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APPENDICES

ศูนย์วิทยทรัพยากร
จุฬาลงกรณ์มหาวิทยาลัย

APPENDIX A

Staining techniques on rock slabs and thin sections.

The three solutions used for staining are 46 % Hydrofluoric acid (HF), 7 % Amaranth and 20 % Sodium cobaltinitrite. The detail of staining procedure is

1. Immerse the smooth face of a dry slab in conc. HF for 30 - 60 seconds.
2. Rinse the slab surface in distilled water bath about 5 seconds to remove the excess HF then dry its surface.
3. Immerse the slab's surface into the Amaranth solution for approximately 2-5 seconds.
4. Rinse the slab in distilled water as described in step 2 (in another bath) to remove excess Amaranth solution. Then allowed it to air-dry or in the oven, plagioclase will form a red or pink color on its surface.
5. Immerse the same surface in the sodium cobaltinitrite solution for 1 minute.
6. Rinse the slab's surface with distilled water to remove excess sodium cobaltinitrite and allowed it to air-dry or in the oven. K-feldspar will form yellow color on its surface.

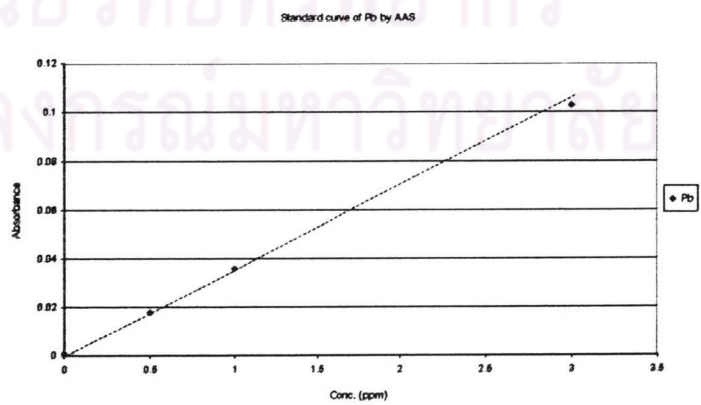
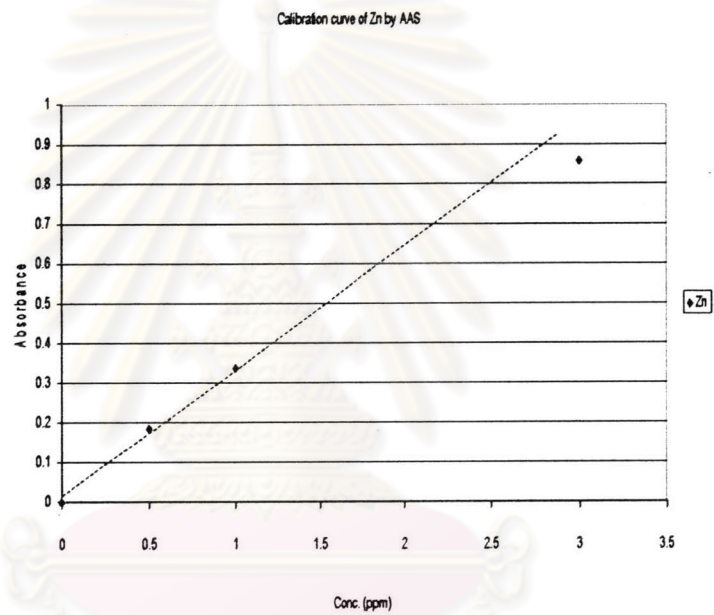
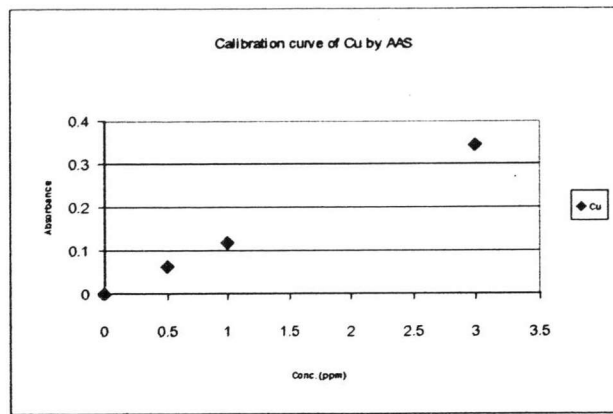
ศูนย์วิทยทรัพยากร
จุฬาลงกรณ์มหาวิทยาลัย

APPENDIX B Major and minor element concentrations by XRF

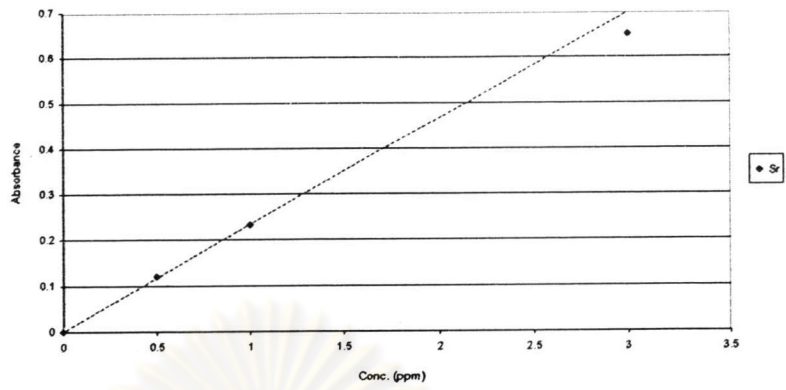
Major & minor (%)	Gabbro					Diorite				
	pn65	pn66	pn68	pn69	pn70	pn22	pn30	pn44	pn50	pn54
SiO ₂	56.06	52.25	50.22	54.28	58.05	58.64	54.27	54.74	60.62	56.48
TiO ₂	0.79	0.87	0.75	0.95	0.87	0.56	0.65	0.78	0.48	0.62
Al ₂ O ₃	16.58	18.74	17.44	17.61	16.10	16.27	17.38	16.92	17.05	17.51
FeO total	4.32	4.22	7.23	6.64	5.83	5.57	6.86	6.70	5.15	5.76
MgO	5.76	4.22	3.85	3.83	4.27	5.21	6.49	6.41	3.94	5.76
CaO	7.76	13.27	15.41	9.77	6.69	6.24	8.09	7.16	5.20	7.15
Na ₂ O	5.07	4.84	4.17	5.47	5.59	5.50	4.58	5.07	5.95	5.28
K ₂ O	1.00	0.54	0.15	0.94	1.36	1.47	0.71	1.37	1.02	0.82
P ₂ O ₅	0.41	0.74	0.25	0.32	0.40	0.20	0.24	0.33	0.21	0.20
MnO	0.13	0.11	0.14	0.10	0.11	0.11	0.13	0.13	0.13	0.11
LOI	0.05	0.05	0.36	0.03	0.57	0.17	0.39	0.31	0.20	0.24
Total	97.93	99.85	99.97	99.94	99.84	99.94	99.79	99.92	99.95	99.93
Major & minor (%)	Granodiorite					Quartz diorite				
	pn36	pn37	pn38	pn58	pn59	pn02	pn04	pn06	pn07	pn20
SiO ₂	66.45	63.08	66.59	63.90	63.43	65.13	64.36	64.93	65.36	61.56
TiO ₂	0.39	0.61	0.42	0.60	0.58	0.38	0.37	0.41	0.37	0.51
Al ₂ O ₃	15.20	15.79	15.03	15.16	15.72	15.44	15.80	15.54	15.32	16.80
FeO total	3.03	4.23	3.17	4.34	4.11	3.63	3.97	3.95	3.74	4.46
MgO	2.34	3.26	2.22	2.99	3.18	2.77	3.26	3.04	3.01	3.37
CaO	3.61	4.81	3.79	5.13	4.70	3.95	3.94	4.10	4.10	5.32
Na ₂ O	6.56	5.86	6.14	5.78	5.97	6.55	6.12	5.75	5.83	6.13
K ₂ O	1.85	1.90	2.14	1.65	1.87	1.60	1.59	1.67	1.68	1.17
P ₂ O ₅	0.16	0.24	0.17	0.22	0.23	0.17	0.17	0.17	0.18	0.21
MnO	0.04	0.09	0.04	0.07	0.06	0.09	0.08	0.09	0.10	0.09
LOI	0.30	0.10	0.26	0.13	0.11	0.23	0.27	0.29	0.26	0.30
Total	99.93	99.97	99.97	99.97	99.96	99.94	99.93	99.94	99.95	99.92

APPENDIX C
CALIBRATION CURVE OF TRACE ELEMENTS BY ASA

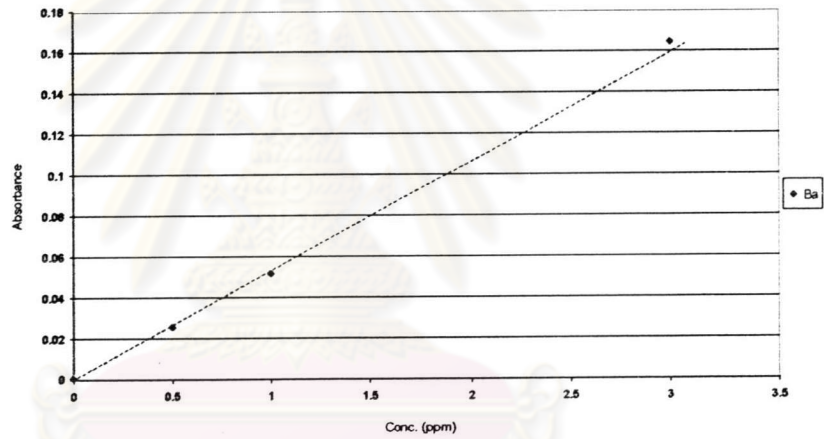
Std conc. (ppm)	absorbance of Cu	absorbance of Zn
0	0	0
0.5	0.063	0.185
1	0.12	0.338
3	0.347	0.859
Std conc. (ppm)	absorbance of Pb	absorbance of Sr
0	0.001	0.002
0.5	0.018	0.121
1	0.036	0.234
3	0.103	0.653
Std conc. (ppm)	absorbance of Ba	absorbance of Rb
0	0.001	0.008
0.5	0.026	0.087
1	0.052	0.192
3	0.165	0.484



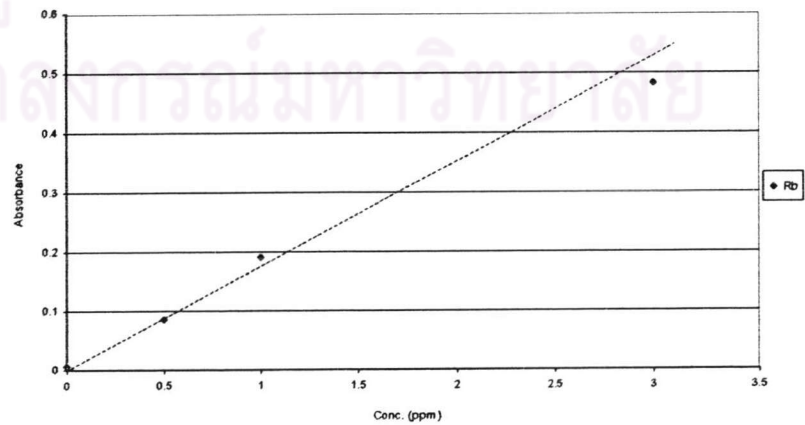
Calibration curve of Sr by AAS



Calibration curve of Ba by AAS



Calibration curve of Rb by AAS



Appendix D-1 EPMA results of plagioclase. Cations were calculated on the basis of 8 Oxygen.

		Gabbro															
plagioclase	94Pl-2-2	94Pl-1-1	94Pl-1-3	94Pl-2-1	94Pl-2-3	94Pl-3-1	94Pl-3-2	94Pl-3-3	94Pl-4-1	94Pl-4-2	94Pl-4-3	94Pl-6-1	94Pl-5-1	94Pl-5-2	94Pl-5-3		
SiO ₂	55.18	58.29	55.71	56.90	54.70	56.74	54.68	54.49	54.47	57.01	56.53	57.41	54.88	55.59	55.04		
TiO ₂	0.06	0.06	0.05	0.05	0.04	0.03	0.06	0.05	0.05	0.00	0.03	0.06	0.06	0.07	0.01		
Al ₂ O ₃	27.82	26.79	27.11	26.41	27.99	26.96	28.22	28.16	28.23	26.44	26.72	26.70	28.22	27.60	28.05		
FeO	0.35	0.19	0.19	0.31	0.33	0.34	0.36	0.45	0.41	0.26	0.35	0.23	0.33	0.35	0.39		
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
CaO	10.28	8.95	9.64	8.66	10.57	9.21	10.63	10.78	10.96	8.85	9.17	8.70	10.40	9.92	10.47		
Na ₂ O	6.38	2.18	6.11	5.64	6.29	6.94	6.06	5.92	6.04	7.18	6.97	7.47	6.16	6.40	6.13		
K ₂ O	0.36	0.33	0.36	0.30	0.37	0.43	0.33	0.34	0.34	0.39	0.47	0.40	0.34	0.37	0.34		
Total	100.41	96.78	99.16	98.27	100.29	100.64	100.33	100.19	100.50	100.13	100.25	100.96	100.38	100.30	100.43		
Si	2.74	2.91	2.78	2.84	2.73	2.79	2.73	2.72	2.72	2.81	2.79	2.81	2.73	2.76	2.74		
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00		
Al	0.81	0.79	0.80	0.78	0.82	0.78	0.83	0.83	0.83	0.77	0.78	0.77	0.83	0.81	0.82		
Fe	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.02		
Mg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Ca	0.55	0.48	0.52	0.46	0.56	0.49	0.57	0.58	0.59	0.47	0.49	0.46	0.55	0.53	0.56		
Na	0.61	0.21	0.59	0.55	0.61	0.66	0.59	0.57	0.58	0.69	0.67	0.71	0.59	0.62	0.59		
K	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02		
Total	4.76	4.42	4.72	4.66	4.76	4.77	4.75	4.75	4.76	4.77	4.77	4.78	4.75	4.75	4.75		
%Ca	46.2	67.3	45.6	45.0	47.2	41.3	48.4	49.2	49.2	39.7	41.0	38.3	47.4	45.2	47.6		
%Na	51.9	29.7	52.3	53.1	50.8	56.4	49.9	48.9	49.0	58.3	56.4	59.6	50.8	52.8	50.5		
%K	1.9	3.0	2.0	1.8	2.0	2.3	1.8	1.8	1.8	2.1	2.5	2.1	1.8	2.0	1.8		

Appendix D-1 EPMA results of plagioclase. Cations were calculated on the basis of 8 Oxygen (cont.).

	Gabbro															
plagioclase	94PI 6-1	94iPI 1-1	94iPI 1-2	94iPI 2-1	94iPI 2-2	94iPI 2-3	94iPI 3-1	94iPI 4-1	94iPI 5-1	94iPI 5-2	94iPI 5-3	94iPI 6-2	94iPI 6-1	94iPI 6-3		
SiO ₂	56.86	56.27	57.84	56.28	54.97	55.50	50.75	54.97	57.62	56.10	55.65	54.25	57.27	56.64		
TiO ₂	0.06	0.07	0.03	0.02	0.04	0.07	0.00	0.05	0.02	0.04	0.05	0.08	0.07	0.09		
Al ₂ O ₃	27.22	27.48	26.59	27.66	28.66	28.21	30.99	28.41	26.63	27.59	27.98	28.56	27.03	27.33		
FeO	0.40	0.39	0.35	0.28	0.40	0.29	0.29	0.37	0.37	0.36	0.42	0.29	0.37	0.16		
MgO	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
CaO	9.08	9.73	8.58	9.92	10.92	10.47	13.97	10.74	8.50	9.63	10.40	11.11	9.13	9.64		
Na ₂ O	7.16	3.87	3.63	4.20	4.04	3.82	3.21	3.93	4.01	4.23	4.28	4.08	4.08	4.39		
K ₂ O	0.37	0.38	0.41	0.36	0.33	0.39	0.16	0.35	0.43	0.39	0.41	0.27	0.40	0.39		
Total	101.15	98.18	97.43	98.71	99.37	98.75	99.36	98.83	97.58	98.54	99.19	98.65	98.35	98.65		
Si	2.79	2.82	2.89	2.81	2.75	2.78	2.60	2.76	2.88	2.81	2.78	2.74	2.85	2.82		
Ti	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01		
Al	0.79	0.81	0.78	0.81	0.84	0.83	0.93	0.84	0.78	0.81	0.82	0.85	0.79	0.80		
Fe	0.02	0.02	0.01	0.01	0.02	0.01	0.01	0.02	0.02	0.01	0.02	0.01	0.02	0.01		
Mg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Ca	0.48	0.52	0.46	0.53	0.59	0.56	0.77	0.58	0.45	0.53	0.56	0.60	0.49	0.51		
Na	0.68	0.38	0.35	0.41	0.39	0.37	0.32	0.38	0.39	0.41	0.41	0.40	0.39	0.42		
K	0.02	0.02	0.03	0.02	0.02	0.02	0.01	0.02	0.03	0.03	0.03	0.02	0.03	0.03		
Total	4.78	4.57	4.52	4.59	4.61	4.58	4.63	4.60	4.55	4.60	4.62	4.62	4.57	4.60		
%Ca	40.4	56.6	54.8	55.3	58.6	58.7	70.0	58.7	52.2	54.8	55.8	59.0	53.7	53.4		
%Na	57.7	40.7	42.0	42.4	39.3	38.8	29.1	39.0	44.6	42.6	41.6	39.2	43.5	44.0		
%K	2.0	2.6	3.1	2.4	2.1	2.6	0.9	2.3	3.2	2.6	2.6	1.7	2.8	2.6		

Appendix D-1 EPMA results of plagioclase. Cations were calculated on the basis of 8 Oxygen (cont.).

	Hbl-Bt granodiorite													
	91-2Pl 1-2	91-2Pl 2-2	91-2Pl 3-1	91-2Pl 4-1	91-2Pl 5-1	91-2Pl 6-1	90Pl 1-1	90Pl 1-2	90Pl 2-3	90Pl 2-4	90Pl 3-1	90Pl 3-2	90Pl 3-3	92-1Pl 2-1
plagioclase	57.96	58.96	57.06	57.98	58.67	57.53	57.66	58.73	56.13	54.80	58.56	59.29	56.96	58.15
SiO ₂	0.03	0.04	0.05	0.03	0.06	0.00	0.05	0.01	0.05	0.06	0.04	0.04	0.02	0.03
TiO ₂	26.79	26.06	27.23	26.54	26.07	26.86	26.41	25.68	26.49	27.34	26.18	25.52	26.54	25.52
FeO	0.19	0.26	0.21	0.36	0.27	0.36	0.23	0.31	0.37	0.39	0.22	0.20	0.28	0.30
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	8.39	7.67	9.24	8.56	7.67	8.70	8.14	7.51	8.97	9.77	7.98	7.26	8.67	7.61
Na ₂ O	3.95	3.91	4.22	4.06	4.28	4.09	6.69	6.10	6.58	6.38	7.30	6.63	7.01	5.79
K ₂ O	0.34	0.43	0.31	0.37	0.42	0.36	0.35	0.47	0.36	0.32	0.43	0.52	0.36	0.55
Total	97.65	97.33	98.31	97.90	97.44	97.90	99.52	98.82	98.95	99.05	100.70	99.46	99.84	97.95
Si	2.88	2.78	2.84	2.88	2.91	2.87	2.84	2.90	2.80	2.76	2.85	2.90	2.82	2.89
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.79	0.92	0.80	0.78	0.76	0.79	0.77	0.75	0.78	0.81	0.75	0.74	0.77	0.75
Fe	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01
Mg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ca	0.45	0.39	0.49	0.46	0.41	0.46	0.43	0.40	0.48	0.53	0.42	0.38	0.46	0.41
Na	0.38	0.36	0.41	0.39	0.41	0.40	0.64	0.58	0.64	0.62	0.69	0.63	0.67	0.56
K	0.02	0.03	0.02	0.02	0.03	0.02	0.02	0.03	0.02	0.02	0.03	0.03	0.02	0.03
Total	4.53	4.49	4.57	4.55	4.54	4.55	4.72	4.66	4.74	4.75	4.75	4.69	4.76	4.65
%Ca	52.6	50.3	53.6	52.4	48.2	52.6	39.4	39.3	42.1	45.0	36.8	36.5	39.8	40.6
%Na	44.9	46.4	44.3	44.9	48.7	44.8	58.6	57.8	55.9	53.2	60.8	60.4	58.2	55.9
%K	2.5	3.4	2.1	2.7	3.1	2.6	2.0	2.9	2.0	1.8	2.4	3.1	2.0	3.5

Appendix D-1 EPMA results of plagioclase. Cations were calculated on the basis of 8 Oxygen (cont.).

plagioclase	Hbl-Bt granodiorite							Diorite						
	92-1Pl 2-2	92-1Pl 3-2	92-1Pl 4-1	92-1Pl 7-2	95Pl 1-1	95Pl 3-1	95Pl 4-1	95Pl 5-2	95Pl 6-1*	95Pl 7-1	95Pl 8-1*	29Pl 1-1	29Pl 2-1	29Pl 2-2
SiO ₂	58.47	59.04	62.09	62.20	57.02	50.02	55.27	52.36	48.29	51.87	47.14	57.25	59.06	57.12
TiO ₂	0.01	0.00	0.03	0.00	0.01	0.01	0.03	0.00	0.04	0.02	0.01	0.00	0.02	0.00
Al ₂ O ₃	25.40	25.07	23.01	23.18	27.08	31.74	27.68	30.15	32.29	30.33	33.20	26.20	24.81	26.35
FeO	0.24	0.19	0.19	0.19	0.25	0.51	0.64	0.70	0.60	0.60	0.60	0.22	0.18	0.25
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00
CaO	7.47	6.83	4.57	4.63	9.23	14.59	10.44	12.82	15.74	12.99	16.78	8.61	7.23	8.94
Na ₂ O	6.34	5.95	7.20	6.17	6.24	3.75	6.14	4.70	2.98	4.32	2.33	5.66	5.56	5.52
K ₂ O	0.33	0.36	0.47	0.43	0.20	0.04	0.12	0.18	0.02	0.14	0.06	0.37	0.38	0.30
Total	98.27	97.43	97.56	96.80	100.03	100.66	100.31	100.98	99.95	100.28	100.12	98.31	97.24	98.48
Si	2.90	2.79	3.03	3.05	2.81	2.55	2.75	2.63	2.49	2.62	2.45	2.85	2.94	2.84
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.74	0.89	0.66	0.67	0.79	0.95	0.81	0.89	0.98	0.90	1.02	0.77	0.73	0.77
Fe	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.03	0.03	0.03	0.03	0.01	0.01	0.01
Mg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ca	0.40	0.35	0.24	0.24	0.49	0.80	0.56	0.69	0.87	0.70	0.93	0.46	0.39	0.48
Na	0.61	0.54	0.68	0.59	0.60	0.37	0.59	0.46	0.30	0.42	0.23	0.55	0.54	0.53
K	0.02	0.02	0.03	0.03	0.01	0.00	0.01	0.01	0.00	0.01	0.00	0.02	0.02	0.02
Total	4.68	4.60	4.66	4.59	4.71	4.69	4.74	4.71	4.67	4.69	4.66	4.66	4.62	4.66
%Ca	38.6	37.9	25.2	28.4	44.5	68.1	48.1	59.5	74.4	61.9	79.6	44.6	40.8	46.3
%Na	59.3	59.7	71.8	68.5	54.4	31.7	51.2	39.5	25.5	37.3	20.0	53.1	56.7	51.8
%K	2.0	2.4	3.1	3.1	1.1	0.2	0.6	1.0	0.1	0.8	0.3	2.3	2.6	1.8

* = inclusion

Appendix D-1 EPMA results of plagioclase. Cations were calculated on the basis of 8 Oxygen (cont.).

plagioclase	Quartz diorite																			
	29PI 2-3	11PI 1-2	11PI 3-1	11PI 3-2	87PI 2-1	87PI 4-1	87PI 4-2	87PI 1-1	87PI 3-1	87PI 3-2	29PI 2-3	11PI 1-2	11PI 3-1	11PI 3-2	87PI 2-1	87PI 4-1	87PI 4-2	87PI 1-1	87PI 3-1	87PI 3-2
SiO ₂	57.33	53.68	57.63	55.47	54.70	58.06	57.36	60.70	56.25	58.31	57.33	53.68	57.63	55.47	54.70	58.06	57.36	60.70	56.25	58.31
TiO ₂	0.02	0.02	0.01	0.06	0.02	0.01	0.00	0.06	0.02	0.03	0.02	0.02	0.01	0.06	0.02	0.01	0.00	0.06	0.02	0.03
Al ₂ O ₃	25.58	28.49	25.45	27.31	28.85	26.92	27.61	25.01	28.38	27.05	25.58	28.49	25.45	27.31	28.85	26.92	27.61	25.01	28.38	27.05
FeO	0.28	0.34	0.24	0.25	0.31	0.18	0.38	0.58	0.32	0.34	0.28	0.34	0.24	0.25	0.31	0.18	0.38	0.58	0.32	0.34
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	8.26	11.19	7.97	9.69	11.31	8.89	9.54	7.28	10.42	8.66	8.26	11.19	7.97	9.69	11.31	8.89	9.54	7.28	10.42	8.66
Na ₂ O	5.49	5.73	6.64	6.50	3.83	4.23	4.02	3.65	4.02	3.48	5.49	5.73	6.64	6.50	3.83	4.23	4.02	3.65	4.02	3.48
K ₂ O	0.41	0.13	0.25	0.28	0.12	0.19	0.16	0.29	0.16	0.18	0.41	0.13	0.25	0.28	0.12	0.19	0.16	0.29	0.16	0.18
Total	97.37	99.57	98.19	99.57	99.13	98.48	99.07	97.57	99.56	98.04	97.37	99.57	98.19	99.57	99.13	98.48	99.07	97.57	99.56	98.04
Si	2.88	2.70	2.87	2.77	2.74	2.87	2.84	2.98	2.79	2.89	2.88	2.70	2.87	2.77	2.74	2.87	2.84	2.98	2.79	2.89
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.76	0.85	0.75	0.80	0.85	0.78	0.80	0.72	0.83	0.79	0.76	0.85	0.75	0.80	0.85	0.78	0.80	0.72	0.83	0.79
Fe	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.01
Mg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ca	0.44	0.60	0.43	0.52	0.61	0.47	0.51	0.38	0.55	0.46	0.44	0.60	0.43	0.52	0.61	0.47	0.51	0.38	0.55	0.46
Na	0.53	0.56	0.64	0.63	0.37	0.41	0.39	0.35	0.39	0.33	0.53	0.56	0.64	0.63	0.37	0.41	0.39	0.35	0.39	0.33
K	0.03	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.01	0.01	0.03	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.01	0.01
Total	4.65	4.73	4.71	4.75	4.60	4.55	4.56	4.48	4.58	4.50	4.65	4.73	4.71	4.75	4.60	4.55	4.56	4.48	4.58	4.50
%Ca	44.3	51.6	39.3	44.5	61.5	53.0	56.1	51.2	58.3	57.1	44.3	51.6	39.3	44.5	61.5	53.0	56.1	51.2	58.3	57.1
%Na	53.1	47.8	59.2	54.0	37.7	45.6	42.8	46.4	40.7	41.5	53.1	47.8	59.2	54.0	37.7	45.6	42.8	46.4	40.7	41.5
%K	2.6	0.7	1.5	1.5	0.8	1.4	1.1	2.4	1.1	1.4	2.6	0.7	1.5	1.5	0.8	1.4	1.1	2.4	1.1	1.4

Appendix D-2 EPMA results of clinopyroxene.

pyroxene	px1-1	px1-2	px1-3	94px2-1	94px2-2	94px2-3	94px3-1	94px3-2	94px3-3	94px4-1	94px4-3	94px5-1	94px5-2	94px5-3	90PX1-1	94lIPX1	94lIPX1-2
SiO2	53.31	52.80	53.33	52.75	48.76	53.07	53.21	53.05	52.97	52.84	53.15	52.47	53.34	53.55	50.50	51.47	52.45
TiO2	0.29	0.27	0.10	0.17	1.75	0.15	0.03	0.10	0.14	0.19	0.13	0.24	0.05	0.12	0.77	0.68	0.08
Al2O3	0.74	0.75	0.41	0.74	6.37	0.63	0.34	0.51	0.72	0.78	0.51	0.98	0.45	0.42	4.24	2.37	0.83
Fe2O3	2.47	2.32	1.83	1.91	2.70	1.90	1.87	2.08	2.23	2.40	2.16	2.67	1.49	1.86	0.30	4.02	2.26
FeO	18.19	18.05	18.88	6.29	8.23	5.80	5.59	5.83	6.04	5.85	5.54	6.52	6.08	6.02	12.40	7.43	5.66
Cr2O3	0.02	0.01	0.00	0.00	0.01	0.00	0.04	0.03	0.00	0.03	0.03	0.03	0.07	0.00	0.02	0.07	0.00
MnO	0.44	0.51	0.62	0.34	0.21	0.36	0.35	0.33	0.29	0.34	0.28	0.30	0.36	0.39	0.26	0.29	0.15
NiO	0.00	0.00	0.02	0.01	0.01	0.00	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00
MgO	24.49	24.05	24.26	14.99	16.04	14.78	14.72	14.85	14.55	14.83	14.99	15.03	14.70	14.89	15.87	14.71	14.26
CaO	1.25	1.42	0.85	21.98	11.98	22.85	23.47	22.74	22.92	22.71	23.30	21.44	23.18	23.14	11.62	20.16	23.55
Na2O	0.03	0.03	0.01	0.37	1.58	0.40	0.30	0.38	0.39	0.36	0.28	0.40	0.30	0.34	0.90	0.52	0.31
K2O	0.00	0.00	0.00	0.01	0.05	0.00	0.01	0.01	0.02	0.00	0.00	0.02	0.03	0.00	0.36	0.00	0.00
Total	101.23	100.22	100.29	99.54	97.70	99.92	99.94	99.90	100.28	100.33	100.36	100.10	100.05	100.73	97.24	101.74	99.54
Cation on the basis of 6 (O)																	
Si	1.95	1.95	1.97	1.97	1.84	1.98	1.98	1.98	1.97	1.97	1.97	1.96	1.98	1.98	1.92	1.91	1.97
Ti	0.01	0.01	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.02	0.02	0.00
Al(IV)	0.03	0.03	0.02	0.03	0.16	0.02	0.02	0.02	0.03	0.03	0.02	0.04	0.02	0.02	0.08	0.09	0.03
Al(VI)	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.01	0.00
Fe3+	0.08	0.07	0.06	0.06	0.09	0.06	0.06	0.06	0.07	0.07	0.07	0.08	0.05	0.06	0.01	0.12	0.07
Fe2+	0.56	0.56	0.58	0.20	0.26	0.18	0.17	0.18	0.19	0.18	0.17	0.20	0.19	0.19	0.39	0.23	0.18
Cr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mn	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00
Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mg	1.34	1.33	1.34	0.84	0.90	0.82	0.82	0.83	0.81	0.82	0.83	0.84	0.81	0.82	0.90	0.81	0.80
Ca	0.05	0.06	0.03	0.88	0.48	0.91	0.94	0.91	0.91	0.90	0.93	0.86	0.92	0.92	0.47	0.80	0.95
Na	0.00	0.00	0.00	0.03	0.12	0.03	0.02	0.03	0.03	0.03	0.02	0.03	0.02	0.02	0.07	0.04	0.02
K	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00
Total	4.03	4.02	4.02	4.02	4.03	4.02	4.02	4.02	4.02	4.02	4.02	4.03	4.02	4.02	4.00	4.04	4.02
Mg	68.80	68.34	68.41	43.67	54.81	42.90	42.38	43.09	42.28	43.06	43.02	44.08	42.27	42.66	50.90	44.09	41.50
Fe2+	28.67	28.77	29.88	10.28	15.78	9.44	9.03	9.49	9.84	9.54	8.91	10.72	9.81	9.68	22.31	12.49	9.24
Ca	2.53	2.90	1.71	46.05	29.41	47.67	48.59	47.42	47.88	47.40	48.06	45.19	47.92	47.65	26.79	43.42	49.26

Appendix D-2 EPMA results of clinopyroxene (cont.).

pyroxene	94lipx2-1	94lipx3-1	94lipx4-1	94lipx5-1	94lipx6-1	94lipx7-1	94lipx7-1	94lipx7-1	94lipx8-1	94lipx8-2	94lipx9-1	94lipx10-1	94lipx11-1	94lipx11-2
SiO ₂	53.18	52.85	51.33	53.19	53.31	52.93	53.83	49.94	53.21	53.16	53.09	53.38	53.38	48.68
TiO ₂	0.18	0.14	0.40	0.05	0.07	0.13	0.02	1.17	0.12	0.11	0.10	0.08	0.08	1.35
Al ₂ O ₃	0.64	0.73	2.16	0.24	0.46	0.61	0.19	5.15	0.68	0.42	0.44	0.29	0.29	5.89
Fe ₂ O ₃	2.64	1.63	3.16	1.99	1.89	2.52	0.26	2.27	1.46	1.72	1.62	1.20	1.20	3.92
FeO	5.76	6.67	6.27	4.40	5.72	5.73	5.67	7.60	6.71	5.69	5.73	6.23	6.23	7.69
Cr ₂ O ₃	0.00	0.06	0.00	0.00	0.03	0.00	0.00	0.11	0.00	0.00	0.00	0.01	0.01	0.02
MnO	0.38	0.37	0.23	0.31	0.32	0.38	0.28	0.24	0.31	0.40	0.39	0.28	0.28	0.22
NiO	0.01	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MgO	14.91	14.73	14.70	14.61	14.60	14.75	14.84	14.60	14.86	14.75	14.57	14.82	14.82	15.92
CaO	22.60	22.18	21.20	24.72	23.63	22.88	24.73	16.83	22.45	23.24	23.37	23.23	23.23	12.02
Na ₂ O	0.45	0.35	0.40	0.27	0.31	0.37	0.07	1.03	0.32	0.33	0.33	0.27	0.27	1.25
K ₂ O	0.00	0.00	0.01	0.00	0.01	0.00	0.01	0.19	0.00	0.00	0.00	0.00	0.00	0.65
Total	100.75	99.71	99.87	99.80	100.36	100.30	99.88	99.13	100.12	99.81	99.64	99.78	99.78	97.61
Cation on the basis of 6 (O)														
Si	1.97	1.97	1.92	1.98	1.98	1.97	2.00	1.87	1.98	1.98	1.98	1.99	1.99	1.85
Ti	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.04
Al(IV)	0.03	0.03	0.08	0.01	0.02	0.03	0.00	0.13	0.02	0.02	0.02	0.01	0.01	0.15
Al(VI)	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.10	0.01	0.00	0.00	0.00	0.00	0.11
Fe ³⁺	0.08	0.05	0.10	0.06	0.06	0.08	0.01	0.07	0.05	0.05	0.05	0.04	0.04	0.12
Fe ²⁺	0.18	0.21	0.20	0.14	0.18	0.18	0.18	0.24	0.21	0.18	0.18	0.19	0.19	0.24
Cr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mg	0.82	0.82	0.82	0.81	0.81	0.82	0.82	0.81	0.82	0.82	0.81	0.82	0.82	0.90
Ca	0.90	0.89	0.85	0.99	0.94	0.91	0.98	0.67	0.89	0.93	0.94	0.93	0.93	0.49
Na	0.03	0.03	0.03	0.02	0.02	0.03	0.00	0.07	0.02	0.02	0.02	0.02	0.02	0.09
K	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.03
Total	4.03	4.02	4.03	4.02	4.02	4.03	4.00	4.02	4.02	4.02	4.02	4.01	4.01	4.04
Mg	43.36	42.80	43.94	41.93	41.96	42.86	41.45	47.16	42.75	42.57	42.13	42.32	42.32	55.13
Fe ²⁺	9.40	10.87	10.51	7.08	9.23	9.34	8.88	13.78	10.84	9.21	9.29	9.98	9.98	14.94
Ca	47.25	46.32	45.55	50.99	48.82	47.80	49.67	39.06	46.42	48.22	48.57	47.70	47.70	29.93

Appendix D-3 EPMA Data of Hornblende (cont.).

Quartz diorite

Hornblende	92-1hb7	87hb1-1	87hb2-1	87hb3-1	87hb4-1	87hb5-1	87hb6-1	87hb7-1	87hb8-1	87hb9-1	11hb1-1	11hb1-2	11hb2-1	11hb4-1	11hb3-1
SiO ₂	48.59	47.22	49.78	49.52	48.94	47.73	48.67	47.09	47.55	47.19	46.20	46.37	47.75	48.54	47.01
Al ₂ O ₃	5.49	7.67	5.29	5.92	5.95	7.42	6.42	8.06	7.22	7.67	8.06	7.62	6.58	6.22	7.12
Cr ₂ O ₃	0.02	0.00	0.03	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.01
TiO ₂	1.43	1.84	1.21	1.28	1.36	1.89	1.66	1.89	1.73	1.82	1.93	1.93	1.53	1.45	1.71
Fe ₂ O ₃	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FeO	13.91	12.04	12.04	11.88	12.30	12.04	11.54	12.00	11.94	11.94	12.06	11.87	11.44	11.49	11.53
MnO	0.44	0.25	0.36	0.30	0.24	0.22	0.23	0.29	0.18	0.16	0.22	0.19	0.24	0.26	0.24
MgO	14.85	15.98	16.73	17.04	16.06	15.83	16.38	15.93	16.02	15.89	15.37	15.45	16.15	16.34	15.61
CaO	11.16	11.30	11.30	11.14	11.21	11.31	11.41	11.34	11.38	11.57	11.24	11.34	11.11	11.22	11.09
Na ₂ O	1.64	1.96	1.65	1.59	2.28	1.78	2.17	2.03	1.89	1.99	2.00	1.86	1.64	1.63	1.74
K ₂ O	0.56	0.27	0.18	0.20	0.21	0.21	0.23	0.23	0.20	0.28	0.23	0.26	0.24	0.20	0.24
Total	98.06	98.52	98.57	98.86	98.55	98.46	98.72	98.84	98.11	98.50	97.31	96.89	96.69	97.36	96.30
Cation on the basis of 23 (O)															
Si	7.115	6.829	7.161	7.091	7.069	6.892	6.999	6.788	6.894	6.827	6.774	6.821	6.997	7.058	6.930
Al(IV)	0.885	1.171	0.839	0.909	0.931	1.108	1.001	1.212	1.106	1.173	1.226	1.179	1.003	0.942	1.070
Al(VI)	0.061	0.136	0.058	0.090	0.082	0.154	0.088	0.157	0.128	0.134	0.166	0.142	0.134	0.123	0.166
Cr	0.002	0.000	0.004	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.002	0.003	0.002	0.001
Ti	0.157	0.200	0.130	0.138	0.148	0.205	0.179	0.205	0.189	0.198	0.212	0.214	0.168	0.158	0.190
Fe ₃₊	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fe ₂₊	1.703	1.456	1.448	1.422	1.486	1.453	1.387	1.446	1.447	1.444	1.479	1.460	1.402	1.397	1.421
Mn	0.054	0.031	0.043	0.036	0.030	0.027	0.028	0.035	0.022	0.019	0.028	0.023	0.029	0.031	0.030
Mg	3.241	3.445	3.587	3.637	3.457	3.408	3.512	3.423	3.462	3.428	3.361	3.387	3.529	3.543	3.431
Ca	1.750	1.750	1.741	1.709	1.734	1.749	1.758	1.751	1.768	1.793	1.766	1.787	1.744	1.748	1.752
Na	0.467	0.550	0.460	0.442	0.639	0.498	0.605	0.567	0.531	0.559	0.567	0.529	0.465	0.458	0.496
K	0.104	0.049	0.033	0.036	0.039	0.039	0.043	0.042	0.038	0.051	0.044	0.048	0.045	0.037	0.046
Total	15.539	15.617	15.505	15.510	15.615	15.539	15.601	15.626	15.585	15.626	15.623	15.593	15.520	15.498	15.533

Appendix D-3 EPMA Data of Hornblende (cont.).

Diorite

Hornblende	95hb1-2	95hb1-3	95hb2-1	95hb3-1	95hb5-1	95hb5-2
SiO ₂	43.35	43.35	45.04	43.32	42.97	42.71
Al ₂ O ₃	11.33	10.99	9.39	10.60	11.80	11.79
Cr ₂ O ₃	0.02	0.00	0.03	0.00	0.09	0.03
TiO ₂	2.59	3.18	2.58	2.87	2.66	2.81
Fe ₂ O ₃	0.00	0.00	0.00	0.00	0.00	0.00
FeO	11.52	12.05	12.40	12.13	11.44	11.00
MnO	0.16	0.21	0.22	0.25	0.19	0.09
MgO	15.29	14.93	15.08	14.95	15.30	15.32
CaO	11.32	11.36	11.07	11.31	11.46	11.45
Na ₂ O	2.91	2.87	2.77	2.90	2.99	2.97
K ₂ O	0.21	0.24	0.25	0.23	0.23	0.22
Total	98.71	99.17	98.82	98.55	99.12	98.41
Cation on the basis of 23 (O)						
Si	6.298	6.289	6.543	6.330	6.225	6.220
Al(IV)	1.702	1.711	1.457	1.670	1.775	1.780
Al(VI)	0.238	0.168	0.150	0.155	0.240	0.244
Cr	0.003	0.000	0.004	0.000	0.010	0.004
Ti	0.283	0.347	0.282	0.316	0.290	0.308
Fe ³⁺	0.000	0.000	0.000	0.000	0.000	0.000
Fe ²⁺	1.399	1.462	1.506	1.481	1.385	1.340
Mn	0.020	0.026	0.027	0.031	0.023	0.011
Mg	3.312	3.229	3.265	3.257	3.305	3.326
Ca	1.763	1.766	1.723	1.770	1.778	1.786
Na	0.819	0.808	0.779	0.820	0.839	0.838
K	0.039	0.044	0.046	0.044	0.042	0.041
Total	15.876	15.850	15.781	15.874	15.913	15.899

BIOGRAPHY

Mr. Prayath Nantasin was born in January 14, 1977, at Nan province, Thailand. He graduated with a bachelor degree in Geology from the Department of Geology, Faculty of Science, Chulalongkorn University in 2001. His senior project required for completing the degree was " Quaternary Stratigraphy ; Study from Deep Borehole, Northern part of Lower Central Thailand.

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