

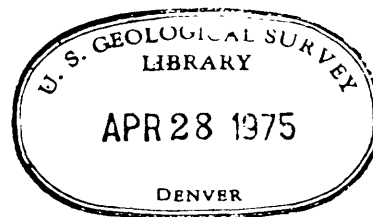
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UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Geochemistry of the Ancient Gneiss Complex
of Swaziland: A Preliminary Investigation

By

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GEOCHEMISTRY OF THE ANCIENT GNEISS COMPLEX
OF SWAZILAND: A PRELIMINARY INVESTIGATION

By

D. R. Hunter*, F. Barker, Z. E. Peterman and H. T. Millard

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The Ancient Gneiss Complex of Swaziland, which lies in the eastern part of the Kaapvaal craton, consists of (i) a largely bimodal suite of light-colored gneisses and amphibolites, (ii) a suite of metamorphites that includes recognizable metasediments, light-colored gneisses, and amphibolite, and (iii) hornblende tonalite. Structural data suggests that the metamorphite succession is younger than the more widespread bimodal suite, which has yielded the oldest Rb-Sr age in the Kaapvaal craton. It is believed that the bimodal suite pre-dates the Barberton greenstone belt.

Twenty-seven samples have been analyzed for major elements: twenty belong to the bimodal suite; eleven of these are high-SiO₂, low-K₂O gneisses and five are tholeiitic to low-K tholeiitic metabasalts and metabasaltic andesites. One of the latter five contains 20.3% MgO and 5.9% Al₂O₃, and apparently represents high-magnesia tholeiite. [Two further samples of light-colored gneiss have major element chemistry that may represent hornblende-rich tonalite.] Two samples of hornblende tonalite (66-68% SiO₂) that builds a discrete member of the Ancient Gneiss Complex in southwestern Swaziland also were analyzed. The remaining seven samples are from the metamorphite succession; four of these are high-SiO₂ gneisses, two are tholeiitic metabasaltic andesites, and one a calc-alkaline gneiss.

The eleven high-SiO₂, low-K₂O gneisses of the bimodal suite plot on the normative Qz-Ab-Or diagram largely in the tonalite-trondhjemite field. These rocks show a gap in SiO₂ content of 59.2 to 69%. The light-colored metamorphite gneisses plot in the quartz monzonite field close to the low-P_{H₂O} granite minima, although one sample does contain 8.3% of normative An. These gneisses probably formed by partial melting of pre-existing light colored gneisses of the bimodal suite. The metabasaltic and metaandesitic rocks of the bimodal suite show a calc-alkaline trend in the Alk-F-M diagram, as do the rocks of similar composition from the metamorphite succession.

The Ancient Gneiss Complex shows consistent but unusual distributions on the K/Rb plot. Preliminary data on two amphibolites and three light-colored gneisses of the bimodal suite give a K/Rb ratio of about 130, but one light gneiss has a ratio of 270. The hornblende tonalites plot almost linearly along a ratio of 230 (additional data from Davies, 1970).

The light gneisses of the bimodal suite plot on the Rb-Sr diagram in a position intermediate between Keswatin metarhyolite and Twilight Gneiss. The Rb-Sr ratios range from about 0.3 to 1.1.

The K/Rb ratios of the light-colored metamorphite gneisses are 250 to 360; the interlayered amphibolite has a ratio of 1,200. The Rb-Sr ratios of the light metamorphite gneisses are greater than 1; those of the associated amphibolite are less than 0.1. Thus the metamorphites differ from their older bimodal counterparts in respect to both their K/Rb and Rb/Sr ratios.

Patterns of rare earth elements (REE) of the light-colored gneisses of the bimodal suite are diverse; slopes of the light REE range from gentle to steep. Eu anomalies range from strongly negative to slightly positive, and slopes of the heavy REE range from flat to moderately steep. The two metabasalts analyzed show flat REE patterns, and the presumed meta-andesite has a pattern of gentle slope of the light REE and of flat slope for the heavy REE with no Eu anomaly.

REE patterns of two light-colored gneisses of the metamorphite group show moderate and pronounced negative Eu anomalies, moderate slopes of the light REE, and flat slopes of the heavy REE. The only interlayered amphibolite analyzed shows an REE pattern approaching that of calc-alkaline andesite.

Tables 1, 2, and 3 follow. These show abundances of major elements, of Rb and Sr, and of minor elements, respectively.

Table 1.-- Major element analyses of selected rocks from the Ancient Gneiss Complex of Swaziland

Serial No.	Field No.	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	FeO	CaO	MgO	K ₂ O	Na ₂ O	TiO ₂	P ₂ O ₅	CO ₂	Cl	Z	Sum total	Loss 0	Total
D103195	SWZ-1	71.60	12.39	2.07	3.13	0.42	2.02	3.12	3.91	0.35	0.05	0.12	0.03	0.03	99.94	0.02	99.92
D103196	SWZ-2	76.91	11.90	1.95	0.79	0.61	0.62	3.52	3.51	0.21	0.03	0.02	0.01	0.01	99.69	0.60	99.69
D103197	SWZ-3	57.31	17.34	0.69	4.65	4.21	8.47	4.11	0.60	1.15	0.03	0.07	0.00	0.05	99.95	0.03	99.90
D103198	SWZ-4	74.14	13.91	0.23	0.97	1.03	0.23	3.55	4.07	0.33	0.07	0.12	0.03	0.04	99.65	0.01	99.67
D103199	SWZ-5	76.19	12.47	0.55	1.73	0.42	0.69	4.64	2.14	0.23	0.04	0.06	0.01	0.10	99.91	0.04	99.87
D103200	SWZ-6	65.95	15.03	0.55	3.23	2.05	4.49	4.05	1.73	0.77	0.06	0.14	0.09	0.23	99.91	0.07	99.63
D103201	SWZ-7	72.80	14.40	0.36	2.14	0.70	2.77	4.42	1.16	0.56	0.03	0.23	0.07	0.05	99.64	0.01	99.63
D103202	SWZ-8	77.19	10.83	1.70	2.70	0.29	1.51	4.04	0.97	0.39	0.02	0.17	0.02	0.04	99.97	0.01	99.95
D103203	SWZ-9	69.05	16.33	0.43	2.36	1.01	3.15	5.24	1.27	0.39	0.03	0.11	0.01	0.04	99.65	0.03	99.67
D103204	SWZ-10	49.15	14.83	2.02	8.77	7.75	11.83	2.08	0.53	1.89	0.05	0.69	0.08	0.18	100.03	0.02	100.01
D103205	SWZ-11	54.23	13.47	2.11	8.55	6.05	8.55	3.19	0.53	1.01	0.03	0.24	0.01	0.01	99.73	0.02	99.75
D103206	SWZ-12	49.51	16.57	1.26	7.20	7.50	13.56	1.59	0.35	1.52	0.09	0.35	0.03	0.15	100.11	0.02	100.11

SAMPLE LOCALITIES AND DESCRIPTIONS

Serial No.	Field No.	Location	Description
D103195	SWZ-1	Mkhondo Valley, Swaziland	Flag-Qz Gneiss
D103196	SWZ-2	Mkhondo Valley, Swaziland	Microcline-Flag-Qz Gneiss
D103197	SWZ-3	Kibuta, Ebatsean River, Swaziland	Flag-Qz Gneiss
D103198	SWZ-4	Mahlengatsha Turn-Off, Swaziland	Flag-Qz Gneiss
D103199	SWZ-5	Dudusa River, Swaziland	Flag-Qz Gneiss
D103200	SWZ-6	Tawele River, Swaziland	Flag-Qz Gneiss
D103201	SWZ-7	Mgempisi River, Swaziland	Flag-Qz Gneiss
D103202	SWZ-8	Mankayane Forest, Swaziland	Flag-Qz Gneiss
D103203	SWZ-9	Road Cut North of Piggs Peak, Swaziland	Flag-Qz Gneiss
D103204	SWZ-10	Kibuta, Ebatsean River, Swaziland	Amphibolite
D103205	SWZ-11	Mkhondo Valley, Swaziland	Amphibolite
D103206	SWZ-12	Kibuta, Mpopota River, Swaziland	Amphibolite

Table 2. -- Rb and Sr analyses of selected rocks from the Ancient Gneiss Complex of Swaziland

Oct. 12, 1972

Granites

Run at 75 kV, 46 Ma.

Sample No.	M	V	W	X	Y	Z	Rb(ppm)	Sr(ppm)	Rb/Sr
Repacked	170256	25214	14500	26126	23236	11216	127	110	1.1617
SWZ-1	167774	24966	14286	25957	23217	11040	131	112	1.174
Re.	197884	25862	16095	22318	21408	12465	79.6	58.7	1.356
SWZ-2	194644	25376	15881	22572	21288	12305	81.4	59.5	1.372
Re	159319	18501	14037	42704	16193	10332	62.5	274	0.228
SWZ-3	156205	18187	13846	42281	16007	10220	63.0	277	0.228
Re.	203472	24985	16500	32929	37930	13169	225	127	1.768
SWZ-4	198527	24996	16429	33247	38686	13327	236	133	1.781
Re.	206770	33912	16557	22217	20541	12702	65.9	49.5	1.331
SWZ-5	203826	33706	16325	22151	20287	12543	66.1	50.4	1.299
Re	175734	20406	15284	49041	18668	11327	72.2	291	0.248
SWZ-6	172332	20115	14977	48841	18303	11160	71.7	292	0.241
Re.	177475	21019	16404	48088	20098	12198	69.1	245	0.283
SWZ-7	193084	20805	16197	47864	19936	12058	70.6	250	0.283
Re.	191257	34206	15723	27072	17980	11915	54.0	96.7	0.558
SWZ-8	188472	33313	15722	27204	17962	11879	54.7	97.4	0.552
Re.	192709	21662	16650	71204	21448	12154	54.4	425	0.199
SWZ-9	191968	21620	16728	72560	21321	12126	83.6	436	0.192

Sept. 15, 1972

Amphibolites

Sample No.	Rb(ppm)	Sr(ppm)	Rb/Sr
SWZ-10	49.6	112	0.445
SWZ-11	3.6	385	0.009
SWZ-12	19.9	151	0.131

Table 3. --Minor element analyses of selected rocks from the Ancient Gneiss Complex of Swaziland

LAB NO. = D103195		FIELD NO. = SWZ-1	
		Normal	
OXIDE	PERCENT	CV(%N)	EL/CH
HAZO =	3.1151	2.3	3.17
K2O =	3.9852	3.2	3.51
FE2O3 =	5.7022	9.5	5.60
MNO =	0.0771	1.1	.08
		0.1	
ELEMENT	PPM	CV(%N)	EL/CH
CS =	0.2896	4.2	3.9674
RS =	117.9230	0.2	40.1346
BA =	644.2625	0.8	189.4890
SR =	33083.5508	3.2	39.3852
NA =	23110.4915	2.3	3.6110
TH =	6.5219	1.8	163.0482
U =	3.9300	25.7	137.8571
LA =	46.30	0.4	142.4738
CE =	56.45	4.5	120.8826
NC =	42.6247	5.9	75.5286
SM =	10.1041	0.3	54.3230
EU =	1.6703	0.7	24.1368
GS =	7.0268	26.8	27.5560
T5 =	1.4537	5.7	30.9293
DY =	7.9790	2.6	26.1607
TX =	0.6566	1.8	19.8979
YS =	5.0636	6.4	24.2279
LU =	0.7134	2.7	20.4415
TA =	1.1540	6.2	50.1728
ZR =	293.0084	0.2	8.8790
HF =	7.7900	1.1	5.5643
SB =	0.0880	51.0	0.8800
SC =	7.8475	1.6	1.3079
MN =	596.7955	1.1	0.2984
FE =	39881.3374	9.5	0.1595
CR =	6.6523	6.9	0.0019
CO =	6.3181	2.1	0.0090
BA/CS (PPM) =	2224.5193		
K/CS (PPM) =	*****		
K/RB (PPM) =	.280.5522		
NA/K (PPM) =	0.5985		
K/TH (PPM) =	5072.6628		
TH/U (PPM) =	3.3792		
SUN REE(PPM) =	220.2605		
HVY REE(CHND)=	24.8689		
LA/HVY (CHND)=	5.7290		
LA/YB (PPM) =	9.1444		
EU/EU* (CHND)=	0.6096		
YB/TA (PPM) =	4.3880		
HF/TA (PPM) =	6.7506		
ZR/HF (PPM) =	37.6134		
SC/FE (PPM) =	0.000197		

Table 3. --Minor element analyses of selected rocks from the Ancient Gneiss Complex of Swaziland (cont.)

LAB NO. = D103196 FIELD NO. = SWZ-2

Oxide	Percent	CV(%,N)	ELEM/CH	0.1/ T	ELEMENT/CHONDRITE		
					1.0 T	10 T	100 T
Na ₂ O	3.7134	0.2	3.3722				
K ₂ O	3.3849	3.5	31.7320				
Fe ₂ O ₃	2.8468	12.2	191.7494				
MnO	0.0257	0.5	7.2769				
			33.4524				
			4.3047				
CS	0.2462	4.2	3.3722				
PB	80.9568	14.0	31.7320				
BA	657.0490	3.5	191.7494				
SR	94.6000	49.4	7.2769				
K	24100.0000	3.6	33.4524				
NA	27549.6186	0.2	4.3047				
TH	11.0772	0.6	276.9304				
U	1.3855	42.4	91.0548				
LA	100.58	0.7	309.3878				
CE	172.72	1.0	216.4469				
ND	90.5253	2.0	159.6566				
SH	17.9000	0.0	96.2366				
EU	1.9529	4.0	28.2210				
GD	16.1438	16.1	63.3088				
TB	1.3159	12.6	40.7629				
OY	7.7947	7.7	25.5563				
TM	0.5826	7.0	17.6548				
YB	4.2236	8.2	20.2887				
LU	0.5472	2.6	15.6800				
TA	0.3827	5.1	16.6390				
ZR	396.0105	0.2	12.0003				
HF	11.9000	1.1	8.5000				
SA							
SC	2.7139	1.6	0.4523				
MX	198.8914	0.5	0.0994				
FE	19910.8252	12.2	0.0756				
CR	7.8666	15.2	0.0022				
CO	0.5292	1.4	0.0008				
BA/CS	(PPM) = 2669.0672						
K/CS	(PPM) = 0.00000000						
K/BA	(PPM) = 347.0985						
NA/K	(PPM) = 0.9604						
K/TH	(PPM) = 2536.7389						
TR/U	(PPM) = 8.0045						

SAMPLE = D103197 SWZ-3

PEAK	NUCLIDE	N	SUMW	SUMWX	SUMWXX	PPM	CV	ELEMENT	PPM	CV	CV(N)	CV(W)
19	6 NA-24	2.0	1.152E-05	3.372E-01	9.873E+03	2.928E+04	2.050E-01					
19	9 NA-24	2.0	8.714E-06	2.830E-01	9.191E+03	3.248E+04	1.687E-01					
19	42 SC-46	3.0	3.177E+01	6.547E+02	1.350E+04	2.061E+01	2.884E+00	11 NA	3.065E+04	6.0	3.0	0.7
								21 SC	2.061E+01	2.9	1.7	0.9

Table 3. --Minor element analyses of selected rocks from the Ancient Gneiss Complex of Swaziland (cont.)

LAB NO. = D103197 FIELD NO. = SWZ-3

OXIDE PERCENT CV(%N) *Handwritten: 1000*
 Na2O = 4.1319 *Handwritten: 3.0*
 K2O = 0.0000 *Handwritten: 3.6*
 Fe2O3 = 6.2141 *Handwritten: 11.8*
 MnO = 0.1207 *Handwritten: 0.5*

ELEMENT PPM		CV(%N)	EL/CH	0.1 T	1.0 T	ELEMENT/CHONDRITE 10 T	100 T	1000 T
CS	=	4.8582	2.4	66.5511				
RB	=	58.5742	8.1	24.4059				
BA	=	82.5725	36.4	24.2860				
SR	=							
K	=							
NA	=	30854.2568	3.0	4.7897				
TH	=	1.9146	1.0	47.8640				
U	=	0.4145	11.7	29.6075				
LA	=	8.9034	2.6	27.3952				
CE	=	20.0052	1.1	25.0692				
ND	=	7.8455	10.9	13.8368				
SM	=	2.6400	0.0	14.1935				
EU	=	0.8548	5.9	12.4973				
GO	=	5.0224	8.7	19.6958				
TB	=	1.3548	2.7	28.8245				
DY	=	2.9080	23.6	9.5343				
TM	=	0.3350	3.3	10.1515				
YB	=	1.8837	6.6	9.0130				
LU	=	0.3567	5.4	10.2213				
TA	=	0.5453	2.4	23.7106				
ZR	=	105.0000	0.0	3.1818				
HF	=	1.9100	1.1	1.3643				
SB	=	0.0391	41.4	0.3910				
SC	=	20.6092	1.7	3.4349				
HN	=	934.6441	0.5	0.4673				
FE	=	43451.5503	11.8	0.1738				
CR	=	11.5693	7.2	0.0033				
CO	=	24.1018	0.4	0.0344				
BA/CS	(PPM) =	16.9964						
K/CS	(PPM) =	0.0000						
K/FE	(PPM) =	0.0000						
NA/K	(PPM) =	0.0000						
K/TH	(PPM) =	0.0000						
TH/U	(PPM) =	4.6189						
SUN REE(PPM) =	52.1195							
HVY REE(CHND) =	14.5734							
LA/HVY(CHND) =	3.8788							
LA/YB (PPM) =	4.7265							
EU/EU* (CHND) =	0.8689							
YB/TA (PPM) =	3.4542							
HF/TA (PPM) =	3.5024							
ZR/HF (PPM) =	54.9738							
SC/FE (PPM) =	0.000474							

Table 3. --Minor element analyses of selected rocks from the Ancient Gneiss Complex of Swaziland (cont.)

LAR NO. = D103198

FIELD NO. = SWZ-4

OXIDE PERCENT CV(%N) EL/CH T
NA2O = 3.8887 0.6 3.25
K2O = 4.6974 1.4 4.87
Fe2O3 = 1.3561 19.8 1.31
MNO = 0.0288 1.1 .04

ELEMENT PPM CV(%N) EL/CH T

CS = 5.1196 1.8 70.1317
RB = 30.5463 13.3 12.7276
BA = 493.0291 1.3 145.0086
SR = 165.0178 9.9 12.6937
K = 33995.2178 1.4 46.4229
NA = 28850.1934 0.6 4.5078

TH = 13.1121 1.5 328.5587
U = 2.5553 29.2 182.5201
LA = 31.3025 0.6 96.0077
CE = 49.3870 5.6 61.8885
ND = 14.9482 12.9 26.3636

SH = 2.7200 0.0 14.6237
EU = 0.5635 1.9 8.2157
GD = 4.3000 25.7 17.3725
TA = 0.1647 12.5 3.9289
DY = 0.8449 6.7 2.7703

TM = 0.1870 5.5 5.6667
YB = 0.4604 4.1 2.2030
LU = 0.0777 1.7 2.2264

TA = 0.7785 6.6 33.8463
ZR = 109.0267 0.8 3.2735
HF = 3.2100 1.1 2.2929
SB =

SC = 1.3094 1.8 0.2182
MN = 222.5103 1.1 0.1114
FE = 9484.2522 19.8 0.0179
CH = 9.2445 17.2 0.0026
CO = 1.3030 1.0 0.0019

BA/CS (PPM) = 96.3020
K/CS (PPM) = 7616.8251
K/RB (PPM) = 1276.5941
NA/K (PPM) = 0.7398
K/TH (PPM) = 2967.1426
TH/U (PPM) = 5.1432

SUM REE(PPM) = 105.0109
HVV REE(CHND) = 5.6946
LA/HVV (CHND) = 16.0594
LA/YB (PPM) = 67.7695
EU/EU* (CHND) = 0.8087

YB/TA (PPM) = 0.5914
HF/TA (PPM) = 4.1235
ZR/HF (PPM) = 33.6532
SC/FE (PPM) = 0.000138

(1000. X EL/CH)

ELEMENT/CHONDRITE

10
T

1.0
T

100
T

1000
T

SAMPLE = D103198

SWZ-5

PEAK NUCLIDE N SUMW SUMXX SUMHXX PPM CV ELEMENT PPM CV CV(N) CV(N)

21 6 NA-24 2.0 0.212E-06 2.250E-01 8.153E+03 3.623E+04 1.717E-01 11 NA 3.651E+04 1.3 0.7 0.9

21 9 NA-24 2.0 3.038E-06 1.134E-01 4.208E+03 3.710E+04 3.812E-01 19 K 1.724E+04 2.9 2.0 4.4

21 7 K -42 2.0 1.768E-06 3.047E-02 5.254E+02 1.724E+04 2.869E+00 19 K 1.724E+04 2.9 2.0 4.4

Table 3. --Minor element analyses of selected rocks from the Ancient Gneiss Complex of Swaziland (cont.)

LAGS NO. = D103199

OXIDE	PERCENT	CV(%N)	ANALYST
Na2O	4.9218	0.7	4.84
K2O	2.0762	2.0	2.14
Fe2O3	2.3094	11.8	2.34
MND	0.0255	0.8	.04

ELEMENT	PPM	CV(3.N)	EL/CH	T	1.0	10	100	1000
CHROMIUM	100	10	100	1000	100	10	100	1000

CS =	1.8229	4.6	24.9706
RG =	71.1000	0.0	29.6250
BA =	147.1310	6.5	43.2738
SR =			
K K =	1735.8030	2.0	20.5188
NA =	36514.2266	0.7	5.7053

TH =	15.0437	1.0	376.0932			I + I	I + I
V =	1.8160	30.5	129.7175				I + I
LA =	105.1714	0.4	323.6044				I + I
CE =	210.3351	1.4	263.5779				I + I
ND =	80.1234	2.1	141.3111				I + I
SM =	15.8000	0.0	84.9462			I + I	
EU =	1.1144	1.5	16.1045				
GD =	12.2111	36.9	47.8858				
TB =	2.4716	11.6	51.5238			I + I	
EY =	12.3507	2.4	40.4942			I + I	

TM =	1.0065	6.0	30.4986	101
YB =	10.5922	9.1	50.6802	101
LU =	1.3265	4.9	38.0075	101

TA	=	3.3050	S.2	143.6968
ZR	=	395.0006	0.0	11.9697
DE	=	13.4466	1.0	0.0047

SC =	3.149	2.6	0.530		
HN =	17.148	0.8	0.086		
LN =	41.120	0.8	0.046		
				1000. X EL/CH	
					100
					100
					100

[illegible]

K/2B	(PPV) = 242.4164	LA/4VY (CHND) = 7.4940	ZR/HF (PPM) = 29.3735
NA/K	(PPV) = 2.1195	LA/YB (PPH) = 5.9292	SC/FE (PPH) = 0.000195
K/TH	(PPM) = 1145.7135	EU/EU* (CHND) = 0.2514	
TH/U	(PPM) = 8.2438		

Table 3. --Minor element analyses of selected rocks from the Ancient Gneiss Complex of Swaziland (cont.)

LAB NO. = D103200				FIELD NO. = SWZ-6			
OXIDE	PERCENT	CV(%,N)	Notes				
Na2O =	4.1873	0.7	4.187				
K2O =	2.0170	1.7	1.74				
Fe2O3 =	5.2386	17.0	4.11				
MnO =	0.0801	1.2	1.04				

ELEMENT/CHONDRITE				ELEMNT/CHONDRITE			
ELFMENT	PPM	CV(%,N)	EL/CH	T	100	1000	T
CS =	3.3096	1.7	45.3367	I+I	I+I	I+I	I+I
BA =	71.7030	3.9	29.8763	I+I	I+I	I+I	I+I
BA =	229.7617	3.4	67.5770	I+I	I+I	I+I	I+I
SR =	462.8824	12.1	35.6063	I+I	I+I	I+I	I+I
K =	16744.995	1.7	19.9339	I+I	I+I	I+I	I+I
NA =	31055.3975	0.7	4.8540	I+I	I+I	I+I	I+I
TH =	6.1769	0.9	154.4223	I+I	I+I	I+I	I+I
U =	0.5632	24.8	61.7007	I+I	I+I	I+I	I+I
LA =	31.947	1.0	97.0515	I+I	I+I	I+I	I+I
CE =	59.8196	5.2	74.9870	I+I	I+I	I+I	I+I
ND =	22.4964	7.3	39.6763	I+I	I+I	I+I	I+I
SM =	4.2500	0.0	22.8495	I+I	I+I	I+I	I+I
EU =	1.0106	0.3	14.6042	I+I	I+I	I+I	I+I
GD =	4.6400	22.9	18.1961	I+I	I+I	I+I	I+I
TB =	0.7052	12.3	15.0051	I+I	I+I	I+I	I+I
DI =	2.4364	4.0	7.9883	I+I	I+I	I+I	I+I
TM =	0.2450	5.9	7.4242	I+I	I+I	I+I	I+I
YR =	2.1907	7.3	10.4820	I+I	I+I	I+I	I+I
LU =	0.3209	6.6	9.1958	I+I	I+I	I+I	I+I
TA =	1.1634	9.1	50.5805	I+I	I+I	I+I	I+I
ZR =	190.0233	0.7	5.7583	I+I	I+I	I+I	I+I
HF =	4.6300	1.1	3.3071	I+I	I+I	I+I	I+I
SB =	0.0472	65.1	0.4720	I+I	I+I	I+I	I+I
SC =	9.2805	1.4	1.5468	I+I	I+I	I+I	I+I
PN =	620.3196	1.2	0.3102	I+I	I+I	I+I	I+I
FE =	36638.4512	17.0	0.1466	I+I	I+I	I+I	I+I
CR =	63.5151	12.9	0.0181	I+I	I+I	I+I	I+I
CO =	12.6467	2.0	0.0181	I+I	I+I	I+I	I+I
BA/CS (PPM) =	69.4232	SUM REE(PPM) =	129.6767	YB/TA (PPM) =	1.8831		
K/CS (PPM) =	5059.4018	HVY REE(CHND) =	11.3819	HF/TA (PPM) =	3.9799		
K/RB (PPM) =	233.5257	LA/HVY (CHND) =	8.5268	ZR/HF (PPM) =	41.0417		
NA/K (PPM) =	1.8553	LA/YR (PPM) =	14.3977	SC/FE (PPM) =	0.000253		
K/TH (PPM) =	2710.2288	EU/EU* (CHND) =	0.8533				
TH/U (PPM) =	7.1508						

SAMPLE = D103201				SWZ-7			
PEAK	NUCLIDE	N	SUMW	SUNWX	SUNWXX	PPH	CV
23 8	NA-24	2.0	3.604E-04	1.162E-01	3.748E+03	3.225E+04	2.192E-01
23 9	NA-24	2.0	3.505E-06	1.146E-01	3.748E+03	3.270E+04	0.000E-01
23 7	K-42	2.0	4.201E-06	4.610E-02	5.084E+02	1.097E+04	4.214E+00

ELEMENT				ELEMNT			
PEAK	NUCLIDE	N	SUMW	SUNWX	SUNWXX	PPH	CV
23 8	NA-24	2.0	3.604E-04	1.162E-01	3.748E+03	3.225E+04	2.192E-01
23 9	NA-24	2.0	3.505E-06	1.146E-01	3.748E+03	3.270E+04	0.000E-01
23 7	K-42	2.0	4.201E-06	4.610E-02	5.084E+02	1.097E+04	4.214E+00

Table 3. --Minor element analyses of selected rocks from the Ancient Gneiss Complex of Swaziland (cont.)

LAB NO. = D103201 FIELD NO. = SWZ-7

OXIDES PERCENT CV(1.0N) *Matrix*

NA2O = 4.3769 0.4 *4.42*
 K2O = 1.3220 3.0 *1.16*
 Fe2O3 = 2.5404 0.9 *2.74*
 MnO = 0.0430 0.2 *.05*

ELEMENT PPM CV(1.0N) EL/CH *0.1* T

CS = 3.7013 1.8 50.7024
 RB = 71.4000 3.3 28.7500
 BA = 118.3753 4.5 34.8163
 SR = 280.4759 22.2 21.5751
 K = 10974.6793 3.0 13.0651
 NA = 32471.8030 0.4 5.0737

TH = 2.6941 0.9 67.3529
 U = 0.5161 25.8 36.8675
 LA = 15.8506 0.8 48.7710
 CE = 26.3446 2.0 33.0133

ND = 10.7270 16.9 18.9189

SM = 2.0279 2.4 10.9029
 EU = 0.7863 19.5 11.3522
 GD =
 TA = 0.3852 23.4 8.1953
 DY = 1.2952 2.5 4.2466

TM =
 YR = 0.9086 4.2 4.3475
 LU = 0.1926 2.6 5.5177

TA = 0.5694 4.2 24.7584
 ZR = 131.0194 0.5 3.9703
 HF =
 SB =

SC = 4.4206 4.8 0.7368
 MN = 332.9407 0.2 0.1665
 FE = 17767.2583 0.9 0.0711
 CR = 11.3628 8.2 0.0032
 CO = 4.8100 1.2 0.0069

BA/CS (PPM) = 31.9823
 K/CS (PPM) = 2965.1054
 K/PB (PPM) = 153.7070
 NA/K (PPM) = 2.9568
 F/TH (PPM) = 4073.5734
 TH/U (PPM) = 5.2197

SUM REE(PPM) = 58.5180
 HVT REE(CHND) = 5.5768
 LA/HVT (CHND) = 8.7453
 LA/YR (PPM) = 17.4444
 EU/EU* (CHND) = 1.3789

ELEMENT/CHONDRITE *1000* T

YR/TA (PPM) = 1.5956
 HF/TA (PPM) = 0.0000
 ZR/HF (PPM) = 0.0000
 SC/FE (PPM) = 0.000249

(1000. X EL/CH)

2

Table 3. --Minor element analyses of selected rocks from the Ancient Gneiss Complex of Swaziland (cont.)

LAS NO. = D103202

FIELD NO. = SWZ-8

OXIDE PERCENT CV(%N) Norvex
NA2O = 4.0434 0.3 4.04
K2O = 1.1181 4.9 4.7
Fe2O3 = 4.7213 11.3 4.7
MNO = 0.0420 1.5 0.4

ELEMENT PPM CV(%N) EL/CH T
CS = 2.7789 2.1 38.0666
PB = 58.0792 12.3 24.1997
BA = 154.4964 2.3 45.4401
SR = 9282.0369 4.9 11.0500
K = 29998.0200 0.3 4.6872

ELEMENT/CHONDRITE

1.0

T

100

T

1000

TH = 9.2111 1.2 230.2783
U = 2.145 16.8 154.6976
LA = 54.17 8.6 166.8833
CE = 128.76.7 1.6 161.3592
ND = 76.9295 7.3 135.6781

SH = 20.7261 1.1 111.4306
EU = 3.0816 0.8 44.5316
GD = 20.7524 7.9 81.5386
TB = 2.9219 13.5 62.1677
DY = 15.8296 4.2 51.9003

TH = 0.9537 10.1 28.8994
YB = 10.0528 5.7 48.2907
LU = 1.4299 3.8 40.9427
TA = 1.2171 2.8 52.9191
TR = 439.0055 0.1 13.3032
HF = 14.1079 15.9 10.0771
SB =

SC = 1.2416 1.9 0.2069
PN = 324.5070 1.5 0.1625
FE = 33020.5210 11.3 0.1321
CR = 5.3154 16.7 0.0015
CO = 0.7650 5.0 0.0011

BA/CS (PPM) = 55.5970
K/K/CS (PPM) = 3340.2316
K/K/PB (PPM) = 159.8169
NA/K (PPM) = 3.2238
K/TH (PPM) = 1007.6978
TR/U (PPM) = 4.2531

(1000. X EL/CH)

SUM REE(PPM) = 335.6931
HVF REE(CHND) = 52.2899
LA/HVY (CHND) = 3.1877
LA/YB (PPM) = 5.3674
EU/EU* (CHND) = 0.5440

YB/TA (PPM) = 8.2922
HF/TA (PPM) = 11.5911
ZR/HF (PPM) = 31.1177
SC/FE (PPM) = 0.000038

SAMPLE = D103203

SWZ-9

PEAK	NUCLIDE	N	SUMW	SUMHX	SUMXX	PPM	CV	ELEMENT	PPM	CV	CV(N)	CV(N)
25	3 NA-24	2.0	4.548E-06	1.672E-01	6.146E+03	3.676E+04	3.535E-01					
25	9 NA-24	2.0	2.665E-06	9.995E-02	3.748E+03	3.750E+04	3.768E-01	11	NA	3.703E+04	1.2	0.6 1.0
25	7 K-42	2.0	1.311E-06	1.417E-02	1.563E+02	1.081E+04	2.028E+01	19	K	1.081E+04	20.3	14.3 8.1

Table 3. --Minor element analyses of selected rocks from the Ancient Gneiss Complex of Swaziland (cont.)

LAB NO. = D103203 FIELD NO. = SW2-9

OXIDE PERCENT CV(%.N) *Aluminum*

Na₂O = 4.9318 0.6
K₂O = 1.3018 1.27
Fe₂O₃ = 3.0992 12.7
MnO = 0.0340 1.1 .04

ELEMENT PPM CV(%.N) EU/CH T

CS = 10.0491 1.8 137.6583
PS = 80.2000 4.2 33.4167
BA = 365.7458 3.3 107.5723
SR = 473.5494 2.6 36.4269
K = 10807.2227 14.3 12.8657
NA = 37033.5659 0.6 5.7865

TH = 5.8688 1.4 146.7109
U = 2.0090 11.0 143.5011
LA = 31.4865 0.5 96.8915
CE = 57.0472 0.5 71.4877
ND = 20.1353 8.5 35.5119

SM = 3.7432 0.7 20.1247
EU = 1.0661 2.4 15.4055
GD = 3.0300 24.8 11.8824
TA = 0.4080 7.0 8.6817
DY = 1.9278 2.7 6.3207

TM = 0.2620 2.6 7.9394
YS = 1.2179 10.0 5.8273
LU = 0.1343 14.8 3.8470

TA = 0.6505 2.8 36.9782
ZR = 183.0018 0.1 5.5455
HF = 4.7600 1.1 3.4000
SB =

SC = 3.1533 2.0 0.5255
MN = 263.1524 1.1 0.1116
FE = 21675.6436 12.7 0.0867
CR = 23.4781 15.1 0.0067
CO = 7.1706 0.8 0.0102

BA/CS (PPM) = 36.3960
K/KCS (PPM) = 1075.4462
M/PB (PPM) = 134.7534
NA/K (PPM) = 3.4267
K/TH (PPM) = 1841.4721
TH/U (PPM) = 2.9212

SUM REE(PPM) = 120.4582
HVV REE(CHND)= 7.4164
LA/HVY (CHND)= 13.0631
LA/YB (PPM) = 25.8532
EU/EUC (CHND)= 1.1187

ELEMENT/CHONDRITE
10 T
100 T
1000 T

(1000. X EU/CH)

YR/TA (PPM) = 1.4320
HF/TA (PPM) = 5.5967
ZR/HF (PPM) = 38.4458
SC/FE (PPM) = 0.000145

Table 3. --Minor element analyses of selected rocks from the Ancient Gneiss Complex of Swaziland (cont.)

[illegible]

Table 3. --Minor element analyses of selected rocks from the Ancient Gneiss Complex of Swaziland (cont.)

LAB NO. = D103205 FIELD NO. = SWZ-11

OXIDE	PERCENT	CV(%,N)	<i>Normal</i>
Na2O =	3.2013	0.9	3.14
K2O =	0.4090	4.4	.13
Fe2O3 =	12.0421	13.0	12.07
MnO =	0.1698	0.8	.18

ELEMENT	PPM	CV(%,N)	EL/CH	T
CS =	0.3262	16.8	4.4686	
PRB =	39.3000	40.0	16.3750	
RA =	190.4893	1.7	56.0263	
SR =	205.5192	19.2	15.8092	
K =	3395.0305	4.4	4.0417	
NA =	23750.2380	0.9	3.7110	

TH =	1.1557	6.5	28.8918	
U =	22.0137	0.7	67.7345	
LA =	41.6574	6.2	52.2023	
ND =	22.6422	6.6	39.9333	
SK =	5.6200	0.0	30.2151	
EU =	1.6347	1.9	23.6226	
GD =	1.1799	38.5	25.1048	
TR =	4.5673	9.1	14.9749	
TM =	0.5560	1.3	16.9091	
YB =	1.8746	7.1	8.9694	
LU =	0.4743	2.9	12.1586	

TA =	0.3769	4.5	16.3884	
ZR =	155.0099	0.5	4.6973	
HF =	3.4400	2.0	2.4571	
SB =	0.0814	43.8	0.8140	
SC =	25.3966	2.7	4.2328	
PH =	1314.9329	0.8	0.6575	
FE =	84352.0674	13.0	0.3374	
CR =	223.7415	12.6	0.0639	
CO =	47.0540	0.5	0.0672	

BA/CS	PPM	CV(%,N)	EL/CH	T
BA/CS	583.9486			
K/CS	10407.5124			
K/PRB	86.3875			
NA/K	6.9956			
K/TH	2937.1160			
TH/TH	0.0000			

SUN REE(PPM)	102.1722
REE(PPM)	15.6234
LA/HVY (CHND)	4.3355
LA/YR (PPM)	11.7432
EU/FU* (CHND)	1.0307

YR/TA	PPM	CV(%,N)	EL/CH	T
YR/TA	4.9733			
HF/TA	9.1263			
ZR/HF	45.0610			
SC/FE	0.000301			

Table 3. --Minor element analyses of selected rocks from the Ancient Gneiss Complex of Swaziland (cont.)

LAB NO. = D103206		FIELD NO. = SWZ-12	
OXIDE		PERCENT	CV(%,N)
NA2O =		1.9249	0.8
K2O =		0.3734	2.4
FE2O3 =		9.4342	10.2
MNO =		0.1360	0.8
		<i>Norton</i>	
		1.44	
		0.31	
		9.246	
		0.15	
ELEMENT PPM		CV(%,N)	EL/CH
		0.1	T
CS =		10.0105	2.1
PS =		20.8000	19.0
BA =		52.7000	6.1
SR =		193.9499	0.2
K =		3100.1554	2.4
NA =		14281.0679	0.8
		2.2314	
TH =		0.7401	21.1
U =		23.5029	
LA =		1.5253	16.8
CE =		4.5100	38.0
		5.6516	
ND =		4.7890	0.2
		8.4462	
S4 =		0.9209	0.1
EU =		0.3184	0.6
GD =		3.5473	10.1
TB =		1.3208	46.0
DT =		1.7689	66.7
		5.7997	
TM =		0.3250	3.7
YB =		1.3505	3.7
LU =		0.1981	20.1
		5.6196	
TA =		0.0417	73.0
ZR =		54.8000	11.0
HF =		0.5910	14.0
		0.4221	
SB =			
SC =		35.3249	1.9
MN =		1053.4737	0.8
FE =		6596.3477	10.2
CP =		207.5015	16.5
CO =		49.4000	0.0
		0.0706	
BA/CS (PPM) =		5.2645	
K/CS (PPM) =		309.6898	
K/PB (PPM) =		149.0459	
NA/K (PPM) =		4.6066	
K/TH (PPM) =		3297.6314	
TH/U (PPM) =		0.0000	
SUM PEE(PPM) =		20.5731	
HVV REE(CHND) =		11.6287	
LA/HVV (CHND) =		0.4036	
LA/YB (PPM) =		1.1294	
EU/EU* (CHND) =		0.5550	
YB/TA (PPM) =		16.5298	
HF/TA (PPM) =		7.2338	
ZR/HF (PPM) =		92.7242	
SC/FE (PPM) =		0.000581	
SAMPLE = D103207		SWZ-13	
PEAK NUCLIDE		N	SUMW
29 8 NA-24		2.0	3.107E-05
29 9 NA-24		2.0	1.220E-05
29 7 K-42		2.0	3.363E-05
		2.248E+03	
		8.175E+03	
		5.645E-01	
		SUMWX	SUMWXX
		PPM	CV
		ELEMENT	PPM
		CV	CV(N)
		CV(N)	CV(N)
11 NA		2.121E+04	1.9
19 K		8.175E+03	0.6
		0.4	2.1