(2) Chemical Analysis of Rock (11 samples)

The result of the chemical analysis of eleven rock samples, namely three serpentinites, four metagabbros, two metaandesites, one metaandesite and one amphibolite, and C. I. P. W. Norms calculated from the analyses are shown in the Table II-1-5.

Three Norm minerals, quartz, orthoclase and plagioclase, of seven altered mafic igneous rocks, namely two metaandesites, one metabasalt and four metagabbros, have been plotted on the Q-Kf-Pl trigonal diagram of the Fig. II-1-7. The Fig. II-1-7 shows that every rock is situated in the territory of diorite (andesite) and gabbro (basalt).

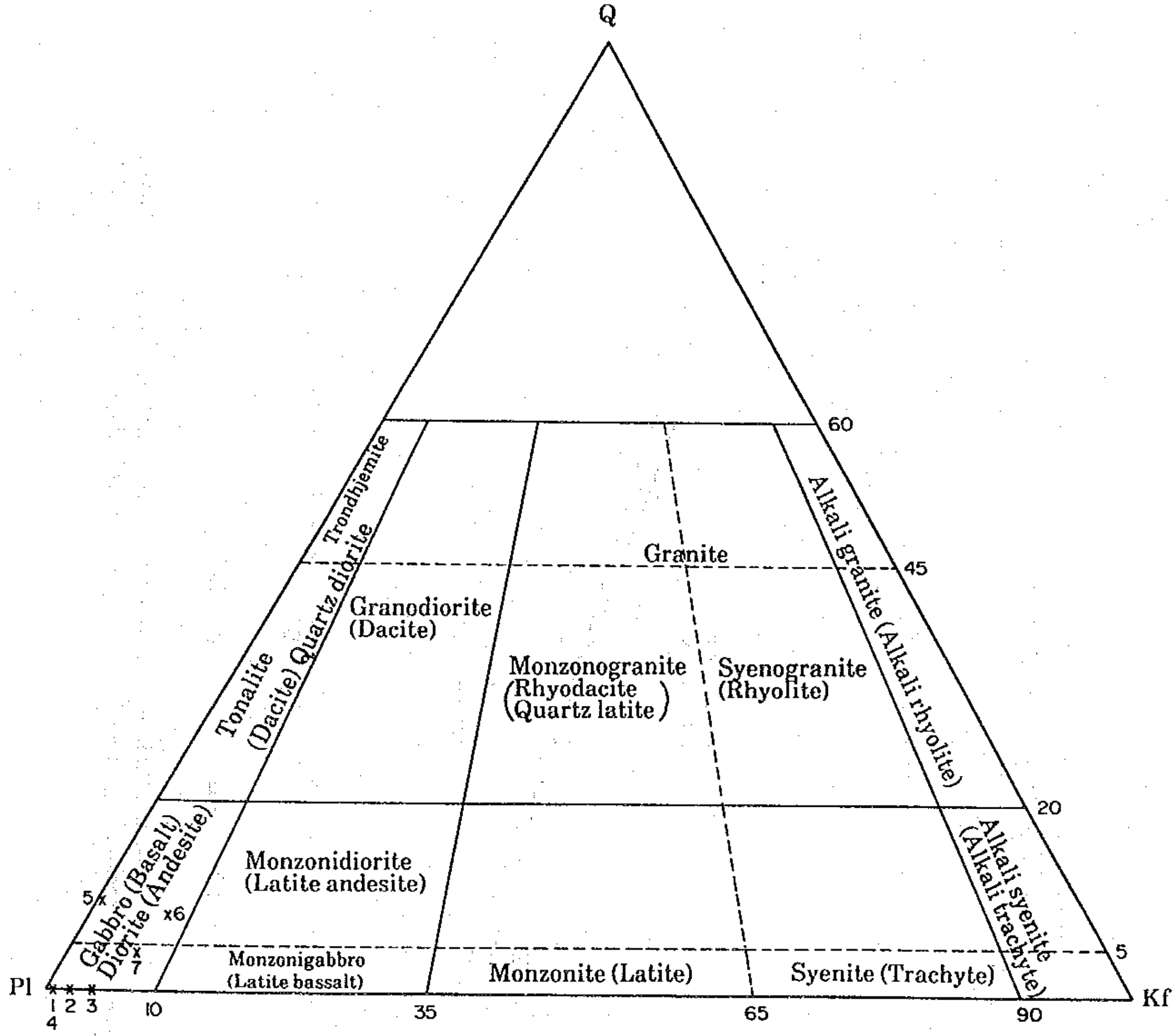
SiO_2 and Na_2O+K_2O of the analyses of two metaandesites and one metabasalt have been plotted on the Na_2O+K_2O-SiO_2 diagram of the Fig. II-1-8. The Fig. II-1-8 shows that three altered mafic volcanic rocks are situated around the boundary between alkali rock and non-alkali rock after Kuno (1966).

FeO+Fe_2O_3, Na_2O+K_2O and MgO of the same rocks have been plotted on the MFA trigonal diagram of the Fig. II-1-9. The Fig. II-1-9 shows that three altered mafic volcanic rocks belong to the calc-alkali rock series.

Table II-1-5 Assay Result and C.I.P.W. Norm of Rock Samples taken in Segama-Darvel Bay Region

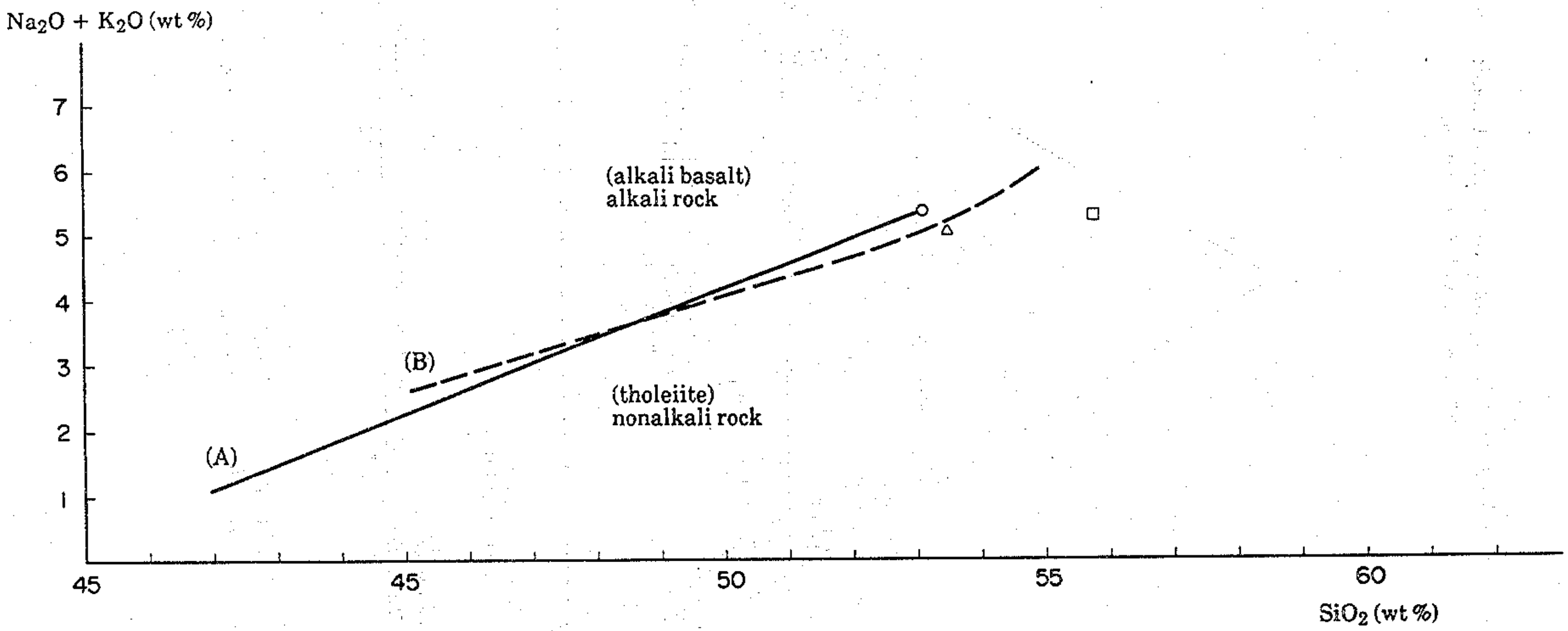
Locality	S-1	S-7	S-9	S-10	S-11	S-12	S-15	S-16	S-17	S-18	S-23
Sample Number	S-R-1-B	S-R-8-B	S-R-10-B	S-R-11-B	S-R-12-B	S-R-13-B	S-R-16-B	S-R-17-B	S-R-18-B	S-R-19-B	S-R-20-B
Rock Name	Serpentinite	Serpentinite	Metabasalt	Metagabbro	Metagabbro	Metagabbro	Serpentinite	Amphibolite	Metaandesite	Metaandesite	Metagabbro
[Major Element]											
SiO_2 %	39.61	46.71	53.05	41.30	46.15	45.66	40.30	48.51	53.47	55.78	51.30
TiO_2 %	0.02	0.02	0.72	0.96	1.54	1.44	0.03	0.95	1.35	1.07	0.67
Al_2O_3 %	0.27	0.11	15.75	19.59	16.57	14.38	1.47	15.66	15.84	15.20	18.27
Fe_2O_3 %	10.95	4.92	2.95	6.53	3.72	3.82	4.92	2.23	4.70	3.53	3.73
FeO %	0.73	2.35	5.17	6.25	7.72	7.59	2.61	7.08	6.25	5.54	5.17
MnO %	0.13	0.06	0.21	0.23	0.16	0.20	0.12	0.18	0.11	0.17	0.18
MgO %	30.54	25.59	6.99	7.50	9.02	9.34	37.97	7.20	5.72	3.67	4.57
CaO %	0.39	0.02	7.06	12.11	10.16	12.70	1.61	11.78	3.49	5.77	8.83
Na_2O %	0.33	0.31	5.33	1.68	2.52	2.11	0.02	3.12	5.01	5.05	3.50
K_2O %	0.04	0.03	0.07	0.22	0.42	0.05	<0.01	0.11	0.03	0.28	0.74
P_2O_5 %	0.04	0.03	0.09	0.31	0.20	0.06	0.03	0.18	0.18	0.16	0.25
I.L. %	15.44	11.54	1.89	2.62	1.30	2.00	10.01	2.47	3.37	3.22	2.27
Total %	98.49	91.69	99.28	99.30	99.48	99.35	99.10	99.47	99.52	99.44	99.48
[Minor Element]											
Au ppb	<1	<1	<1	<1	<1	<1	3	<1	<1	<1	<1
Ag ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Co ppm	120	74	33	46	55	51	85	39	35	30	30
Cr ppm	4,718	39,691	137	161	418	171	1,831	178	49	56	60
Cu ppm	8	6	247	112	74	45	5	47	5	42	127
Ni ppm	1,280	2,504	49	61	189	71	1,598	57	22	30	24
S %	0.047	0.027	0.047	0.310	0.189	0.191	0.057	0.068	0.026	0.116	0.056
[Norm]											
Q	-	6.727	-	-	-	-	-	-	6.180	5.467	2.719
or	0.236	0.177	0.414	1.300	2.482	0.295	0.030	0.650	0.177	5.200	4.373
ab	1.166	0.399	45.101	14.216	21.323	17.854	0.169	26.400	42.393	42.732	29.616
an	-	-	18.843	45.262	32.660	29.618	3.906	28.400	16.138	16.207	31.955
ac	1.433	1.960	-	-	-	-	-	-	-	-	-
wo-di	0.699	0.041	6.511	5.340	6.863	13.777	1.622	12.052	-	4.748	4.266
en-di	0.604	0.035	4.418	3.893	4.565	9.251	1.392	7.349	-	2.767	2.677
fs-di	0.000	0.000	1.588	0.949	1.795	3.489	0.013	4.029	-	1.757	1.326
en-hy	48.801	63.703	5.127	1.030	4.416	1.957	28.900	1.693	14.247	6.375	8.705
fs-hy	0.000	0.888	1.842	0.251	1.737	0.738	0.275	0.928	5.568	4.048	4.313
fo-ol	18.684	-	5.511	9.640	9.451	8.448	45.046	6.231	-	-	-
fa-ol	0.000	-	2.182	2.589	4.097	3.511	0.473	3.764	-	-	-
mt	2.717	6.151	4.277	9.468	5.393	5.538	7.132	3.233	6.814	5.118	5.407
hm	8.580	-	-	-	-	-	-	-	-	-	-
il	0.038	0.038	1.367	1.823	2.925	2.735	0.057	1.804	2.564	2.032	1.272
ap	0.093	-	0.209	0.718	0.463	0.139	0.070	0.417	0.417	0.371	0.579
c	-	-	-	-	-	-	-	-	0.177	-	-
Total	83.050	80.120	97.390	96.480	98.170	97.350	89.085	96.950	96.150	96.820	97.210

Figure II-1-7 Q-Kf-Pl Triangle Diagram of Basic Rock
in Segama-Darvel Bay Region



1: S-R-10-B, 2: S-R-11-B, 3: S-R-12-B, 4: S-R-13-B
5: S-R-18-B, 6: S-R-19-B, 7: S-R-20-B, ( ): volcanic rocks

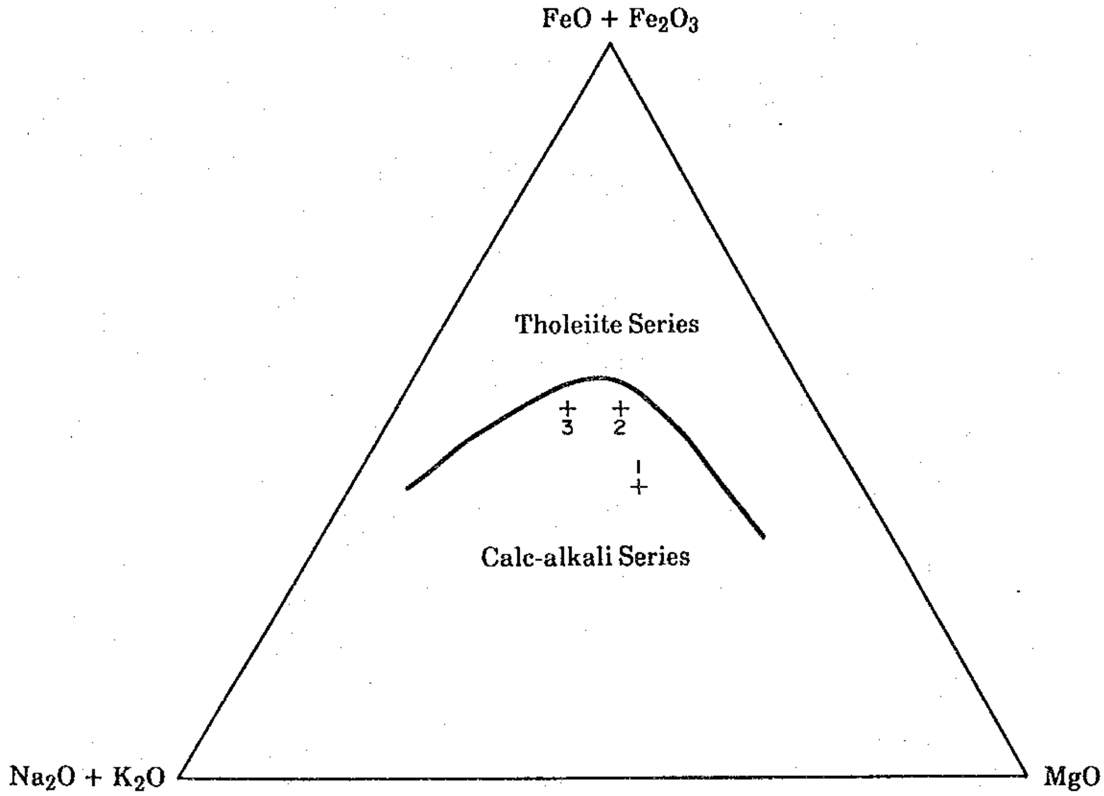
Figure II-1-8 $Na_2O + K_2O - SiO_2$ Diagram of Basic Volcanic Rock in Segama-Darvel Bay Region



○ : S-R-10-B, △ : S-R-18-B □ : S-R-19-B

(A) Boundary line between alkali basalt and tholeiite in Hawaii after Macdonald and Katsura (1964)
(B) Boundary line between alkali rock and nonalkali rock of volcanic rock in Japan after Kuno (1966)

Figure II-1-9 FeO + Fe_2O_3 - Na_2O + K_2O - MgO Trigonal Diagram (MFA Diagram) of Altered Mafic Volcanic Rock in Segama-Darvel Bay Region



1: S-R-10-B, 2: S-R-18-B, 3: S-R-19-B

Solid line is boundary between tholeiite series and calc-alkali series after Irvine and Barager (1971)

(3) Microscopic Observation of Thin Section of Rock (11 samples)

The thin sections made from eleven same rock samples as analyzed chemically were observed microscopically. The result of the observation is shown in the Table II-1-6.

Table II-1-6 Result of Microscopic Observation of Thin Sections of Rock Samples taken in Segama-Darvel Bay Region

Locality	S-1	S-7	S-9	S-10	S-11	S-12	S-15	S-16	S-17	S-18	S-23
Sample Number	S-T-1	S-T-8	S-T-10	S-T-11	S-T-12	S-T-13	S-T-16	S-T-17	S-T-18	S-T-19	S-T-20
Rock Name	Serpentinite	Serpentinite	Metabasalt	Metagabbro	Metagabbro	Metagabbro	Serpentinite	Amphibolite	Metaandesite	Metaandesite	Metagabbro
Texture	mesh	mesh	decussate	hypidiomorphic	hypidiomorphic	granoblastic	mesh	granoblastic	aphyric	aphyric	hypidiomorphic
[Primary Minerals]											
Plagioclase				◎	◎	◎		○	◎	◎	◎
Quartz											
Olivine							△				
Orthopyroxene					○						
Clinopyroxene	•				○	○	△				
Hornblende				◎		◎					
Others											
[Metamorphic or Alteration Minerals]											
Plagioclase			◎								
Quartz				△	△	○			○	○	△
Hornblende					◎			◎			
Cummingtonite				○							○
Actinolite			◎	○	△						○
Epidote			○	○		○		△	○	◎	△
Chlorite			○		△	○			◎	◎	○
Serpentine	◎	◎					◎			△	
Calcite	•							△		○	△
Tremolite						○		○			
Sericite								△			○
Others		△*			△*						
[Accessary Minerals]											
Opaque				○	○	○	△		△	△	△
Sphene			○				○	◎	△		△
Chromite		△	○								
Hematite		△	△								•
Others											
[Remarks]		* Brucite	metamor-phosed mafic rock		* Talc		serpentinised wehrlite		aphyric metaandesite	aphyric metaandesite	

[Notes] ◎: Abundant, ○: Medium, △: Little, •: Trace

(4) Chemical Analysis of Ore (10 samples)

The assay result of ten ore samples is shown in the Table II-1-8 in the section 1-4 mentioned below.

(5) Microscopic Observation of Polished Section of Ore (10 samples)

The polished sections made from ten same ore samples as analyzed chemically were observed microscopically. The result of the observation is shown in the Table II-1-7. As shown in the Table II-1-7, ore mineral of chromite orebody at five localities of mineral occurrence is chromite. Ore minerals of the Cyprus type cupriferous iron sulfide ore consist of middle amount of malachite, a little chalcocite and trace chalcopyrite at the S-9 locality and trace chalcopyrite, chalcocite, covelline and pyrite at the S-21 locality.

Table II-1-7 Result of Microscopic Observation of Polished Sections of Ore Samples taken in Segama-Darvel Bay Region

Locality	Sample No.	Occurrence	Chalcopyrite	Chalcocite	Covellite	Sphalerite	Galena	Pyrite	Pyrrhotite	Malachite	Hematite	Goethite	Chromite	Gangue	Remarks
S-1	S-P-1	Chromite ore						•					◎	◎	Pyrite inclusion in chromite
S-5	S-P-3	Foliated chromite ore				•		•					◎	◎	
S-5	S-P-4	Chromite ore							•				◎	◎	Pyrrhotite veinlets in chromite
S-6	S-P-5	Massive chromite ore											◎	○	
S-6	S-P-6	Banded chromite ore											○	◎	
S-7	S-P-7	Massive chromite ore											◎	○	
S-7	S-P-8	Banded chromite ore											○	◎	
S-8	S-P-9	Foliated chromite ore							•				◎	◎	Pyrrhotite veinlets in chromite
S-9	S-P-10	(Oxidized) chalcopyrite dissemination	•	●						○				◎	
S-21	S-P-13	(Chalcopyrite)-quartz vein	•	•	•			•						◎ Q	Q: Quartz

[Notes]

◎: Abundant, ○: Medium, ●: Little, •: Trace

1-4 Assay Result of Ore

The assay result of ten ore samples taken at seven localities of mineral occurrence in the Silam area and on the small islands in the Darvel Bay in the Segama-Darvel Bay region is shown in the Table II-1-8.

The sample (S-O-10-A) taken from the Cyprus type cupriferous sulfide ore embedded in spilite of the Chert-Spilite Formation at the S-9 locality in the small island near the Silam harbour is composed of malachite, azurite, chalcocite, quartz, calcite and limonite and contains 6.54% of copper. However, the ore body at the outcrop is lenticular in shape and is extremely small in scale, 80 centimeters long and 7 centimeters wide.

Table II-1-8 List of Assay Result of Ore Samples taken in Segama-Darvel Bay Region

Locality	Sample Number	Au ppb	Ag ppm	Co ppm	Cr %	Cu ppm	Fe %	Ni ppm	Pd ppb	Pt ppb	S %	Pb ppm	Zn ppm	Occurrence of ore
S-1	S-O-1-B	<2	0.2	47	29.07	24	10.67	1,042	<2	10	0.022	-	-	massive chromite in serpentised ultramafic rock
S-5	S-O-3-B	<2	0.3	30	22.97	16	10.00	1,003	<2	10	0.018	-	-	foliated chromite in serpentised ultramafic rock
"	S-O-4-B	<2	0.2	38	21.96	50	13.86	672	<2	<5	0.021	-	-	massive chromite in serpentised ultramafic rock
S-6	S-O-5-B	<2	<0.1	39	31.60	19	9.96	730	<2	5	0.015	-	-	massive chromite in serpentised ultramafic rock
"	S-O-6-B	<2	<0.1	35	21.37	8	7.99	1,239	2	<5	0.024	-	-	banded chromite in serpentised ultramafic rock
S-7	S-O-7-B	<2	<0.1	40	32.42	12	9.72	826	<2	<5	0.016	-	-	massive chromite in serpentised ultramafic rock
"	S-O-8-B	<2	0.2	33	19.32	7	7.53	1,774	2	10	0.021	-	-	banded chromite in serpentised ultramafic rock
S-8	S-O-9-B	<2	0.4	33	22.19	10	8.63	1,116	2	<5	0.024	-	-	foliated chromite in serpentised ultramafic rock
S-9	S-O-10-A	<0.01 g/t	<0.1	-	-	65,443	-	-	-	-	0.054	10	561	mal · az · qz · cal · cc-lens in spilite
S-21	S-O-13-A	<0.01 g/t	<0.1	-	-	1,535	-	-	-	-	0.288	3	28	py-cp-mal-bearing quartz vein in spilite

Abbreviations; mal: malachite, az: azurite, qz: quartz, cal: calcite, lim: limonite, py: pyrite, cp: chalcopyrite, cc: chalcocite

1-5 Consideration

As both chromite orebodies emplaced in serpentinized ultramafic rock and orebodies, which are embedded in spilite of Chert-Spilite Formation and seem to be the indication of stockwork deposit accompanying, in general, Cyprus type cupriferous massive iron sulfide deposit upwards, are small in scale and are situated in the small islands, it is concluded that no further exploration in the small island for both ore bodies are recommended.

However, as four localities of mineral occurrence in the unnamed small island to the south of the Silam harbour seem to be the indication of stockwork deposit accompanying, in general, Cyprus type cupriferous massive iron sulfide deposit upwards, it seems that there is a possibility of the emplacement of Cyprus type cupriferous massive iron sulfide deposit in the area where spilite of Chert-Spilite Formation is distributed in the Silam area.

CHAPTER 2 SEMPORNA REGION

2-1 Contents of the Survey

2-1-1 Investigation of Locality of Mineral Occurrence

The localities of mineral occurrence of epithermal gold-sulfide-limonite-secondary hematite-bearing quartz veins and networks, which are embedded in acidic to intermediate volcanic and pyroclastic rocks of Pliocene in age and are thought to be typical mineralization in the Semporna Peninsula region, in the Mantri, Wullersdorf, Pock and Nagos areas were investigated in order to understand geology, mineralization and hydrothermal alteration at the localities of mineral occurrence in the Semporna Peninsula region and then to clarify the characteristic of mineralization and hydrothermal alteration in the region. The investigated localities of mineral occurrence were forty-six in total, namely 19 in Mantri, 4 in Wullersdorf, 9 in Pock and 14 in Nagos area.

The locations of mineral occurrence investigated in Mantri, Wullersdorf, Pock and Nagos areas are shown in Fig. II-2-1, Fig. II-2-2, Fig. II-2-3 and Fig. II-2-4 attached at the end of this report respectively.

2-1-2 Sampling

Samples of ore, hydrothermally altered host rock, and quartz at each locality of mineral occurrence investigated and unaltered typical rock in the above-mentioned four areas were taken for the purpose of conducting the following experiments, microscopic observations and chemical analyses to understand mineralization and hydrothermal alteration at the localities of mineral occurrence and geology at and around the localities of mineral occurrence in the Semporna Peninsula region.

The contents of the samples taken are as follows and details are shown in the Table II-2-1. The locations of the samples are shown in Fig. II-2-5 and Fig. II-2-6 attached at the end of this report.

(1) Samples of Rock for Age Determination by Means of K-Ar Method (16 samples)

Sixteen samples of rock in total, namely one sample of trachy andesite, two samples of andesitic tuff, two sample of andesite, one sample of basalt, one sample of porphyrite and one sample of strongly silicified rock in Mantri and Wullersdorf areas and six samples of andesite, one sample of diorite and one sample of porphyrite, were taken in order to determine the age of volcanic and pyroclastic rocks of Pliocene to Quaternary time widely distributed in the Semporna Peninsula region.

(2) Samples of Rock for Chemical Analysis (29 samples)

Twenty-nine samples in total, namely sixteen samples taken from the same locality as the samples for age determination and thirteen samples of hydrothermally altered host rock at and around the localities of mineral occurrence, three in Mantri, three in Wullersdorf, five in Pock and two in Nagos area, were obtained for chemical analysis.

(3) Samples of Rock for Thin Section (29 samples)

Twenty-nine samples were taken from the same localities as the samples for chemical analysis.

(4) Samples of Ore for Chemical Analysis (40 samples)

Forty samples of gold-sulfide-limonite-secondary hematite-bearing quartz veins and networks were taken at forty localities of mineral occurrence, namely nineteen in Mantri, four in Wullersdorf, seven out of nine in Pock and ten out of fourteen in Nagos area, out of forty-six localities of mineral occurrence investigated.

(5) Samples of Ore for Polished Section (20 samples)

Typical twenty samples of ore, namely seven in Mantri, four in Wullersdorf, five in Pock and four in Nagos area, out of forty ore samples for chemical analysis were obtained at the same localities as the samples for chemical analysis.

(6) Samples of Hydrothermally altered Rock for X-ray Diffraction Examination (40 samples)

Forty samples of hydrothermally altered rock in total, namely eleven samples of hydrothermally altered host rock at eleven localities of mineral occurrence and seven samples of hydrothermally altered rock in the Mantri area, three samples of hydrothermally altered host rock at three localities of mineral occurrence in the Wullersdorf area, six samples of hydrothermally altered host rock at six localities of mineral occurrence, two samples of hydrothermally altered rock around the localities of mineral occurrence, one sample of porphyrite and one sample of andesite in the Pock area, and seven samples of hydrothermally altered host rock at seven localities of mineral occurrence and one sample of hydrothermally altered rock in the Nagos area, were taken for X-ray diffraction examination.

(7) Samples of Quartz for Fluid Inclusion Examination (20 samples)

Twenty samples of transparent to semitransparent and crystalline quartz which is said to include many fluid inclusions in general were obtained from gold-sulfide-limonite-secondary hematite-bearing quartz veins at the twenty localities of mineral occurrence out of forty-six localities investigated, namely thirteen localities out of nineteen in the Mantri area, one locality out of four in the Wullersdorf area, three localities out of nine in the Pock area and three localities out of fourteen in the Nagos area, in order to measure homogenization temperature of the fluid inclusions in quartz.

(8) Typical Samples of Rock and Ore for Specimen (28 samples)

Twenty-eight typical samples of rock and ore, namely six samples of andesite, one sample of trachy andesite, two samples of andesitic tuff, three samples of porphyrite, one sample of strongly silicified rock, three samples of hydrothermally altered host rock, eleven samples of gold-sulfide-limonite-secondary hematite-bearing quartz veins and one sample of quartz in quartz vein, out of 194 samples taken for the above-mentioned examinations, microscopic observations and chemical analyses, were obtained at the same localities as the above-mentioned samples.

Table II-2-1 List of Samples taken in the Semporna Peninsula Region

Location	Analysis of Rock	Thin Section	Dating	Analysis of Ore	Polished Section	X-ray Diffraction	Fluid Inclusion	Specimen
M-1	M-R-1-A	M-T-1		M-O-1-A		M-X-1	M-Q-1	
M-2						M-X-2		
M-3				M-O-3-A	M-P-1	M-X-3		
M-4				M-O-4-A		M-X-4		
M-5						M-X-5		
M-6				M-O-5-A	M-P-2		M-Q-3	M-Q-3-S
M-7						M-X-6		
M-8				M-O-6-A				
M-9						M-X-7		
M-9'	M-R-2-A	M-T-5				M-X-8		
M-10	M-R-3-A	M-T-6		M-O-7-A	M-P-3	M-X-9	M-Q-4	M-O-7-A-S
M-11	M-R-5-A	M-T-8	M-D-1					M-D-1-S
M-12	M-R-6-A	M-T-9	M-D-2					M-D-2-S
M-13	M-R-7-A	M-T-10	M-D-3					
M-14	M-R-8-A	M-T-11	M-D-4					M-D-4-S
M-15	M-R-9-A	M-T-12	M-D-5					
M-16				M-O-8-A	M-P-4	M-X-10	M-Q-5	
M-17	M-R-10-A	M-T-14	M-D-6			M-X-11		M-D-6-S
M-18				M-O-9-A		M-X-12	M-Q-6	M-O-9-A-S
M-19				M-O-10-A				
M-20				M-O-11-A			M-Q-8	
M-21				M-O-12-A		M-X-13	M-Q-9	
M-22				M-O-13-A				
M-23				M-O-14-A		M-X-14	M-Q-10	
M-24				M-O-15-A	M-P-5			
M-25				M-O-16-A		M-X-15	M-Q-12	
M-26				M-O-17-A			M-Q-13	
M-27				M-O-18-A		M-X-17	M-Q-14	
M-28				M-O-19-A	M-P-6		M-Q-15	
M-29				M-O-20-A	M-P-7	M-X-16	M-Q-16	
M-30	M-R-11-A	M-T-15	M-D-7					M-D-7-S
M-31						M-X-19		
Sub Total	10	10	7	19	7	18	13	8

Location	Analysis of Rock	Thin Section	Dating	Analysis of Ore	Polished Section	X-ray Diffraction	Fluid Inclusion	Specimen
W-1				W-O-1-A	W-P-1	W-X-1		
W-3	W-R-2-A	W-T-2		W-O-2-A	W-P-2	W-X-3		W-R-2-A-S
W-4	W-R-3-A	W-T-3		W-O-3-A	W-P-3	W-X-4		W-O-3-A-S
W-8	W-R-5-A	W-T-5	W-D-1					W-R-5-A-S
W-11				W-O-5-A	W-P-4		W-Q-2	W-O-5-A-S
W-12	W-R-8-A	W-T-8				W-X-9		W-R-8-A-S
Sub Total	4	4	1	4	4	4	1	5
P-1	P-R-1-A	P-T-1	P-D-1			P-X-1		P-D-1-S
P-2	P-R-2-A	P-T-2	P-D-2					
P-3	P-R-3-A	P-T-3	P-D-3			P-X-3		P-D-3-S
P-4	P-R-4-A	P-T-4	P-D-4					P-D-4-S
P-5	P-R-5-A	P-T-5	P-D-5					P-D-5-S
P-6	P-R-6-A	P-T-6	P-D-6					
P-7	P-R-7-A	P-T-7	P-D-7					P-D-7-S
P-9	P-R-9-A	P-T-9	P-D-8					
P-10				P-O-1-A	P-P-1	P-X-6		P-O-1-A-S
P-12	P-R-11-A	P-T-11				P-X-8		
P-13	P-R-12-A	P-T-12		P-O-2-A	P-P-2	P-X-9		P-R-12-A-2 P-O-2-A-S
P-14				P-O-3-A	P-P-3	P-X-10	P-Q-2	P-O-3-A-S
P-17	P-R-13-A	P-T-13						
P-19	P-R-14-A	P-T-14				P-X-15		P-R-14-A-S
P-20	P-R-15-A	P-T-15		P-O-6-A	P-P-5	P-X-16		P-O-6-A-S
P-21				P-O-7-A	P-P-6	P-X-17	P-Q-4	
P-22				P-O-8-A		P-X-18	P-Q-5	
P-23				P-O-9-A				
Sub Total	13	13	8	7	5	10	3	11

Location	Analysis of Rock	Thin Section	Dating	Analysis of Ore	Polished Section	X-ray Diffraction	Fluid Inclusion	Specimen
N-1				N-O-1-A		N-X-1		N-O-1-A-S
N-2				N-O-2-A	N-P-1	N-X-2		
N-3				N-O-3-A	N-P-2	N-X-3	N-Q-2	N-O-3-A-S
N-4				N-O-4-A	N-P-3	N-X-4		
N-5				N-O-5-A		N-X-5		
N-8				N-O-8-A	N-P-4		N-Q-4	
N-9				N-O-9-A		N-X-9		
N-10	N-R-2-A	N-T-2		N-O-10-A		N-X-10		
N-11				N-O-11-A			N-Q-7	N-O-11-A-S
N-12				N-O-12-A				
N-15	N-R-1-A	N-T-4				N-X-15		N-R-1-A-S
Sub Total	2	2	-	10	4	8	3	4
Total	29	29	16	40	20	40	20	28

Abbreviations; M: Mantri, W: Wullersdorf, P: Pock, N: Nagos

2-2 Geology

2-2-1 Wullersdorf Area

(1) Stratigraphy

The stratigraphy of the area is summarised in Table II-2-2 and the geology in Fig. II-2-7. The oldest rocks are tuff, shale, tuffite, mudstone, conglomerate, and limestone of the Kalumpang Formation. These rocks were deposited in a shallow to neritic marine environment in lower to middle Miocene (Te-Tf_1) times. Limestone was accumulated in shoal areas. Deposition of the sediments alternated with pyroclastic deposition. During the mid-Miocene, the rocks of the Kalumpang Formation were strongly folded and faulted.

The Balung Formation, comprising of volcanic ash, shale, mudstone, and tuff, was probably deposited in the middle to upper Miocene (Tf_{2-3}) just after the period of strong earth movements that affected the Kalumpang Formation. The volcanic ash and tuff were derived from eruptions from nearby volcanoes. The rocks of the Balung Formation were deposited in a paralic marine environment with fluctuations from nearshore shallow water to swamp conditions.

Volcanic activity in the Pliocene resulted in eruption of predominantly andesitic lavas and pyroclastics followed by dacitic lavas and pyroclastics. During this volcanic activity, stocks and dykes of microgranodiorite porphyry and microdiorite porphyry intruded into the volcanic rocks and the surrounding sediments.

Towards late Pliocene and early Quaternary times, uplift, faulting and erosion took place causing the volcanoes to be deeply dissected, and the formation of areas of low relief between them. Volcanic activity recurred during the period with eruptions of dacite from Gunung Maria.

Volcanic activity began again during the late Quaternary with the eruptions of hypersthene andesite and olivine basalt from Bukit Quoin causing local changes in the drainage.

(2) Volcanic Rocks

During the middle Pliocene to late Quaternary, large volumes of andesitic and dacitic lavas and pyroclastics, and basalt were erupted from Gunung Magdalena and Gunung Maria to the northwest of the area, Gunung Wullersdorf, Bukit Muul, and Bukit Quoin. These volcanic rocks form part of the calc-alkaline basalt-andesite-dacite association of the Semporna Peninsula and are a southwest continuation of the volcanic belt in the Philippines extending from Mindanao through the Sulu Archipelago.

The earlier eruptions in the Pliocene were of the explosive type. The oldest volcanic rocks in the Wullersdorf area appear to be andesites erupted from Gunung Magdalena, probably in the Pliocene, followed by eruptions of dacitic lavas and pyroclastics from Gunung Wullersdorf. The dacites in the Gunung Maria area were probably erupted in the early Quaternary, and olivine basalt from Bukit Quoin in the late Quaternary.

(3) Intrusive Rocks

Volcanism during the Pliocene was accompanied by the intrusion of microdiorite porphyry and microgranodiorite porphyry stocks and dykes into the folded formations and the overlying volcanic rocks. The stocks form low conical hills and are apparently characterised by an absence of contact metamorphism although the dykes that intruded the Kalumpang Formation baked rocks adjacent to that unit.

Microgranodiorite porphyry forms a stock, less than 1 km^2, at Bukit Bald; other outcrops form hills south of Bukit Quoin and southeast of Bukit Bald, and a small intrusion occurs near Milestone 12, Apas Road.

The microgranodiorite porphyry is a grey rock composed of phenocrysts of hornblende, biotite, and plagioclase in a microcrystalline groundmass. Inclusions (up to 10 cm) of greenish-black, fine-grained basic rock are common in the microgranodiorite porphyry at Bukit Bald.

Microdiorite porphyry forms a stock at Bukit Kawa at the top of which the outcrops are characterised by closely-spaced (0.5 to 1 cm) sheet joints. The rock weathers to yellowish-brown, brown or brownish-red soil.

The rock is porphyritic and contains augite, plagioclase and hypersthene phenocrysts.

Dykes of microdiorite porphyry intruding the Kalumpang Formation and dacitic rocks occur in the upper reaches of Sungai Tundong and the tributaries of Sungai Pang Burong. These dykes occur near the contact between the Kalumpang Formation and the dacitic rocks. They have a north to northeasterly trend and are most probably fault-controlled.

The typical dyke rock is greyish-green, dense, and hard with phenocrysts of plagiocalse and black mafic minerals. Green altered mafic phenocrysts are common.

The intrusion of the microgranodiorite porphyry and the microdiorite porphyry probably accompanied the Pliocene volcanism. The microdiorite porphyry dykes intruded the Kalumpang Formation and dacitic rocks. The field relationship of the microgranodiorite porphyry and microdiorite porphyry stocks is not clear but it appears that they intruded into the andesites.

(4) Structure

The Wullersdorf area was affected by a period of strong earth movements during the middle Miocene that affected the Kalumpang Formation. The Balung Formation, which was deposited just after this period of earth movements, strikes northwest to north and dips gently to the southwest and west. Faults in the dacite and silicified volcanic rocks trend northwest and northeast.

The marine sediments and interbedded volcanic rocks of the Kalumpang Formation were believed to be deposited along the southern end of a geosynclinal belt extending through central and eastern Sabah. Strong earth movements during the middle Miocene have folded and faulted the Kalumpang Formation. The major fold structures in the Kalumpang Formation are dominantly towards the west and southwest.

The calc-alkaline basalt-andesite-dacite association in the Semporna Peninsula is a southwesterly extension of the volcanic belt of the Philippines extending from Mindanao through the Sulu Archipelago. This volcanic belt continues further to the southwest through central Kalimantan and eastern Sarawak. The andesite and dacite volcanic centres are aligned east-west along the spine of the Peninsula.

The distribution of Quaternary basaltic lavas in the Mostyn area is elongated in the northwest-southeast direction which is also the trend of centres of eruption. The basaltic lavas appear to have been erupted along fissures which are possibly reactived along northwest-southeast trending faults or fracture zones. The Quaternary basaltic lavas in the Tawau area were erupted from three small cones (Bukit Tiger, Bukit Middle, and Gunung Bombalai) which are also aligned northwest-southeast. In the Wullersdorf area, basaltic lavas were erupted from a single volcano, Bukit Quoin.

(5) Geological History

A) Miocene (Te_5-Tf_3)

The Wullersdorf area was part of a geosynclinal belt during lower to middle Miocene (Te_5-Tf) time. A neritic environment predominated and limestones accumulated in shoal areas. Deposition of the Kalumpang Formation was dominated by the influx of basaltic and dacitic volcanic detritus.

Earth movements that intensely folded and faulted the Kalumpang Formation may have occurred immediately after the deposition of that unit as the unconformably overlying Balung Formation is of Tf_{2-3} age.

Deposition recommenced in Tf_{2-3} time when ash, probably derived from a volcano sited at Gunung Wullersdorf, together with mudstone, shale and tuff accumulated in the surrounding shallow sea and coastal swamps (Balung Formation).

B) Pliocene (Tgh)

Extensive volcanic activity recommenced in the Pliocene and continued into early Quaternary times. The first eruption were predominantly of andesitic lava and pyroclastics from Gunung Magdalena and Gunung Andrassy to the west of the area. These were accompanied by eruptions of dacitic lava and pyroclastics from Gunung Wullersdorf. At the same time, stock and dykes of microgranodiorite and microdiorite were intruded into the volcanic rocks and the surrounding sediments.

Towards late Pliocene and early Quaternary, uplift, faulting and erosion took place.

C) Quaternary

By early Quaternary times, erosion had deeply dissected the earlier volcanic rocks and formed areas of low relief between the volcanoes. Sea level then was probably 70 to 100 m higher than at present.

Volcanic activity recommenced and explosive eruptions of dacite occurred in the Gunung Maria area to the west of the area.

During late Quaternary, hypersthene andesite followed by olivine basalt were erupted from Bukit Quoin. The basaltic lavas flowed along valleys in the older volcanic rocks and caused a change in the drainage system of Sungai Balung and the formation of lake-bed alluvium. (Taken from "Wullersdorf Area, Sabah", Report 15, Geological Survey of Malaysia, 1981)

Table II-2-2 Stratigraphy of the Wullersdorf Area

AGE	TERTIARY LETTER CLASSIFICATION (after Adams,1970)	SEDIMENTARY-VOLCANIC ROCKS	IGNEOUS ROCKS AND ACTIVITY	PALAEOGEOGRAPHY AND DIASTROPHISM
HOLOCENE		RECENT ALLUVIUM: Coastal and fluviatile alluvium—clay, mud, silt, sand, gravel and plant remains.	Siliceous sinter deposited by hot spring.	Recession of sea level and emergence of land along the coast.
PLEISTOCENE		HIGH LEVEL ALLUVIUM AND INLAND VALLEY DEPOSITS: Mainly tuffaceous with gravel, sand, silt and clay.	Olivine basalt Hypersthene andesite Dacitic lava from Gunung Maria Eruption of dacitic lava and pyroclastics from Gunung Wullersdorf and associated intrusion of micrognanodiorite porphyry. Eruption of andesitic lava and pyroclastics from Gunung Magdalena and associated intrusion of microdiorite porphyry.	Uplift, faulting and erosion
PLIOCENE	Tgh	NO KNOWN SEDIMENTS OF THIS AGE		
UPPER MIOCENE	Tf_3	BALUNG FORMATION: Volcanic ash, shale, tuff, mudstone and coaly beds.	Volcanic activity associated with the Balung Formation	Deposition in paralic environment with fluctuations from nearshore shallow water to swamp conditions
MIDDLE MIOCENE	Tf_{1-2}			Strong folding and faulting
LOWER MIOCENE	Te_5	KALUMPANG FORMATION: Tuffite, tuff, shale, mudstone, tuffaceous sandstone, conglomerate and limestone	Volcanic activity associated with the Kalumpang Formation	Deposition in a neritic environment. Limestone deposition on shoal areas
UPPER OLIGOCENE	Te_{1-4}			

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(Taken from "Wullersdorf Area, Sabah", Report 15, Geological Survey of Malaysia, 1981)

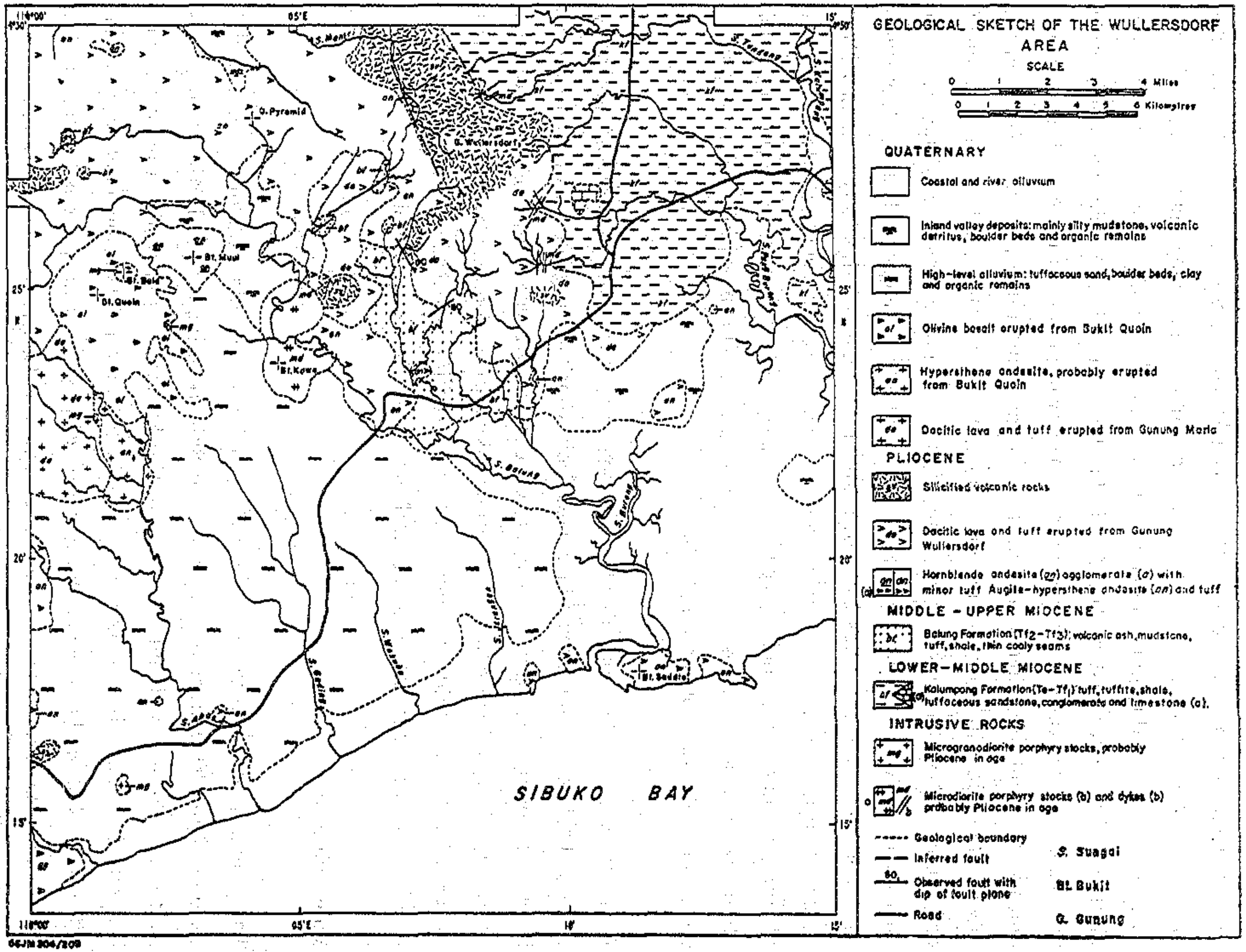


Figure II-2-7 Geological Sketch Map of the Wullersdorf Area

(Taken from "Wullersdorf Area, Sabah", Report 15, Geological Survey of Malaysia, 1981)

2-2-2 Pock Area

(1) Stratigraphy

The stratigraphy of the Gunung Pock area is summarised in Table II-2-3. The oldest exposed rocks are the folded sandstone, siltstone, mudstone, tuff and tuffite of the Kalumpang Formation of Miocene age. The rocks crop out mainly in the northwest at the foothills of Gunung Pock. The overlying rocks are basalt, andesite, dacite and pyroclastics which form the rugged hills in the central and southern part of the area. Andesitic agglomerates are found on the lower volcanic hill slopes and are thought to be the product of the early eruptions. Basalts which form the hills in the northwest and underlie the northern foothills of Gunung Pock, are thought to succeed the agglomerate, which is followed by andesitic flows and tuff forming the lower parts of the volcanic hills. Dacitic materials were the last to be erupted, and are found capping several hills and ridges. The main volcanic activity probably took place during late Miocene to Pliocene, the early part of which probably occurred under submarine conditions.

A microgranitic intrusion, about 6 km long and 3 km wide, occurs just southeast of Gunung Pock. The intrusion varies from dioritic to granitic in composition. It was probably intruded into a minor caldera at the close of the volcanic activity. Many intermediate and acidic dikes are associated with the intrusion. Late-stage acidic fluids invaded both the intrusion and the volcanics, resulting in extensive propylitisation and silicification along fracture zones.

(2) Volcanic Rocks

The Gunung Pock volcanoes form part of a Cenozoic volcanic chain which extends from Tawau in the west to the Sulu Archipelago and Mindanao in the east (Fig. II-2-8). Volcanic activity in the Semporna Peninsula started at least in early Miocene time, coinciding with the Miocene tectonic movements that affected Sabah and Sarawak. Volcanic ejectamenta from various centres in the Peninsula were laid down in the sea together with the marine sediments which form the Kalumpang Formation. Volcanism reached its peak intensity in the Pliocene and continued through its waning stages to Quaternary, resulting in large quantities of basalt, andesite, and dacite flows and pyroclastics being erupted from several centres-Gunung Magdalena, Gunung Wullersdorf, Gunung

Pock, and Pulau Gaya. The last volcanic activity in the Peninsula took place in the late Quaternary when extensive olivine basalt and andesite lavas were erupted at Mostyn and Tawau. No late Quaternary volcanics were, however, identified in the Gunung Pock area.

(3) Intrusive Rocks

The intrusive rocks in the area consist of microgranite, aplite and lamprophyre dykes of Pliocene age. They occupy the central part of the area and have a total surface outcrop of about 10 square kilometres. The intrusive rocks cut the volcanic pile in the Gunung Pock area.

The term 'Gunung Pock Microgranite' is introduced here for a microgranite intrusion exposed in the central part of the area. The outcrop is oblong in plan, about 4 km long and 2.5 km wide. It occupies a flat upland bordered by steep volcanic ridges on three sides. Small microgranite bodies, ten to several hundred metres across, are found in the immediate surroundings.

A porphyritic chilled zone occurs at the contact with the volcanic rocks in the northern and eastern parts of the intrusion. Apart from the chilled zone there appears to be no distinct zoning within the microgranite body. Exposures found in the western part of the intrusion are more basic and richer in hornblende as a result of contamination of the magma by the basic volcanic rocks, whereas those to the east are more acidic. The centre of the intrusion is mainly granitic in composition, generally coarser grained, both porphyritic and non-porphyritic, whereas towards the margin the rock is finer-grained, porphyritic, and has numerous xenoliths.

All features observed in outcrops indicate that only the top part of the main intrusion is exposed by erosion. The river systems that cut the intrusion are all very young and have not cut deep into microgranite. This probably explains the overall fine-grained nature despite the size of the intrusion.

(4) Structure

The Gunung Pock area has been affected by folding and faulting in the Middle Miocene, and faulting and uplift in the Pliocene and Quaternary. The Mid-Miocene folding affected the strata of the Kalumpang Formation whereas subsequent faulting and uplifts affected all the rocks and the Quaternary alluvium in the Gunung Pock area.

The Kalumpang Formation in the whole Semporna Peninsula is intensively folded and faulted. Tight folds are seen along the middle course of the Kalumpang River as well as along the first northern tributary of Sungai Timbangan. The fold axes generally trend east-west to southeast. Contorted beds are also seen along a logging road just north of the area, as well as along a logging track on the western slope of Gunung Pock where the strata dip steeply towards the north. Minor faults and shearing are observed in the formation.

The volcanic rocks are fractured, jointed and sheared, and therefore are deeply weathered in places. Some fractures may be filled by quartz veins. Minor faults have also been observed in some outcrops. Columnar joints are well developed in andesite at Milestone 52, and brecciation of dacite is seen in an outcrop at the Sungai Timbangan dam site.

The microgranite body is well jointed and strongly sheared in places. Five sets of joints are apparent, three of which are prominent and occur in most outcrops. Two of the most prominent sets strike roughly north-south and north-northeast. One set dips towards the east, the other towards the west, both at moderate angles. These joint sets are generally closely-spaced from a few centimetres to several metres apart. The north-south sets have a shear component; strong shear zones, up to 1 m wide, occur along this trend. Most of the mafic and acidic dykes as well as quartz veins follow this trend. The north-south shearing appears to be the latest movement to have occurred in the intrusive body because it cuts other joint sets.

(5) Geological History

Compared with the complex and much longer geological history of the neighbouring Segama region to the north and northwest, the history of the Gunung Pock area dates back only to early Miocene.

A) Miocene

The whole of the Semporna Peninsula including the Gunung Pock area was a shallow emerging basin during the Early and Middle Miocene. Fine marine sediments and pyroclastics were deposited forming the Kalumpang Formation. It is not certain where the large quantities of materials and pyroclastics came from, but probably from the northwest, in the now uplifted basement area of the Upper Segama valley. The sediments together with the pyroclastics were folded along a roughly east-west axes during late Miocene.

B) Pliocene

By early Pliocene the chain of volcanoes in the Semporna Peninsula had partially emerged above sea level. In the Gunung Pock area the early eruptions were basaltic lava and pyroclastics which built up the hills of Gunung Sigalong. This was followed by more active and violent eruptions of andesitic pyroclastics and flows which built volcanic cones southeast of Gunung Pock and at Gunung Siagil, and partly covered the earlier basalt. Andesitic material was also emplaced along fractures. The sites southeast of Gunung Pock became the central vent and more eruptions of dacitic lava, tuff and breccia took place, covering the earlier deposits and forming the high volcanic mountain complex of Gunung Pock. A minor caldera about 3 km across was formed at this stage through explosive eruption and collapse. At Gunung Siagil the volcanic activity seems to have stopped earlier. In the final stage, an acidic magma was injected into the caldera and fractures, forming the main microgranite body southeast of Gunung Pock and many small plugs and dykes of microgranite and aplite. The intrusion was accompanied by uplift of the caldera and the surrounding volcanics, resulting in faulting and shearing of the country rocks. Siliceous fluids carrying metals such as copper, lead and zinc invaded the volcanics and the microgranite through fissures, resulting in intense silicification and alteration of the volcanic rocks and the periphery of the main microgranite body.

C) Quaternary

By early Quaternary the present features of the Gunung Pock complex had been formed. Volcanic eruptions had stopped in the area but hot springs continued to discharge hot water through fractures.

Rapid erosion had deeply dissected the young volcanic hills and formed low-lying plains in between these hills. The advance of the sea to a level about 100 m higher than present resulted in submergence, and filling of these plains with coarse detritus, silt, sand and fine volcanic material from the volcanic hills. In the Pleistocene sea-level changes resulted in the emergence of the wide sediment-laden coastal plains, followed by a recession of sea level of about 10 m in Recent times which caused further emergence of the coastal plains. (Taken from "Gunung Pock Area, Semporna Peninsula, Sabah", Report 9, Geological Survey of Malaysia, 1988)

Table II-2-3 Stratigraphy of the Gunung Pock Area

AGE		SEDIMENTARY AND VOLCANIC ROCKS	IGNEOUS ACTIVITY	CONDITIONS OF DEPOSITION
HOLOCENE		RECENT ALLUVIUM: Coastal and fluviatile alluvium and mangrove swamp deposits.		Erosion and deposition
PLEISTOCENE	Th	HIGH-LEVEL ALLUVIUM: Terrace deposits, gravel beds, sand, clay and tuffaceous deposits.		Uplift, erosion and deposition
PLIOCENE	Tg	VOLCANICS: Dacite, andesite and pyroclastics at Gunung Pock and Gunung Siagil. Basalt and andesitic basalt at Gunung Sigalong. Agglomerate, tuff, tuffite in volcanic foothills.	Intrusion of Microgranite and dykes Active volcanism	Uplift and faulting
MIOCENE	Tf			Uplift, folding and faulting
	Te_5	KALUMPANG FORMATION: Sandstone, shale, tuff, tuffite and minor calcarenite.		Deposition of marine sediments and volcanic detritus
	Te 1-4			

(Taken from "Gunung Pock Area, Semporna Peninsula, Sabah", Report 9, Geological Survey of Malaysia, 1988)

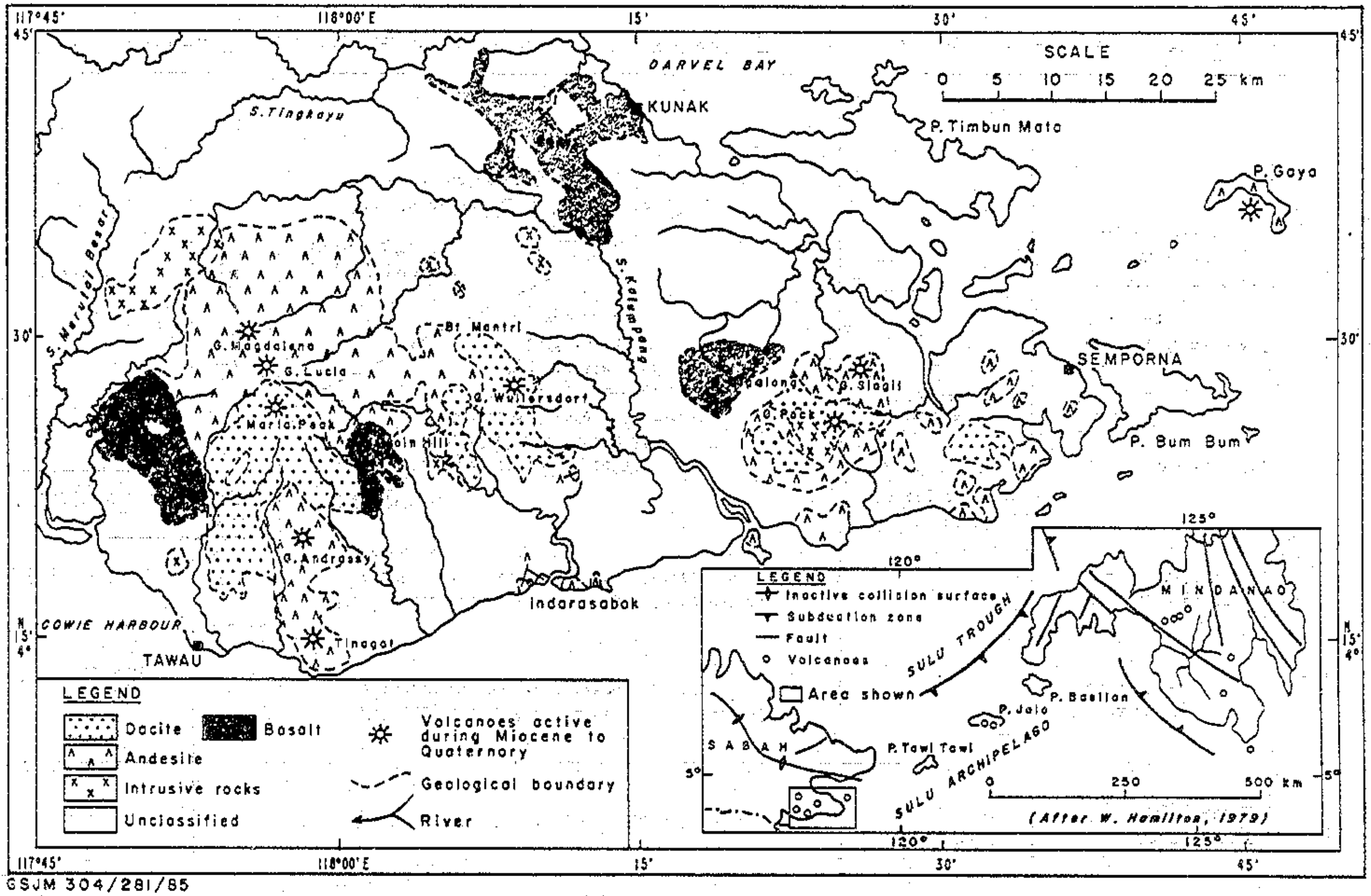


Figure II-2-8 Cenozoic Volcanoes, Semporna Peninsula
(Taken from "Gunung Pock Area, Sabah", Report 9, Geological Survey of Malaysia, 1988)

2-3 Result of the Investigation

2-3-1 Investigation of the Locality of Mineral Occurrence

The localities of mineral occurrence of epithermal gold-sulfide-limonite-secondary hematite-bearing quartz vein and network, embedded in acidic to intermediate volcanic and pyroclastic rocks of Miocene to Pliocene in age which are widely distributed in the Semporna peninsula, were investigated in order to clarify the characteristic of mineralization and hydrothermal alteration in the Semporna peninsula.

Forty-six localities of mineral occurrence in total, namely nineteen in the Mantri, four in the Wullersdorf, nine in the Pock and fourteen in the Nagos area, were investigated.

The result of the investigation in the four areas mentioned above is summarized in the Table II-2-4 and the localities of mineral occurrence and geology of four areas are shown respectively in the Fig. II-2-1, Fig. II-2-2, Fig. II-2-3 and Fig. II-2-4 attached at the end of this report. The assay result of the ore samples taken at the localities of mineral occurrence is shown in the Table II-2-11 of the section 2-4 mentioned below.

The result of the investigation of the localities of mineral occurrence in the Mantri, Wullersdorf, Pock and Nagos areas is as follows.

(1) Mantri Area (19 localities of mineral occurrence)

At the time of the investigation, a Australian private company (Wullersdorf Services Sdn. Bhd., a member of the RGC group) was carrying out exploration for gold by means of trenching and dimond drilling in the Mantri area. Nineteen localities of mineral occurrence which were found in the trenches and valleys and by the side of the roads were investigated in the Mantri area.

The detailed geology at and around the localities of mineral occurrence investigated is shown in the Fig. II-2-17 and Fig. II-2-18 attached at the end of this report.

The geological sketches of the ore outcrops at eight representative localities of mineral occurrence out of nineteen localities are shown in the Fig. II-2-9 to the Fig. II-2-16 at the end of this section.

As shown in the Table II-2-4, mineralization at the localities of mineral occurrence in the Mantri area is of gold-sulfide-limonite-secondary hematite-bearing quartz vein and/or network (stockwork). These quartz veins and/or networks are divided into three groups, that is, such veins as shown in the Fig. II-2-9, Fig. II-2-13, Fig. II-2-14, Plate-18 and Plate-19, veins and networks as shown in the Fig. II-2-10, Fig. II-2-11, Fig. II-2-16, Plate-13, Plate-15 and Plate-22, and networks as shown in the Fig. II-2-12, Fig. II-2-15, Plate-16, Plate-20 and Plate-24, and seem to be the part of a big network body as a whole.

The width of vein is 2 centimeters to 1.5 meters and small veinlets in the network are 5 millimeters to 5 centimeters wide.

Fissure along which quartz vein and network occur is mostly joint, but relatively wide quartz veins at the M-4, M-23, M-26 and M-28 outcrops are embedded in the brecciated zone.

The strike of quartz vein and quartz veinlet in the network is mostly northeastern (N40°E to 65°E), next is the east-west direction (N75°E to N80°W), then the north-south. Faults trending northeast and northwest are distributed in the Mantri-Wullersdorf area (after Lim, P.S., 1981).

As shown in the Table II-2-11 in the following section 2-4, Gold of low grade (1.16 to 3.42 g/t Au) has been detected from the samples of quartz veins and quartz veinlets in networks taken at six localities of mineral occurrence (M-4, M-19, M-20, M-22, M-23 and M-24) out of nineteen localities.

Besides gold, silver of 53.4 g/t in quartz vein at the M-10 locality, zinc of 0.7% in lenticular quartz vein at the M-6 locality, lead of 1.02% in addition to gold of 1.16 g/t in quartz veinlet in network at the M-20 locality and lead of 0.86% in quartz vein at the M-29 locality have been also detected.

Almost all host rock is composed of hydrothermally altered rock, original rock of which is uncertain due to very strong hydrothermal alteration, and hydrothermally altered andesitic tuff, with subordinate trachyandesite hydrothermally altered.

Hydrothermal alteration in the Mantri area is firstly intense and pervasive silicification which is observed at and around every locality of mineral occurrence, followed in order of intensity and universality by sericitization and kaolinization. Kaolinization after sericitization is observed at about half localities of mineral occurrence out of nineteen localities. However, it is possible that kaolinite has been generated by weathering.

(2) Wullersdorf Area (4 localities of mineral occurrence)

Four localities of mineral occurrence in the southeastern part of the Wullersdorf area were investigated. However, no useful mineral other than pyrite was observed with the naked eye and under a microscope, and the assay of four samples resulted in detecting no useful constituent.

The geological sketch of the outcrop at the W-4 locality is shown in the Fig. II-2-19 at the end of this section. Disseminated pyrite in propylite was observed at two localities. Quartz-disseminated pyrite-clay mineral-vein and secondary hematite-limonite-bearing quartz vein were seen at other two localities. Veins which are 60 centimeters and 2.5 meters wide strike in the direction of east-west and are embedded in the brecciated zone.

Host rock in which pyrite is disseminated at two localities is propylite and host rock of veins is strongly hydrothermally altered rock, original rock of which is uncertain due to very strong hydrothermal alteration.

Propylite has been subjected to silicification, albitization, chloritization and sericitization and strongly hydrothermally altered rock has undergone silicification, sericitization and weak chloritization.

(3) Pock Area (9 localities of mineral occurrence)

The investigation of nine localities of mineral occurrence in the Pock area resulted in only finding useful minerals such as sphalerite and galena with the naked eye in quartz-pyrite-sphalerite-galena-clay mineral-vein at the P-13 locality. The assay of six ore samples reveals that only one sample taken at the P-13 locality contains the useful constituents (0.74% Pb and 2.38% Zn).

The geological sketches of two representative outcrops at the P-10 and P-13 localities are shown in the Fig. II-2-20 and Fig. II-2-21 at the end of this section respectively.

The mineral assemblage at the localities of mineral occurrence is composed mainly of quartz, accompanied by one to four mineral(s) in different localities among limonite, secondary hematite, pyrite, clay mineral, sphalerite and galena.

Occurrence is mostly of vein, followed by lens and network.

Veins, which are 5 to 35 centimeters wide, at six localities of mineral occurrence occur along joint and strike northeast (N20°E to 66°E) and north-northwest (N4°W to 32°W). Host rock is composed mainly of propylite followed by hydrothermally altered rock, original rock of which is uncertain due to very intense hydrothermal alteration, and strongly silicified rock. Hydrothermal alteration consists mainly of intense and pervasive silicification, which is observed at and around all the localities of mineral occurrence, followed in order of universality by chloritization, albitization and sericitization.

(4) Nagos Area (14 localities of mineral occurrence)

The investigation of fourteen localities of mineral occurrence in the area failed to find useful mineral at all the localities, and the assay of ten samples taken at ten localities has resulted in only detecting gold of 1.18 g/t from the sample at the outcrop of the N-12 locality.

The geological sketches of four representative outcrops at the N-1, N-3, N-4, and N-10 localities are shown in the Fig. II-2-22 to Fig. II-2-25 at the end of this section respectively, and detailed geology at and around localities of mineral occurrence is shown in the route map of Fig. II-2-26 attached at the end of this report.

The mineral assemblage at the localities of mineral occurrence is composed mainly of quartz, accompanied by limonite, secondary hematite, clay mineral and pyrite (in places). Occurrence is of vein, network and lens (in places).

Veins are embedded along fault, brecciated zone and joint whereas veinlets in network occur along joint.

Veins strike mainly north-south to north-northwest (N4°W to 20°W) followed by northeast (N33°E to 35°E) and very few east-west.

Veins are 15 centimeters to 7 meters and veins embedded in the brecciated zone are relatively wide.

Host rock is composed mostly of hydrothermally altered rock, original rock of which is uncertain due to very strong hydrothermal alteration, and strongly silicified rock followed by hydrothermally altered andesitic tuff. Hydrothermal alteration consists mainly of intense and pervasive silicification, which is observed at and around all the localities of mineral occurrence, followed in order of universality by kaolinization at the most localities and alunitization at two localities.

Table II-2-4 Result of Investigation of Localities of Mineral Occurrence in Semporna Peninsula Region

Area	Location	Mineral Assemblage	Occurrence	Strike & Dip	Scale (m)	Host Rock	Alteration of Host Rock	Nature of Vein Fissure
Mantri	M-1	qz+lim	vein	N18°E·52°E	H=2.0+, W=0.2	hydrothermally altered rock	silicification, sericitization	joint
"	M-3	qz·lim·hm	network		W=0.06	hydrothermally altered rock	silicification, kaolinization (sericitization)	joint
"	M-4	qz+lim·hm	vein	N5°W·90°	H=1.5+, W=0.25	hydrothermally altered andesitic tuff	silicification, sericitization kaolinization	brecciated zone
"	M-6	qz+py·sp	lenticular		L=0.35, W=0.08	hydrothermally altered rock	silicification, sericitization	
"	M-8	qz·lim	vein	N75°E·45°S	H=2.0+, W=0.06	hydrothermally altered rock	silicification, sericitization	joint
"	M-10	qz+lim·hm	vein	N75°E·65°N	L=4.0+, W=0.05~0.1	hydrothermally altered trachy andesite	silicification, sericitization, kaolinization	joint
"	M-16	qz+py·lim·hm	vein & network	N80°W·80°N	H=2.0+, W=0.4~0.5	hydrothermally altered andesitic tuff	silicification, sericitization	joint
"	M-18	qz	vein & network	N82°W·70°S	L=4.0+, W=0.02~0.1	hydrothermally altered andesitic tuff	silicification, sericitization	joint
"	M-19	qz+hm	vein & network	N42°E·70°W	H=2.0+, W=0.02~0.06	hydrothermally altered rock	silicification, sericitization (kaolinization)	joint
"	M-20	qz+lim·hm·gn	network		H=2.0+, W=0.01~0.05	hydrothermally altered rock	silicification, sericitization (kaolinization)	joint
"	M-21	qz+hm·lim	lenticular & network		W=0.05	hydrothermally altered rock	silicification, sericitization (kaolinization)	joint
"	M-22	qz+hm·lim	vein	N5°E·80°E	H=1.2+, W=0.2~0.25	hydrothermally altered andesitic tuff	silicification, sericitization (kaolinization)	joint
"	M-23	qz+hm·lim	vein	N43°E·90°	H=3.0+, W=0.8~1.0	hydrothermally altered andesitic tuff	silicification, sericitization	brecciated zone
"	M-24	qz+hm·lim	vein	N22°W·85°N	H=1.0+, W=0.5	hydrothermally altered andesitic tuff	silicification, sericitization	joint
"	M-25	qz+hm·lim	network	N40°E·90°	H=2.0+, W=0.04	hydrothermally altered andesitic tuff	silicification, sericitization, kaolinization	joint
"	M-26	qz+hm·lim	vein	N64°E·68°S	H=2.0+, W=0.12~0.3	hydrothermally altered andesitic tuff	silicification, sericitization, kaolinization	brecciated zone
"	M-27	qz+hm·lim	vein & network	N40°E·63°E	H=2.0+, W=0.1~0.15	hydrothermally altered andesitic tuff	silicification, sericitization	joint
"	M-28	qz+hm·lim	vein	N35°E·90°	H=2.0+, W=1.5	hydrothermally altered rock	silicification, sericitization, kaolinization	brecciated zone
"	M-29	qz+hm·gn	vein	N65°E·70°S	H=2.0+, W=0.02~0.08	hydrothermally altered rock	silicification, kaolinization, (sericitization)	joint

Area	Location	Mineral Assemblage	Occurrence	Strike & Dip	Scale (m)	Host Rock	Alteration of Host Rock	Nature of Vein Fissure
Wullersdorf	W-1	py	dissemination			propylite	silicification, chloritization, albitization, (sericitization)	
"	W-3	qz·py·cm	dissemination	N73°E	W=1.4	propylite	silicification, albitization, chloritization, sericitization	
"	W-4	py	vein & dissemination	N72°E·90°	W=0.6	hydrothermally altered rock	silicification, sericitization	brecciated zone
"	W-11	qz+hm·lim	vein	E-W	L=5.0+, W=2.5	hydrothermally altered rock	silicification, sericitization, kaolinization	brecciated zone
Pock	P-10	qz·py·cm	vein	N20°E·60°W	L=1.4+, W=0.25	hydrothermally altered rock	silicification, chloritization, sericitization	joint
"	P-13	qz·py·sp·gn·cm	vein	N14°W·90°	H=0.6+, W=0.05~0.08	propylite	silicification, chloritization, sericitization	joint
"	P-14	qz+lim	vetwork & massive			strongly silicified rock	silicification (sericitization)	joint
"	P-15	qz+lim·hm	vein & network	N50°E·90°	H=2.5+, W=0.35	strongly silicified rock	silicification (sericitization)	joint
"	P-16	qz+lim·hm·cm	lenticular		H=0.6, W=0.35	hydrothermally altered rock	silicification, sericitization	
"	P-20	qz·py·cm	vein	N66°E·85°N	H=1.7+, W=0.2~0.3	propylite	silicification, chloritization, sericitization	joint
"	P-21	qz·lim·py	lenticular		H=0.8, W=0.4	propylite	silicification, albitization, chloritization	
"	P-22	qz	vein	N32°W·90°	L=2.0+, W=0.06	propylite	silicification, albitization, chloritization, sericitization	joint
"	P-23	qz+py·lim	vein	N4°W·74°E	H=0.8+, W=0.2~0.25	propylite	silicification, albitization, chloritization, sericitization	joint
Nagos	N-1	qz+cm	vein	N10°W·90°	L=2.5+, W=1.3	hydrothermally altered rock	silicification, kaolinization	joint
"	N-2	qz+hm·lim·cm	vein	N33°E·48°E	L=2.0+, W=0.15	hydrothermally altered rock	silicification, sericitization, kaolinization	joint
"	N-3	qz+hm·lim·cm	vein	N80°W·70°S	H=1.6+, W=0.6	hydrothermally altered andesitic tuff	silicification, sericitization, kaolinization	joint
"	N-4	qz·hm·lim	vein	N14°W·90°	H=2.0+, W=4.0	hydrothermally altered rock	silicification	brecciated zone
"	N-5	qz+lim·hm·cm	vein	N20°W·90°	H=4.0+, W=3.0	hydrothermally altered rock	silicification, kaolinization	brecciated zone
Nagos	N-6	qz·cm	vein	N4°W·47°E	H=2.0+, W=7.0	hydrothermally altered rock	silicification, kaolinization	brecciated zone
"	N-7	qz·cm	lenticular		H=1.2, W=0.35	hydrothermally altered rock	silicification, kaolinization	
"	N-8	qz+hm·lim	network		4.0 (L) × 3.0 (W) × 2.0 (H)	strongly silicified rock	silicification	joint
"	N-9	qz+hm·lim·cm	network		L=4.5, W=1.5	hydrothermally altered rock	silicification, alunitization, kaolinization	joint
"	N-10	qz·cm+lim	vein	N4°W·70°E	H=3.0+, W=0.55	hydrothermally altered andesitic tuff	silicification, alunitization, kaolinization	fault

Area	Location	Mineral Assemblage	Occurrence	Strike & Dip	Scale (m)	Host Rock	Alteration of Host Rock	Nature of Vein Fissure
Nagos	N-11	qz+lim·hm·py	network		W=4.0	hydrothermally altered rock	silicification, kaolinization	joint
"	N-12	qz+lim·hm	network	N35°E·90°	W=1.5	hydrothermally altered rock	silicification, kaolinization	joint
"	N-13	qz·cm+hm·lim	vein	N12°W·80°E	H=2.0+, W=1.25	hydrothermally altered rock	silicification, kaolinization	brecciated zone
"	N-14	qz·cm+hm·lim	vein	N12°W	H=1.0+, W=0.5	hydrothermally altered andesitic tuff	silicification, kaolinization	brecciated zone

Abbreviations:

qz : quartz, py : pyrite, cp :chalcopyrite lim: limonite hm: hematite (secondary)

sp : sphalerite, gn : galena, cm: clay mineral

L : horizontal length, T : thickness, H : vertical height, W : width

Figure II-2-9 Sketch of M-4 Outcrop

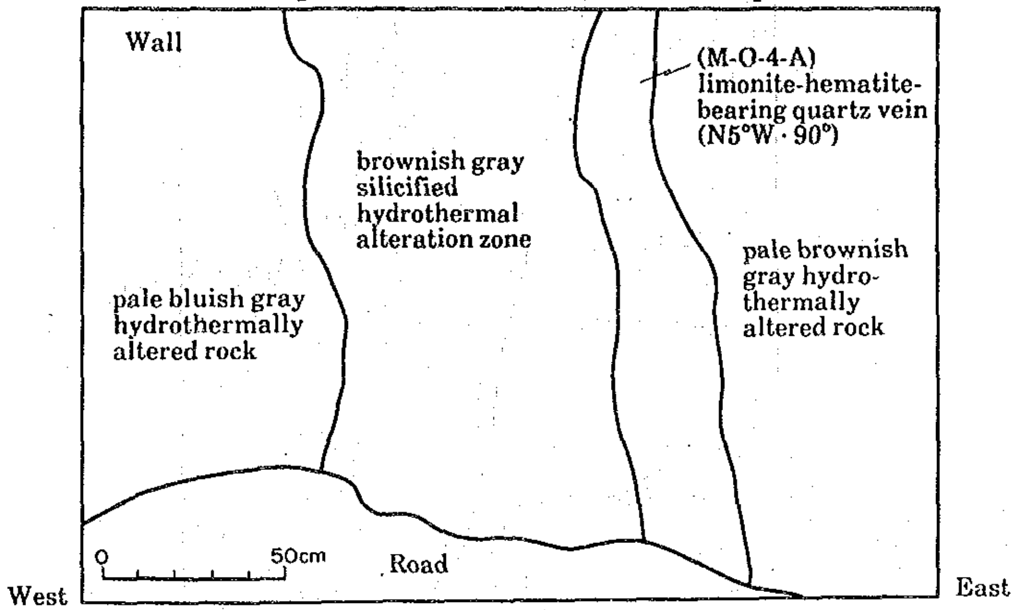


Figure II-2-10 Sketch of M-16 Outcrop

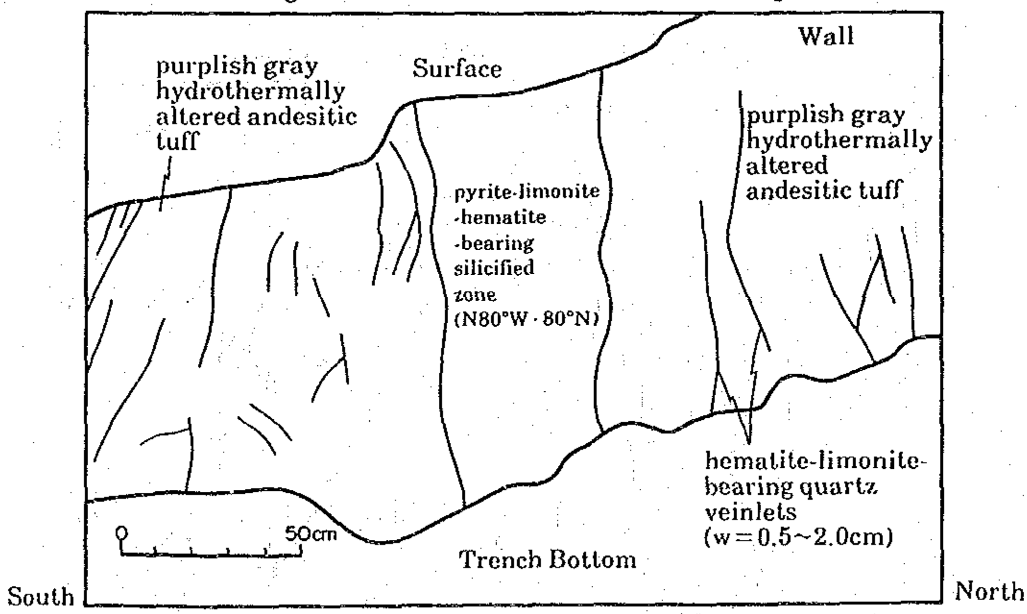


Figure II-2-11 Sketch of M-19 Outcrop

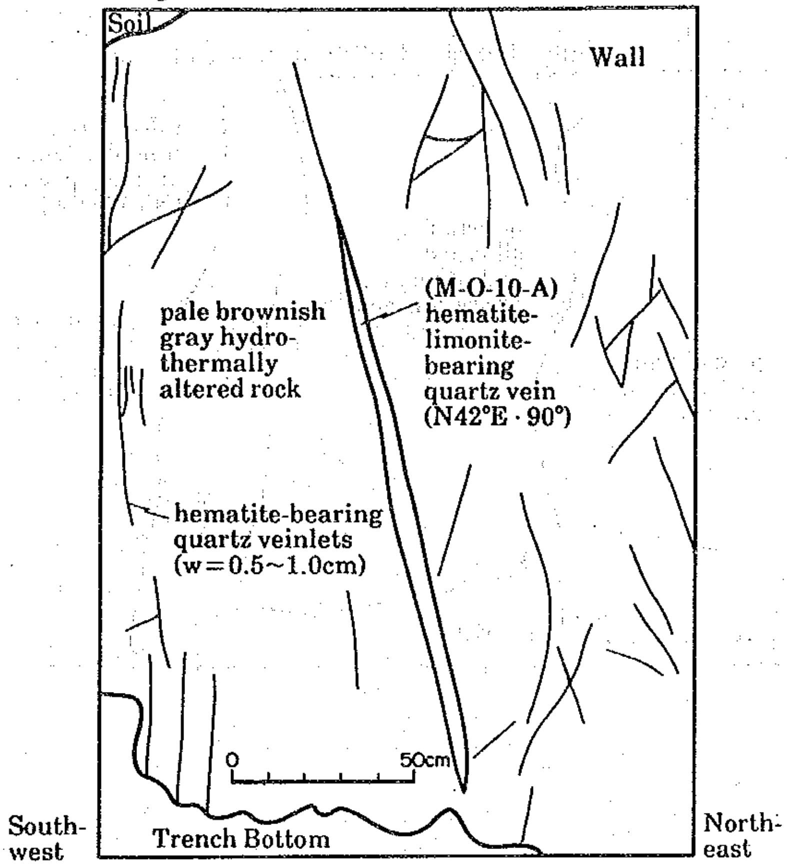


Figure II-2-12 Sketch of M-20 Outcrop

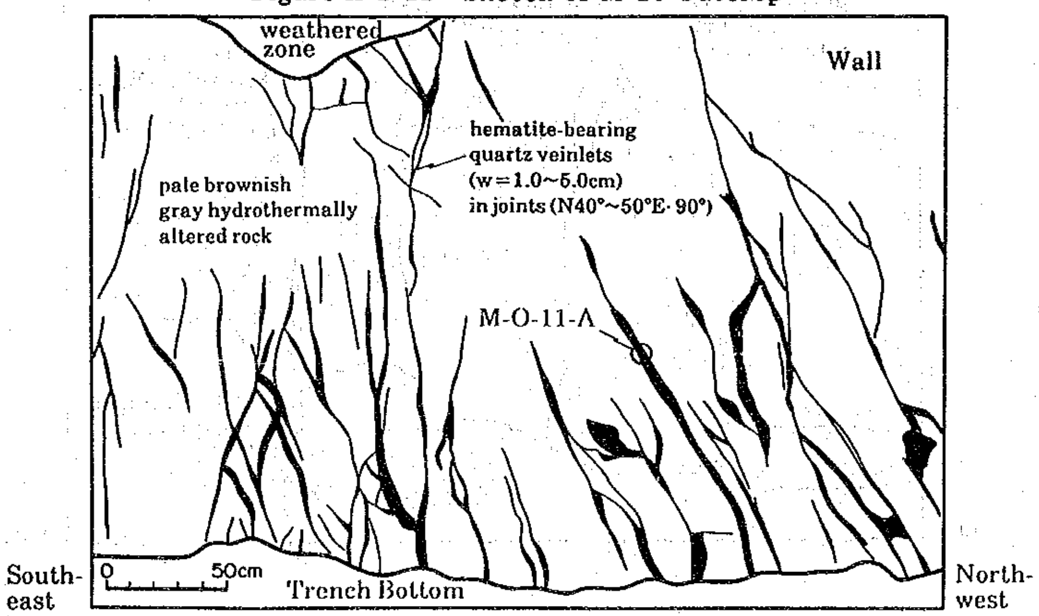


Figure II-2-13 Sketch of M-22 Outcrop

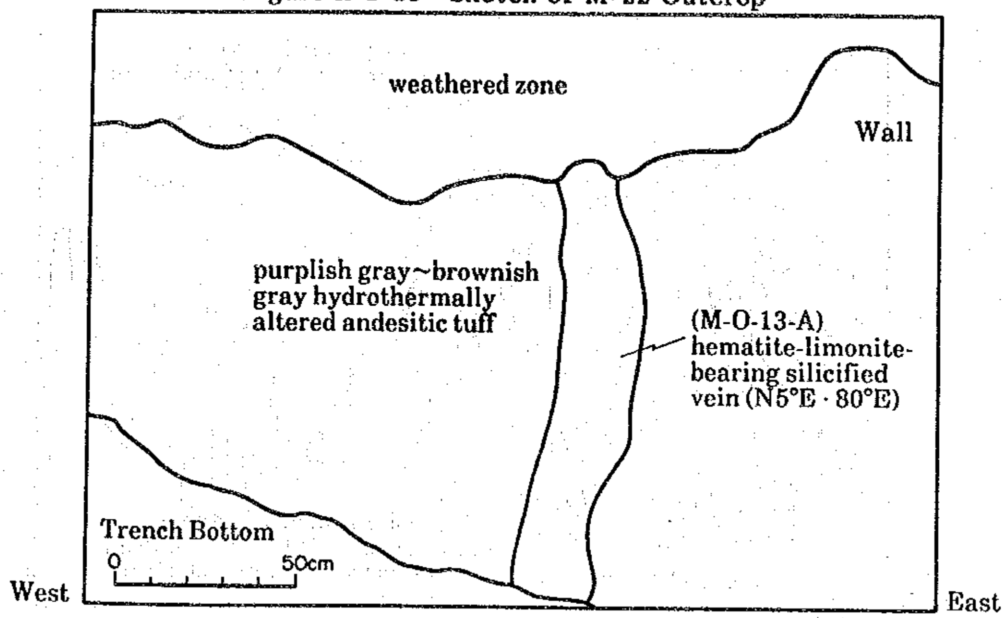


Figure II-2-14 Sketch of M-23 Outcrop

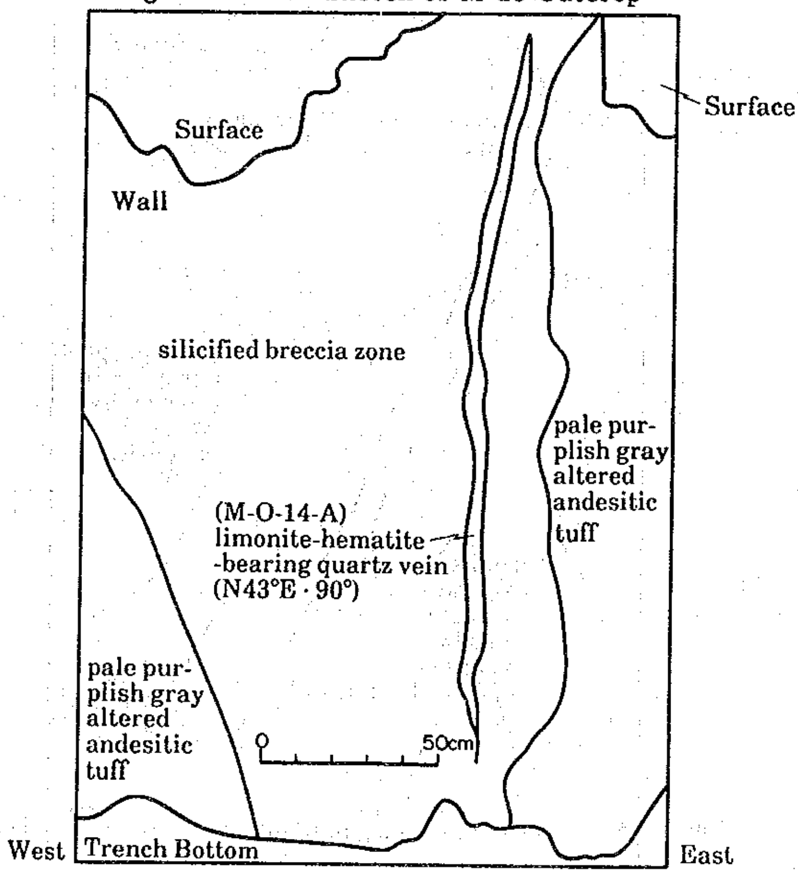


Figure II-2-15 Sketch of M-25 Outcrop

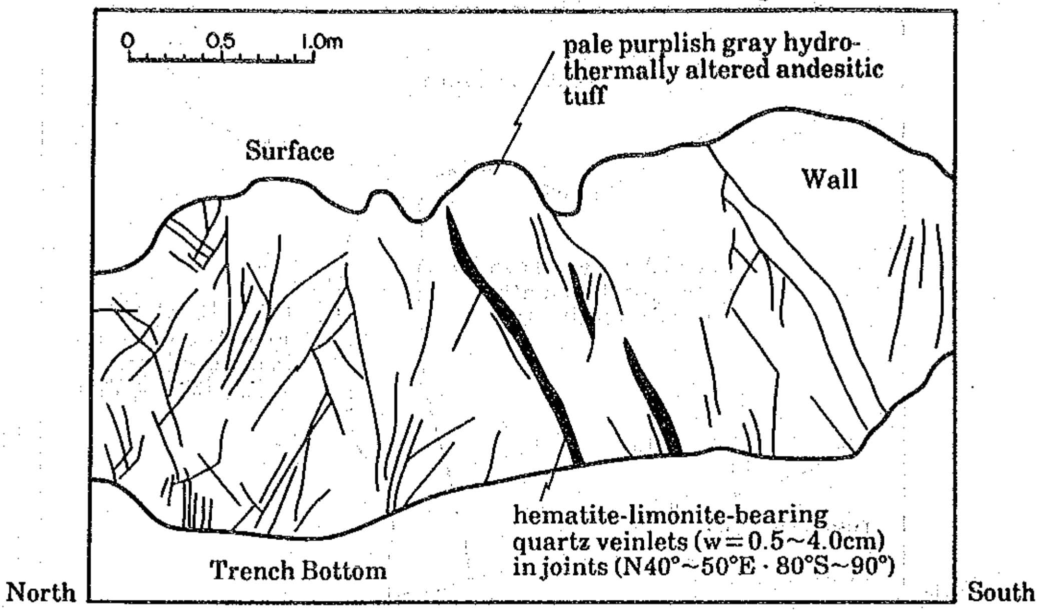


Figure II-2-16 Sketch of M-27 Outcrop

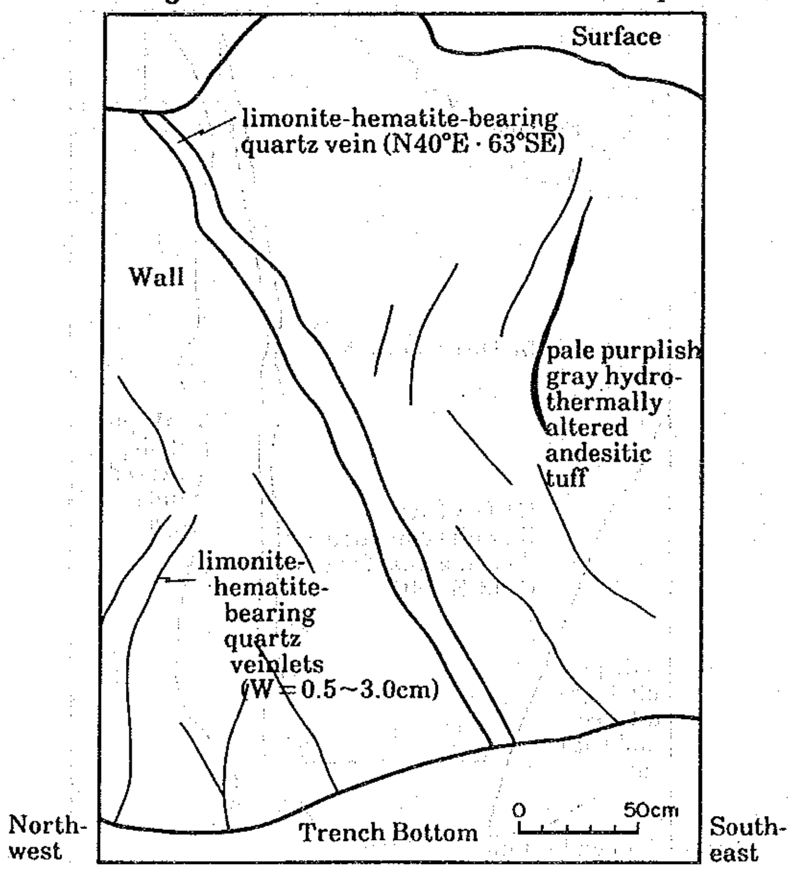


Figure II-2-19 Sketch of W-4 Outcrop

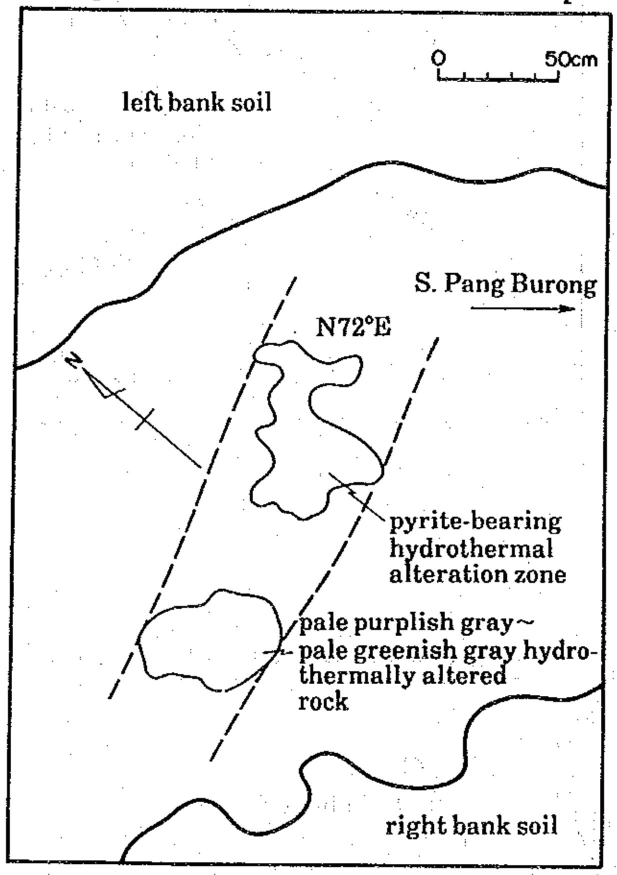


Figure II-2-20 Sketch of P-10 Outcrop

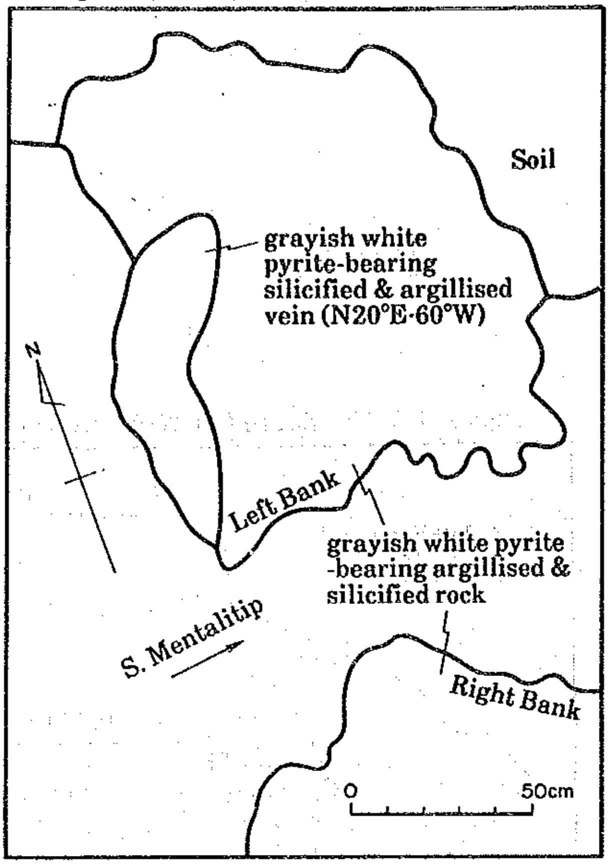


Figure II-2-21 Sketch of P-13 Outcrop

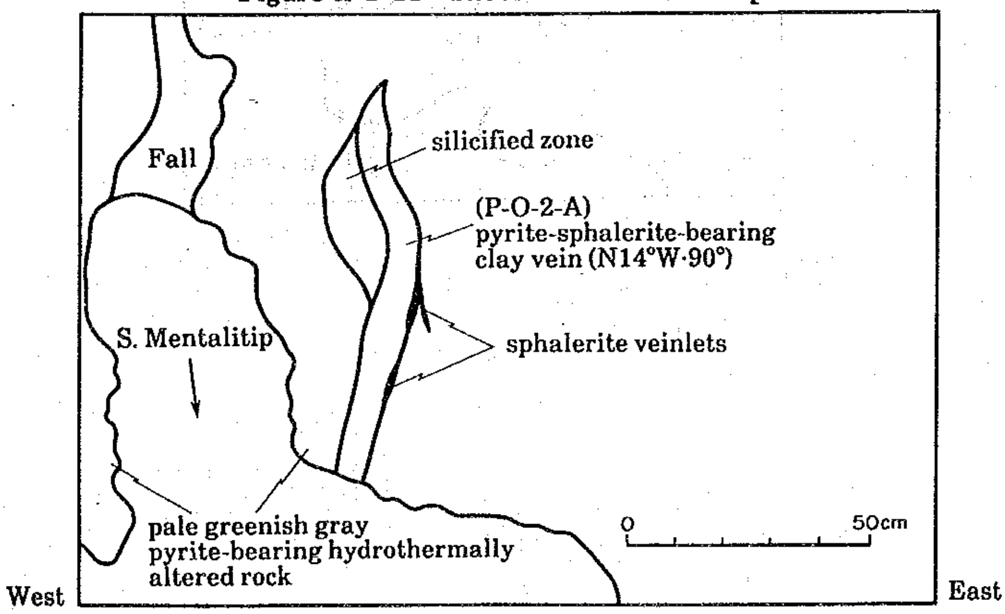


Figure II-2-22 Sketch of N-1 Outcrop

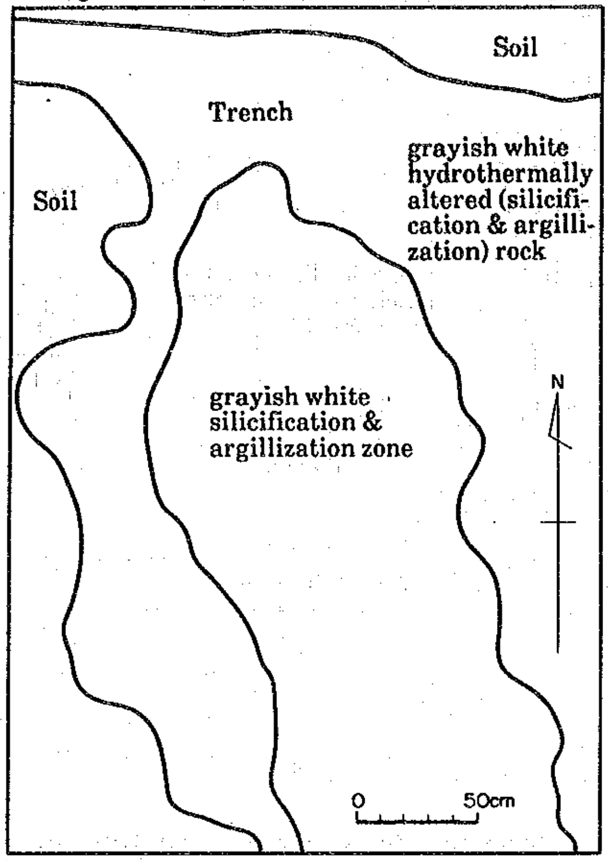


Figure II-2-23 Sketch of N-3 Outcrop

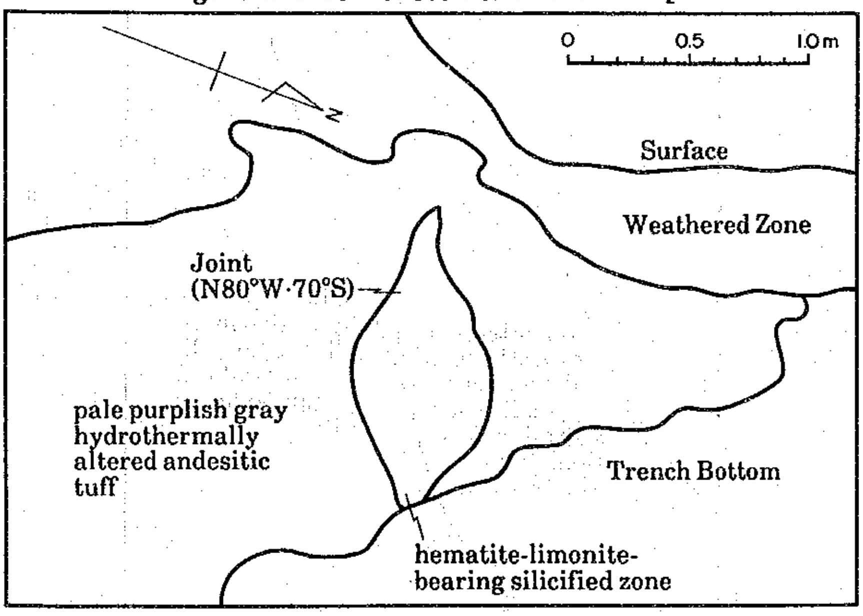


Figure II-2-24 Sketch of N-4 Outcrop

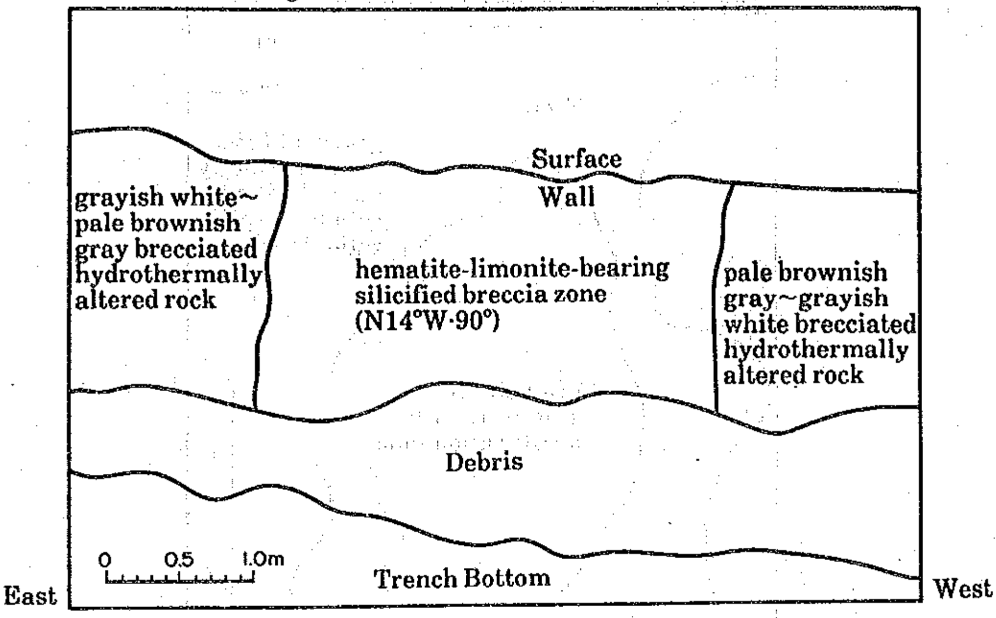
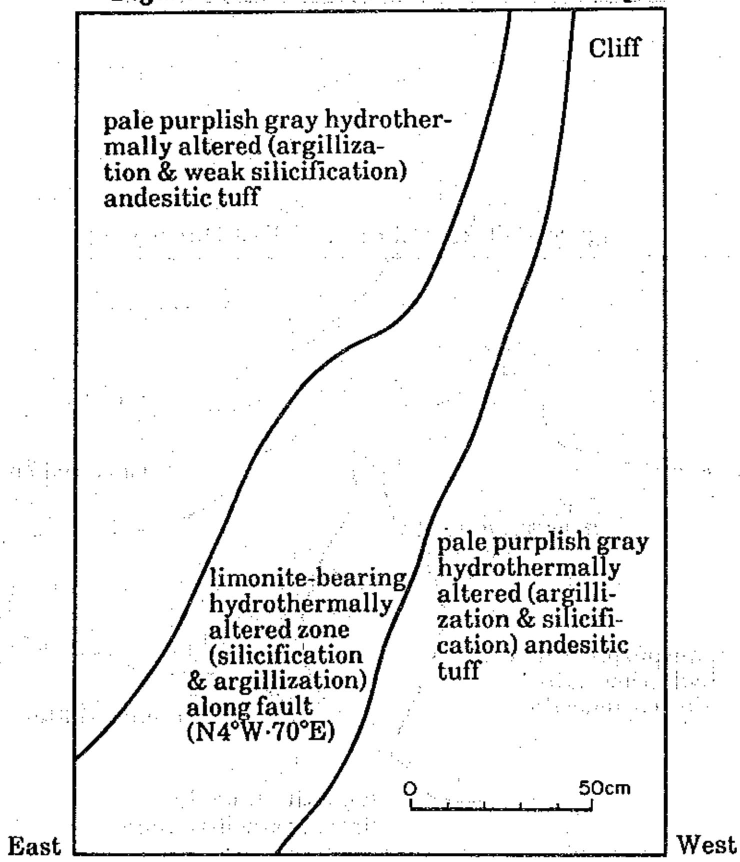


Figure II-2-25 Sketch of N-10 Outcrop



2-3-2 Indoor Experiment and Chemical Analysis

(1) K-Ar Age Determination of Rock (16 samples)

The result of the K-Ar age determination by means of whole rock for sixteen rock samples taken in the Mantri, Wullersdorf and Pock areas is shown in the Table II-2-5 and reveals that there is no great difference in different rock types and areas, except for basalt dated as 0.20 ± 0.12 Ma (Quaternary). That is, five samples of andesite and andesitic tuff in the Mantri area have been dated as 9.09 ± 0.52 to 11.05 ± 2.55 (late Miocene) and the ages of five andesite samples, except for P-D-6 sample which has been dated with big error, have been determined as 7.75 ± 1.06 Ma (late Miocene) to 13.3 ± 0.5 Ma (middle Miocene). The ages of porphyrite in the Wullersdorf and Pock areas are 8.38 ± 0.70 Ma (late Miocene) and 9.52 ± 0.23 Ma (late Miocene) respectively and the age of 13.9 ± 3.1 Ma (middle Miocene) has been obtained from diorite in the Pock area.

Table II-2-5 Result of K-Ar Dating of Rock Samples taken in Semporna Peninsula Region

Area	Sample Number	Numbers in Laboratory	Sample Type	Potassium (K wt %)	Rad. ^{40}Ar (10^{-8} cc/g)	K-Ar Age (Ma)	Air Cont. (%)	Rock Name
Mantri	M-D-1	SH4 -250 -251	Whole Rock	1.64 ±0.05	62.6±1.4 63.2±1.1	9.81±0.37 9.91±0.34 avg. 9.86±0.35	45.0 27.8 36.4	Andesite
"	M-D-2	SH4 -248 -249	Whole Rock	1.06 ±0.32	43.9±0.8 42.4±0.8	10.7±0.4 10.3±0.4 avg. 10.5±0.4	28.3 27.3 27.8	Andesite
"	M-D-3	SH4 -252 -253	Whole Rock	1.34 ±0.40	47.4±2.3 47.1±2.2	9.12±0.52 9.07±0.51 avg. 9.09±0.52	72.7 72.0 72.3	Andesitic tuff
"	M-D-4	SH4 -254 -255	Whole Rock	1.94 ±0.58	70.9±1.2 73.0±1.2	9.40±0.32 9.67±0.33 avg. 9.53±0.33	30.0 27.7 28.8	Andesitic tuff
"	M-D-5	SH4 -256 -257	Whole Rock	1.47 ±0.04	1.1±0.7 0.3±0.4	0.20±0.12 <0.2 avg. 0.20±0.12	94.9 98.4 96.6	Basalt
"	M-D-6	SH4 -258 -259	Whole Rock	0.16 ±0.03	6.2±0.7 7.3±0.9	10.4±2.3 11.7±2.8 avg. 11.05±2.55	85.6 83.4 84.5	Trachy andesite
"	M-D-7	SH4 -260 -262	Whole Rock	<0.01 +0.01	0.3±0.6 0.8±0.6	7.60±16.3 19.7±18.9 avg. 13.65±17.6	99.0 97.4 98.2	Silicified rock
Wullersdorf	W-D-1	SH4 -263 -264	Whole Rock	0.50 ±0.03	16.0±0.9 16.6±1.0	8.24±0.69 8.53±0.71 avg. 8.38±0.70	75.0 73.2 74.1	Porphyrite
Pock	P-D-1	SH4 -265 -266	Whole Rock	7.97 ±0.16	296±4 294±4	9.56±0.24 9.48±0.23 avg. 9.52±0.23	10.2 7.3 8.7	Porphyrite
"	P-D-2	SH4 -267 -268	Whole Rock	0.12 ±0.02	5.9±0.6 7.1±0.7	12.7±2.8 15.2±3.4 avg. 13.9±3.1	84.0 81.5 82.7	Diorite
"	P-D-3	SH4 -269 -270	Whole Rock	1.09 ±0.03	55.5±1.6 56.7±1.7	13.2±0.5 13.4±0.6 avg. 13.3±0.5	57.0 52.5 54.7	Andesite?
"	P-D-4	SH4 -273 -274	Whole Rock	1.13 ±0.03	51.9±1.3 53.5±1.4	11.9±0.5 12.2±0.5 avg. 12.05±0.5	49.6 50.3 49.9	Andesite
"	P-D-5	SH4 -275 -276	Whole Rock	0.61 ±0.04	26.4±2.3 25.6±2.2	11.1±1.2 10.8±1.1 avg. 10.9±1.2	82.0 82.4 82.2	Andesite
"	P-D-6	SH4 -271 -272	Whole Rock	0.40 ±0.04	30.5±14.8 25.7±13.7	19.5±9.7 16.5±8.9 avg. 18.0±9.3	96.7 96.9 96.8	Andesite
"	P-D-7	SH4 -277 -278	Whole Rock	0.31 ±0.03	9.5±1.0 9.2±0.8	7.90±1.12 7.61±0.99 avg. 7.75±1.06	84.5 81.1 82.8	Andesite
"	P-D-8	SH4 -279 -280	Whole Rock	0.56 ±0.03	25.6±0.8 26.5±1.0	11.8±0.8 12.2±0.8 avg. 12.0±0.8	58.9 54.0 56.4	Andesite

(2) Chemical Analysis (29 samples)

The result of the chemical analysis of twenty-nine samples of andesite, andesitic tuff, trachyandesite, basalt, porphyrite, and hydrothermally altered host rock taken in the Mantri, Wullersdorf, Pock and Nagos areas and C.I.P.W. Norms calculated from the analyses are shown in the Table II-2-6 and Table II-2-7 respectively.

SiO_2 and Na_2O+K_2O of the analyses of twelve unaltered rocks, namely four samples of andesite and andesitic tuff and one sample of basalt in the Mantri area, six samples of andesite in the Pock area and one sample of andesitic tuff in the Nagos area, have been plotted on the $Na_2O+K_2O-SiO_2$ diagram of the Fig. II-2-27. Fig. II-2-27 shows that twelve rocks belong to the nonalkali rock series after Kuno (1966).

Then, $FeO+Fe_2O_3$, Na_2O+K_2O and MgO of the same rocks have been plotted on the MFA trigonal diagram of the Fig. II-2-28. The Fig. II-2-28 shows that andesites in the Pock area belong to the tholeiite series and andesites and andesitic tuffs in the Mantri and Nagos areas to the calc-alkali rock series after Irvine and Barager (1971).

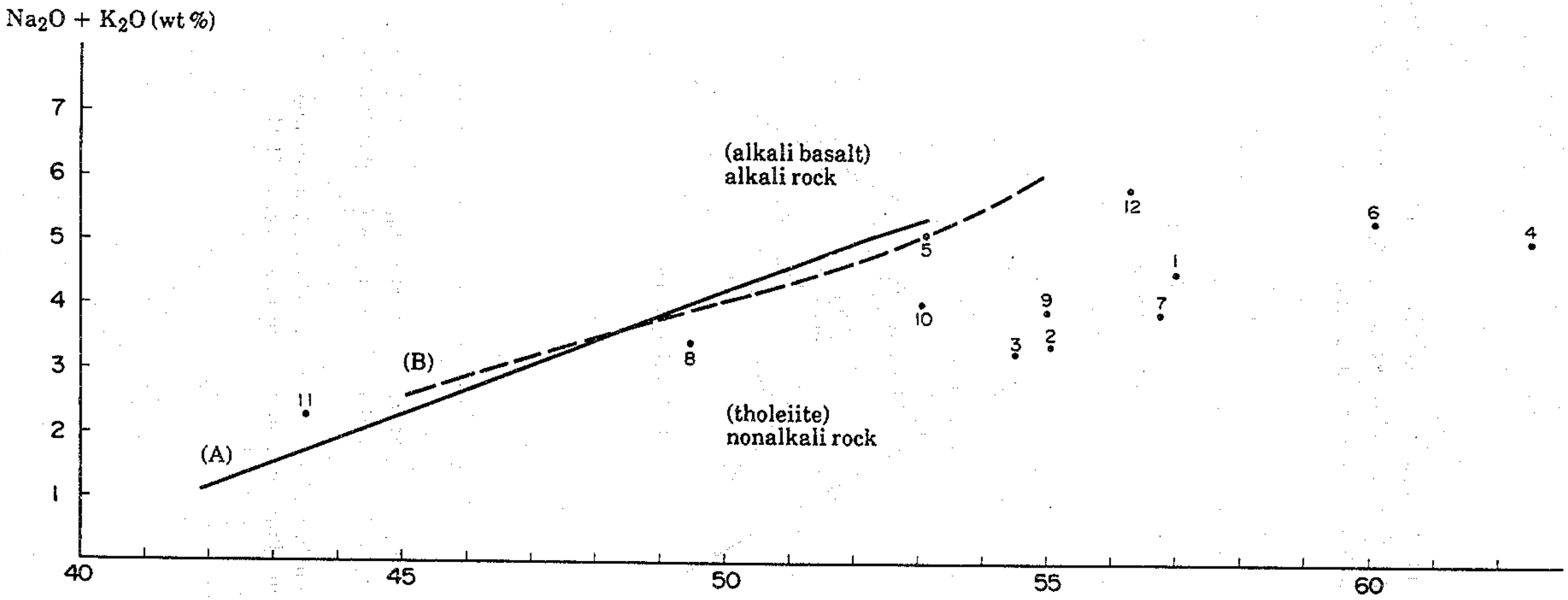
Table II-2-6 Assay Result of Rock Samples taken in Semporna Peninsula Region

Locality	Sample Number	Rock Name	SiO_2 %	TiO_2 %	Al_2O_3 %	Fe_2O_3 %	FeO %	MnO %	MgO %	CaO %	Na_2O %	K_2O %	P_2O_3 %	Ig-loss %	Total	Au ppb	Ag ppm	Cu ppm	Mo ppm	Pb ppm	S %	Zn ppm
M-1	M-R-1-A	Altered Rock	63.82	0.69	16.93	5.28	0.13	0.04	0.96	0.03	0.05	4.52	0.11	6.94	99.50	16	1.1	394	<1	1,801	3.908	244
M-9′	M-R-2-A	Altered Rock	54.28	0.76	20.95	6.20	0.26	0.05	0.68	0.03	0.07	1.50	0.07	14.86	99.71	2	0.6	113	<1	46	4.482	227
M-10	M-R-3-A	Trachyandesite	59.59	0.92	23.30	1.52	0.13	0.03	0.23	0.04	0.08	6.49	0.11	7.34	99.78	<1	<0.5	39	<1	947	0.048	103
M-11	M-R-5-A	Andesite	56.99	0.50	17.00	4.98	0.89	0.08	2.74	5.65	2.44	2.04	0.17	6.13	99.61	<1	<0.5	27	<1	22	0.040	54
M-12	M-R-6-A	Andesite	55.04	0.83	18.78	3.60	3.95	0.13	3.73	8.76	2.20	1.17	0.17	1.08	99.44	<1	<0.5	43	<1	16	0.055	85
M-13	M-R-7-A	Andesitic tuff	54.51	0.71	18.39	4.93	3.00	0.13	3.92	7.54	1.85	1.42	0.17	3.19	99.76	<1	<0.5	34	<1	19	0.045	63
M-14	M-R-8-A	Andesitic tuff	62.43	0.48	16.52	4.52	0.95	0.10	2.35	5.50	2.81	2.23	0.16	1.37	99.42	<1	<0.5	26	<1	21	0.037	59
M-15	M-R-9-A	Basalt	53.12	1.57	16.22	2.89	5.74	0.15	5.84	8.31	3.34	1.79	0.36	0.11	99.44	<1	0.8	44	<1	13	0.048	80
M-17	M-R-10-A	Trachyandesite	59.23	0.61	15.54	3.06	3.82	0.54	2.03	0.04	0.14	10.40	0.06	3.65	99.12	7	1.1	54	<1	2,052	2.222	3,792
M-30	M-R-11-A	Silicified Rock	97.78	0.70	0.24	0.33	0.06	<0.01	<0.01	<0.01	0.02	<0.01	0.04	0.20	99.41	1	<0.5	10	<1	8	0.017	4
W-3	W-R-2-A	Altered Rock	55.67	0.92	19.28	4.73	1.60	0.11	2.95	1.34	3.66	3.29	0.16	5.74	99.45	<1	<0.5	51	<1	28	3.082	69
W-4	W-R-3-A	Altered Rock	55.34	0.73	16.57	3.82	4.59	0.33	4.45	6.79	2.16	0.49	0.10	3.94	99.31	<1	0.5	64	<1	18	0.201	79
W-8	W-R-5-A	Porphyrite	62.91	0.76	15.61	7.53	0.26	0.01	0.82	0.19	0.17	4.02	0.09	7.31	99.68	<1	<0.5	20	<1	22	5.643	20
W-12	W-R-8-A	Altered Rock	57.95	0.58	16.02	4.05	0.32	0.01	2.05	0.17	0.12	2.46	0.07	5.90	89.71	<1	<0.5	42	<1	22	2.920	71
P-1	P-R-1-A	Porphyrite	67.43	0.60	15.13	1.10	1.98	0.08	2.03	3.52	4.49	0.19	0.18	2.58	99.31	<1	<0.5	4	<1	12	0.040	19
P-2	P-R-2-A	Diorite	61.51	0.72	15.56	2.17	4.21	0.34	2.26	5.39	3.34	0.18	0.24	3.47	99.39	<1	<0.5	5	<1	11	0.037	32
P-3	P-R-3-A	Andesite?	68.40	0.46	13.44	1.30	3.51	0.16	1.85	1.43	4.47	1.49	0.17	3.02	99.40	<1	0.6	10	<1	12	0.065	73
P-4	P-R-4-A	Andesite	60.60	0.75	14.75	4.09	1.60	0.16	1.35	3.91	2.94	2.43	0.23	6.70	99.51	<1	0.9	8	<1	14	0.042	85
P-5	P-R-5-A	Andesite	56.76	0.88	17.79	2.26	6.64	0.20	2.13	7.83	3.15	0.72	0.17	1.23	99.76	<1	0.6	40	<1	16	0.065	89
P-6	P-R-6-A	Andesite	49.38	0.85	17.87	5.92	4.72	0.28	4.73	10.29	2.53	0.90	0.21	2.07	99.75	<1	<0.5	49	<1	14	0.709	79
P-7	P-R-7-A	Andesite	54.99	0.73	15.84	3.22	5.22	0.32	2.87	8.37	3.54	0.36	0.23	4.02	99.71	<1	<0.5	42	<1	12	0.065	72
P-9	P-R-9-A	Andesite	53.15	0.89	17.91	5.53	4.27	0.20	2.41	8.07	3.47	0.55	0.15	3.24	99.84	<1	0.5	36	<1	11	0.076	94
P-12	P-R-11-A	Andesite?	64.72	0.65	16.26	2.03	3.19	0.19	2.72	0.43	2.36	2.62	0.21	4.11	99.49	<1	<0.5	9	<1	12	0.341	207
P-13	P-R-12-A	Altered Rock	56.91	0.76	17.49	4.29	2.87	0.24	6.38	0.14	0.08	3.21	0.07	6.97	99.41	<1	0.7	9	<1	417	2.437	1,591
P-17	P-R-13-A	Andesite	43.47	0.80	18.47	5.25	4.08	0.13	5.25	7.60	1.75	0.53	0.12	12.30	99.75	<1	<0.5	45	<1	11	0.050	65
P-19	P-R-14-A	Porphyrite	63.40	0.80	15.37	2.75	3.45	0.18	2.57	3.46	4.76	0.36	0.28	2.47	99.85	<1	0.6	145	<1	14	0.170	77
P-20	P-R-15-A	Andesite	65.66	0.67	16.22	1.56	2.42	0.17	4.29	0.04	0.18	2.41	0.06	5.71	99.39	<1	0.7	5	2	13	0.599	109
N-10	N-R-2-A	Altered Rock	61.63	0.54	14.01	4.12	0.26	<0.01	<0.01	0.08	0.10	1.73	0.20	16.77	99.46	<1	1.4	7	<1	494	0.459	8
N-15	N-R-1-A	Andesitic tuff	56.30	0.63	19.07	6.46	0.51	0.11	2.84	0.69	4.28	1.56	0.04	7.26	99.75	<1	0.5	17	<1	21	0.023	61

Table II-2-7 Calculation Result of C.I.P.W. Norm from Assay Result of Rock Samples taken in Semporna Peninsula Region

Locality	Sample Number	Rock Name	Q	C	or	ab	an	ac	wo-di	en-di	fs-di	en-hy	fs-hy	fo-ol	fa-ol	mt	hm	il	ru	ap	Total
M-1	M-R-1-A	Altered Rock	40.082	10.585	26.712	7.192	0.149	-	-	-	-	2.391	0.000	-	-	-	-	0.360	0.500	-	93.250
M-9'	M-R-2-A	Altered Rock	47.054	19.157	8.864	0.592	0.149	-	-	-	-	1.694	0.000	-	-	-	6.200	0.655	0.415	-	84.780
M-10	M-R-3-A	Trachy andesite	28.623	14.590	38.353	8.292	0.198	-	-	-	-	0.573	0.000	-	-	-	1.520	0.338	0.742	-	93.230
M-11	M-R-5-A	Andesite	19.278	0.912	12.056	20.647	26.919	-	-	-	-	6.825	0.000	-	-	1.679	3.821	0.949	-	0.394	93.480
M-12	M-R-6-A	Andesite	13.437	-	6.914	18.616	37.912	-	1.852	1.272	0.431	8.018	2.718	-	-	5.219	-	1.576	-	0.394	98.360
M-13	M-R-7-A	Andesitic tuff	16.564	0.508	8.392	15.654	36.295	-	-	-	-	9.764	0.505	-	-	7.147	-	1.348	-	0.394	96.570
M-14	M-R-8-A	Andesitic tuff	22.792	-	13.178	23.777	25.876	-	0.152	0.131	0.000	5.722	0.000	-	-	1.996	3.143	0.911	-	0.371	98.050
M-15	M-R-9-A	Basalt	1.903	-	10.578	28.262	23.978	-	6.219	4.117	1.652	10.429	4.185	-	-	4.190	-	2.982	-	0.834	99.330
M-17	M-R-10-A	Trachy andesite	13.459	3.980	61.460	1.185	0.198	-	-	-	-	5.056	4.480	-	-	4.435	-	1.158	-	-	95.410
M-30	M-R-11-A	Silicified Rock	97.664	0.207	-	0.169	-	-	-	-	-	-	-	-	-	-	0.380	1.267	0.033	-	99.670
W-3	W-R-2-A	Altered Rock	14.972	7.645	19.443	30.970	5.602	-	-	-	-	7.348	0.000	-	-	2.848	2.765	1.747	-	0.371	93.710
W-4	W-R-3-A	Altered Rock	17.943	0.380	2.896	18.277	33.032	-	-	-	-	11.084	4.513	-	-	5.537	-	1.386	0.232	0.232	95.280
W-8	W-R-5-A	Porphyrite	45.160	10.849	23.757	1.438	0.355	-	-	-	-	2.042	0.000	-	-	-	7.530	0.570	0.460	0.209	92.370
W-12	W-R-8-A	Altered Rock	44.599	13.018	14.538	1.015	0.386	-	-	-	-	5.131	0.000	-	-	-	4.050	0.697	0.213	0.162	83.810
P-1	P-R-1-A	Porphyrite	29.667	1.569	1.123	37.993	16.287	-	-	-	-	5.056	1.884	-	-	1.595	-	1.139	-	0.417	96.730
P-2	P-R-2-A	Diorite	29.875	1.745	1.064	19.800	26.660	-	-	-	-	5.629	5.378	-	-	3.145	-	1.367	-	0.556	95.220
P-3	P-R-3-A	Andesite?	29.199	2.281	8.805	37.824	5.984	-	-	-	-	4.608	4.908	-	-	1.885	-	0.874	-	0.394	96.760
P-4	P-R-4-A	Andesite	24.457	0.725	14.360	24.877	17.895	-	-	-	-	3.363	0.000	-	-	3.503	1.673	1.424	-	0.533	92.810
P-5	P-R-5-A	Andesite	13.177	-	4.255	26.654	32.275	-	2.279	0.847	1.475	4.458	7.767	-	-	3.276	-	1.671	-	0.394	98.530
P-6	P-R-6-A	Andesite	4.618	-	5.319	21.408	34.745	-	6.235	4.540	1.114	7.242	1.778	-	-	8.582	-	1.614	-	0.487	97.680
P-7	P-R-7-A	Andesite	11.551	-	2.127	29.954	26.267	-	5.743	2.968	2.621	4.181	3.691	-	-	4.668	-	1.386	-	0.533	95.690
P-9	P-R-9-A	Andesite	11.004	-	3.250	29.362	31.668	-	3.084	2.090	0.757	3.913	1.417	-	-	8.017	-	1.690	-	0.348	96.600
P-12	P-R-11-A	Andesite?	35.297	9.345	15.483	19.546	0.761	-	-	-	-	6.775	3.459	-	-	2.943	-	1.234	-	0.487	95.330
P-13	P-R-12-A	Altered Rock	34.546	13.797	18.970	0.677	0.237	-	-	-	-	15.891	0.000	-	-	6.216	0.001	1.443	-	0.162	91.940
P-17	P-R-13-A	Andesite	6.544	1.487	3.132	14.808	36.919	-	-	-	-	13.077	2.075	-	-	7.611	-	1.519	-	0.278	87.450
P-19	P-R-14-A	Porphyrite	22.479	1.529	2.127	40.278	15.336	-	-	-	-	6.401	3.076	-	-	3.986	-	1.519	-	0.649	97.380
P-20	P-R-15-A	Andesite	47.832	13.242	14.242	1.523	0.198	-	-	-	-	10.685	2.364	-	-	2.261	-	1.272	-	-	93.620
N-10	N-R-2-A	Altered Rock	54.256	11.827	10.224	0.846	0.397	-	-	-	-	-	-	-	-	-	4.120	0.549	0.251	-	82.470
N-15	N-R-1-A	Andesitic tuff	19.835	9.182	9.219	36.216	3.162	-	-	-	-	7.074	0.000	-	-	0.176	6.338	1.195	-	0.093	92.490

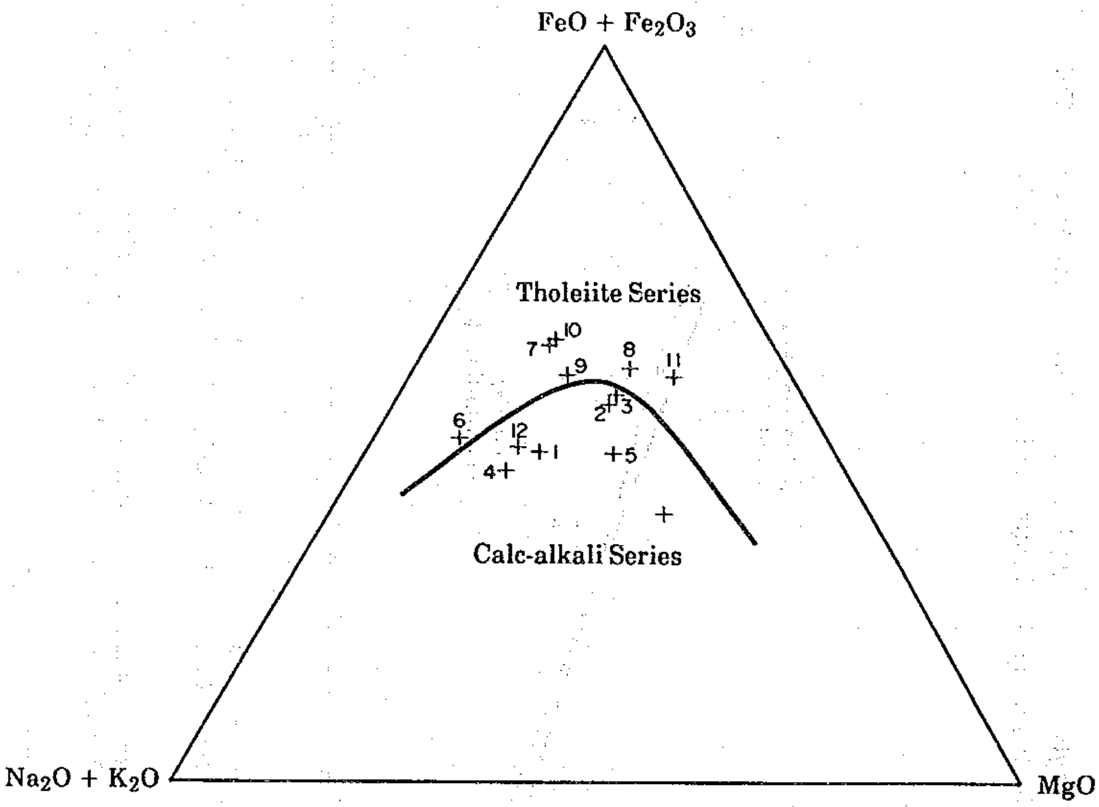
Figure II-2-27 $Na_2O + K_2O - SiO_2$ Diagram of Andesite, Andesitic Tuff and Basalt in Semporna Peninsula Region



1: M-R-5-A, 2: M-R-6-A, 3: M-R-7-A, 4: M-R-8-A, 5: M-R-9-A, 6: P-R-4-A, 7: P-R-5-A
8: P-R-6-A, 9: P-R-7-A, 10: P-R-9-A, 11: P-R-13-A, 12: N-R-1-A

(A) Boundary line between alkali basalt and tholeiite in Hawaii after Macdonald and Katsura (1964)
(B) Boundary line between alkali rock and nonalkali rock of volcanic rock in Japan after Kuno (1966)

Figure II-2-28 $FeO + Fe_2O_3 - Na_2O + K_2O - MgO$ Trigonal Diagram (MFA Diagram) of Andesite, Andesitic Tuff and Basalt in Semporna Peninsula Region



1: M-R-5-A, 2: M-R-6-A, 3: M-R-7-A, 4: M-R-8-A, 5: M-R-9-A, 6: P-R-4-A
7: P-R-5-A, 8: P-R-6-A, 9: P-R-7-A, 10: P-R-9-A, 11: P-R-13-A, 12: N-R-1-A

Solid line is boundary between tholeiite series and calc-alkali series after Irvine and Barager (1971)

(3) Microscopic Observation of Thin Section of Rock (29 samples)

The sections made from twenty-nine same rock samples as analyzed chemically were observed microscopically. The result of the observation is shown in the Table II-2-8.

Table II-2-8 Result of Microscopic Observation of Thin Sections of Rock Samples taken in Semporna Peninsula Region

Area	Mantri	"	"	"	"	"	"	"	"	"	Wullersdorf	"	"	"
Sample Number	M-T-1	M-T-5	M-T-6	M-T-8	M-T-9	M-T-10	M-T-11	M-T-12	M-T-14	M-T-15	W-T-2	W-T-3	W-T-5	W-T-8
Rock Name	Altered rock	Altered rock	Trachyandesite	Andesite	Andesite	Andesitic tuff	Andesitic tuff	Basalt	Trachyandesite	Silicified rock	Altered rock	Altered rock	Porphyrite	Altered rock
Texture			Porphyritic	Porphyritic Hyalopilitic	Porphyritic Intergranular	Pyroclastic	Pyroclastic	Porphyritic Intergranular	Porphyritic Trachytic				Porphyritic	
[Phnocryst, Fragments]														
Plagioclase				◎	◎	◎	◎	○			○*		○	
K-felspar			○*						◎					
Olivine								△						
Augite				△	○	○		○						
Hypersthene				△	○	◎		△						
Hornblende													△*	
Biotite				△			△							
Others						△*	△*			◎*				
[Groundmass, Matrix, Accessary]														
Plagioclase				◎	◎	◎	◎	◎					◎	
K-felspar			◎						◎					
Quartz													○	
Hypersthene						△		△						
Augite					◎	△		◎						
Glass						◎	◎		◎					
Zircon							●			●				●
Sphene									△		△			
Opaque	○	◎	◎	△	◎	○	●	◎	○	△	○	○	○	△
[Alteration, Metamorphic Mineral]														
Quartz	◎	◎	◎				○		◎		◎	◎	○	◎
Sericite	◎	△	◎				△		◎	●	◎	◎		◎
Plagioclase	△													
Montmorillonite		△		◎		○		△						
Kaolinite		△	△											
Chlorite				○	△		△	△	○		△		○	○
Calcite				△									△	
Epidote													○	
Actinolite													○	
Others								△*				○* △**		
Remarks			* replaced by sericite, altered trachy andesite with K-felspar			* andesite fragment, relatively fresh andesitic crystal tuff	* andesite fragment, slightly altered andesitic crystall tuff	* hematite		* quartz, aggregates of minute quartz grains (strongly silicified rock)	* plagioclose pseudomorph, replaced by sericite, unknown origin, strongly altered	* fluorite ** cristobalite, strongly altered rock, unknown origin	* pseudomorph replaced by epidote, actinolite, chlorite	

Area	Pock	"	"	"	"	"	"	"	"	"	"	"	"	Nagos	"
Sample Number	P-T-1	P-T-2	P-T-3	P-T-4	P-T-5	P-T-6	P-T-7	P-T-9	P-T-11	P-T-12	P-T-13	P-T-14	P-T-15	N-T-2	N-T-4
Rock Name	Porphyrite	Diorite	Andesite?	Andesite	Andesite	Andesite	Andesite	Andesite	Andesite?	Altered rock	Andesite	Porphyrite	Andesite	Altered rock	Andesitic tuff
Texture	blasto-porphyritic	hypidiomorphic	porphyritic	porphyritic Hyalopilitic	Porphyritic hyalopilitic	Porphyritic hyalopilitic	Porphyritic hyalopilitic	Porphyritic intersertal			porphyritic	porphyritic	porphyritic		
[Phnocryst, Fragments]															
Plagioclase	△	◎	△*	○	◎	◎	○	◎			○*	○	△*		○
K-felspar															
Olivine															
Augite				△	○	△	●	○			○*				
Hypersthene				△	○	○		△							
Hornblende															
Biotite															
Others															△*
[Groundmass, Matrix, Accessary]															
Plagioclase	◎			○	◎	○	◎	◎	◎			◎			◎
K-felspar															◎
Quartz		◎													
Hypersthene					△	△									
Augite					△	△									
Glass				◎	◎	◎	◎	◎							
Zircon															
Sphene	△	●										△			
Opaque		△		△	△	△		△	○	○*		●		○	○
[Alteration, Metamorphic Mineral]															
Quartz	○		◎	△			○		◎	◎	○	△	◎	◎	○
Sericite	△		○					○	◎	◎		○	◎	○	△
Plagioclase			○										△		
Montmorillonite			○	△	△			○			◎				○
Kaolinite														○	○
Chlorite	○	○	○		△		○	△	△	○	◎	○	△		△
Calcite			○	△	○		△				◎				
Epidote	○	○	△				△					◎			
Actinolite															
Others		●*		△*											
Remarks		* clinozoisite, metamorphosed diorite	* pseudomorph replaced by calcite, strongly altered rock, probably andesite	* chalcedony filling vesicles						* pyrite, strongly altered rock, unknown origin	* pseudomorphs phenocrysts of pl., aug., strongly altered rock, probably andesite		* pseudomorph replaced by sericite, strongly altered rock, probably andesite		* andesite fragment, altered rock of unknown origin

[Notes] ◎: Abundant, ○: Medium, △: Little, ●: Trace

(4) Chemical Analysis of Ore (40 samples)

The assay result of ore samples taken at the forty localities of mineral occurrence, namely nineteen in the Mantri, four in the Wullersdorf, seven in the Pock and ten in the Nagos area, is shown in the Table II-2-11 in the following section 2-4.

(5) Microscopic Observation of Polished Section of Ore (20 samples)

The polished sections made from twenty samples out of forty ore samples analyzed chemically were observed microscopically. The result of the observation is shown in the Table II-2-9. The Table II-2-9 shows that the main constituents of quartz vein in the Mantri and Nagos areas are quartz, goethite and secondary hematite except for one sample whereas quartz (or host rock) and pyrite except for one sample in the south-eastern part of the Wullersdorf and Pock areas.

Considering that goethite and hematite are secondary minerals altered from sulfide minerals such as pyrite and so on by oxidation, it seems that oxidation has been intense in the Mantri and Nagos areas.

A little sphalerite and trace of chalcopyrite, chalcocite, covelline and galena in the sample M-P-2 of the Mantri area, trace of chalcopyrite in the sample W-P-1 of the Wullersdorf area, trace of sphalerite in the sample P-P-2, trace of chalcopyrite and sphalerite in the sample P-P-5 and trace of chalcopyrite in the sample P-P-6 of the Pock area were identified as accessory minerals.

Table II-2-9 Result of Microscopic Observation of Polished Sections of Ore Samples taken in Semporna Peninsula Region

Locality	Sample No.	Occurrence	Chalcopyrite	Chalcocite	Covellite	Sphalerite	Galena	Pyrite	Pyrrhotite	Malachite	Hematite	Goethite	Gangue	Remarks
M-3	M-P-1	(Oxidized) altered wall rock and quartz veinlet (?)						•			○	○	Q ◎	Q: quartz
M-6	M-P-2	Sphalerite-pyrite-quartz vein	•	•	•	●	•	●					Q ◎	Q: quartz
M-10	M-P-3	(Oxidized) altered wall rock and quartz veinlet (?)						•			●	○	Q ◎	Q: quartz
M-16	M-P-4	(Oxidized) altered wall rock with pyrite dissemination						•			●	○	Q ◎	Q: quartz
M-24	M-P-5	(Oxidized) quartz vein									○	○	Q ◎	Q: quartz, colloform bands of hematite and goethite
M-28	M-P-6	(Oxidized) altered wall rock and quartz veinlet (?)									○	○	Q ◎	Q: quartz
M-29	M-P-7	(Oxidized) quartz vein									●	●	Q ◎	Q: quartz, colloform bands of hematite and goethite
W-1	W-P-1	Pyrite dissemination	•					●					◎	
W-3	W-P-2	Pyrite dissemination						●					◎	
W-4	W-P-3	Pyrite veinlet and dissemination						○					◎	
W-11	W-P-4	(Oxidized) quartz vein						•			●	●	Q ◎	Q: quartz
P-10	P-P-1	Pyrite-quartz veinlet and pyrite dissemination						○					Q ◎	Q: quartz
P-13	P-P-2	Pyrite-quartz veinlet and dissemination				•		○					Q ◎	Q: quartz
P-14	P-P-3	(Oxidized) quartz vein											Q ◎	Q: quartz
P-20	P-P-5	Pyrite dissemination	•			•		○					Q ◎	Q: quartz
P-21	P-P-6	Pyrite dissemination	•					○					Q ◎	Q: quartz
N-2	N-P-1	(Oxidized) altered wall rock and quartz veinlet (?)						•			●	●	Q ◎	Q: quartz
N-3	N-P-2	(Oxidized) quartz vein						•			●	○	Q ◎	Q: quartz
N-4	N-P-3	(Oxidized) altered wall rock (?)						•	•		●	○	Q ◎	Q: quartz
N-8	N-P-4	(Oxidized) altered wall rock (?)									○	○	Q ○	Q: quartz

[Notes]

◎>○>●>•

(6) X-ray Diffraction Examination (40 samples)

The result of X-ray diffraction examination of forty samples of hydrothermally altered rock at and around the localities of mineral occurrence, that is eighteen in the Mantri area, four in the southeastern part of Wullersdorf area, ten in the Pock area and eight in the Nagos area, is shown in the Table II-2-10.

Table II-2-10 reveals that the hydrothermally altered zone in the each area has a different mineral assemblage. That is, the hydrothermal alteration minerals consist of abundant quartz, abundant to middle amount of potash felspar, middle amount to trace of sericite, kaolinite and pyrite in the Mantri area, abundant quartz, abundant to middle amount of plagioclase (albite), middle amount of chlorite, middle amount to trace of sericite and a little to trace of pyrite in the southeastern part of the Wullersdorf and Pock areas, and abundant quartz, middle amount to a little kaolinite, abundant to middle amount of alunite and middle amount to trace of montmorillonite.

The mineral assemblage of the hydrothermal alteration minerals in each area shows that the hydrothermal alteration zone is silicified and argillized zone which was formed by intermediate to alkaline hydrothermal solution accompanied by gold mineralization and the hydrothermal alteration zone in the southeastern part of the Wullersdorf and Pock areas is propylitized zone and that the hydrothermal alteration zone is silicified and argillized zone which is, in general, found around the top of the gold and silver-bearing quartz vein formed by acidic hydrothermal solution.

Table II-2-10 Result of X-ray Diffraction of Hydrothermally Altered Host Rock in Semporna Peninsula Region

Area	Sample No.	Rock Name	Clay Mineral					Silica Mineral		Others								
			Montmorillonite	Mixed-layer mineral of Ser. & Mont.	Chlorite	Sericite	Kaolinite	Cristobalite	quartz	Alunite	Diaspore	Epidote	Talc	Plagioclase	K-felspar	Hematite	Goethite	Pyrite
Mantri	M-X-1	Hydrothermally altered rock				○			◎									○
"	M-X-2	Hydrothermally altered rock				●	●		◎						○		●	
"	M-X-3	Hydrothermally altered rock				●	○		◎							●		
"	M-X-4	Altered andesitic tuff				○	◦		◎							●	●	
"	M-X-5	Hydrothermally altered rock				○			◎									○
"	M-X-6	Hydrothermally altered rock				○			◎									◦
"	M-X-7	Hydrothermally altered rock		○					●									○
"	M-X-8	Hydrothermally altered rock	●				◦		◎						◦			○
"	M-X-9	Altered trachy andesite				●	◦		◎						◎	●		
"	M-X-10	Altered andesitic tuff				○			◎							◦		
"	M-X-11	Trachy andestie			◦	●			◎						◎			◦
"	M-X-12	Altered andesitic tuff				◦			◎						○			●
"	M-X-13	Hydrothermally altered rock				◦	●		◎						○	●	●	
"	M-X-14	Altered andesitic tuff				○			◎							◦		
"	M-X-15	Altered andesitic tuff				◦	◦		◎									
"	M-X-16	Hydrothermally altered rock				●	○		◎						○			
"	M-X-17	Altered andesitic tuff				●	●		◎						◎			◦
"	M-X-19	Altered andesitic tuff				○			◎							◦		
Wullersdorf	W-X-1	Propylite			○	●			◎					○				◦
"	W-X-3	Propylite			◦	◦			◎					◎				○
"	W-X-4	Hydrothermally altered rock				○		◦	◎									◦
"	W-X-9	Hydrothermally altered rock			◦	◦			◎									◦
Pock	P-X-1	Porphyrite	●		○				◎			●		◎				●
"	P-X-3	Propylite	●		○	●			◎					◎				●
"	P-X-6	Hydrothermally altered rock			○	◦			◎									◦
"	P-X-8	Propylite			○	○			◎					○				●
"	P-X-9	Propylite			○	◦			◎									◦
"	P-X-10	Strongly silicified rock							◎		◦		○					
"	P-X-15	Propylite			○	●			◎			●		◎				
"	P-X-16	Propylite			○	◦			◎									●
"	P-X-17	Propylite			○	●			◎					◎				●
"	P-X-18	Propylite			◦	◦			◎					◎				●

Area	Sample No.	Rock Name	Clay Mineral					Silica Mineral		Others								
			Montmorillonite	Mixed-layer mineral of Ser. & Mont.	Chlorite	Sericite	Kaolinite	Cristobalite	quartz	Alunite	Diaspore	Epidote	Talc	Plagioclase	K-felspar	Hematite	Goethite	Pyrite
Nagos	N-X-1	Hydrothermally altered rock					◦		◎		○		○					
"	N-X-2	Hydrothermally altered rock	●			◦	◦		◎									
"	N-X-3	Altered andesitic tuff				◦	◦		◎							●		
"	N-X-4	Hydrothermally altered rock							◎		○							
"	N-X-5	Hydrothermally altered rock					◦		◎				◦			●		
"	N-X-9	Hydrothermally altered rock					◦		◎	◎						◦		
"	N-X-10	Altered andesitic tuff					○		◎	○						●	●	
"	N-X-15	Altered andesitic tuff	○				●		◎					◎				◦

[Notes] ◎: Abundant, ○: Medium, ◦: Little, ●: Trace

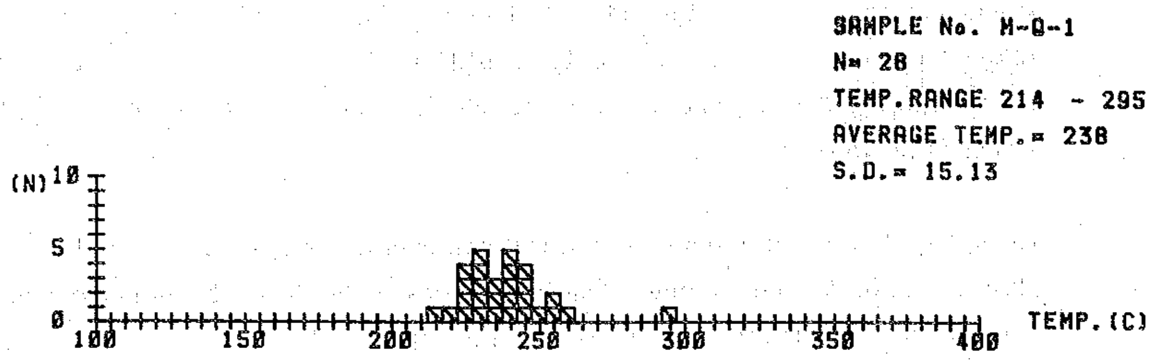
(7) Measurement of Homogenization Temperature of Fluid Inclusions in Quartz

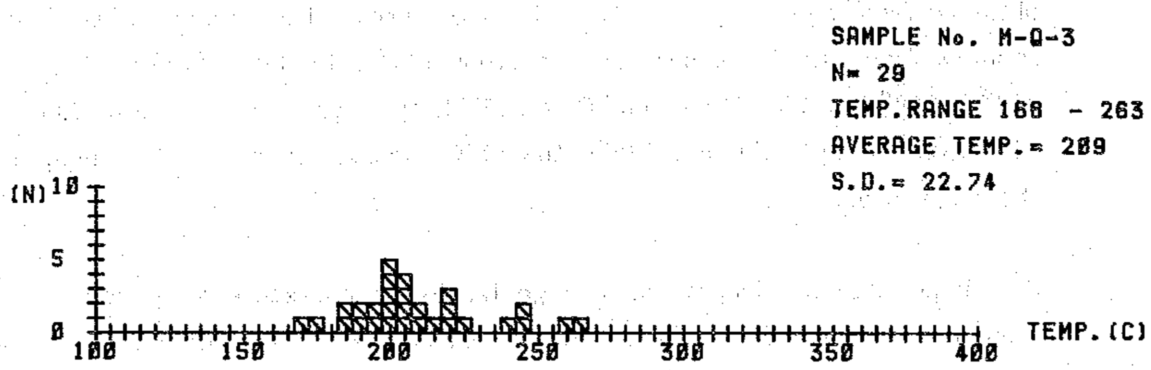
Homogenization temperature of fluid inclusions in nineteen samples of quartz taken from quartz veins at twenty localities of mineral occurrence, namely thirteen in the Mantri, one in the Wullersdorf, three in the Pock and two in the Nagos area, were measured.

However, it was impossible to measure homogenization temperature due to no fluid inclusion in one sample. The histograms made from the homogenization temperature measured are shown in the Fig. II-2-29 to Fig. II-2-35. The homogenization temperature of fluid inclusions in thirteen quartz samples in the Mantri area were 140° to 260°C and the temperature of 200° to 290° was obtained from one sample in the Wullersdorf area. The temperature of three samples from the Pock area ranged from 175°C to 385°, namely 175°C to 210°C, 260°C to 280°C and 345°C to 385°C, and high temperature of 230°C to 340°C (230°C to 275°C and 320°C to 340°C) was obtained from two samples in the Nagos area.

It is impossible to discuss the homogenization temperature of quartz samples from the Wullersdorf, Pock and Nagos areas due to few number of samples measured.

The homogenization temperature of fluid inclusions in quartz taken in the Mantri area is close to the formation temperature (170°C to 270°C) of low sulfidation type gold deposit, after Hendenquist (1987), which has the majority of epithermal gold deposits distributed in the circum-Pacific region and is one type of the epithermal gold mineralization accompanying hydrothermal fluid related to the volcanic activity. According to Hedenquist, another type of the epithermal gold mineralization is of high sulfidation and was formed at the temperature of 200°C to 300°C.





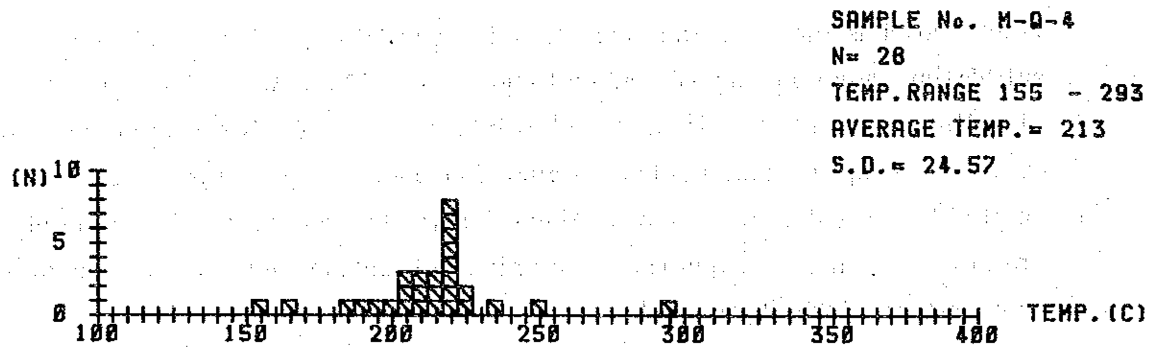
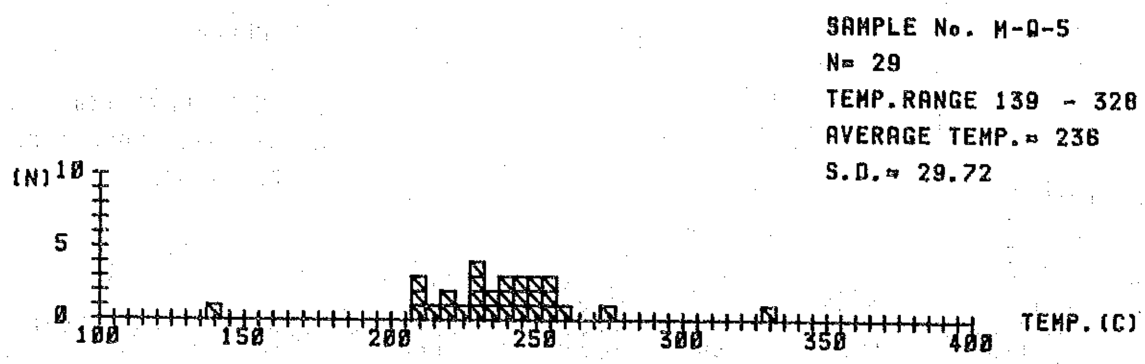
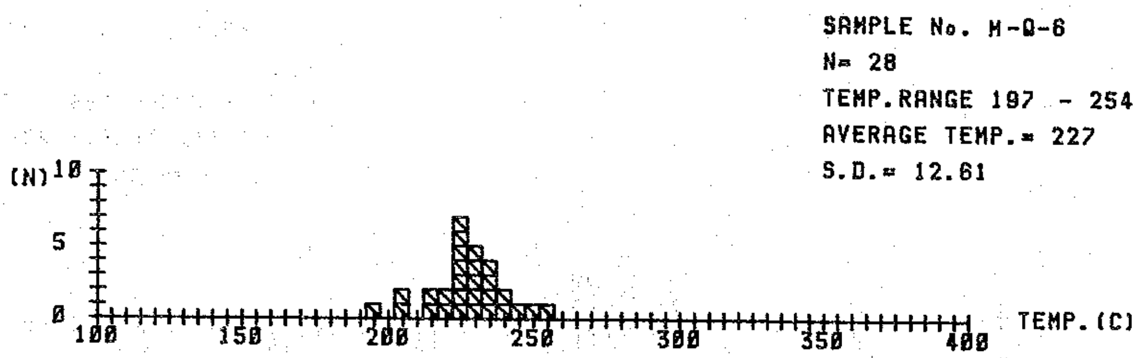


Figure II-2-29 Homogenization Temperature of Fluid Inclusions in Quartz from the Mantri Area (M-Q-1, M-Q-3, M-Q-4)





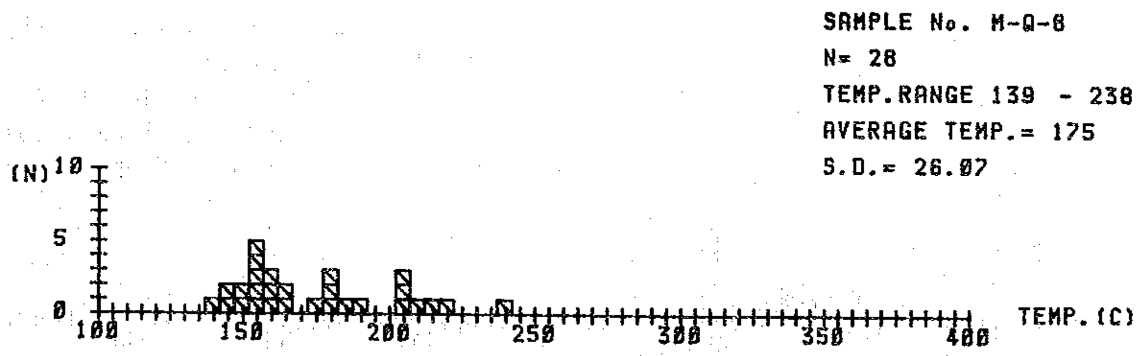
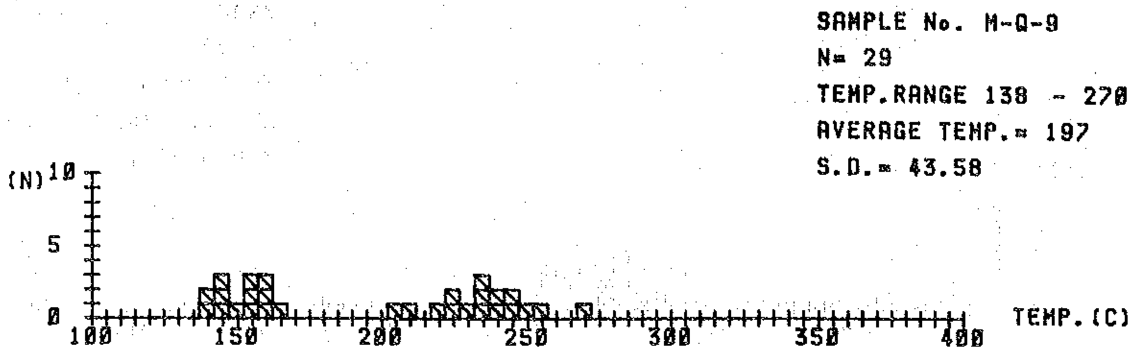
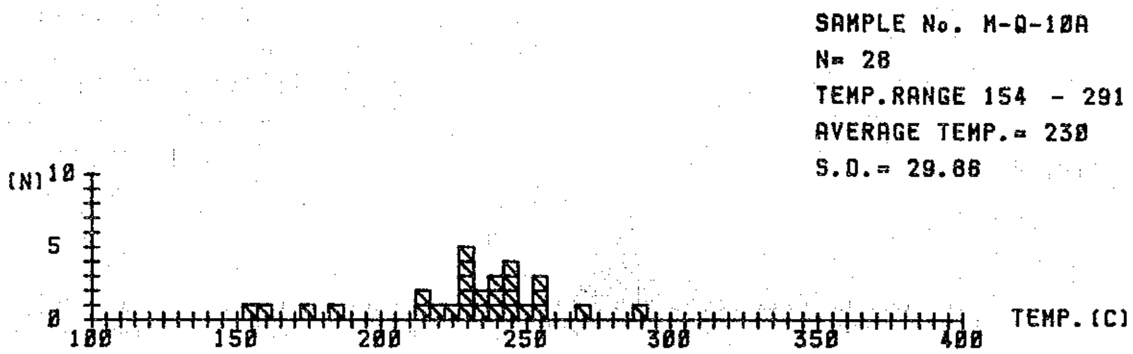


Figure II-2-30 Homogenization Temperature of Fluid Inclusions in Quartz from the Mantri Area (M-Q-5, M-Q-6, M-Q-8)





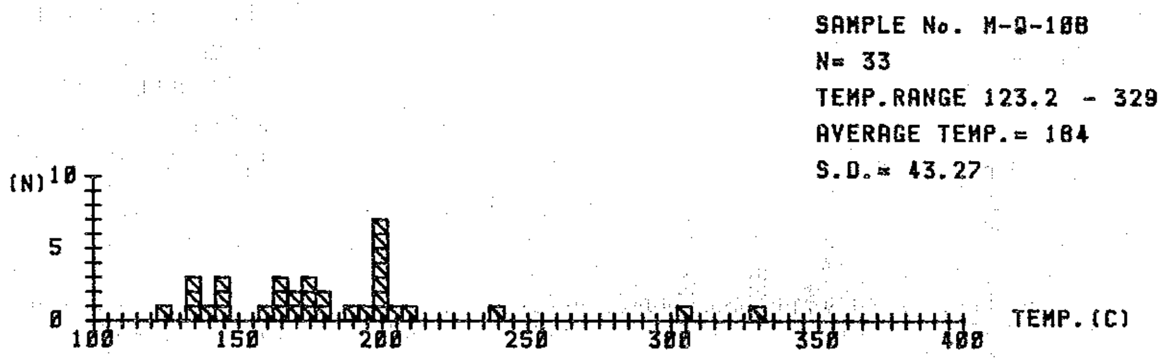


Figure II-2-31 Homogenization Temperature of Fluid Inclusions in Quartz from the Mantri Area (M-Q-9, M-Q-10A, M-Q-10-B)

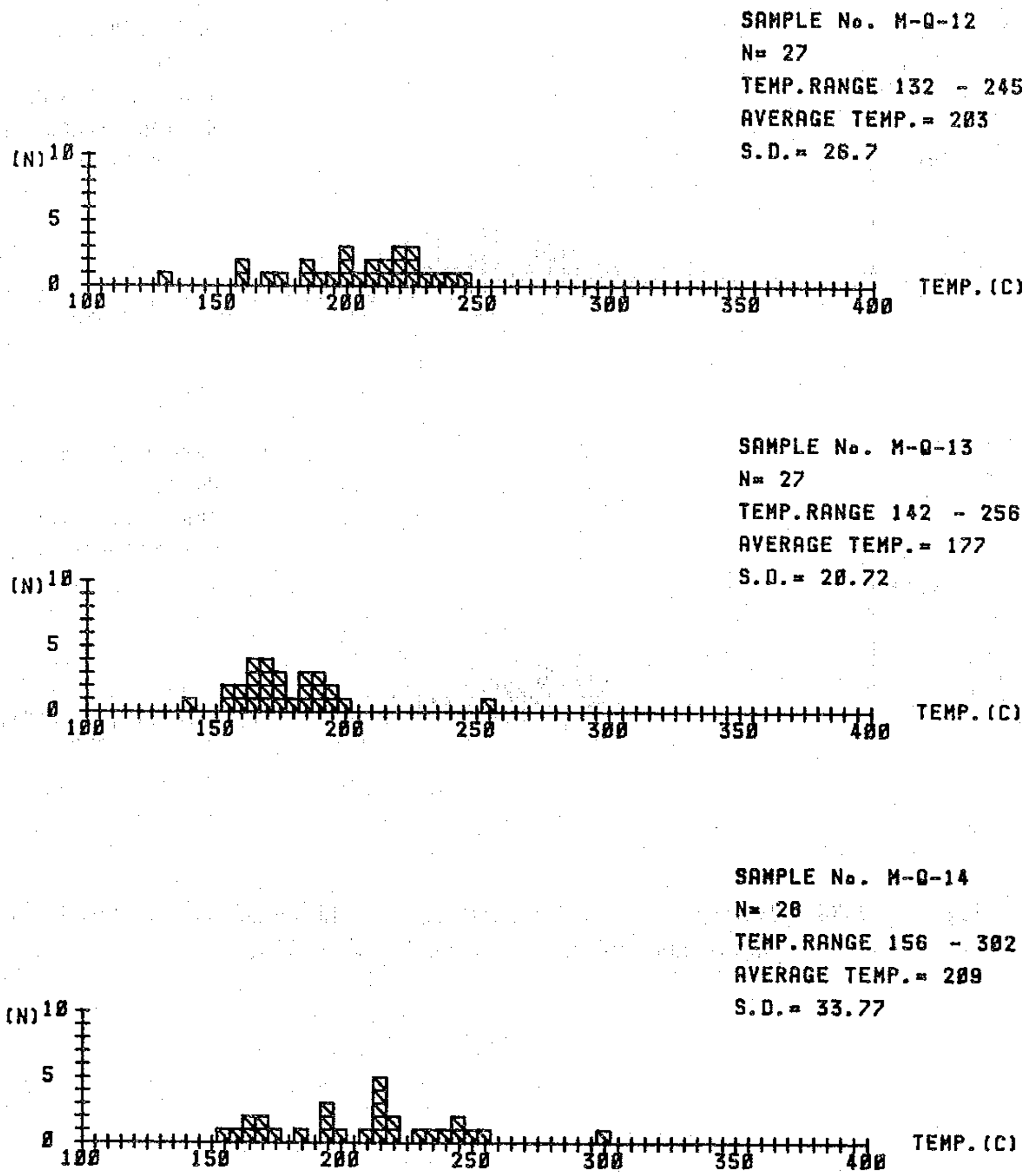
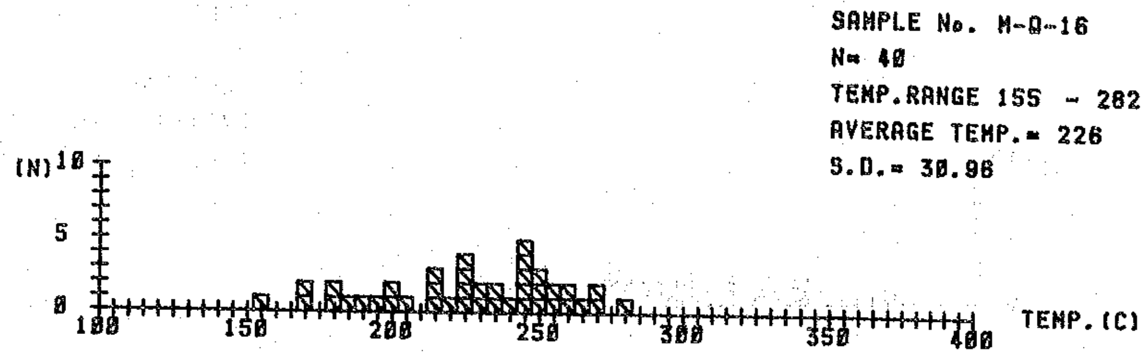


Figure II-2-32 Homogenization Temperature of Fluid Inclusions in Quartz from the Mantri Area (M-Q-12, M-Q-13, M-Q-14)



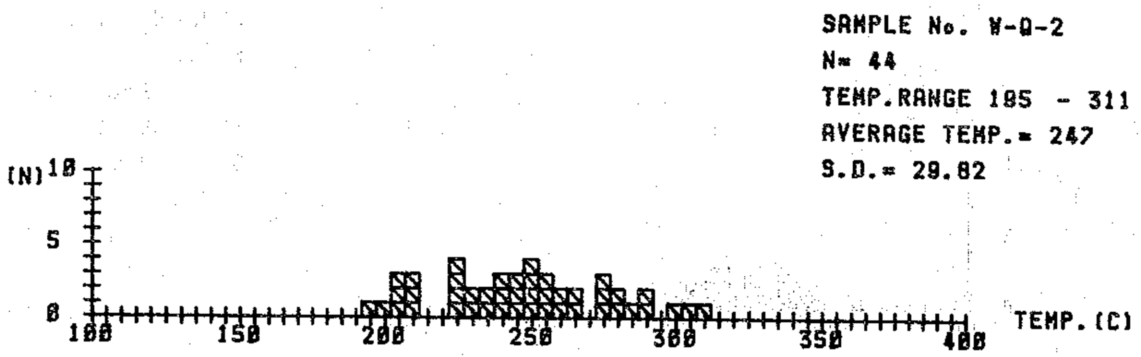


Figure II-2-33 Homogenization Temperature of Fluid Inclusions in Quartz from the Mantri and Wullersdorf Areas (M-Q-16, W-Q-2)

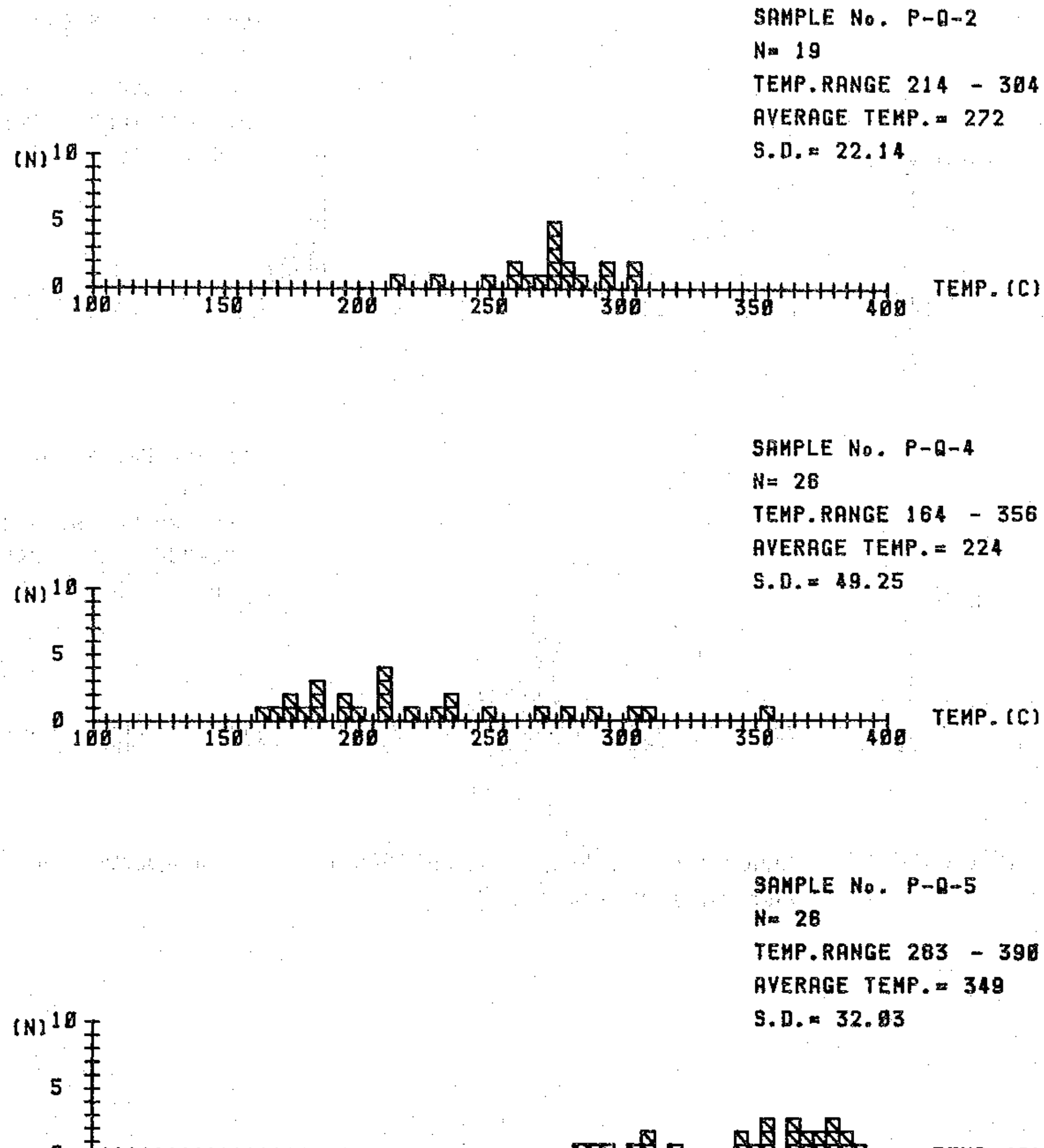


Figure II-2-34 Homogenization Temperature of Fluid Inclusions in Quartz from the Pock Area (P-Q-2, P-Q-4, P-Q-5)

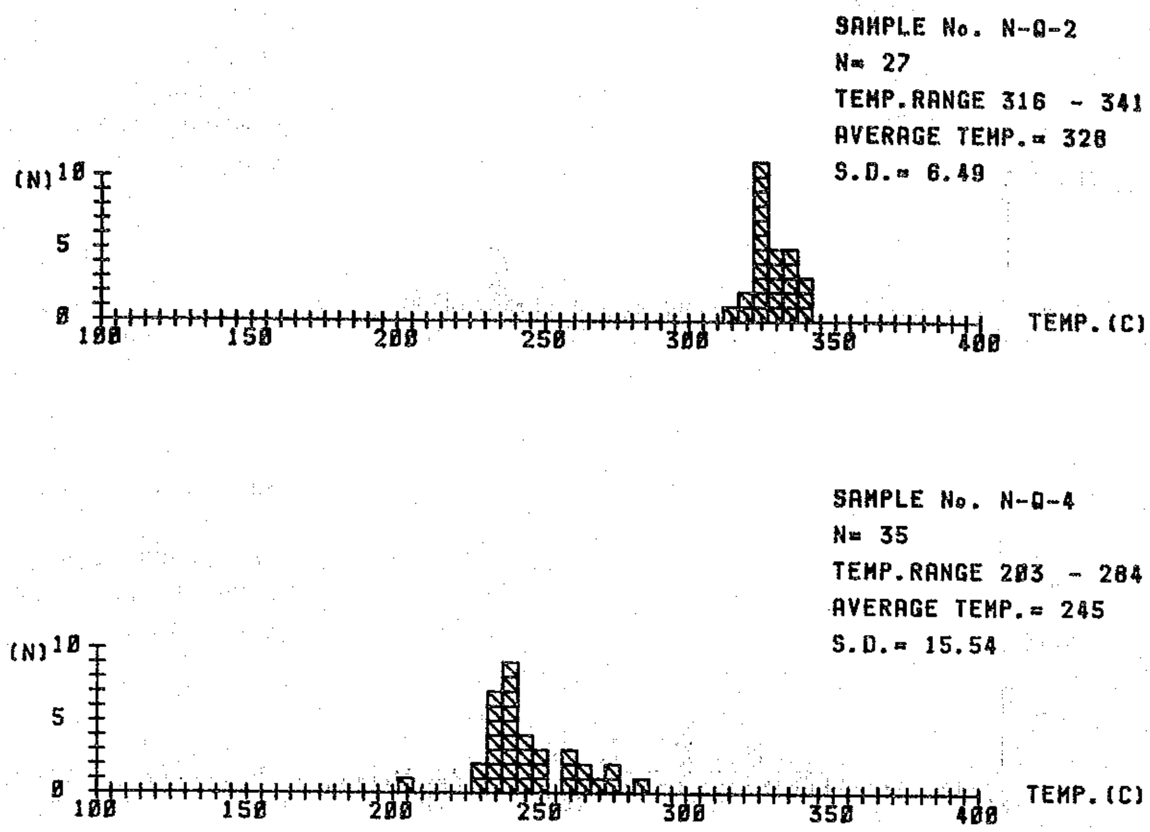


Figure II-2-35 Homogenization Temperature of Fluid Inclusions in Quartz from the Nagos Area (N-Q-2, N-Q-4)

2-4 Assay Result of Ore

The assay result of forty ore samples in total taken at forty localities of mineral occurrence in Mantri, Wullersdorf, Pock and Nagos areas in the Semporna Peninsula region, namely nineteen in Mantri, four in Wullersdorf, seven in Pock and ten in Nagos, is shown in the Table II-2-11.

The assay result shown in the Table II-2-11 reveals that gold is contained in limonite-hematite (secondary)-bearing quartz veins in the Mantri area and in some limonite-hematite-bearing quartz network in the Nagos area and that some quartz veins or network contain a little lead and/or zinc in the Mantri and Pock areas.

The samples which contain gold of over one gram per ton out of forty samples are six samples in the Mantri area, namely M-O-4-A (1.90 g/t), M-O-10-A (3.42 g/t), M-O-11-A (1.16 g/t), M-O-13-A (1.42 g/t), M-O-14-A (2.08 g/t), and M-O-15-A (2.02 g/t), and one sample (N-O-12-A, 1.18 g/t) in the Nagos area. The sample which contains silver of over one ounce per ton is one sample (M-O-7-A, 53.4 g/t) at the M-10 locality in the Mantri area.

The samples containing lead or zinc of over 0.5% are three samples in the Mantri area, namely M-O-5-A (0.70% Zn), M-O-11-A (1.02% Pb) and M-O-20-A (0.86% Pb), and one sample (P-O-2-A, 0.74% Pb and 2.38% Zn) in the Pock area.

Table II-2-11 List of Assay Result of Ore Samples taken in Semporna Peninsula Region

Location	Sample Number	Au (g/t)	Ag (g/t)	Cu (ppm)	Mo (ppm)	Pb (ppm)	S (%)	Zn (ppm)	Occurrence of Ore
M-1	M-O-1-A	<0.01	<0.1	29	<1	31	0.011	35	lim-bearing qz vein
M-3	M-O-3-A	0.26	7.9	167	<1	330	0.110	90	qz-lim·hm network
M-4	M-O-4-A	1.90	3.7	48	<1	152	0.017	25	lim-hm-bearing qz vein
M-6	M-O-5-A	<0.01	0.9	95	<1	258	0.911	6,992	py-sp-bearing qz lens
M-8	M-O-6-A	<0.01	<0.1	43	<1	157	0.019	22	qz·lim vein
M-10	M-O-7-A	0.10	53.4	135	<1	374	0.074	53	lim-hm-bearing qz vein
M-16	M-O-8-A	0.08	2.5	68	18	359	2.057	116	py-lim-hm-bearing qz vein & network
M-18	M-O-9-A	0.06	9.1	34	<1	753	0.815	60	qz vein & network
M-19	M-O-10-A	3.42	4.1	171	<1	1,670	0.012	235	hm-bearing qz vein & network
M-20	M-O-11-A	1.16	9.8	664	<1	10,176	0.035	508	lim-hm-gn-bearing qz network
M-21	M-O-12-A	<0.01	3.7	168	<1	1,585	0.029	100	hm-lim-bearing qz lens & network
M-22	M-O-13-A	1.42	1.3	213	<1	731	0.051	74	hm-lim-bearing qz vein
M-23	M-O-14-A	2.08	16.7	288	<1	356	0.078	320	hm-lim-bearing qz vein
M-24	M-O-15-A	2.02	2.9	229	<1	160	0.027	119	hm-lim-bearing qz vein
M-25	M-O-16-A	<0.01	<0.1	147	<1	2,579	0.040	209	hm-lim-bearing qz network
M-26	M-O-17-A	0.08	2.2	124	<1	633	0.025	59	hm-lim-bearing qz vein
M-27	M-O-18-A	0.30	22.1	336	<1	188	0.880	14	hm-lim-bearing qz vein & network
M-28	M-O-19-A	<0.01	<0.1	39	<1	136	0.013	19	hm-lim-bearing qz vein
M-29	M-O-20-A	0.82	5.9	117	<1	8,596	0.008	183	hm-gn-bearing qz vein
W-1	W-O-1-A	<0.01	<0.1	40	<1	27	0.452	142	dissemination of py
W-3	W-O-2-A	<0.01	<0.1	24	<1	33	4.450	65	dissemination of py
W-4	W-O-3-A	<0.01	<0.1	15	<1	20	6.495	38	qz·py·cm vein & diss.
W-11	W-O-5-A	<0.01	<0.1	77	<1	50	0.017	87	hm-lim-bearing qz vein
P-10	P-O-1-A	<0.01	<0.1	155	<1	143	1.535	17	qz·py·cm vein
P-13	P-O-2-A	<0.01	3.2	55	1	7,388	8.404	23,803	qz·py·sp·gn·cm vein
P-14	P-O-3-A	<0.01	<0.1	17	8	333	0.021	29	lim-bearing qz network
P-20	P-O-6-A	<0.01	<0.1	41	291	63	1.297	113	qz·py·cm vein
P-21	P-O-7-A	<0.01	<0.1	343	60	28	6.358	20	qz·lim·py lens
P-22	P-O-8-A	<0.01	<0.1	7	<1	7	0.017	11	qz vein
P-23	P-O-9-A	<0.01	<0.1	20	<1	19	0.545	810	py-lim-bearing qz vein
N-1	N-O-1-A	<0.01	<0.1	85	<1	217	0.007	7	cm-bearing qz vein
N-2	N-O-2-A	<0.01	<0.1	41	5	22	0.003	10	hm-lim-bearing qz vein
N-3	N-O-3-A	<0.01	<0.1	140	<1	79	0.141	23	hm-lim-cm-bearing qz vein
N-4	N-O-4-A	<0.01	<0.1	247	8	106	0.052	35	qz·lim·hm·cm vein
N-5	N-O-5-A	<0.01	<0.1	82	17	47	0.007	20	lim-hm-cm-bearing qz vein
N-8	N-O-8-A	<0.01	<0.1	88	<1	149	0.232	14	hm-lim bearing qz network
N-9	N-O-9-A	<0.01	<0.1	19	<1	364	0.203	25	hm-lim-cm-bearing qz network
N-10	N-O-10-A	<0.01	<0.1	15	<1	376	0.058	11	lim-bearing qz·cm vein
N-11	N-O-11-A	0.30	14.3	153	<1	434	1.719	18	lim-hm-py-bearing qz network
N-12	N-O-12-A	1.18	6.2	517	4	294	0.034	203	lim-hm-bearing qz network

Abbreviations; M : Mantri, W : Wullersdorf, P : Pock, N : Nagos,
lim: limonite, hm: hematite (secondary), qz : quartz, py: pyrite,
cp : chalcopyrite, cm: clay mineral, diss: dissemination, gn: galena,
sp : sphalerite.

2-5 Consideration

The result of the investigation for the localities of mineral occurrence in the Semporna peninsula region and the indoor experiment・chemical analysis of rock, ore and quartz samples taken at and around the localities of mineral occurrence is summarized as follows.

(1) Ore deposit in the Semporna peninsula region is epithermal gold-bearing quartz vein and network, which are embedded in volcanic and pyroclastic rocks of Miocene to Pliocene in age, formed by hydrothermal fluid related to the volcanic activity of the Miocene to Pliocene age.

The assay of ore samples resulted in detecting low grade gold of 1.16 to 3.42 g/t in the Mantri area and 1.18 g/t in the part of the Nagos area.

(2) Chemical analysis of rock reveals that intermediate to mafic volcanic and pyroclastic rocks in the Mantri and Nagos areas belong to the calc-alkali rock series and andesites in the Pock area fall within the tholeiite series.

(3) It is inferred that gold mineralization in the Semporna peninsula region is related possibly to the volcanic activity of the calc-alkali rock series from the explanation in the above (1) and (2).

(4) The result of the X-ray diffraction examination and the microscopic observation of the thin sections lead to the inference that hydrothermal alteration zone in the Mantri area, which consists of silicified and argillized zone at and around Mt. Wullersdorf located at the center of the alteration zone, was formed by intermediate to alkaline hydrothermal fluid accompanied by gold mineralization, and alteration zone in the southeast part of the Wullersdorf and Pock areas is propylitized zone resulting from regional or deuteric alteration, which had probably no direct relation with mineralization, before mineralization and that hydrothermal alteration zone in the Nagos area is silicified and argillized zone, which is found, in general, near the top of gold - silver-bearing quartz vein, formed by acidic hydrothermal solution.

(5) It seems that gold mineralization in the Mantri area, judging from the mineral assemblage of hydrothal alteration minerals and homogenization temperature of fluid inclusions in quartz, is epithermal gold mineralization, similar to the

majority of epithermal gold deposits distributed in the circum-Pacific region, accompanying hydrothermal fluid related to the volcanic activity of Miocene to Pliocene age and belongs to the low sulfidation type after Hendenquist (1987).

(6) As gold deposit in the Mantri area seems to be of the stockwork (network) type as a whole, there is a possibility of the emplacement of the bonanza type (vein type) gold-bearing quartz vein below the network. There is also possibility of the emplacement of the stockwork type and/or bonanza type deposit below the massive silicified and argillized zone in the Nagos area.

Part III Conclusion and Recommendation

PART III CONCLUSION AND RECOMMENDATION

CHAPTER 1 CONCLUSION

It seems that base metal deposit with possibility of discovery in the future in the Segama and Semporna regions surveyed in 1991, firstly, is gold deposit in the Semporna region.

Ore deposit in the Semporna peninsula region is epithermal gold-bearing quartz vein and network, which are embedded in volcanic and pyroclastic rocks of Miocene to Pliocene in age, formed by hydrothermal fluid related to the volcanic activity of the Miocene to Pliocene age.

As seen in the Mantri, host rock was subjected to hydrothermal alteration consisting of intense silicification, argillization (sericitization, kaolinization), formation of potash felspar and pyritization caused by hydrothermal fluid, which is mainly intermediate to alkaline, accompanied by gold mineralization. On the other hand, host rock in the Nagos area underwent acidic alteration, which is composed of intense silicification, argillization (kaolinization, sericitization and montmorillonitization) and alunitization and is found, in general, near the top of gold-silver-bearing quartz vein.

The structure controlling the emplacement of ore deposit seems to be faults which strike northeast, northwest, north-south and east-west.

As gold deposit in the Mantri area seems to be of the stockwork of low grade as a whole, there is a possibility of the emplacement of the bonanza type (vein type) gold-bearing quartz vein below the stockwork. There is also possibility of the emplacement of the stockwork type deposit and/or bonanza type deposit below the acidic massive silicified and argillized zone in the Nagos area.

Since volcanic and pyroclastic rocks of the Miocene to Pliocene age are also distributed in the area other than Mantri, Wullersdorf, Pock and Nagos areas in the Semporna peninsula area, it seems that there is a possibility of the emplacement of gold deposit in the other area where volcanic and pyroclastic rocks are subjected to hydrothermal alteration similar to that of Mantri and Nagos areas.

It is inferred that gold mineralization in the Semporna peninsula region is related possibly to the volcanic activity of the calc-alkali rock series, judging from the assay result of ore and the MFA trigonal diagram made from the analyses of volcanic and pyroclastic rocks.

Therefore, in case hydrothermally altered volcanic and pyroclastic rocks in the other area belong to the calc-alkali rock series, the possibility of the emplacement of gold deposit seems to be raised.

Secondarily, there is a possibility of the emplacement of Cyprus type cupriferous massive iron sulfide deposit.

Four localities of mineral occurrence which were found in spilite of the Chert-Spilite Formation in the unnamed small island to the south of the Silam harbour seem to be the indication of the stockwork deposit accompanying, in general, Cyprus type cupriferous massive iron sulfide deposit upwards.

Judging from the above, there is a possibility of the emplacement of massive sulfide deposit which is expected to be emplaced above stockwork deposit.

Therefore, it seems that there is a possibility of the emplacement of Cyprus type cupriferous massive iron sulfide deposit, which is expected to be embedded in spilite of the Chert-Spilite Formation or along the boundary between spilite and overlying chert or shale, on land in the Silam area.

CHAPTER 2 RECOMMENDATION

2-1 Recommendation for Phase III Survey

The investigation of the localities of mineral occurrence and indoor experiment · chemical analysis, that is, K-Ar age determination of rock, chemical analysis of rock, microscopic observation of thin section, chemical analysis of ore, microscopic observation of polished section, X-ray diffraction examination, and measurement of homogenization temperature of fluid inclusion, of the samples taken at the time of investigation conducted in the Segama and Semporna regions in 1991 to understand geology and mineralization at the localities of mineral occurrence in the both regions and then to clarify the characteristic of mineralization in the regions, have revealed the followings.

(1) Localities of mineral occurrence which seem to be the indication of the Cyprus type cupriferous massive iron sulfide deposit were confirmed in the Segama region.

(2) Metal deposit in the Semporna region is epithermal gold-bearing quartz vein and network formed by intermediate to alkaline hydrothermal fluid related to the volcanic activity of the Miocene to Pliocene age.

(3) The hydrothermal alteration related to the gold mineralization is different in different areas.

(4) The homogenization temperature of fluid inclusions in quartz taken from gold-bearing quartz vein in the Mantri area, Semporna region, is close to the formation temperation of the majority of epithermal gold deposits which are distributed in the circum-Pacific area.

As mentioned above, some fruits have been obtained by the survey in the Segama and Semporna regions in 1991. Therefore, it is recommended that the survey in the Kinabalu and Labuk regions in 1992 should be conducted by means of the same following methods as 1991.

1) The investigation of the localities of mineral occurrence

2) Indoor experiments and chemical analysis
   a) K-Ar age determination of representative rock
   b) Chemical analysis of rock
   c) Microscopic observation of thin section
   d) Assay of ore
   e) Microscopic observation of polished section
   f) X-ray diffraction examination for hydrothermally altered rock (in Kinabalu region)
   g) Measurement of homogenization temperature of fluid inclusion in quartz (in Kinabalu region)

2-2 Recommendation for the Future Survey

It is recommended that the following survey and prospecting for gold deposit, firstly, should be conducted in the Semporna peninsula region.

(1) Drilling to search for higher grade gold-bearing quartz vein of the bonanza type which is expected to be emplaced below the network orebody of low grade in the Mantri area.

(2) Drilling to search for the stockwork type or bonanza type ore deposit which is expected to be emplaced below the silicified zone in the Nagos area.

(3) Detailed geological mapping and investigation of the hydrothermal alteration zone in the area, where hydrothermally altered volcanic and pyroclastic rocks are distributed in the Semporna peninsula region, other than Mantri, Wullersdorf, Pock and Nagos areas.

In case the hydrothermal alteration zone is confirmed, the following survey as the next step is recommended.

a) Geochemical prospecting of soil for gold on the surface of the hydrothermal alteration zone.

b) Identification of hydrothermal alteration mineral by means of X-ray diffraction examination to clarify the mineral assemblage of the hydrothermal alteration zone.

c) Measurement of the homogenization temperature of fluid inclusion in quartz (in case quartz vein is confirmed.)

d) Chemical analysis and K-Ar dating of volcanic and pyroclastic rocks.

e) Microscopic observation of volcanic, pyroclastic and hydrothermally altered rocks.

In case a possibility of the emplacement of gold deposit is expected, trenching is recommended as the third step.

Secondarily, the detailed geological mapping of the Chert-Spilite Formation in the Silam area, Segama region is recommended in order to find a indication of Cyprus type cupriferous massive iron sulfide deposit.

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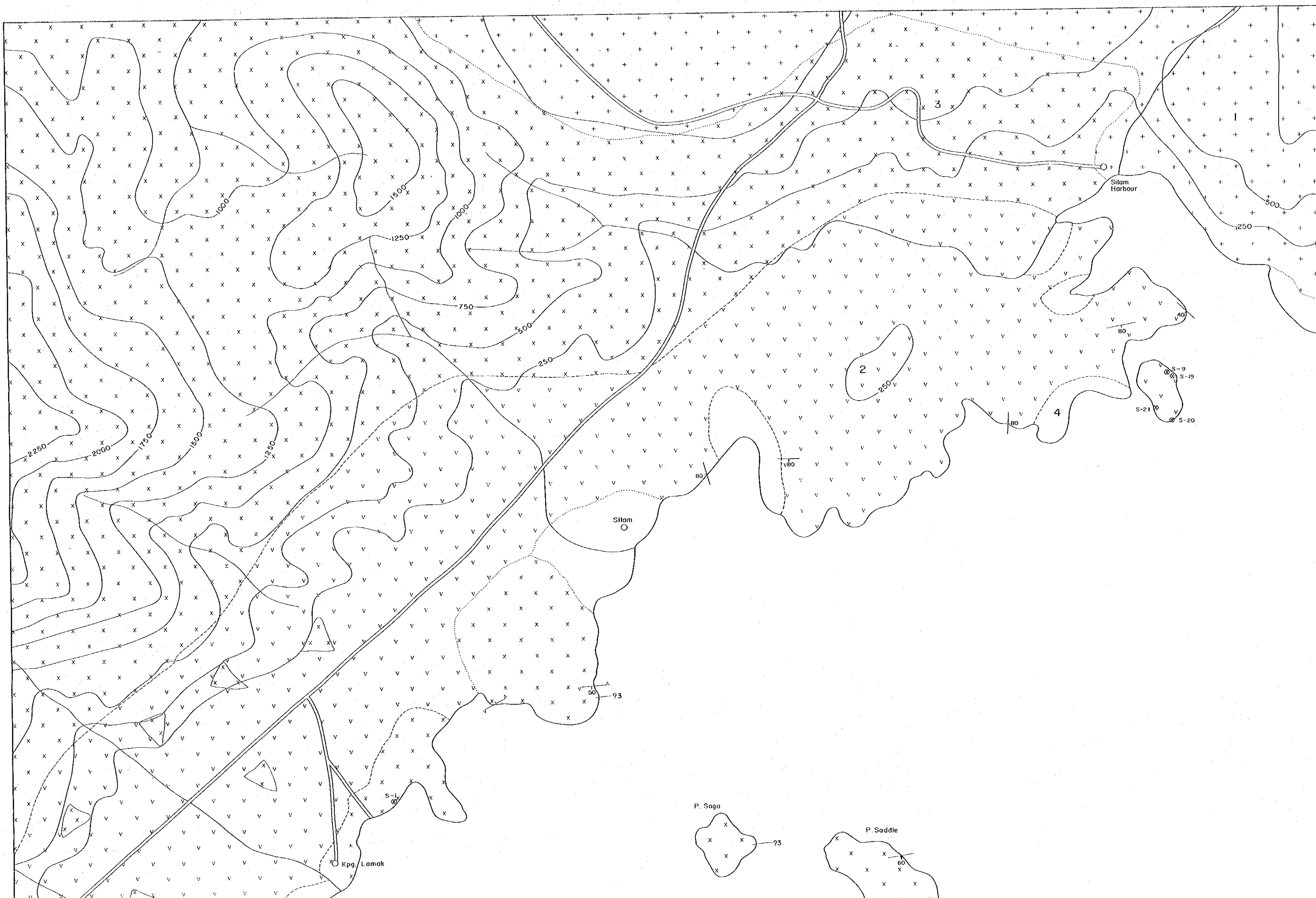


Silam Harbour
Silam
Kpg. Lamak
P. Saga
P. Saddle
S-9
S-19
S-21
S-20
S-1
1
2
3
4
2250
2000
1750
1500
1250
1000
750
500
250
80
40
60
50
93

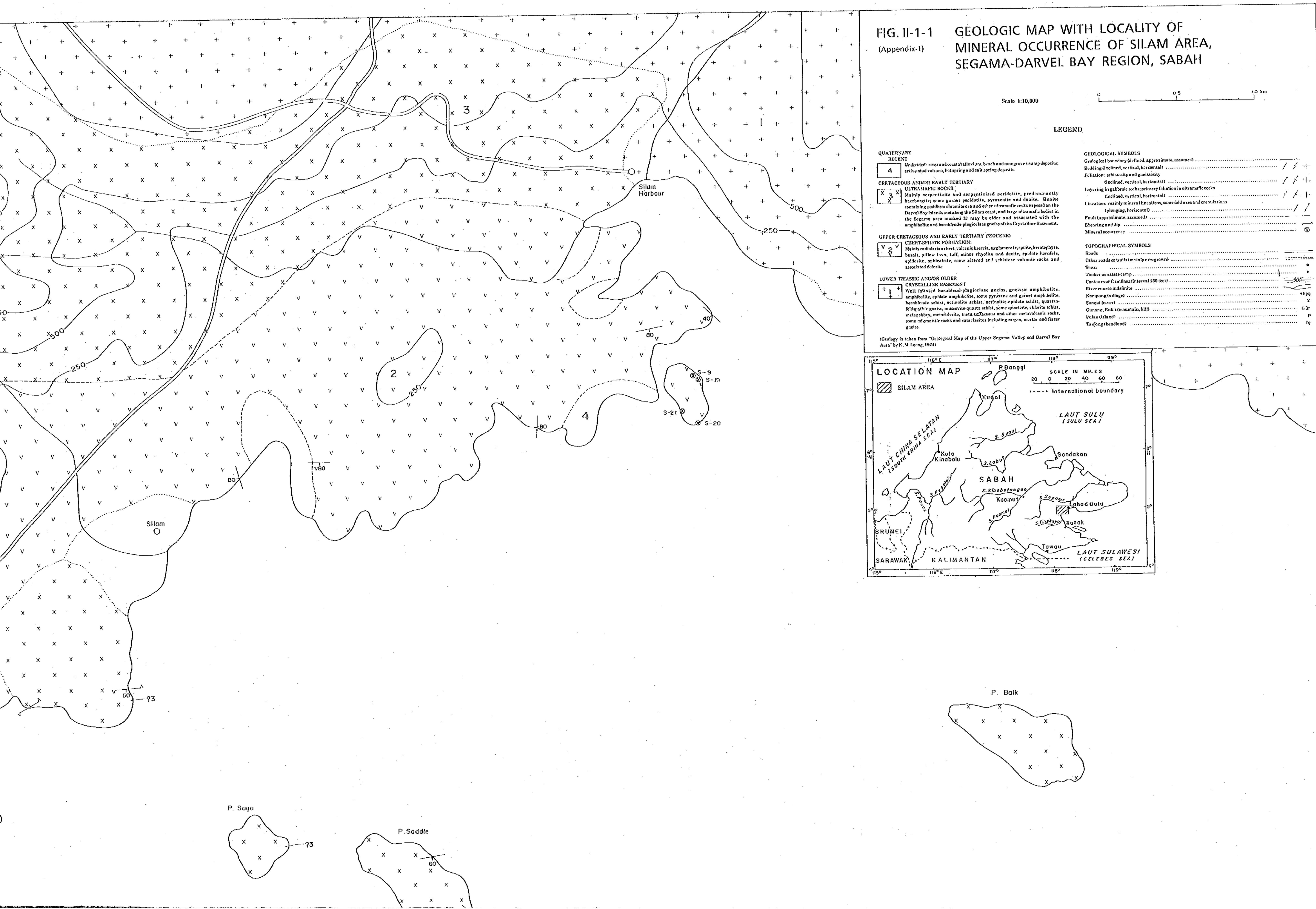
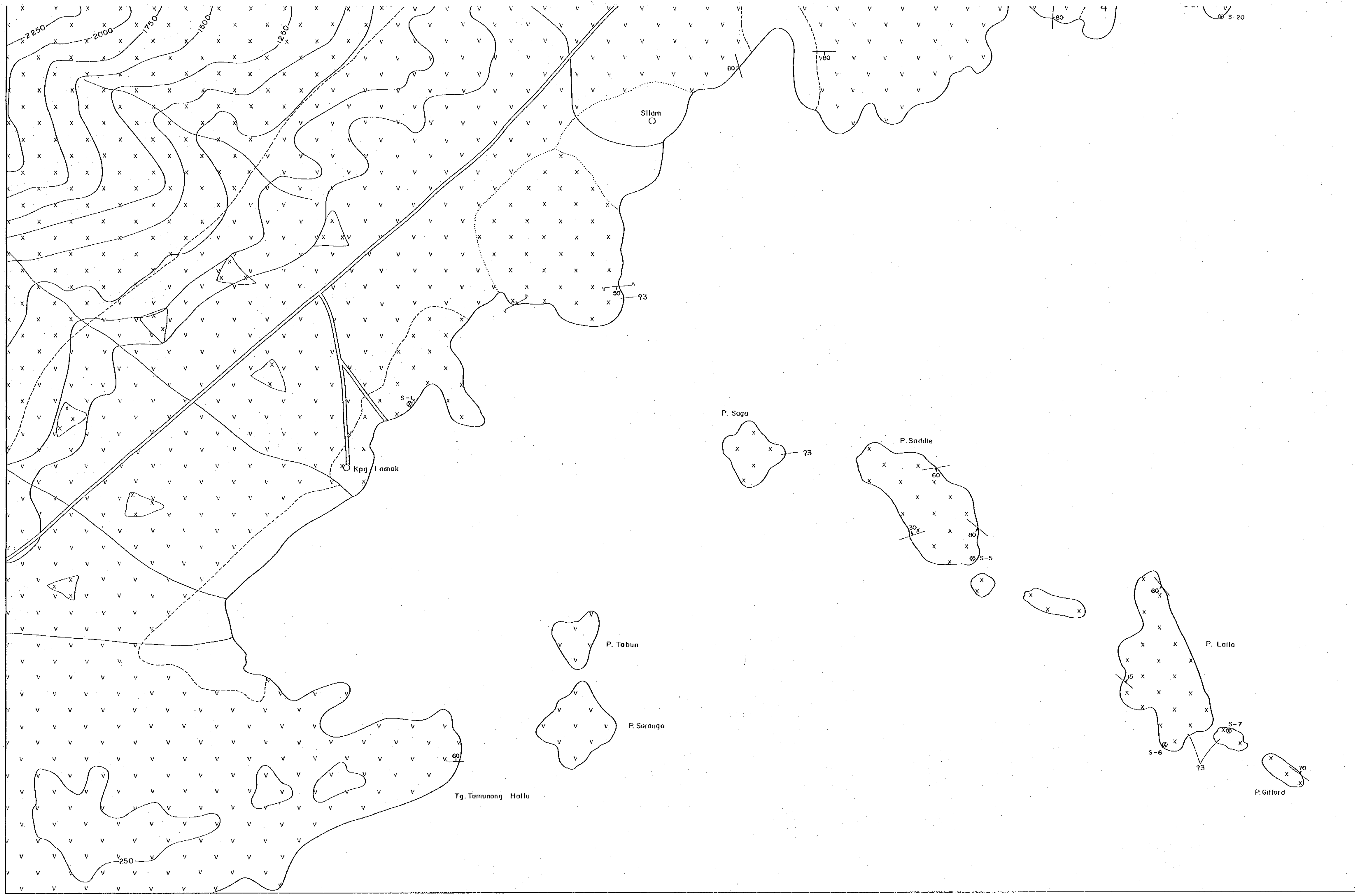
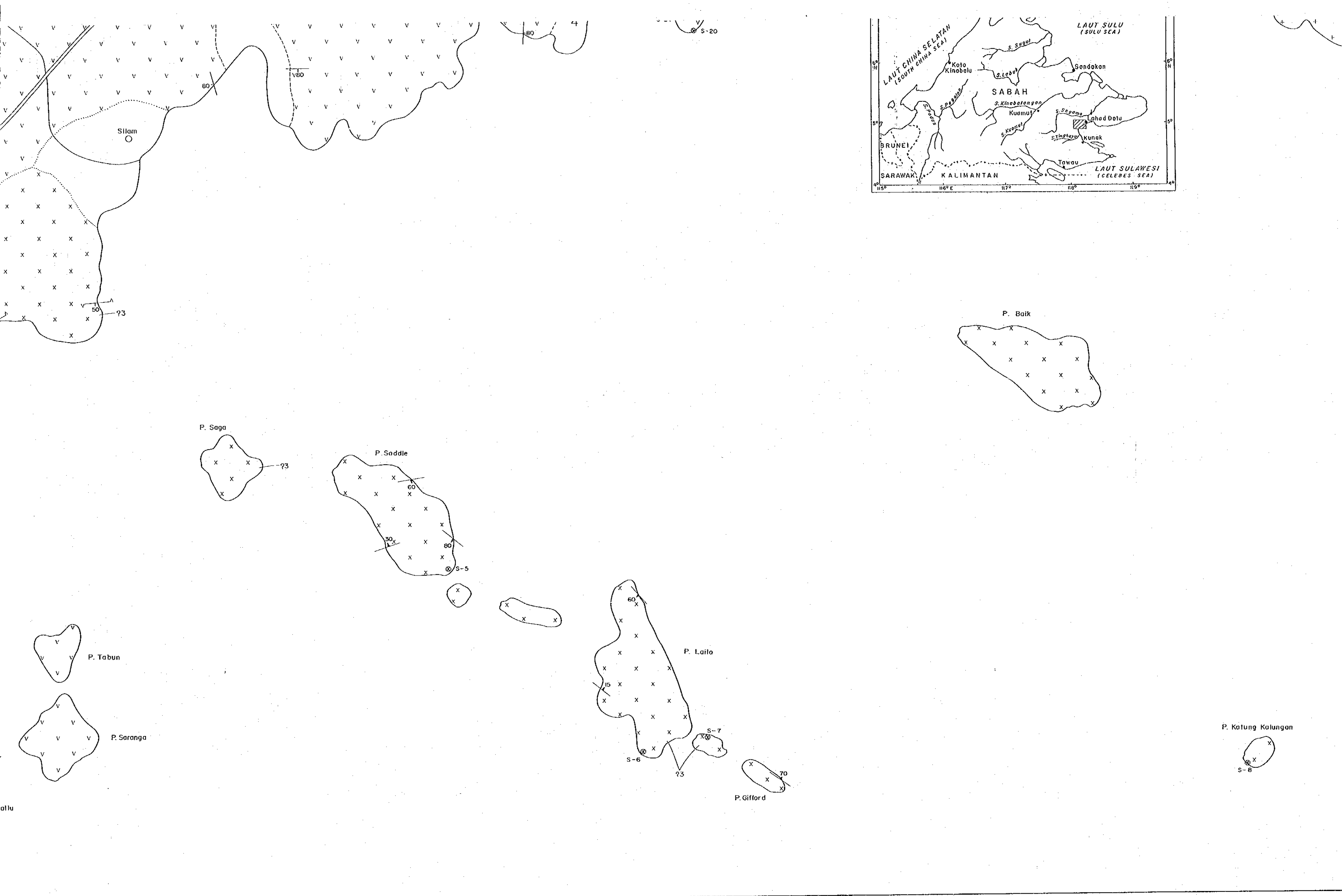


FIG. II-1-1
(Appendix-1)
GEOLOGIC MAP WITH LOCALITY OF MINERAL OCCURRENCE OF SILAM AREA, SEGAMA-DARVEL BAY REGION, SABAH
Scale 1:10,000
LEGEND
QUATERNARY
RECENT
4 Undivided: river and coastal alluvium, beach and mangrove swamp deposits; active mud volcano, hot spring and salt spring deposits
CRETACEOUS AND/OR EARLY TERTIARY
3 ULTRAMAFIC ROCKS
Mainly serpentinite and serpentinized peridotite, predominantly harzburgite; some garnet peridotite, pyroxenite and dunite. Dunite containing podiform chromite ore and other ultramafic rocks exposed on the Darvel Bay islands and along the Silam coast, and large ultramafic bodies in the Segama area marked ?3 may be older and associated with the amphibolite and hornblende-plagioclase gneiss of the Crystalline Basement.
UPPER CRETACEOUS AND EARLY TERTIARY (?EOCENE)
2 CHERT-SPILITE FORMATION:
Mainly radiolarian chert, volcanic breccia, agglomerate, spilite, keratophyre, basalt, pillow lava, tuff, minor rhyolite and dacite, epidote hornfels, epidosite, ophicalcite, some altered and schistose volcanic rocks and associated dolerite
LOWER TRIASSIC AND/OR OLDER
1 CRYSTALLINE BASEMENT
Well foliated hornblend-plagioclase gneiss, gneissic amphibolite, amphibolite, epidote amphibolite, some pyroxene and garnet amphibolite, hornblende schist, actinolite schist, actinolite-epidote schist, quartzo-feldspathic gneiss, muscovite-quartz schist, some quartzite, chlorite schist, metagabbro, metadolerite, meta-tuffaceous and other metavolcanic rocks, some migmatitic rocks and cataclasites including augen, mortar and flaser gneiss
(Geology is taken from "Geological Map of the Upper Segama Valley and Darvel Bay Area" by K. M. Leong, 1974)
GEOLOGICAL SYMBOLS
Geological boundary (defined, approximate, assumed)
Bedding (inclined, vertical, horizontal)
Foliation: schistosity and gneissosity (inclined, vertical, horizontal)
Layering in gabbroic rocks; primary foliation in ultramafic rocks (inclined, vertical, horizontal)
Lineation: mainly mineral lineations, some fold axes and crenulations (plunging, horizontal)
Fault (approximate, assumed)
Shearing and dip
Mineral occurrence
TOPOGRAPHICAL SYMBOLS
Roads
Other roads or trails (mainly overgrown)
Town
Timber or estate camp
Contours or formlines (interval 250 feet)
River course indefinite
Kampong (village) Kpg
Sungai (river) S
Gunong, Bukit (mountain, hill) G Bt
Pulau (island) P
Tanjong (headland) Tg
LOCATION MAP
SILAM AREA
SCALE IN MILES
International boundary
P. Banggi
Kudat
LAUT SULU (SULU SEA)
LAUT CHINA SELATAN (SOUTH CHINA SEA)
Kota Kinabalu
Sandakan
SABAH
Kuamut
Lahad Datu
Kunak
Tawau
BRUNEI
SARAWAK
KALIMANTAN
LAUT SULAWESI (CELEBES SEA)
Silam Harbour
Silam
S-9
S-19
S-20
S-21
P. Baik
P. Saga
P. Saddle


2250
2000
1750
1500
1250
S-20
Silam
S-1
Kpg. Lamak
P. Saga
P. Saddle
S-5
P. Tabun
P. Saranga
Tg. Tumunong Hallu
P. Laila
S-7
S-6
P. Gifford
250



LAUT SULU
(SULU SEA)
LAUT CHINA SELATAN
(SOUTH CHINA SEA)
Kota Kinabalu
Sandakan
SABAH
Kuamut
Lahad Datu
Kunak
Tawau
BRUNEI
SARAWAK
KALIMANTAN
LAUT SULAWESI
(CELEBES SEA)
S-20
Silam
P. Baik
P. Saga
P. Saddle
S-5
P. Laila
P. Tabun
P. Saranga
S-6
S-7
P. Gifford
P. Katung Kalungan
S-8

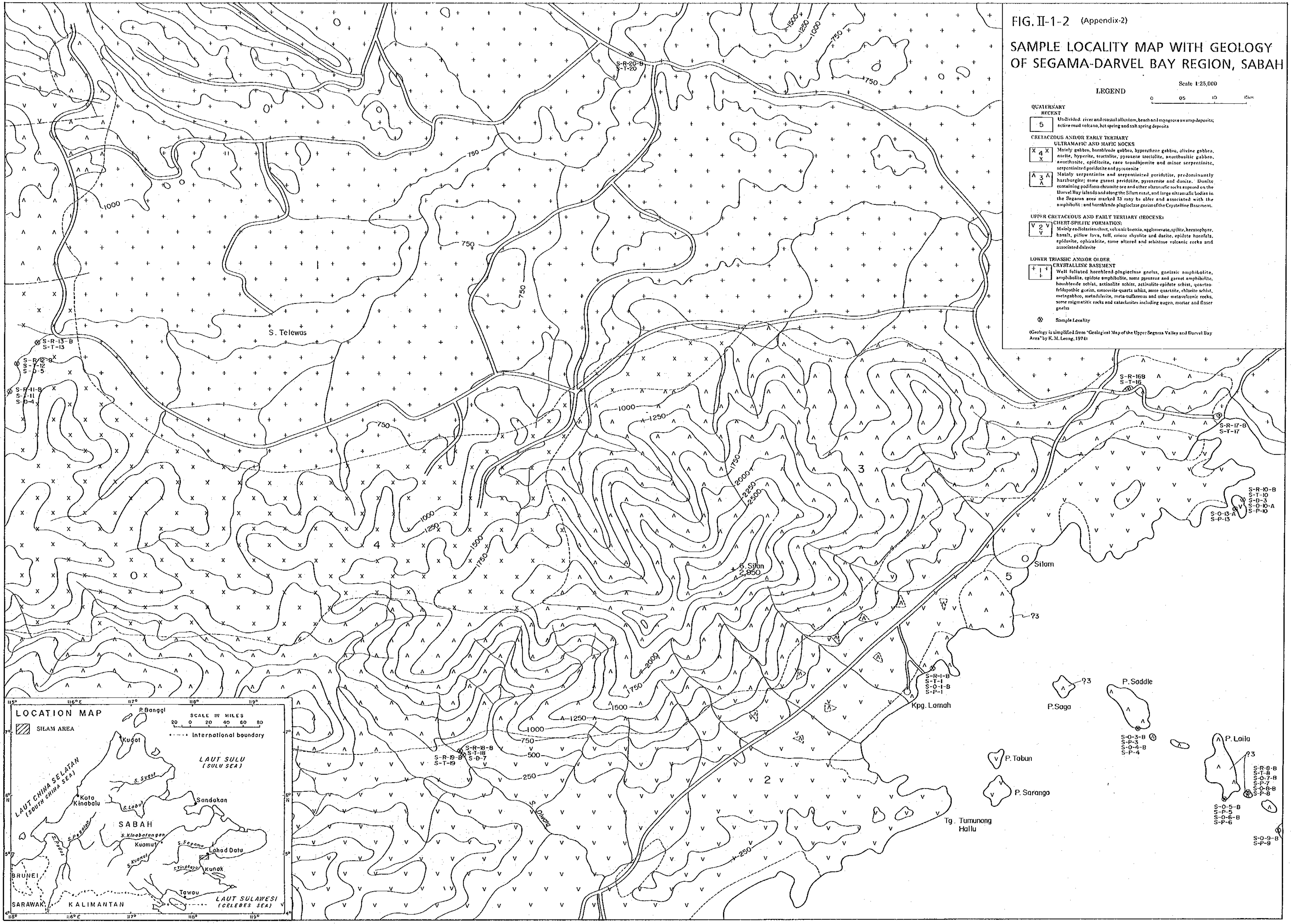


FIG. II-1-2 (Appendix-2)

SAMPLE LOCALITY MAP WITH GEOLOGY OF SEGAMA-DARVEL BAY REGION, SABAH