... ppm ..	INAA	<2	<0.9	1.86	0.85	<2	<3	1.7
Yb ..... ppm ..	INAA	2.77	0.81	3.08	2.57	3.63	2.20	3.65
Lu ..... ppm ..	INAA	0.370	0.110	0.392	0.383	0.498	0.298	0.486
Hf ..... ppm ..	INAA	4.72	3.61	2.78	0.68	5.84	8.35	1.19
Ta ..... ppm ..	INAA	4.85	3.58	2.79	0.466	4.71	11.02	1.21
Th ..... ppm ..	INAA	3.85	2.53	2.06	5.70	6.99	11.85	2.56
U ..... ppm ..	INAA	8.6	5.08	2.05	1.51	5.77	3.37	1.35
Au ..... ppb ...	INAA	12.9	<5	<7	<5	<6	<6	<5

	Lab No.	W-258909	W-258910	W-258911	W-258912	W-258913	W-258914	W-258915
Y ..... ppm ..	ICP	26	7.2	28	19	27	24	33
Sr ..... ppm ..	ICP	5100	2400	5500	1600	4700	1200	7600
Zr ..... ppm ..	ICP	320	260	130	59	360	520	65
Ba ..... ppm ..	ICP	2500	2300	1500	780	2200	1400	1100
Mo ..... ppm ..	ICP	1.8	2.2	<1	<1	2.9	<1	<1
Nb ..... ppm ..	ICP	340	285	128	33	315	267	72

Table 1. Geochemical data of M162 drill core samples - Continued

		Sample	M162-148.5	M162-167.5	M162-178.5	M162-211	M162-233	M162-311	M162-345
		Lab No.	W-257453	W-257437	W-257438	W-257454	W-257439	W-257440	W-257455
		Rock type	ijolite	alt. syenite	carbonatite	ijolite	carbonatite	carbonatite	alt. syenite
SiO_2	pct	WDXRF	38.7	55.2	4.22	39.9	4.94	14.1	41.3
TiO_2	pct	WDXRF	0.75	0.12	0.32	0.68	0.59	2.64	0.43
Al_2O_3	pct	WDXRF	11.2	16.8	0.79	13.5	0.58	3.24	14.6
Fe_2O_3	pct	calc.	5.77	1.51	1.46	6.19	2.06	0	2.76
FeO	pct	col. titra	2.43	0.94	2.02	5.95	1.67	20.43	3.19
MnO	pct	WDXRF	0.39	0.13	0.30	0.22	0.19	0.73	0.39
MgO	pct	WDXRF	1.63	0.92	1.60	1.41	1.21	6.53	4.88
CaO	pct	WDXRF	22.3	4.59	47.4	10.4	48.7	23.7	11.1
Na_2O	pct	WDXRF	5.49	4.43	0.29	3.41	<0.15	0.59	6.10
K_2O	pct	WDXRF	2.54	9.44	0.64	6.74	0.31	2.50	3.73
P_2O_5	pct	WDXRF	1.64	0.14	2.57	0.69	3.27	5.75	0.43
F^-	pct	SIE	0.17	0.03	0.38	0.23	0.18	0.92	0.51
Cl^-	pct	SIE	0.068	0.028	0.003	0.044	0.005	0.002	0.006
Total S	pct	comb./IR	0.88	0.24	0.42	4.50	0.27	5.78	0.10
CO_2	pct	coul. titra.	3.92	2.61	35.8	5.36	33.9	14.0	5.61
H_2O^+	pct	diff.	0.73	1.44	0.19	1.06	0.20	1.26	3.86
H_2O^-	pct	wt. loss	0.19	0.10	0.05	0.12	0.11	0.17	0.26
-F≡oxy	pct	calc.	0.07	0.01	0.16	0.10	0.08	0.39	0.21
-Cl≡oxy	pct	calc.	0.015	0.006	0.001	0.010	0.001	0	0.001
-S≡oxy	pct	calc.	0.44	0.12	0.21	2.25	0.14	2.89	0.05
Sum	pct	calc.	98.3	98.8	98.8	98.0	98.4	99.1	99.0
LOI	pct	925°C	3.33	3.75	34.8	1.76	33.3	3.74	8.82
Na	pct	INAA	4.39	3.27	0.253	2.69	0.075	0.486	4.78
K	pct	INAA	<3	7.4	0.73	6.1	<0.5	2.06	3.2
Ca	pct	INAA	16.4	3.22	33.8	8.7	35.4	17.3	7.77
Fe	pct	INAA	6.31	1.80	2.80	9.55	2.98	15.71	4.63
V	ppm	ICP	626	335	252	460	60	215	576
Li	ppm	ICP	5.4	<5	<5	15	<5	11	49
Ba	ppm	EDXRF	580	4700	820	1900	590	1100	1150
Cu	ppm	EDXRF	38	<10	<10	39	27	112	<10
Ni	ppm	EDXRF	<10	<10	<10	<10	<10	19	<10
Zn	ppm	EDXRF	77	27	52	81	37	164	194
Sc	ppm	INAA	0.889	1.41	0.80	0.801	2.18	5.49	2.90
Cr	ppm	INAA	3.1	4.1	<1	5.1	<1	5.4	5.9
Co	ppm	INAA	18.2	2.47	6.70	18.9	7.64	51.75	4.91

Table 1. Geochemical data of M162 drill core samples - Continued

	Sample	M162-148.5	M162-167.5	M162-178.5	M162-211	M162-233	M162-311	M162-345
Ni ..... ppm ..	INAA	<10	<9	<11	24	<19	<31	<17
Zn ..... ppm ..	INAA	99.5	31.5	65.8	84.4	49.5	183	185
As ..... ppm ..	INAA	3.3	2.02	3.1	2.2	2.9	3.8	2.9
Rb ..... ppm ..	INAA	52.2	163	31.3	237	17.3	110	96.3
Sr ..... ppm ..	INAA	1980	1100	8970	2260	7030	4810	1580
Zr ..... ppm ..	INAA	307	108	<12	--	1520	1250	333
Mo ..... ppm ..	INAA	<4	2	<2	<18	<5	<7	<7
Sb ..... ppm ..	INAA	0.109	0.121	<0.08	0.355	<0.2	0.15	0.267
Cs ..... ppm ..	INAA	0.87	1.12	0.446	5.63	0.268	1.67	1.08
Ba ..... ppm ..	INAA	623	4360	870	1860	593	1160	1200
La ..... ppm ..	INAA	130	15.8	339	67	297	373	57.3
Ce ..... ppm ..	INAA	183	19.3	432	95	394	536	85
Nd ..... ppm ..	INAA	55.7	10.6	117	26	122	161	26.2
Sm ..... ppm ..	INAA	8.89	0.82	18.4	5.79	27.0	27.7	4.51
Eu ..... ppm ..	INAA	2.32	0.226	4.89	1.41	8.96	7.78	1.22
Tb ..... ppm ..	INAA	0.806	0.086	1.67	0.528	4.67	2.99	0.495
Ho ..... ppm ..	INAA	--	<0.5	2.09	--	6.7	5.2	--
Yb ..... ppm ..	INAA	2.15	0.43	3.59	1.52	18.6	7.34	1.84
Lu ..... ppm ..	INAA	0.301	0.083	0.448	0.210	2.36	0.940	0.284
Hf ..... ppm ..	INAA	3.38	0.84	0.780	2.50	6.07	8.13	3.69
Ta ..... ppm ..	INAA	2.79	0.204	0.915	5.71	7.02	5.07	1.75
Th ..... ppm ..	INAA	7.51	0.387	7.24	1.33	9.93	7.44	0.95
U ..... ppm ..	INAA	2.87	0.82	3.02	165	4.90	16.6	1.65
Au ..... ppb ...	INAA	<10	<4	<7	<5	<8	<8	<11

	Lab No.	W-258932	W-258916	W-258917	W-258933	W-258918	W-258919	W-258934
Y ..... ppm ..	ICP	25	2.2	43	16	160	72	13
Sr ..... ppm ..	ICP	1700	980	9100	1900	6700	5000	1200
Zr ..... ppm ..	ICP	320	130	82	150	1900	220	280
Ba ..... ppm ..	ICP	600	4500	1000	2100	630	1400	1100
Mo ..... ppm ..	ICP	1.1	3.1	<1	8	<1	<1	5.1
Nb ..... ppm ..	ICP	87	18	95	2430	216	662	403

Table 1. Geochemical data of M162 drill core samples - Continued

			Sample	M162-393.5	M162-431	M162-447	M162-454	M162-456	M162-469.5	M162-492.5
			Lab No.	W-257441	W-257442	W-257456	W-257443	W-257457	W-257458	W-257459
			Rock type	hybrid	carbonatite	ijolite	hybrid	hybrid	neph. syenite	alt. syenite
SiO_2	pct	WDXRF		23.3	1.71	34.3	45.1	17.9	51.3	42.3
TiO_2	pct	WDXRF		1.46	<0.02	1.65	0.45	2.82	0.15	0.65
Al_2O_3	pct	WDXRF		7.49	0.3	8.17	18.5	4.90	20.5	17.7
Fe_2O_3	pct	calc.		3.37	4.18	4.05	1.49	33.70	1.14	2.60
FeO	pct	col. titra		6.15	2.24	2.82	2.15	16.2	1.00	0.85
MnO	pct	WDXRF		0.37	0.60	0.4	0.16	0.98	0.09	0.15
MgO	pct	WDXRF		6.16	2.12	3.95	1.31	1.92	0.49	0.43
CaO	pct	WDXRF		24.5	44.2	21.7	6.67	12.7	2.41	9.95
Na_2O	pct	WDXRF		2.39	0.16	6.40	6.61	1.78	7.45	8.54
K_2O	pct	WDXRF		3.47	0.22	0.73	6.41	0.70	8.70	5.75
P_2O_5	pct	WDXRF		1.48	0.20	0.95	0.12	2.92	0.05	0.39
F^-	pct	SIE		0.38	0.11	0.11	0.14	0.27	0.02	0.04
Cl^-	pct	SIE		0.024	0.019	0.058	0.023	0.006	0.067	0.344
Total S	pct	comb./IR		0.97	3.98	1.19	0.77	0.55	0.67	0.73
CO_2	pct	coul. titra.		16.2	38.6	10.4	5.32	2.02	1.43	5.30
H_2O^+	pct	diff.		1.46	0.27	1.29	3.43	1.12	1.99	1.18
H_2O^-	pct	wt. loss		0.20	0.08	0.13	0.17	0.23	0.49	0.28
-F≡oxy	pct	calc.		0.16	0.05	0.05	0.06	0.11	0.01	0.02
-Cl≡oxy	pct	calc.		0.005	0.004	0.013	0.005	0.001	0.015	0.078
-S≡oxy	pct	calc.		0.49	1.99	0.60	0.39	0.28	0.34	0.37
Sum	pct	calc.		100.0	101.0	97.6	99.3	100.3	97.6	96.7
LOI	pct	925°C		15.4	31.1	10.2	7.93	0.92	3.35	6.39
Na	pct	INAA		1.83	0.162	5.14	4.95	1.31	5.82	6.88
K	pct	INAA		3.15	<1	1.01	5.0	0.55	7.9	5.4
Ca	pct	INAA		17.2	33.3	15.9	4.22	12.6	1.80	7.4
Fe	pct	INAA		7.40	5.20	5.31	2.77	38.1	1.59	2.58
V	ppm	ICP		212	15	706	91	3300	145	449
Li	ppm	ICP		8.4	19	<5	15	<5	<5	<5
Ba	ppm	EDXRF		1400	1200	210	2500	122	1550	2650
Cu	ppm	EDXRF		62	<10	29	15	18	13	<10
Ni	ppm	EDXRF		20	<10	29	<10	60	<10	<10
Zn	ppm	EDXRF		174	<10	92	69	570	30	30
Sc	ppm	INAA		4.70	2.44	15.00	0.385	1.58	0.247	0.482
Cr	ppm	INAA		24.4	<1	131.3	5.82	15.8	2.39	1.12
Co	ppm	INAA		26.2	6.89	14.66	5.48	17.4	3.91	1.54

Table 1. Geochemical data of M162 drill core samples - Continued

	Sample	M162-393.5	M162-431	M162-447	M162-454	M162-456	M162-469.5	M162-492.5
Ni ..... ppm ..	INAA	27	<18	38	<10	<24	<7	<15
Zn ..... ppm ..	INAA	178	13.8	92	71.6	893	29.7	38.9
As ..... ppm ..	INAA	2.9	6.5	5.8	3.2	2.4	2.6	4.0
Rb ..... ppm ..	INAA	133	10	14.5	119	39	144	112
Sr ..... ppm ..	INAA	4130	13510	2920	1860	1180	766	1840
Zr ..... ppm ..	INAA	310	<60	330	223	250	439	439
Mo ..... ppm ..	INAA	<2	<4	5.8	4.7	3.6	3.0	7.3
Sb ..... ppm ..	INAA	0.136	0.313	0.628	0.229	0.141	0.22	0.276
Cs ..... ppm ..	INAA	1.97	0.195	0.35	0.89	0.82	0.80	0.94
Ba ..... ppm ..	INAA	1340	1410	247	2290	160	1490	2580
La ..... ppm ..	INAA	109	554	105.3	31.0	90.8	9.66	36.3
Ce ..... ppm ..	INAA	147.8	800	159	41.7	143.3	12.2	48.1
Nd ..... ppm ..	INAA	46.6	217	51.4	15.2	50.5	3.3	16.6
Sm ..... ppm ..	INAA	7.96	29.7	8.90	2.15	8.39	0.697	4.00
Eu ..... ppm ..	INAA	2.07	7.64	2.42	0.557	2.36	0.181	1.23
Tb ..... ppm ..	INAA	0.763	2.43	0.87	0.213	0.784	0.069	0.579
Ho ..... ppm ..	INAA	0.60	<5	--	<1	--	--	--
Yb ..... ppm ..	INAA	2.07	6.42	2.32	0.70	1.71	0.44	2.31
Lu ..... ppm ..	INAA	0.292	0.867	0.357	0.101	0.235	0.071	0.310
Hf ..... ppm ..	INAA	3.45	<0.1	5.26	2.24	2.03	4.13	5.70
Ta ..... ppm ..	INAA	3.48	0.086	4.86	1.63	3.62	1.53	1.80
Th ..... ppm ..	INAA	3.45	2.47	4.34	0.679	6.01	1.36	1.94
U ..... ppm ..	INAA	1.48	<0.8	2.59	3.18	2.53	5.91	1.15
Au ..... ppb ...	INAA	<10	18	<8	<5	<4	<5	<8

	Lab No.	W-258920	W-258921	W-258935	W-258922	W-258936	W-258937	W-258938
Y ..... ppm ..	ICP	16	55	18	2.9	20	1.6	22
Sr ..... ppm ..	ICP	3500	11000	2100	1900	1000	680	1500
Zr ..... ppm ..	ICP	320	9.0	320	110	280	130	450
Ba ..... ppm ..	ICP	1400	1300	210	2800	160	1700	2900
Mo ..... ppm ..	ICP	1	2.4	4.6	3.9	1	4.4	7.6
Nb ..... ppm ..	ICP	285	407	372	139	231	135	158

Table 2. Geochemical data of outcrop samples, Potash Sulphur Springs Igneous Complex, Arkansas

[Lab No. - USGS laboratory sample number; pct - percent; WDXRF - wavelength-dispersive X-ray fluorescence spectrometry; calc. - calculated; col. titra. colorimetric titration; SIE - selective ion electrode; comb./IR - combustion/IR spectroscopy; coul. titra. - coulometric titration; diff. - by difference (H_2O^+ is the difference between total H_2O determined coulometrically by Karl Fischer titration and H_2O^-); wt. loss - H_2O^- determined by weight loss of a 1-g sample after heating for 1hr. at 110°C; INAA - instrumental neutron activation analysis; LOI - loss on ignition; 925°C - LOI determined after heating sample to 925°C; EDXRF - energy-dispersive X-ray fluorescence; ICP-AES - inductively coupled plasma-atomic emission spectrometry; ppm - parts per million; ppb - parts per billion; woll. - wollastonite; meltg. - melteigite; -- - not analyzed]

		Sample	PSS-2	PSS-3	PSS-4	PSS-5	PSS-6	PSS-7	PSS-8
		Lab No	W-257426	W-257460	W-257461	W-257427	W-257462	W-257463	W-257464
		Rock type	carbonatite	syenite dike	woll. rock	fenite (?)	ijolite	ijolite	ijolite
SiO_2	pct	WDXRF	9.21	44.4	66.9	49.3	46.9	43.5	40.8
TiO_2	pct	WDXRF	<0.02	0.51	0.04	0.11	1.48	0.65	1.33
Al_2O_3	pct	WDXRF	2.68	16.9	0.67	0.31	16.8	10.6	13.4
Fe_2O_3	pct	calc.	0.22	3.07	0.28	1.46	4.91	3.83	5.82
FeO	pct	potent. titra.	0.91	0.93	0.04	1.06	2.70	3.30	2.15
MnO	pct	WDXRF	0.13	0.15	0.12	1.10	0.26	0.40	0.30
MgO	pct	WDXRF	0.16	0.70	<0.10	0.49	1.15	2.72	1.5
CaO	pct	WDXRF	45.6	12.2	22.0	38.4	7.58	20.8	19.9
Na_2O	pct	WDXRF	0.36	3.37	5.57	1.56	5.60	5.67	6.48
K_2O	pct	WDXRF	1.72	6.49	0.61	0.64	5.31	2.21	2.96
P_2O_5	pct	WDXRF	1.61	0.38	0.25	0.37	0.29	1.11	0.89
F^-	pct	SIE	0.14	0.08	0.05	0.46	0.05	0.12	0.08
Cl^-	pct	SIE	0.003	0.008	0.002	0.005	0.005	0.300	0.247
Total S	pct	combustion	0.37	0.19	<0.01	<0.01	0.37	1.00	0.74
CO_2	pct	coul. titra.	35.5	5.25	0.84	3.62	2.12	1.05	1.28
H_2O^+	pct	diff.	0.14	3.47	1.82	0.46	2.66	1.02	0.60
H_2O-	pct	wt. loss	0.07	0.70	0.22	0.10	0.48	0.24	0.19
-F≡oxy	pct	calc.	0.06	0.03	0.02	0.19	0.02	0.05	0.03
-Cl≡oxy	pct	calc.	0.001	0.002	0	0.001	0.001	0.068	0.056
-S≡oxy	pct	calc.	0.19	0.10	0	0	0.19	0.50	0.37
Sum	pct	calc.	99.1	98.7	99.4	99.6	98.5	97.9	98.2
LOI	pct	925°C	34.1	8.87	2.97	3.44	4.67	1.34	1.35
Na	pct	INAA	0.307	2.58	4.25	1.20	4.33	4.56	5.11
K	pct	INAA	1.39	5.9	0.79	0.63	4.8	2.03	2.6
Ca	pct	INAA	31.4	9.4	15.9	28.2	5.6	15.0	15.2
Fe	pct	INAA	0.896	3.03	0.177	1.95	5.84	5.54	6.08
V	ppm	ICP	51	388	17	1110	445	449	787
Li	ppm	ICP	<5	7.6	<5	7.6	45	<5	<5
Ba	ppm	EDXRF	1300	2650	56	64	2200	800	500

Table 2. Geochemical data of outcrop samples - Continued

	Sample	PSS-2	PSS-3	PSS-4	PSS-5	PSS-6	PSS-7	PSS-8
Cu ..... ppm ..	EDXRF ...	<10	11	<10	<10	19	14	15
Ni ..... ppm ..	EDXRF ...	<10	<10	<10	10	<10	11	<10
Zn ..... ppm ..	EDXRF ...	<10	94	22	91	174	90	73
Sc ..... ppm ..	INAA	0.08	0.478	0.090	1.02	1.69	0.760	1.007
Cr ..... ppm ..	INAA	<0.7	1.36	<1	3.5	3.9	1.90	2.18
Co ..... ppm ..	INAA	2.45	2.53	0.25	0.98	10.14	11.9	7.66
Ni ..... ppm ..	INAA	<6	<9	<5	<12	<13	9.63	<12
Zn ..... ppm ..	INAA	12.2	103	25.4	113	170	101.8	81.0
As ..... ppm ..	INAA	1.37	4.33	<1	3.18	3.9	4.4	3.8
Rb ..... ppm ..	INAA	27.9	121	39.0	27.0	134	37.0	49.3
Sr ..... ppm ..	INAA	9820	3670	1810	1360	2190	1510	1400
Zr ..... ppm ..	INAA	<21	297	<40	--	461	265	497
Mo ..... ppm ..	INAA	<2	4.4	<2	--	<3	7.3	4.9
Sb ..... ppm ..	INAA	0.059	0.66	0.047	0.32	0.108	0.354	0.317
Cs ..... ppm ..	INAA	0.150	1.07	0.457	0.180	5.47	0.64	0.71
Ba ..... ppm ..	INAA	1230	2710	50	70	2190	850	529
La ..... ppm ..	INAA	145	36.0	44.5	83.3	51.6	53.6	44.5
Ce ..... ppm ..	INAA	163	45.2	65.5	153.4	66.8	73	69
Nd ..... ppm ..	INAA	38.5	13.0	2.01	63.3	19.4	24.2	29.2
Sm ..... ppm ..	INAA	5.07	1.98	3.65	17.4	3.40	4.04	6.62
Eu ..... ppm ..	INAA	1.24	0.512	0.942	5.58	0.931	1.01	1.83
Tb ..... ppm ..	INAA	0.338	0.169	0.367	3.14	0.438	0.344	0.712
Ho ..... ppm ..	INAA	<0.7	--	--	4.6	--	--	--
Yb ..... ppm ..	INAA	0.63	0.36	0.74	19.0	1.75	1.15	2.22
Lu ..... ppm ..	INAA	0.080	0.061	0.089	2.59	0.258	0.158	0.319
Hf ..... ppm ..	INAA	0.148	2.74	0.112	0.82	7.85	2.93	5.75
Ta ..... ppm ..	INAA	0.090	3.30	0.096	2.91	2.42	1.10	2.37
Th ..... ppm ..	INAA	0.689	0.772	2.84	8.06	7.31	2.41	2.23
U ..... ppm ..	INAA	0.26	0.94	2.17	27.1	4.91	1.63	2.00
Au ..... ppb ...	INAA	<4	<4	<11	<5	<10	<7	<5

	Lab No.	W-258905	W-258939	W-258940	W-258906	W-258941	W-258942	W-258943
Y ..... ppm ..	ICP	9.5	3.9	9.0	130	17	14	27
Sr ..... ppm ..	ICP	9700	3000	1400	1200	1900	1400	1300
Zr ..... ppm ..	ICP	17	200	6.0	57	550	310	580
Ba ..... ppm ..	ICP	1500	2700	52	80	2500	890	490
Mo ..... ppm ..	ICP	<1	5.1	<1	<1	<1	5.8	3.9
Nb ..... ppm ..	ICP	5.4	244	21	2350	136	37	75

Table 2. Geochemical data of outcrop samples - Continued

			Sample	PSS-9	PSS-10	PSS-11B	PSS-12	PSS-13	PSS-14	PSS-15	PSS-16
			Lab No	W-257465	W-257466	W-257467	W-257468	W-257428	W-257429	W-257469	W-257470
			Rock type	meltg.-ijolite	syenite	lamprophyre	syenite	carbonatite	carbonatite	ijolite	ijolite
SiO_2	pct	WDXRF		51.4	62.7	41.1	53.1	9.61	8.45	35.4	38.6
TiO_2	pct	WDXRF		0.73	0.12	3.51	0.39	0.66	0.56	3.53	3.73
Al_2O_3	pct	WDXRF		5.16	16.0	15.8	13.8	1.70	1.38	7.91	8.56
Fe_2O_3	pct	calc.		7.05	2.52	6.38	2.63	2.09	1.85	5.59	4.31
FeO	pct	potent. titra		6.16	0.89	4.16	2.02	3.05	2.88	5.32	6.38
MnO	pct	WDXRF		0.59	0.20	0.24	0.17	0.24	0.22	0.37	0.21
MgO	pct	WDXRF		4.98	0.53	3.71	1.53	2.01	1.84	6.27	10.5
CaO	pct	WDXRF		16.7	1.84	12.1	8.12	43.7	45.0	21.0	15.8
Na_2O	pct	WDXRF		1.79	2.89	3.22	1.84	0.35	0.26	2.32	2.09
K_2O	pct	WDXRF		3.69	11.1	2.64	10.2	0.97	0.84	2.40	3.56
P_2O_5	pct	WDXRF		0.67	<0.05	0.77	3.28	3.98	3.69	2.17	0.68
F^-	pct	SIE		0.06	0.01	0.20	0.26	0.41	0.35	0.33	0.53
Cl^-	pct	SIE		0.004	0.026	0.046	0.014	0.001	0.002	0.018	0.030
Total S	pct	combustion		<0.01	<0.01	0.14	0.75	0.58	0.64	1.65	0.79
CO_2	pct	coul. titra.		0.02	0.07	0.56	0.72	29.1	30.9	4.60	1.99
H_2O^+	pct	diff.		0.05	0.19	4.30	0.24	0.44	0.36	1.07	1.62
H_2O^-	pct	wt. loss		0.15	0.14	0.73	0.08	0.13	0.09	0.07	0.18
-F≡oxy	pct	calc.		0.03	0	0.08	0.11	0.17	0.15	0.14	0.22
-Cl≡oxy	pct	calc.		0.001	0.006	0.010	0.003	0	0	0.004	0.007
-S≡oxy	pct	calc.		0	0	0.07	0.38	0.29	0.32	0.83	0.40
Sum	pct	calc.		99.2	99.2	99.4	98.7	99.5	99.8	99.1	98.9
LOI	pct	925°C		0.10	0.37	5.04	0.57	28.0	29.5	2.94	2
Na	pct	INAA		1.30	2.15	2.45	1.39	0.282	0.223	1.78	1.57
K	pct	INAA		3.28	9.6	2.28	8.9	0.80	0.88	2.21	3.22
Ca	pct	INAA		12.2	1.33	9.8	6.8	31.4	33.5	15.1	12.5
Fe	pct	INAA		10.14	2.54	8.22	3.51	4.04	3.87	8.51	8.55
V	ppm	ICP		3100	264	424	221	394	323	782	458
Li	ppm	ICP		<5	<5	33	<5	5.4	<5	9.5	14
Ba	ppm	EDXRF		930	1950	1450	3600	530	510	335	1200
Cu	ppm	EDXRF		<10	<10	78	28	15	13	89	102
Ni	ppm	EDXRF		<10	<10	13	<10	<10	<10	48	106
Zn	ppm	EDXRF		210	62	91	92	80	74	174	110
Sc	ppm	INAA		4.59	1.518	7.67	1.398	2.13	1.78	26.4	41.9
Cr	ppm	INAA		4.8	2.78	4.1	19.4	13.1	9.6	182	470
Co	ppm	INAA		11.18	1.79	31.4	10.64	9.50	9.42	40.3	50.5
Ni	ppm	INAA		16	<15	20	<30	<13	<14	53	116
Zn	ppm	INAA		233	64.7	121	96.9	86.7	81.3	174	92

Table 2. Geochemical data of outcrop samples - Continued

			Sample	PSS-9	PSS-10	PSS-11B	PSS-12	PSS-13	PSS-14	PSS-15	PSS-16
As	ppm	INAA		1.21	0.54	1.37	2.01	2.18	2.09	3.2	3.6
Rb	ppm	INAA		83.1	231	87	191	31.4	30.1	66	131
Sr	ppm	INAA		772	425	1680	1700	6600	7010	2960	1470
Zr	ppm	INAA		379	81	362	--	160	145	438	214
Mo	ppm	INAA		<2	<3	<4	<7	<7	<2	<3	<4
Sb	ppm	INAA		0.092	0.096	0.190	0.089	<0.06	<0.08	<0.1	0.27
Cs	ppm	INAA		0.372	1.25	2.68	1.44	0.638	0.57	1.00	2.25
Ba	ppm	INAA		976	1890	1543	3580	524	536	355	1290
La	ppm	INAA		23.5	5.30	134	108	314	319	139	78.5
Ce	ppm	INAA		37.4	6.67	248	169	460	451	231	142.3
Nd	ppm	INAA		15.1	<0.6	95	49	139	135	83.3	59.3
Sm	ppm	INAA		3.29	0.297	16.8	8.5	22.1	20.9	14.57	11.2
Eu	ppm	INAA		0.925	0.085	4.18	1.65	5.83	5.68	3.90	2.80
Tb	ppm	INAA		0.324	0.031	1.48	0.458	1.9	1.85	1.43	1.009
Ho	ppm	INAA		--	--	--	--	2.16	2.0	--	--
Yb	ppm	INAA		1.01	0.345	2.68	0.64	3.23	3.10	2.96	1.7
Lu	ppm	INAA		0.199	0.062	0.367	0.065	0.406	0.398	0.373	0.234
Hf	ppm	INAA		3.75	1.43	7.66	2.39	0.991	0.80	8.91	6.23
Ta	ppm	INAA		0.630	0.300	14.94	5.76	2.15	1.79	11.72	6.96
Th	ppm	INAA		1.72	0.688	15.71	6.39	11.66	10.63	9.40	10.21
U	ppm	INAA		1.02	0.50	3.58	116	2.26	1.72	4.43	3.91
Au	ppb	INAA		<5	6.4	<6	<4	<7	<7	<6	<8

			Lab No.	W-258944	W-258945	W-258946	W-258947	W-258907	W-258914	W-258948	W-258949
Y	ppm	ICP		8.8	<1	30	6.4	39	41	32	19
Sr	ppm	ICP		700	370	1400	1500	5900	6700	2500	1300
Zr	ppm	ICP		360	86	410	220	190	150	470	270
Ba	ppm	ICP		1000	1900	1500	3900	570	630	240	1300
Mo	ppm	ICP		<1	<1	1.3	3.1	<1	<1	1.1	2
Nb	ppm	ICP		57	26	208	1010	105	77	429	106