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B. REPORTS

GEOCHEMISTRY OF THE REHOBOTH BASEMENT GRANITOIDS, SWA/NAMIBIA

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ABSTRACT

Geochemical analyses of 102 samples are reported from the 25 largest intrusive bodies of the Gamsberg, Piksteel and Weener Intrusive Suites within the Rehoboth basement inlier. It is shown that all the analysed granitoids are peraluminous and that they plot on calc-alkaline differentiation trends. The high alumina saturation of most of the analysed samples suggests an upper crustal origin for most of the Gamsberg, Piksteel and Weener magmas.

1. INTRODUCTION

The large bodies of intrusive granitoids underlying the Rehoboth area of SWA/Namibia were first investigated by De Kock (1934). He described these granitoids as granites, diorites, quartz diorites and quartz porphyries which were derived from a common magma source. De Waal (1966) distinguished between the Nauchas Granite Suite which comprised the Gamsberg, Piksteel, Koepel and Korabis granites, a green granodiorite and the Weener Quartz Diorite. SACS (1980) renamed the Nauchas Granite Suite the ‘Gamsberg Granite Suite’, but excluded the Piksteel Granodiorite which was believed to belong to an earlier magmatic event.

The aim of this study is to provide more data on the geochemical relationships between the granitoids in the Rehoboth basement and to investigate the possibility of further subdividing these intrusives.

2. LITHOLOGY AND FIELD RELATIONS

2.1 Gamsberg Granite Suite

The Gamsberg Granite Suite, hereafter abbreviated to GGS, is made up predominantly of large plutons which have intruded both meta-volcanosedimentary formations, viz. the Mooirivier, Neuhof, Elim, Marienhof, Gaub Valley, Nückopf and Grauwater Formations, and older granitoids, viz. the Piksteel Intrusive Suite and the Weener Intrusive Suite. Smaller plutons of the GGS are irregularly distributed throughout the Rehoboth area.

U/Pb and Rb/Sr age determinations of the GGS have yielded a range of ages between 1 092 ± 40 Ma and 1 210 Ma (Mailing, in prep.; Seifert, 1986a; Burger *et al.*, 1973, 1973-74, 1975-76), while Nückopf volcanics yielded ages between 1 080 Ma and 1 232 Ma (Burger *et al.*, 1973, 1973-74,1975-76).

Granites of the GGS are typically greyish to reddish in colour, mostly medium- to coarse-grained and occasionally porphyritic. These granites further exhibit moderate alteration and saussuritization, sometimes with significant growth of muscovite and epidote. In the northern parts of the area, towards the southern margin of the Damara Orogen, the granites may develop a strong foliation together with widespread albitization of plagioclase and recrystallization of quartz.

2.2 Piksteel lntrusive Suite

In this report the term ‘Piksteel Intrusive Suite’ (PIS) is preferred to the term ‘Piksteel Granodiorite’ introduced by SACS (1980), since this unit comprises not only granodiorites but to a large extent also consists of granites and tonalites. Rocks of the PIS, first described by De Waal (1966), occur throughout the Rehoboth basement area and have intruded the Weener Intrusive Suite as well as the Mooirivier, Neuhof, Elim, Marienhof and Gaub Valley Formations. These granitoids have in turn been intruded by plutons of the GGS. U/Pb age determinations range between 1 430 Ma and 1630 Ma (Burger *et al.*, 1973-74 and 1975-76), while a single Rb/Sr isochron for the Swartmodder Granite of the PIS yielded an age of 1 660 Ma (Mailing, 1978).

Granitoids of the PIS are mostly greyish to greenish in colour, fine- to medium-grained and often porphyritic. They show wide compositional variation from granite through granodiorite to tonalite. In contrast to the GGS these granitoids exhibit widespread and pervasive saussuritization. A strong foliation, sometimes shear-related, is developed in the northern and eastern parts of the Rehoboth basement.

2.3 Weener Intrusive Suite

Tonalites, quartz diorites, diorites and granodiorites of the ‘Weener Intrusive Suite’ (WIS), previously termed

TABLE 1: Major and trace element analyses of the Gamsberg Granite Suite (no data recorded where concentration of trace element is below detection limit).

Major elements in wt%													
SAMPLE	G01	G02	G03	G04	G05	G06	G07	G08	G09	G10	G12	G13	G14
SiO_2	75,82	74,33	68,43	72,06	72,80	72,94	72,72	72,49	72,93	71,04	72,24	71,39	71,45
TiO_2	0,07	0,19	0,80	0,42	0,45	0,50	0,48	0,35	0,31	0,32	0,21	0,19	0,57
Al_2O_3	12,55	13,06	13,54	12,53	13,04	12,64	12,63	13,16	13,22	13,55	13,89	13,53	13,02
Fe_2O_3	0,71	1,17	4,95	2,47	2,49	2,46	2,56	1,88	1,83	2,17	1,54	1,13	3,64
MnO	0,07	0,03	0,11	0,04	0,06	0,05	0,06	0,03	0,03	0,06	0,04	0,05	0,07
MgO	0,28	0,38	1,27	0,52	0,69	0,69	0,74	0,51	0,53	1,11	0,64	0,61	0,82
CaO	0,60	0,65	2,41	1,45	1,27	0,84	1,54	0,62	0,68	1,41	0,97	1,08	1,74
Na_2O	4,08	2,48	2,66	2,52	2,96	2,61	2,79	2,45	2,54	3,09	3,44	3,31	2,76
K_2O	4,22	5,79	3,80	5,31	5,27	5,32	4,90	5,81	5,72	4,47	5,07	5,06	4,07
P_2O_5	0,08	0,06	0,21	0,07	0,11	0,14	0,09	0,06	0,07	0,09	0,07	0,07	0,22
Cr_2O_3	0,01	0,01	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01
NiO	0,01		0,01		0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01
LOI	0,40	0,56	1,26	0,65	0,44	0,90	0,56	0,87	1,14	1,39	0,76	0,75	0,85
SUM	98,90	98,71	99,47	98,05	99,60	99,11	99,09	98,25	99,02	98,72	98,89	97,19	99,23
Trace elements in ppm													
Nb	18			10		14	11						22
Zr	57	111	263	248		239	286	259	225	153	115	99	101
Y	8	18	36	55		24	42	30	25	22	20	13	25
Sr	107	192	274	56		138	146	86	108	251	185	171	237
Rb	197	132	140	282		184	166	205	212	207	237	221	285
Th			13	25			13	13		15	14		38
Pb	54	23		22		21	17		18	20	31	18	57
Ga	20	14	18	16		17	17	18	15	18	18	16	22
Zn	25		45	37		41	40	41	26	43	29	27	32
Cu		48								9			24
Ni													
Co	22	16	24	18		15	106	160	12	14	89	85	
Cr													
V						53		32		52	22		
Ce		78	125	117		135	108	85	81	62	46		
Nd			62	37		59	45						
Ba	146	1 801	1 004	709		1 112	1 156	1 003	1 100	1 001	782	726	739
La		61	88	64		105	97	56	51	74	46	45	
Sc			9	9		10	8						
S													
SUM	654	2 494	2 101	1 705		2 167	2 258	1 988	1 873	1 941	1 634	1 421	1 582

Detection limits:
Nb 11 Zr 23 Y 5 Sr 16 Rb 14 Th 13 Pb 16 Ga 5 Zn 18 Cu 9
Ni 12 Co 3 Cr 26 V 26 Ce 46 Nd 26 Ba 40 La 44 Sc 7 S 216

Major elements in wt%													
SAMPLE	G15	G16	G17	G18	G19	G20	G21	G22	G23	G24	G25	G26	G27
SiO_2	74,27	69,19	68,25	77,67	67,66	69,48	73,08	70,22	68,03	74,28	71,19	73,76	76,90
TiO_2	0,18	0,45	0,59	0,12	0,68	0,54	0,16	0,31	0,46	0,16	0,29	0,20	0,07
Al_2O_3	12,27	13,62	13,48	11,09	13,53	15,59	13,72	14,17	13,87	12,94	12,72	12,99	12,56
Fe_2O_3	1,33	3,10	3,87	1,02	4,40	3,00	1,28	2,70	2,57	1,21	1,85	1,35	0,82
MnO	0,06	0,07	0,08	0,01	0,08	0,08	0,04	0,05	0,06	0,05	0,05	0,05	0,03
MgO	0,26	0,56	1,07	0,38	1,07	0,97	0,61	1,37	1,09	0,33	1,03	0,49	0,23
CaO	0,59	1,87	2,44	0,02	2,61	0,88	0,92	2,03	1,58	0,79	1,59	1,15	1,02
Na_2O	2,98	3,20	3,14	2,18	2,95	3,73	3,37	3,02	3,18	3,11	3,23	3,55	2,58
K_2O	5,03	4,83	4,62	5,63	4,37	5,57	4,79	3,74	5,41	5,22	4,30	4,60	5,61
P_2O_5	0,06	0,12	0,18	0,07	0,19	0,14	0,07	0,13	0,14	0,04	0,07	0,05	0,02
Cr_2O_3	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,02	0,01
NiO							0,01					0,01	
LOI	0,66	0,80	0,84	0,60	0,93	0,93	0,87	1,63	0,75	0,53	0,67	0,48	0,44
SUM	97,70	97,82	98,57	98,80	98,48	100,92	98,93	99,38	97,15	98,67	97,00	98,70	100,29
Trace elements in ppm													
Nb				23						14			
Zr	213	211	228	94	245	455	135	256	226	118	141	117	105
Y	31	38	40	40	34	32	14	17	31	25	21	15	
Sr	106	131	217	21	232	165	265	223	219	109	171	154	251
Rb	160	199	165	355	165	111	131	112	148	244	180	221	154
Th	16	16		14						13			
Pb							27			33		20	24
Ga	12	18	17	17	18	19	17	18	16	18	15	18	15
Zn	41	41	51	18	52	60	31	48	45	19	30	26	
Cu					9	11					12		
Ni													
Co	26	110	103	94	90	101	10	143	17	11	83	107	13
Cr													
V	151	39	56		59	31		40	32				
Ce	138	96	143		144	256	52	134	95		47		
Nd	42	29			50	106		44	33				
Ba	516	698	1 052	142	1 015	2 117	1 461	1 602	1 254	521	566	705	1 059
La	69	61	91		66	182		98	66				
Sc	11	7	10		11	12			7				
S								596					
SUM	1 532	1 694	2 173	818	2 190	3 658	2 143	3 331	2 189	1 125	1 266	1 383	1 621

Detection limits:
Nb 11 Zr 23 Y 5 Sr 16 Rb 14 Th 13 Pb 16 Ga 5 Zn 18 Cu 9
Ni 12 Co 3 Cr 26 V 26 Ce 46 Nd 26 Ba 40 La 44 Sc 7 S 216

Table 1 — continued

Major elements in wt%													
SAMPLE	G28	G29	G31	G32	G33	G34	G35	G37	G39	G40	G42	G43	G44
SiO_2	70,57	76,67	76,76	73,29	70,70	73,58	65,05	67,41	72,50	70,74	73,35	72,38	72,80
TiO_2	0,44	0,30	0,13	0,18	0,29	0,43	0,83	0,34	0,28	0,60	0,24	0,39	0,33
Al_2O_3	13,45	10,14	11,90	13,75	12,99	13,28	14,78	14,62	12,35	14,59	13,47	12,76	12,38
Fe_2O_3	2,92	1,46	0,89	0,83	1,84	2,07	4,60	2,94	1,52	3,23	1,65	1,96	1,77
MnO	0,07	0,08	0,03	0,03	0,05	0,07	0,10	0,08	0,05	0,08	0,05	0,05	0,04
MgO	0,81	0,55	0,20	0,36	1,19	0,54	1,74	1,82	0,77	0,86	0,72	0,74	0,76
CaO	1,61	7,71	0,06	1,09	0,91	0,67	3,03	2,51	0,68	1,72	0,87	1,25	0,94
Na_2O	2,75	0,19	3,28	4,33	2,76	3,28	3,51	4,54	3,14	3,37	3,51	3,07	3,39
K_2O	5,17	1,09	4,85	4,00	5,57	4,94	3,67	3,21	4,96	4,61	4,66	4,97	4,65
P_2O_5	0,13	0,08	0,03	0,08	0,09	0,08	0,25	0,14	0,06	0,22	0,06	0,12	0,09
Cr_2O_3	0,01	0,01	0,01	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01
NiO	0,01	0,01		0,01						0,01			
LOI	0,93	1,17	0,50	0,62	0,73	0,70	1,07	1,90	0,68	1,04	0,63	0,49	0,52
SUM	98,87	99,46	98,64	98,59	97,13	99,65	98,64	99,52	97,00	101,08	99,22	98,19	97,68
Trace elements in ppm													
Nb		11	16			14	12			18			
Zr	251	276	123	99	200	321	364	144	190	316	172	220	194
Y	36	46	11	7	15	23	63	7	22	23	23	23	8
Sr	175	597	24	261	154	185	468	446	115	310	152	186	144
Rb	251	66	284	90	153	155	95	102	153	111	174	141	149
Th	23	22	13										
Pb	23	69	18	38									
Ga	19	16	20	17	17	19	19	16	15	18	20	15	15
Zn	50	96			26	46	70	52	25	51	26	28	20
Cu	33			313									
Ni													
Co	112	123	9	93	126	13	23	86	94	16	168	110	156
Cr													
V	60				27	44	92	42		94		30	
Ce	147	150			112	135	197		87	134	73	129	59
Nd	51	57			27	39	92			48		41	
Ba	915	250	100	594	1 135	1 377	2 195	1 278	917	1 402	1 117	1 024	780
La	115	75	58		85	86	111			105		66	
Sc	7		7			10	10			11			
S													
SUM	2 268	1 854	683	1 512	2 077	2 467	3 811	2 173	1 618	2 657	1 925	2 013	1 525

Detection limits:
Nb 11 Zr 23 Y 5 Sr 16 Rb 14 Th 13 Pb 16 Ga 5 Zn 18 Cu 9
Ni 12 Co 3 Cr 26 V 26 Ce 46 Nd 26 Ba 40 La 44 Sc 7 S 216

Major elements in wt%													
SAMPLE	G45	G46	G47	G48	G49	G50	G51	G52	G53	G54	G55	G56	G57
SiO_2	75,63	75,04	68,67	70,47	75,21	71,02	73,60	72,36	65,55	67,77	69,82	76,62	70,97
TiO_2	0,14	0,06	0,64	0,47	0,08	0,46	0,40	0,50	0,89	0,83	0,62	0,11	0,41
Al_2O_3	12,00	12,04	13,82	13,24	12,77	12,98	12,69	12,87	13,59	14,19	12,34	11,77	13,17
Fe_2O_3	0,94	1,23	4,16	3,11	1,06	2,70	2,47	3,02	6,02	5,27	3,80	0,86	2,18
MnO	0,07	0,03	0,09	0,07	0,04	0,06	0,06	0,07	0,11	0,11	0,08	0,02	0,05
MgO	0,26	0,28	1,10	0,77	0,15	0,66	0,71	0,81	1,66	1,30	1,00	0,19	0,69
CaO	0,54	0,54	2,36	1,92	0,36	1,55	1,22	1,31	3,54	2,70	1,78	0,13	1,28
Na_2O	3,35	3,26	2,99	2,99	3,36	2,78	2,72	2,59	3,88	3,10	2,79	2,90	3,58
K_2O	4,91	5,03	4,60	4,99	5,04	4,74	4,86	4,86	1,81	3,85	4,30	5,18	4,80
P_2O_5	0,02	0,01	0,17	0,10	0,01	0,09	0,08	0,10	0,21	0,27	0,17	0,06	0,22
Cr_2O_3	0,02	0,01	0,02	0,01	0,01	0,01	0,02	0,02	0,01	0,02	0,01	0,01	0,01
NiO	0,01		0,01	0,01			0,01	0,01		0,01			0,01
LOI	0,33	0,49	0,79	0,72	0,59	0,64	0,65	0,82	0,76	0,94	0,67	0,56	0,68
SUM	98,22	98,02	99,42	98,87	98,68	97,69	99,49	99,34	98,03	100,36	97,38	98,41	98,05
Trace elements in ppm													
Nb	15	36	13		25			15		13		20	
Zr	102	81	247	200	102	243	203	246	187	239	199	93	172
Y	16	107	41	39	93	41	36	39	37	40	36	93	17
Sr	22		168	133		108	116	111	218	196	130	17	165
Rb	304	415	152	186	294	171	165	181	76	115	158	283	149
Th	25			15	14							20	34
Pb	30	17	17	23	28		17					18	
Ga	17	23	18	16	20	15	16	16	16	19	9	14	13
Zn		39	59	36	41	36	34	38	84	68	75		29
Cu									15		14		
Ni									14				
Co	14	144	23	14	87	79	19	19	24	28	45	103	10
Cr													
V			78	37		33	51	81	136	78	48		52
Ce	92		132	189		119	132	138	117	163	93		181
Nd			69	85		40	58	56	41	78	49		33
Ba	117	77	1 304	924	84	1 032	1 087	957	997	1 282	1 256	63	730
La	75		106	125		69	93	108	46	127	68		118
Sc	7		15	9		10	11	14	14	15	10	7	
S													
SUM	836	939	2 442	2 031	788	1 996	2 038	2 019	2 022	2 461	2 190	731	1 703

Detection limits:
Nb 11 Zr 23 Y 5 Sr 16 Rb 14 Th 13 Pb 16 Ga 5 Zn 18 Cu 9
Ni 12 Co 3 Cr 26 V 26 Ce 46 Nd 26 Ba 40 La 44 Sc 7 S 216

Major elements in wt%			
SAMPLE	G58	G59	G60
SiO_2	76,57	75,90	75,12
TiO_2	0,25	0,09	0,50
Al_2O_3	12,00	12,00	13,25
Fe_2O_3	1,25	0,49	2,34
MnO	0,03	0,01	
MgO	0,31	0,23	0,21
CaO	0,37	0,58	0,37
Na_2O	2,85	2,22	7,74
K_2O	5,40	6,33	0,10
P_2O_5	0,04	0,03	0,17
Cr_2O_3	0,01	0,01	0,02
NiO	0,01	0,01	0,01
LOI	0,39	0,40	0,15
SUM	99,48	98,30	99,98
Trace elements in ppm			
Nb			
Zr	164	48	
Y	48		
Sr	72	208	
Rb	132	116	
Th			
Pb			
Ga	12	10	
Zn			
Cu			
Ni			
Co	48	23	
Cr			
V			
Ce	94		
Nd			
Ba	514	1 090	
La	81		
Sc			
S			
SUM	1 165	1 495	

Detection limits:
Nb 11 Zr 23 Y 5 Sr 16 Rb 14 Th 13 Pb 16 Ga 5 Zn 18 Cu 9
Ni 12 Co 3 Cr 26 V 26 Ce 46 Nd 26 Ba 40 La 44 Sc 7 S 216

TABLE 2: Major and trace element analyses of the Piksteel Intrusive Suite (no data recorded where concentration of trace element is below detection limit).

Major elements in wt%													
SAMPLE	P01	P02	P03	P04	P05	P06	P08	P09	P11	P12	P13	P15	P16
SiO_2	71,00	67,05	67,81	68,97	72,29	74,95	59,06	63,85	77,16	75,63	73,06	67,91	52,14
TiO_2	0,47	0,60	0,85	0,41	0,41	0,12	0,70	0,63	0,22	0,21	0,27	0,52	0,15
Al_2O_3	13,26	13,70	13,30	14,92	13,61	12,35	17,20	15,78	11,31	11,83	13,03	14,27	20,97
Fe_2O_3	3,05	3,96	5,47	2,69	2,41	1,10	4,75	4,23	1,72	1,98	2,32	4,07	1,47
MnO	0,06	0,08	0,07	0,05	0,07	0,04	0,09	0,07	0,03	0,06	0,05	0,10	0,08
MgO	0,81	0,95	1,02	0,99	0,61	0,09	2,50	1,69	0,15	0,23	0,28	1,35	0,93
CaO	3,16	2,44	2,78	2,58	1,22	0,69	3,71	3,65	0,09	0,36	0,49	2,32	12,12
Na_2O	2,22	3,03	2,29	3,38	3,58	3,24	3,48	3,75	3,22	3,09	3,42	4,03	6,42
K_2O	4,24	4,02	4,08	3,73	3,93	4,92	4,89	3,03	4,39	5,40	5,66	2,11	0,25
P_2O_5	0,10	0,16	0,21	0,12	0,10	0,01	0,26	0,19	0,04	0,03	0,04	0,18	0,03
Cr_2O_3	0,01	0,01	0,02	0,01	0,01	0,01	0,02	0,01	0,02	0,01	0,01	0,01	0,01
NiO	0,01		0,01	0,01			0,01			0,01	0,01	0,01	
LOI	0,88	1,75	1,29	0,96	0,83	0,56	2,25	1,71	0,40	0,31	0,47	1,66	3,96
SUM	99,27	97,75	99,20	98,82	99,07	98,08	98,92	98,59	98,75	99,15	99,11	98,54	98,62
Trace elements in ppm													
Nb			12			16			13	11	12		
Zr	189	272	386	171	243	104	149	202	217	254	341	227	90
Y	31	41	45	11	11	65	20	21	72	31	41	17	
Sr	470	256	206	630	233	26	525	694	47	37	52	402	309
Rb	92	120	170	94	88	379	149	77	187	149	146	77	
Th						37				18	14		
Pb	26					30			17	19			
Ga	18	20	20	18	16	18	18	21	15	15	17	17	17
Zn	21	44	52	38	41	20	60	53		21	41	57	28
Cu			72				30	16				73	
Ni							16	14					
Co	15	17	26	17	14	65	23	88	12	17	66	15	9
Cr			27				42						
V			95	56	50		117	61				56	
Ce		70	119	78	137		75	94	98	273	304		65
Nd			64	26	48		40	39	78	71	33		39
Ba	1 176	1 047	1 103	1 187	1 351	89	1 700	1 614	591	330	510	995	
La			89	65	65		78	55	150	179	104	46	
Sc		8	17		8		12	8	7	8	11	11	
S													
SUM	2 038	1 895	2 503	2 391	2 305	849	3 054	3 057	1 504	1 433	1 692	1 993	557

Detection limits:
Nb 11 Zr 23 Y 5 Sr 16 Rb 14 Th 13 Pb 16 Ga 5 Zn 18 Cu 9
Ni 12 Co 3 Cr 26 V 26 Ce 46 Nd 26 Ba 40 La 44 Sc 7 S 216

Table 2 — continued

Major elements in wt%													
SAMPLE	P17	P18	P20	P21	P22	P23	P24	SWA18	SWA19	SWA21	SWA22	SWA23	SWA24
SiO_2	76,30	58,77	68,40	72,33	72,51	54,19	70,21	72,37	70,64	70,86	74,68	71,81	70,03
TiO_2	0,18	0,81	0,32	0,30	0,32	0,91	0,64	0,09	0,18	0,16	0,16	0,17	0,34
Al_2O_3	12,47	16,78	15,59	13,79	14,11	15,76	15,78	14,82	15,38	15,03	12,66	15,27	14,30
Fe_2O_3	1,57	6,82	2,87	2,46	2,35	8,33	3,12	0,82	1,69	1,50	0,97	1,42	2,41
MnO	0,04	0,16	0,06	0,03	0,03	0,14	0,10	0,03	0,05	0,05	0,03	0,04	0,06
MgO	0,58	3,20	1,31	1,03	1,06	6,16	1,09	0,24	0,56	0,48	0,11	0,38	1,04
CaO	0,87	5,66	2,20	1,84	1,95	7,32	2,65	2,01	2,19	2,42	0,86	2,29	1,91
Na_2O	3,95	2,83	5,18	2,47	2,54	3,43	4,09	4,05	4,15	4,37	2,86	4,71	3,40
K_2O	1,97	2,20	2,59	3,25	3,29	2,29	2,37	3,25	3,04	2,39	4,89	2,47	4,43
P_2O_5	0,05	0,31	0,15	0,09	0,09	0,37	0,19	0,03	0,10	0,07	0,03	0,12	0,11
Cr_2O_3	0,01	0,02	0,02	0,01	0,01	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,01
NiO	0,01	0,01	0,01	0,01	0,01	0,02			0,01				0,01
LOI	1,23	2,61	0,69	1,48	1,29	1,80	1,14	0,71	1,46	0,61	0,64	0,76	1,06
SUM	99,23	100,18	99,39	99,01	99,56	100,74	101,39	98,43	99,46	97,95	97,90	99,45	99,11
Trace elements in ppm													
Nb			17				12				22		
Zr	91	199	274	136	86	86	404	65	105	105	109	100	157
Y		22	29	7		20	29				25		18
Sr	240	570	177	518	384	774	351	758	789	1 018	128	904	305
Rb	58	87	137	64	98	74	63	65	70	51	165	58	152
Th			14								16		
Pb			37						21	19	28	19	
Ga	16	19	18	19	13	18	20	15	22	20	18	20	17
Zn	28	131	26	48	21	89	39		26	40		32	34
Cu	17	53			17	69	23		18				10
Ni		28				65							
Co	103	27	10	18	11	63	14	14	78	71	64	64	111
Cr		34				144							
V		109		54	34	191			27				42
Ce		79	94	83		204	104				62		
Nd		39	33	33		106	47						37
Ba	740	899	1 323	898	1 765	1 112	1 438	2 474	2 071	1 870	453	1 717	942
La		56	64	63	32	53	47						73
Sc		10				24	8						
S													
SUM	1 293	2 362	2 253	1 941	2 461	3 092	2 599	3 391	3 227	3 194	1 090	2 914	1 898

Detection limits:
Nb 11 Zr 23 Y 5 Sr 16 Rb 14 Th 13 Pb 16 Ga 5 Zn 18 Cu 9
Ni 12 Co 3 Cr 26 V 26 Ce 46 Nd 26 Ba 40 La 44 Sc 7 S 216

Major elements in wt%									
SAMPLE	SWA25	SWA26	SWA27	SWA28	SWA29	SWA30	SWA31	SWA32	SWA33
SiO_2	70,15	53,40	65,17	67,49	69,41	69,14	73,17	71,39	70,29
TiO_2	0,33	0,68	0,82	0,47	0,21	0,37	0,15	0,19	0,31
Al_2O_3	13,94	18,67	14,65	14,79	14,80	14,76	14,39	15,00	15,16
Fe_2O_3	2,36	6,64	5,29	3,41	1,92	2,69	1,46	1,69	2,53
MnO	0,06	0,12	0,10	0,06	0,04	0,07	0,04	0,05	0,06
Mgo	0,83	4,23	1,45	1,21	0,58	0,86	0,32	0,50	0,74
CaO	1,96	7,22	2,40	2,83	2,18	2,64	1,79	1,92	2,15
Na_2O	3,27	3,25	3,29	3,22	4,13	4,09	3,74	4,41	3,99
K_2O	4,30	2,73	4,36	4,04	3,28	2,96	3,70	3,11	3,10
P_2O_5	0,11	0,15	0,27	0,15	0,08	0,12	0,04	0,08	0,12
Cr_2O_3	0,01	0,01	0,02	0,01	0,01	0,01	0,01	0,01	0,01
NiO		0,01							
LOI	0,94	2,26	1,37	1,15	0,70	0,50	0,54	0,73	1,00
SUM	98,26	99,37	99,19	98,83	97,34	98,21	99,35	99,08	99,46
Trace elements in ppm									
Nb			12						
Zr	152	76	322	207	112	128	104	105	156
Y	25	21	37	23		18			
Sr	264	737	369	421	832	738	723	666	611
Rb	180	76	92	129	62	70	68	54	58
Th									
Pb	18		21				20		
Ga	18	24	23	19	20	23	18	20	22
zn	34	81	91	48	37	58	35	42	63
Cu		84	15	17	12				14
Ni		55		12					
Co	62	55	49	74	51	68	59	82	76
Cr		45							
v	38	128	60	54	34	32			37
Ce	85	130	156	139		47			54
Nd	27	68	69	47					
Ba	823	1 069	2 035	1 490	1 680	904	1 876	1 693	1 381
La	62		119	71					
Sc		19	13						
S									
SUM	1 788	2 668	3 483	2 751	2 840	2 086	2 903	2 662	2 472

Detection limits:
Nb 11 Zr 23 Y 5 Sr 16 Rb 14 Th 13 Pb 16 Ga 5 Zn 18 Cu 9
Ni 12 Co 3 Cr 26 V 26 Ce 46 Nd 26 Ba 40 La 44 Sc 7 S 216

the 'Weener Quartz Diorite' (SACS, 1980), were first described by De Waal (1966). The granitoids of the WIS are confined to the western part of the Rehoboth area where they have intruded the Mooirivier, Elim and Gaub Valley Formations and have in turn been intruded by rocks of the PIS. The fine-to medium-grained rocks of the WIS are generally greyish to brownish in colour. Besides plagioclase, quartz, biotite and minor amounts of potassium feldspar, the occurrence of bluish amphiboles is distinctive. Accessory minerals include muscovite, sphene, opaque minerals, epidote, clinozoisite, garnet, apatite, chloritoid and chlorite (after biotite). As in the GGS and PIS, the granitoids of the WIS are locally strongly sheared and folded.

3. METHOD

A total of 102 samples with a mass of between 2 and 30 kg each was collected from the 25 largest intrusive bodies within the Rehoboth basement. Analyses of 11 major and 20 trace elements were carried out on a Philips PW1400 X-ray fluorescence spectrometer at the University of Fribourg, Switzerland (Tables 1-3). Loss on ignition was determined by heating of an aliquot of each sample for two hours at 1150 °C.

4. GEOCHEMISTRY

4.1 Gamsberg Granite Suite

The relatively linear patterns obtained in the Harker variation diagrams (Fig. 1) probably reflect original magmatic processes and suggest that the effect of post-cooling alteration was minimal. Data for 55 samples were plotted on the R1 versus R2 diagram of De la Roche *et al.* (1980) in order to chemically classify members of this suite (Fig. 2). The vast majority of the data points fall within the 'granite' field with only a slight scatter of data points into the 'alkaline granite' and 'granodiorite' fields. According to Shand (1927) and Chappell and White (1974), the degree of alumina saturation allows a first order classification of granitoids. Accordingly, the data were plotted on a wt. % Al_2O_3-CaO-(Na_2O+K_2O) ternary diagram (Fig. 3), which illustrates that all samples have Al_2O_3 > (Na_2O+K_2O+CaO) and can, therefore, be classified as peraluminous. The generally high degree of alumina saturation for most of the Gamsberg granitoids is further illustrated in the mol. % Al_2O_3 versus mol. % (CaO+Na_2O+K_2O) diagram (Fig. 4) where the ratio A/CNK exceeds unity. However, the degree of alumina saturation is insufficient to classify these granitoids as S-type granites according to Chappell and

TABLE 3: Major and trace element analyses of the Weener Intrusive Suite (no data recorded where concentration of trace element is below detection limit).

Major elements in wt%												
SAMPLE	W01	W02	W03	W06	W07	W08	W09	W10	W11	W12	W13	W14
SiO_2	66,82	68,89	63,68	68,38	61,05	58,53	64,56	64,86	60,33	50,49	51,31	48,43
TiO_2	0,39	0,32	0,49	0,54	0,88	0,86	0,84	0,84	0,83	1,53	1,51	0,89
Al_2O_3	14,86	14,71	14,84	13,84	16,42	15,39	15,30	15,55	15,97	14,38	14,95	18,33
Fe_2O_3	3,29	2,57	4,18	3,20	7,39	8,74	6,48	6,12	6,78	14,50	13,97	11,62
MnO	0,07	0,08	0,08	0,06	0,12	0,15	0,09	0,10	0,11	0,24	0,25	0,18
MgO	2,05	1,37	2,76	0,94	3,04	3,87	3,44	2,29	3,22	5,58	6,09	7,35
CaO	3,00	1,46	3,92	2,06	4,78	5,82	3,32	3,86	5,26	8,88	7,97	10,58
Na_2O	3,60	3,17	2,87	3,22	3,38	2,92	3,64	2,93	3,45	2,99	3,47	1,72
K_2O	3,64	4,72	3,83	4,63	1,96	1,79	2,40	2,87	1,75	0,82	1,02	0,34
P_2O_5	0,18	0,14	0,21	0,15	0,19	0,14	0,20	0,15	0,18	0,33	0,29	0,07
Cr_2O_3	0,01	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,02	0,03	0,03	0,02
NiO	0,01	0,01	0,01		0,01	0,01	0,01	0,01	0,02	0,03	0,03	0,02
LOI	1,10	1,16	1,88	0,69	1,13	1,61	0,81	1,22	0,86	0,75	0,70	2,25
SUM	99,02	98,62	98,76	97,72	100,36	99,84	101,10	100,81	98,78	100,55	101,59	101,80
Trace elements in ppm												
Nb				13								
Zr		130	152	258	173	155	175	188	167	238	255	55
Y		8	11	42	52	49	31	33	25	51	52	14
Sr		290	605	267	313	277	246	274	369	187	217	230
Rb		144	100	140	65	61	97	85	54	33	36	
Th												
Pb		25										
Ga		19	19	18	20	19	18	20	20	22	24	20
Zn		140	35	41	76	75	59	68	72	125	124	102
Cu		48	9	13	51	66	11	54	46	48	70	43
Ni		17	45		50	61	54	31	63	51	69	103
Co		93	83	61	84	70	69	88	50	79	96	91
Cr			51		50	72	63	39	91	177	193	167
V		46	68	37	121	159	110	114	141	192	200	201
Ce		50	93	126	97	140	97	103	102	217	186	164
Nd			37	49	65	79	46	54	53	118	107	98
Ba		1 674	1 732	1 315	741	353	723	1 429	1 067	214	305	85
La		58		80				44	63	56	54	
Sc			7	7	19	23	15	13	12	50	55	32
S										902		455
SUM		2 472	3 047	2 467	1 977	1 659	1 814	2 637	2 395	2 760	2 013	1 860

Detection limits:
Nb 11 Zr 23 Y 5 Sr 16 Rb 14 Th 13 Pb 16 Ga 5 Zn 18 Cu 9
Ni 12 Co 3 Cr 26 V 26 Ce 46 Nd 26 Ba 40 La 44 Sc 7 S 216

White (1974) since the A/CNK ratio is generally less than 1,1.

On an AFM diagram of Kuno (1968), the data points of the GGS clearly define a calc-alkaline trend (Fig. 16). In the tectonic discriminant diagram of Pearce *et al.* (1984), the relatively low Rb, Nb and Y contents of these granitoids result in the majority being classified as 'Volcanic Arc Granites' (Fig. 5) However, since high alumina contents and low Nb and Y values are thought to be typical of crustal melt granitoids (Pearce *et al.*, 1984; McDermott, 1986), it can be proposed that the peraluminous Gamsberg Granite Suite represents I-type upper crustal melts. This proposal broadly coincides with the high $^{87}Sr/^{86}Sr$ initial value of 0,708 which has been reported by Reid *et al.* (1988). However, while the low $^{87}Sr/^{86}Sr$ initial ratios of between 0,700 and 0,702 reported by Seifert (1986a, b) confirm I-type magmatism for the GGS, they do not support an upper crustal source.

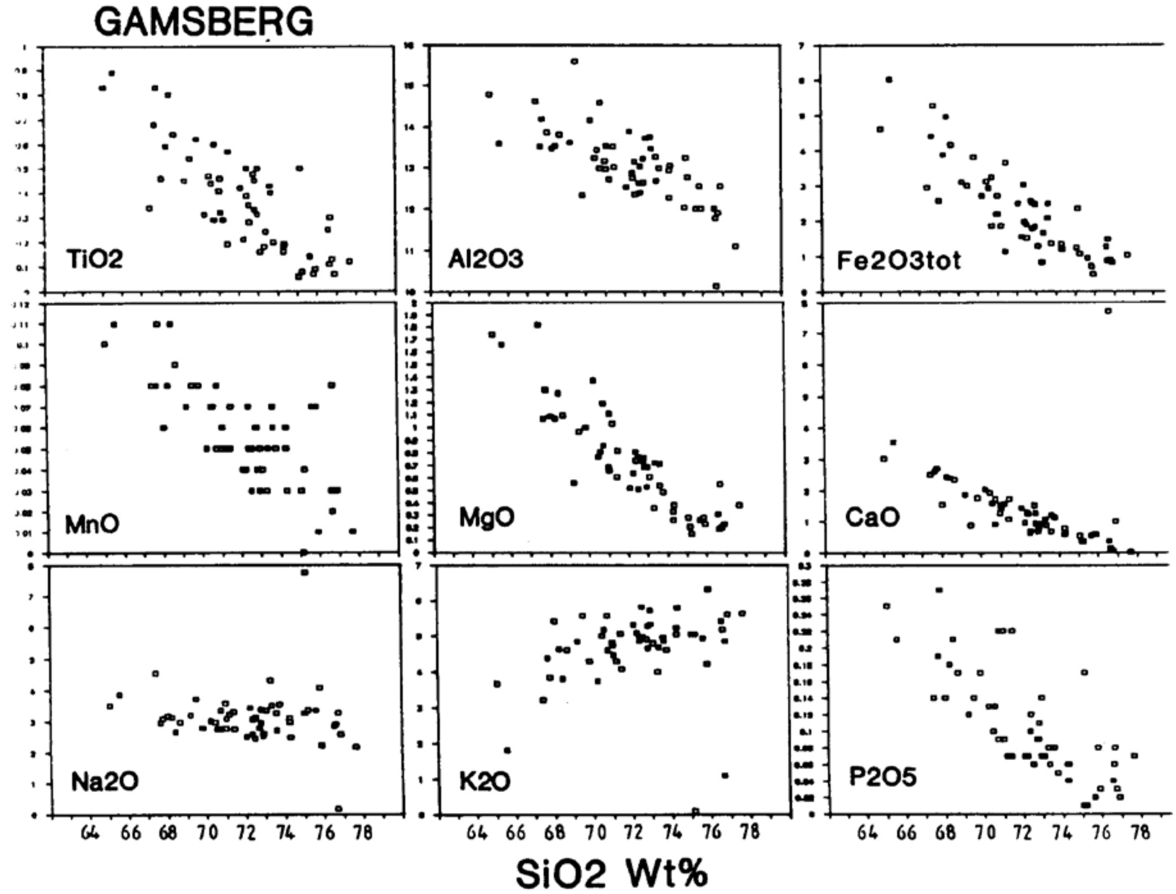


Fig. 1: Harker diagrams for the Gamsberg Granite Suite.

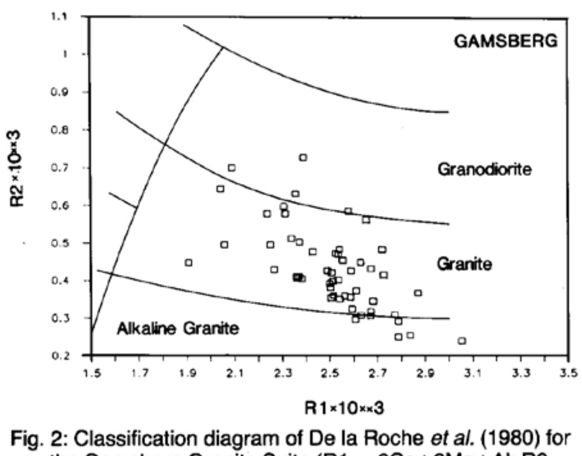


Fig. 2: Classification diagram of De la Roche *et al.* (1980) for the Gamsberg Granite Suite (R1 = 6Ca+2Mg+Al: R2 = 4Si−11(Na+K)−2(Fe+Ti)).

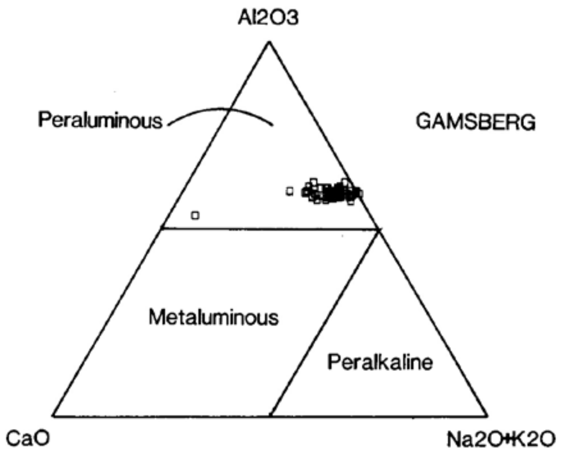


Fig. 3: Wt. % $Al_2O_3-CaO-(Na_2O+K_2O)$ ternary diagram after Shand (1927) for the Gamsberg Granite Suite.

4.2 Piksteel lntrusive Suite

Linear data arrays for 36 Piksteel samples on Harker diagrams (Fig. 6) probably reflect magmatic processes. However, non-linear scatter of data points in plots of Na_2O and K_2O versus SiO_2 are most probably the result of post-intrusive alteration (saussuritization) processes. The diagram of De la Roche *et al.* (1980) illustrates that the PIS is made up largely of granodiorite with lesser plutons of granite, alkali granite, diorite, quartz monzonite and tonalite (Fig. 7). All of these granitoids plot within the peraluminous field on a wt. % Al_2O_3-CaO-(Na_2O+K_2O) diagram (Fig. 8). In the mol. % Al_2O_3 versus mol. % (Na_2O+K_2O+CaO) diagram (Fig. 9) the wide range of A/CNK values from less than 1,0 to greater than 1,4 contrasts markedly with the Gamsberg data. The strong alumina over saturation (A/CNK > 1,1) of many of the Piksteel samples suggests an S-type origin,

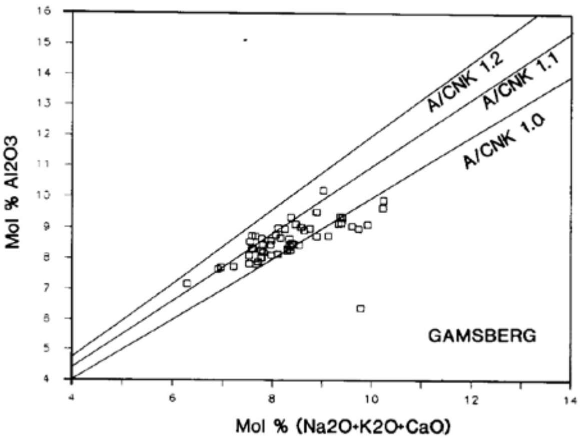


Fig. 4: Mol. % Al_2O_3 versus mol. % ($CaO+Na_2O+K_2O$) diagram for the Gamsberg Granite Suite showing A/CNK alumina saturation values after Chappell and White (1974).

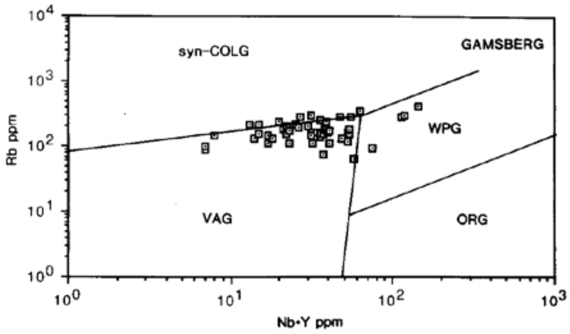
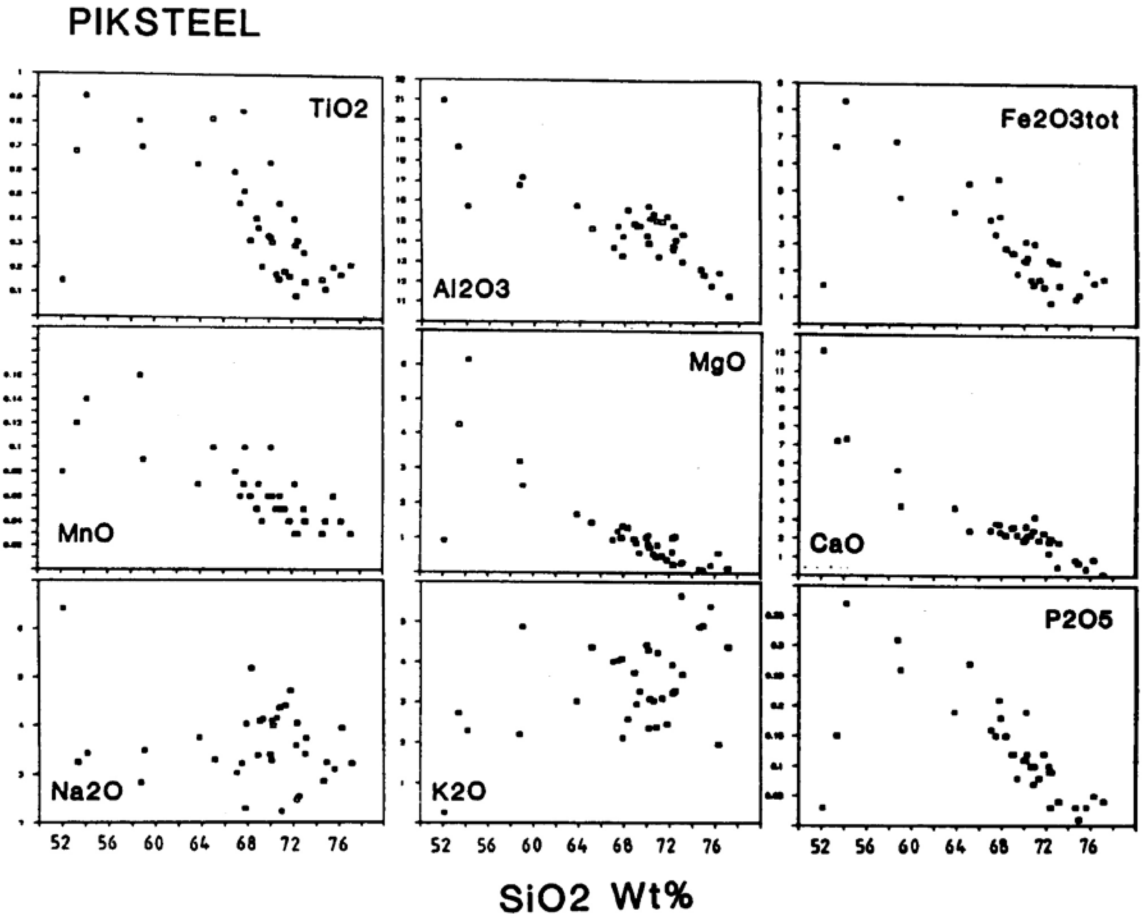


Fig. 5: Rb versus Nb+Y diagram after Pearce *et al.* (1984) for the Gamsberg Granite Suite (VAG = Volcanic Arc Granites; syn-COLG = syn-Collision Granites; WPG = Within Plate Granites; ORG = Ocean Ridge Granites).

Fig. 6: Harker diagrams for the Piksteel Intrusive Suite.



while the few samples which plot below the A/CNK = 1,1 line are probably of I-type origin.

Again, the Piksteel samples which define a calc-alkaline trend in the AFM diagram of Kuno (1968, Fig.

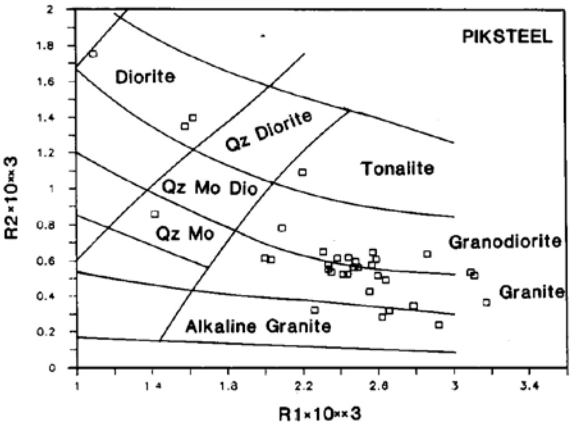


Fig. 7: Classification diagram of De la Roche *et al.* (1980) for the Piksteel Intrusive Suite (R1 = 6Ca+2Mg+Al: R2 = 4Si−11(Na+K)−2(Fe+Ti)).

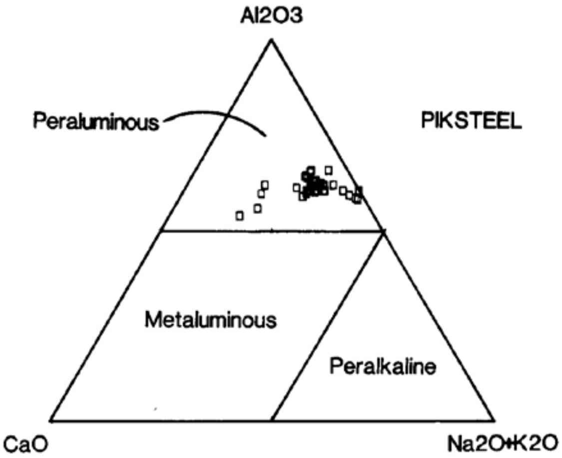


Fig. 8: Wt. % Al_2O_3−CaO−(Na_2O+K_2O) ternary diagram after Shand (1927) for the Piksteel Intrusive Suite.

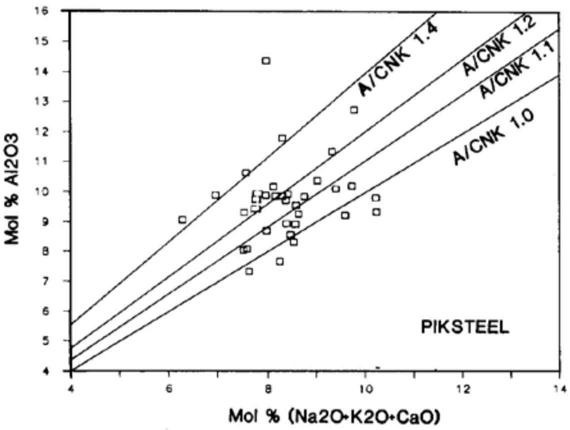


Fig. 9: Mol.% Al_2O_3 versus mol.% (Na_2O+K_2O+CaO) diagram for Piksteel granitoids showing A/CNK alumina saturation values after Chappell and White (1974).

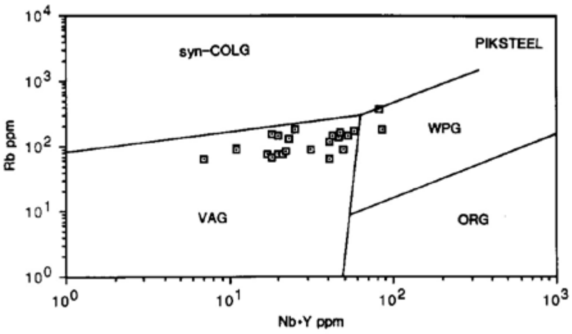
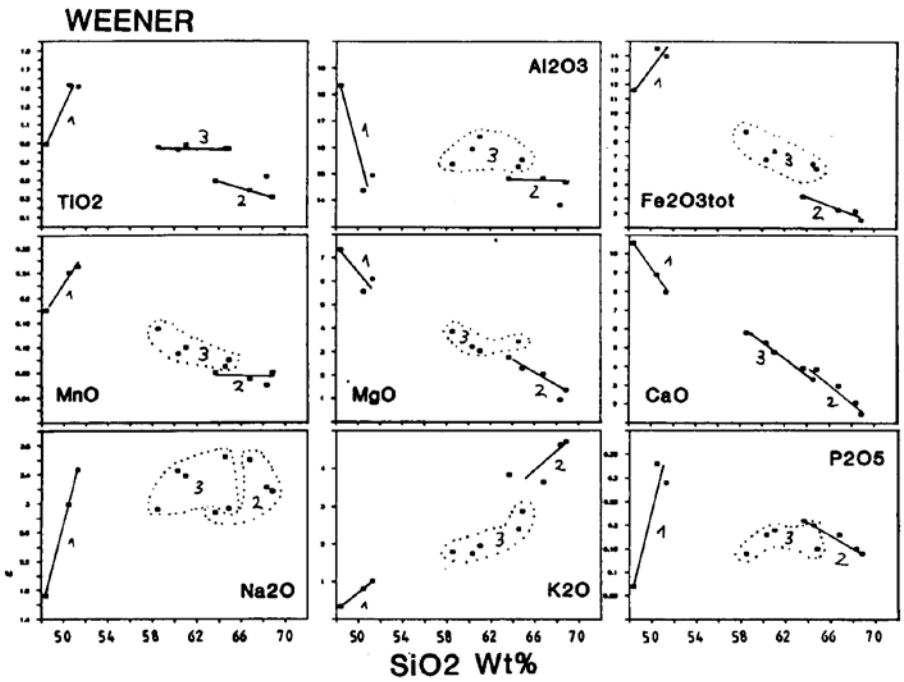


Fig. 10: Rb versus Nb+Y diagram after Pearce *et al.* (1984) for the Piksteel Intrusive Suite (VAG = Volcanic Arc Granites; syn-COLG = syn-Collision Granites; WPG = Within Plate Granites; ORG = Ocean Ridge Granites).

Fig. 11: Harker diagrams for the Weener Intrusive Suite (1, 2, 3 = different plutons of the WIS).



16), are classified as 'Volcanic Arc Granite' according to Fig. 10. Also here the low contents of Rb, Nb and Y and the peraluminous nature are indicative of an upper crustal origin. A crustal origin is supported by the high initial $^{87}Sr/^{86}Sr$ ratios for Piksteel intrusives obtained by Reid *et al.* (1988) which range between 0,707 and 0,709. Insufficient geochemical data exists at present to allow an overall genetic interpretation.

However, detailed work on single intrusions and the application of isotope geochemistry will enable us to elucidate the genetic relationships between the different members of the PIS.

4.3 Weener Intrusive Suite

A total of 12 samples was collected from the three largest bodies of the WIS. Despite plotting on similar differentiation trends in Harker diagrams (Fig. 11), the data points can be grouped together on a regional basis. The WIS is made up of granite, granodiorite, tonalite, diorite and gabbro as indicated by the diagram of De la Roche *et al.* (1980; Fig. 12). As for the GGS and PIS, all the Weener samples are peraluminous according to a wt. % Al_2O_3-CaO-(Na_2O+K_2O) plot (Fig. 13). However, A/CNK ratios of the WIS are, although being within the range of the PIS, notably higher than those of the GGS and the major part of the PIS (Fig. 14). A/CNK ratios above 1,1 indicate an S-type origin for the Weener rocks according to the criteria of Chappell and White (1974).

An S-type origin is supported by the low Rb, Nb and Y contents which classify these granitoids as 'Volcanic Arc Granites' (Fig. 15) according to Pearce *et al.* (1984), but is in contradiction to the relatively low $^{87}Sr/^{86}Sr$ values of 0,700-0,705 reported for the WIS by Seifert (1986a, b) and Reid *et al.* (1988).

5. SUMMARY

All the analysed samples of granitoids from the Rehoboth basement area are peraluminous according to the criteria of Shand (1927) and Chappell and White (1974). The GGS, PIS and WIS are calc-alkaline in character according to the AFM diagram of Kuno (1968; Fig. 16). A/CNK ratios indicate an S-type origin for the Weener granitoids, an S- or I-type origin for the Piksteel granitoids and an I-type origin for the Gamsberg granitoids. These results only partly coincide with isotopic data of Reid *et al.* (1988) and Seifert (1986a, b) which favour I-type origins for almost all of the Rehoboth granitoids. However, the high alumina saturation of most of the analysed samples suggests that the vast majority of the granitoids in the Rehoboth basement inlier are derived from upper crustal melts.

6. ACKNOWLEDGEMENTS

This study is being carried out as part of a University Research Project sponsored by the Geological Survey of SWA/Namibia. We wish to thank Prof. E. Jäger and Dr. R.McG. Miller for supervising the project and D. Vuichard for his kind help in getting the XRF system going. A first manuscript was kindly reviewed and corrected by B. Hoal of the Geological Survey.

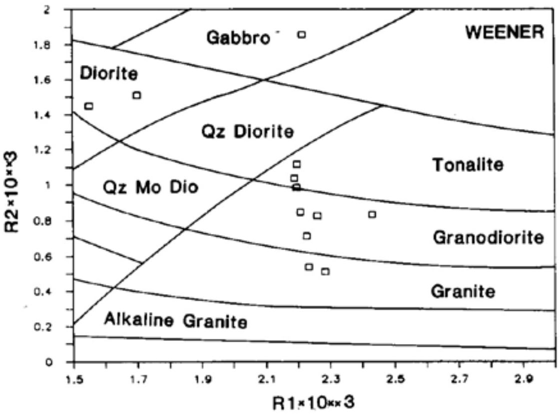


Fig. 12: Classification diagram of De la Roche *et al.* (1980) for the Weener Intrusive Suite (R1 = 6Ca+2Mg+Al; R2 = 4Si−11(Na+K)−2(Fe+Ti)).

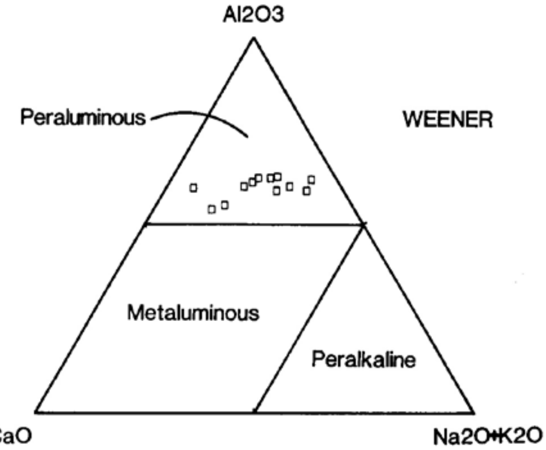


Fig. 13: Wt. % Al_2O_3−CaO−(Na_2O+K_2O) ternary diagram after Shand (1927) for the Weener Intrusive Suite.

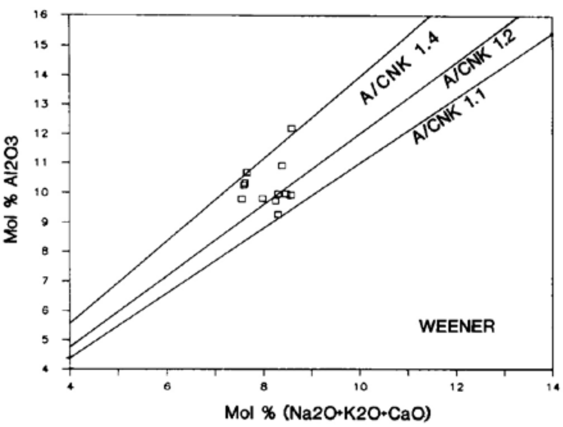


Fig. 14: Mol.% Al_2O_3 versus mol.% (Na_2O+K_2O+CaO) diagram for the Weener Intrusive Suite showing A/CNK saturation values after Chappell and White (1974).

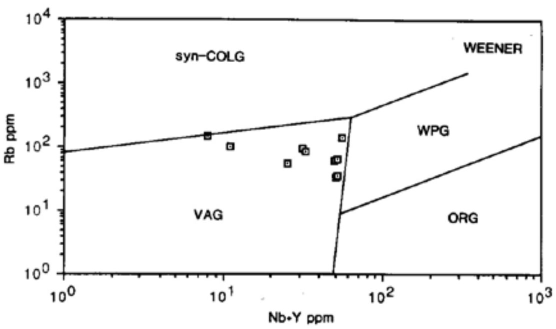


Fig. 15: Rb versus Nb+Y diagram after Pearce *et al.* (1984) for the Weener Intrusive Suite (VAG = Volcanic Arc Granites; syn-COLG = syn-Collision Granites; WPG = Within Plate Granites; ORG = Ocean Ridge Granites).

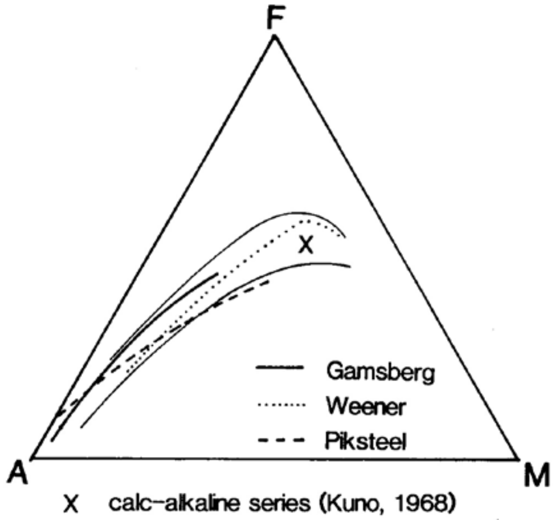


Fig. 16: Trends for all the analysed Rehoboth granitoids on an AFM diagram after Kuno (1968).

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