APPENDIX II

TEST REPORT OF RAW MATERIALS

TEST REPORT OF RAW MATERIALS

TABLE OF CONTENTS

The test report hereinafter is to describe the result of analysis for grab samples collected in the field during May, 1981.
For reference, the previous test results for limestone carried out by Geological Survey Department, Malaysia, are also tabulated in the tables. The present analysis is worked out at the Central Research Laboratory of Ube Industries, Ltd. in Japan.
The sampling positions of the collected samples are shown in the Figures of the interim report as listed below.

Fig. IV-1-3	Geological Map of Gua Setir Limestone Deposit
Fig. IV-1-4	Geological Map of 4 Limestone Hills Near Dabong
Fig. IV-1-5	Geological Map of Gua Panjang Limestone Deposit
Fig. IV-1-12	Sampling Points Map of Jeli
Fig. IV-1-13	Sampling Points Map of Tanah Merah
Fig. IV-1-14	Sampling Points Map of South Gua Musang
Fig. IV-1-15	Sampling Points Map of Northeast Gua Musang
Fig. IV-1-16	Sampling Points Map of River Sand and Coast Sand
Fig. IV-1-17	Route Map along Sungai Bertam
Fig. IV-1-18	Sampling Points Map of Bt. Kuang
Fig. IV-1-20	Sampling Points Map of Temangan Iron Mine
Fig. IV-1-21	Sampling Points Map of Bt. Lata

1. Chemical Analysis

The quantity of samples and that of components analyzed chemically are summarized with the reference in Table 1-1. The sample preparation process for chemical analysis is shown in Fig. 1-1. The visual observation of samples is shown in Table 1-2.
The testing methods are applied by the following Standards. The methods of analysis versus the components are also listed below.

Raw Materials	Testing Method
Limestone	JIS M 8850
Silicious Materials	CAJS I-12
Iron Rich Materials	CAJS I-13
Gypsum	JIS R 9101

JIS : Japanese Industrial Standard
CAJS: Cement Association of Japan Standard

Components	Method of Analysis
SiO_2, AlO_3, SO_3	Gravimetric Analysis
Fe_2O_3, CaO, MgO	Volumetric Analysis
P_2O_5, Chlorine	Colorimetric Analysis
Na_2O, K_2O	Flame Photometric Analysis

The results of chemical analysis are shown in Table 1-3 to Table 1-20.
The moisture content of clay, silica sand, gypsum and iron slime is also indicated in the same table (measured by a drying method.)

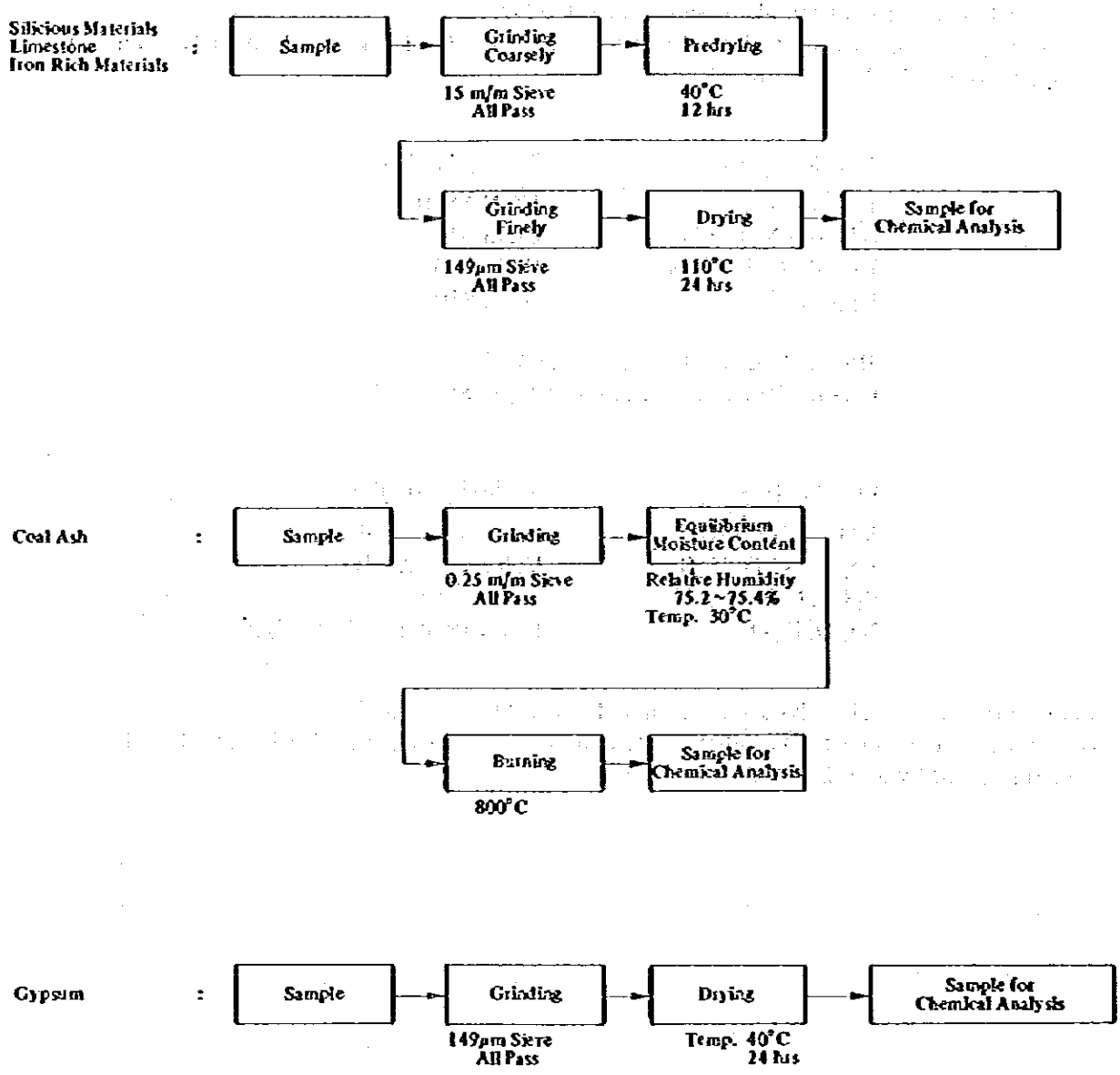

Fig. 1-1 Flow Chart of Sample Preparation

Table 1-1 List of Analyzed Sample

Sample				Quantity of Analyzed Sample (P.C.S)	Quantity of Analyzed Components (Components)	Table of Results to be referred
Raw Materials	Sampling Area					
Limestone	Gua - Setir			2 3	11 6	Table 1-3
	Dabong	Gua Tembakau		2 3	11 6	Table 1-4
		Gua Ikan		2 3	11 6	Table 1-5
		Gua Pagau	East	2 3	11 6	Table 1-7
			West	2 3	11 6	Table 1-8
		Gua Masta		2 3	11 6	Table 1-6
	Gua Panjang	A		3 2 16	11 10 6	
		B		2 1 1 18	11 10 9 6	Table 1-9
		C		4 2 20	11 10 6	
		D		3 8	11 16	
Clay	Tanah Merah	West		14	9	Table 1-10
		North		2	9	
	Gua Musang	North East		2	9	Table 1-11
		South		10	9	
		South East		2	10	
	Jeli			5	9	Table 1-12
Silica Sand	S. Kelantan			1	11	Table 1-13
				2	10	
				1	9	
	Bachok			4	10	Table 1-14
Silica Rock	Gua Musang (South East)			3	9	Table 1-15
	Bt. Kusng			1	9	
				1	10	
Iron Ore	Bt. Lata			2	10	Table 1-17
	Temangan			5	9	Table 1-16
	Bt. Kusng			1	11	

— Continued —

Raw Materials	Sample: Sampling Area	Quantity of Analyzed Sample (P.C.S)	Quantity of Analyzed Components (Components)	Table of Results to be referred
Gypsum	Thai	1	10	Table 1-18
	Australia	1	7	
Iron Slime		1	10	Table 1-19
	Australia	1	8	Table 1-20

Table 1.2 Outward of Samples Taken in Kelantan Area

Kind of Materials: Sampling Area			Materials	Sample No.	Remarks
Gua Setir			Limestone	1 ∿ 5	Graysh white limestone
Dabong	Gua Masta			1 ∿ 5	Graysh white limestone
	Gua Pagau	East		1 ∿ 5	Blackish limestone
		West		1 ∿ 4	Graysh black limestone
				5	Graysh white limestone
	Gua Ikan			1 ∿ 2	Blackish limestone
				3	Graysh black limestone
				4 ∿ 5	Graysh white limestone
	Gua Tembakau			1 ∿ 2	Blackish limestone
				3 ∿ 5	Graysh white limestone
Gua Panjang	A		Limestone	1 ∿ 7, 9 ∿ 14, 21	Graysh white limestone
				8, 16 ∿ 19	White limestone
				15	Blackish limestone
				20	Gray limestone
	B			22 ∿ 23, 25 ∿ 41 43	Graysh white limestone
				24	White limestone
				42	Reddish gray limestone
	C			44, 45, 52, 59, 61	Graysh white limestone
				46 ∿ 47, 51, 60	Gray limestone
				48	Reddish gray limestone
				49 ∿ 50, 53 ∿ 55 62 ∿ 69	Blackish limestone
				56 ∿ 58	Graysh black limestone
	D			70	Blackish limestone
				75, 76 ∿ 80	Gray limestone
				71 ∿ 74	Graysh white limestone

— Continued —

Kind of Materials		Sample No.	Remarks
Sampling Area	Materials		
Jeli	Clay	21-2	Light yellowish Clay with reddish brown speckled clay
		21-3	Graysh white or blakish gray shale
		21-4	Reddish brown tuffaceous shale (half weatherd)
		21-5	Reddish brown or brown shale (half weatherd)
		21-6	Light yellowish clay with reddish brown speckled clay
Tanah Merah	Clay	21-1	Yellowish brown or reddish brown shist (half weatherd)
		26-1	Yellowish brown or reddish brown shist (half weatherd)
		26-2	Yellowish brown or reddish brown shist (half weatherd)
		26-3	Yellowish brown clay with reddish brown speckled clay
		26-4	Yellowish brown weathered clay with quartz pebble
		26-5	Yellowish brown clay with reddish brown speckled clay
		26-6	Yellowish brown weatherd clay
		26-7	Light yellowish clay with reddish brown speckled clay
		26-8	Yellowish brown weatherd clay (Sampling depth is 1 m)*
		26-9	" " (Sampling depth is 2 m)*
		26-10	Yellowish brown clay with reddish brown speckled clay
		26-11	Yellowish brown schist weatherd clay
		26-12	Light yellowish brown gray sandy silt (Sampling depth is 1.5m)**
		26-13	Light yellowish white sandy silt (Sampling depth is 2.5m)**
		26-14	Brown or blackish brown clay
		26-15	" "
Gua Musang	Clay	24-2	Yellowish brown or reddish purple shale (half weatherd)
		24-3	Graysh white or light yellowish brown clay
		24-4	Yellowish brown or reddish purple shale (half weatherd)
		24-5	Light gray siliceous shale
		24-6	Light graysh white clay
		24-7	Reddish brown or graysh white clay
		24-8	Blackish brown tuffaceous shale (half weatherd)
		24-9	Black, gray or brown phyllite (half weatherd)
		24-10	Graysh white or reddish brown clay

—— Continued ——

Kind of Materials		Sample No.	Remarks
Sampling Area	Materials		
Gua Musang	Shale	24-11	Reddish brown shale
		23-2	Yellowish brown ∿ gray shale
		24-1-2	Reddish brown shale
Gua Musang (North East)	Clay	25-1	Reddish brown or gray ∿ blackish gray shale
		25-2	〃 〃
S. Kelantan	Silica Sand	27-1	Light yellowish river sand
		27-2	〃 〃 (include pebble)
		27-3	〃 〃 (include pebble)
		27-4	〃 〃
Gua Musang (S. Bertam)	Silica Rock	23-1	White ∿ light yellowish brown quartzite
		23-3	Light yellowish brown quartzite
		24-1-1	Yellow ∿ white quartzite
Bt. Kuang	Silica Rock	1-1	Light yellowish white quartzite
		1-2	〃 〃 〃
Bachok	Silica Sand	28-1	Grayish white fine sand (Sampling depth is 0.2m)*
		28-2	Brown fine sand (Sampling depth is 0.5m)*
		28-3	Gray fine sand (Sampling depth is 0.2m)**
		28-4	Brown ∿ blackish brown sand (Sampling depth is 0.5m)**
Temangan	Iron Ore	19-1	Yellow or brownish black speckled iron ore
		19-2	Inside is gray black and surface is light yellowish brown iron ore
		19-3	Brownish black and reddish brown iron ore
		19-4	Black or brownish black lumpy iron ore
		19-5	Black or brownish black lumpy iron ore
Bt. Lata	Iron Ore	1-4	Reddish brown lumpy iron ore
		1-5	The ore consist of many granular hematite and clay
Bt. Kuang	Iron Ore	1-3	Reddish brown iron ore

Note: * same sampling point
** same sampling point

Table 1-3 Chemical Analysis of Gua Setir Limestone

Sample No.		Chemical Composition (%)										P_2O_5 (ppm)	Cl^- (ppm)	Note
		L.O.I.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Total			
Gua Setir	1	44.07	0.14	0.11	0.05	52.72	2.71	0.03	0.01	0.02	99.86	90	50	
	2	46.73	0.26	0.07	0.05	50.15	2.22	-	-	-	99.48	-	-	
	3	43.83	0.51	0.10	0.01	53.94	1.21	-	-	-	99.63	-	-	
	4	44.00	0.13	0.06	0.04	52.96	2.22	-	-	-	99.41	-	-	
	5	43.99	0.27	0.17	0.05	53.93	1.48	0.03	0.01	0.03	99.96	100	80	
	6	-	0.39	0.15	0.08	54.2	1.14	-	-	-	55.96	-	-	Geological Survey Report
	7	-	0.20	0.07	0.14	52.3	3.03	-	-	-	55.74	-	-	
	8	-	0.46	0.11	0.10	54.4	1.19	-	-	-	56.26	-	-	
	9	-	0.26	0.05	0.12	53.8	1.78	-	-	-	56.01	-	-	
	10	-	0.39	0.03	0.16	53.1	1.84	-	-	-	55.57	-	-	
	11	-	0.31	0.16	0.07	53.8	1.95	-	-	-	56.29	-	-	
	12	-	0.12	0.08	0.08	53.8	1.95	-	-	-	56.03	-	-	
	13	-	0.71	0.11	0.10	53.1	2.17	-	-	-	56.19	-	-	
	14	-	0.66	0.08	0.12	54.1	1.19	-	-	-	56.20	-	-	
	15	-	0.26	0.11	0.11	52.6	2.93	-	-	-	56.31	-	-	
	16	-	0.51	0.06	0.18	52.9	2.38	-	-	-	56.03	-	-	
	17	-	1.23	0.03	0.36	49.6	4.22	-	-	-	55.44	-	-	
	18	-	0.12	0.01	0.08	54.3	1.30	-	-	-	55.81	-	-	
	19	-	0.10	0.01	0.09	53.8	1.84	-	-	-	55.84	-	-	
	20	-	0.64	0.04	0.04	53.2	1.84	-	-	-	55.76	-	-	
	21	-	0.37	0.02	0.14	54.1	1.14	-	-	-	55.77	-	-	
	22	-	0.05	0.01	0.02	53.6	1.80	-	-	-	55.48	-	-	
	23	-	0.30	0.01	0.02	54.6	0.87	-	-	-	55.80	-	-	
Means of Sample No. 1 ~ 23		44.52	0.36	0.07	0.10	53.26	1.93	-	-	-	100.24	-	-	
Composite Sample of No. 1-5		43.93	0.24	0.17	0.05	53.51	1.92	0.02	0.01	0.02	99.87	110	30	

Table 1-4 Chemical Analysis of Gua Tembakau Limestone

Sample No.		Chemical Composition (%)										P_2O_5 (ppm)	Cl^- (ppm)	Note
		L.O.I.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Total			
Gua Tembakau	1	33.36	16.06	5.49	1.73	38.92	2.18	0.07	0.55	0.95	99.24	930	40	
	2	43.69	1.18	0.08	0.13	54.23	0.50	-	-	-	99.81	-	-	
	3	43.72	0.09	0.02	0.04	55.21	0.30	-	-	-	99.38	-	-	
	4	43.78	0.13	0.13	0.04	55.07	0.30	-	-	-	99.45	-	-	
	5	43.85	0.09	0.07	0.02	55.14	0.67	0.02	-	0.02	99.88	80	20	
	6	-	0.14	0.04	0.03	55.2	0.54	-	-	-	55.95	-	-	Geological Survey Report
	7	-	0.28	0.08	0.05	54.7	0.65	-	-	-	55.76	-	-	
	8	-	0.24	0.11	0.07	54.7	0.98	-	-	-	56.10	-	-	
	9	-	0.29	0.13	0.16	54.7	0.76	-	-	-	56.04	-	-	
	10	-	0.66	0.18	0.14	54.3	0.54	-	-	-	55.82	-	-	
	11	-	0.36	0.23	0.07	54.6	0.87	-	-	-	56.13	-	-	
	12	-	1.51	0.40	0.28	52.6	1.41	-	-	-	56.20	-	-	
	13	-	0.23	0.09	0.05	54.9	0.76	-	-	-	56.03	-	-	
	14	-	1.00	0.18	0.15	53.8	0.87	-	-	-	56.00	-	-	
	15	-	0.27	0.07	0.02	54.9	0.76	-	-	-	56.02	-	-	
Means of Sample No. 1 ~ 15		41.68	1.50	0.49	0.20	53.53	0.80	-	-	-	98.20	-	-	
Composite Sample of No. 1 ~ 5		40.92	4.86	1.46	0.54	50.54	1.03	0.04	0.14	0.25	99.78	310	20	

Table 1-5 Chemical Analysis of Gua Ikan Limestone

Sample No.		Chemical Composition (%)										P_2O_5 (ppm)	Cl^- (ppm)	Note
		L.O.I.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Total			
Gua Ikan	1	43.06	1.44	0.72	0.20	53.32	0.92	0.02	0.05	0.10	99.83	310	70	
	2	42.54	2.57	0.82	0.27	52.00	1.40	-	-	-	99.60	-	-	
	3	43.38	1.21	0.47	0.35	52.28	2.07	-	-	-	99.76	-	-	
	4	41.42	4.92	0.71	0.28	51.38	0.85	-	-	-	99.56	-	-	
	5	41.89	3.42	0.86	0.35	52.52	0.57	0.01	0.03	0.12	99.78	330	100	
	6	-	0.31	0.14	0.05	55.0	0.54	-	-	-	56.04	-	-	Geological Survey Report
	7	-	0.24	0.12	0.04	55.0	0.54	-	-	-	55.94	-	-	
	8	-	6.13	0.40	1.53	40.5	7.93	-	-	-	56.49	-	-	
	9	-	0.10	0.09	0.02	55.2	0.76	-	-	-	56.17	-	-	
	10	-	0.21	0.17	0.04	55.0	0.54	-	-	-	55.96	-	-	
Means of Sample No. 1 ~ 10		42.46	2.06	0.45	0.31	52.22	1.61	-	-	-	99.11	-	-	
Composite Sample of No. 1 ~ 5		42.48	2.77	0.76	0.26	52.01	1.76	0.04	0.04	0.10	99.72	230	20	

Table 1-6 Chemical Analysis of Gua Masta Limestone

Sample No.		Chemical Composition (%)										P_2O_5 (ppm)	Cl^- (ppm)	Note
		L.O.I.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Total			
Gua Masta	1	43.44	0.46	0.24	0.03	55.29	0.02	0.03	0.01	0.04	99.61	180	90	
	2	43.79	0.20	0.07	0.06	55.73	0.03	-	-	-	99.88	-	-	
	3	43.76	0.26	0.15	0.04	55.46	0.16	-	-	-	99.83	-	-	
	4	43.73	0.08	0.12	0.04	55.66	0.04	-	-	-	99.67	-	-	
	5	43.47	0.50	0.28	0.06	54.64	0.49	0.01	0.03	0.05	99.53	170	90	
Means of Sample No. 1 ∿ 5		43.64	0.30	0.17	0.06	55.36	0.15	-	-	-	99.68	-	-	
Composite Sample of No. 1 ∿ 5		43.73	0.34	0.23	0.04	54.61	0.79	0.04	trace	0.02	99.80	270	50	

Table 1-7 Chemical Analysis of Gua Pagau Limestone (East)

Sample No.		Chemical Composition (%)										P_2O_5 (ppm)	Cl^- (ppm)	Note
		L.O.I.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Total			
Gua Pagau East)	1	43.25	0.79	0.60	0.14	54.17	0.78	0.02	0.04	0.10	99.89	190	80	Geological Survey Report
	2	43.72	0.26	0.20	0.05	54.53	1.06	-	-	-	99.82	-	-	
	3	43.67	0.47	0.35	0.12	53.85	1.29	-	-	-	99.75	-	-	
	4	42.84	2.53	0.83	0.30	49.97	3.14	-	-	-	99.61	-	-	
	5	42.87	2.50	0.89	0.26	49.93	3.20	-	0.06	0.13	99.84	330	90	
	6	-	0.63	0.11	0.07	54.6	0.87	-	-	-	56.28	-	-	
	7	-	0.92	0.24	0.16	53.9	0.98	-	-	-	56.20	-	-	
	8	-	1.02	0.13	0.17	53.8	1.09	-	-	-	56.21	-	-	
	9	-	0.78	0.12	0.08	53.0	2.00	-	-	-	55.98	-	-	
Means of Sample No. 1 ∿ 9		43.27	1.10	0.39	0.15	53.08	1.60	-	-	-	99.59	-	-	
Composite Sample of No. 1 ∿ 5		43.31	1.42	0.60	0.16	52.28	2.02	0.03	0.04	0.07	99.93	180	50	

Table 1-8 Chemical Analysis of Gua Pagau Limestone (West)

Sample No.		Chemical Composition (%)										P_2O_5 (ppm)	Cl^- (ppm)	Note
		L.O.I.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Total			
Gua Pagau (West)	1	43.70	0.14	0.09	0.02	55.50	0.08	0.02	0.01	0.01	99.57	210	50	
	2	43.35	0.50	0.18	0.06	54.73	0.32	-	-	-	99.14	-	-	
	3	43.18	0.92	0.27	0.11	54.28	0.49	-	-	-	99.25	-	-	
	4	43.42	0.60	0.24	0.06	54.82	0.32	-	-	-	99.46	-	-	
	5	43.46	0.36	0.09	0.04	55.32	0.02	0.03	-	0.03	99.35	310	50	
	6	-	0.44	0.14	0.11	54.9	0.54	-	-	-	56.13	-	-	Geological Survey Report
	7	-	1.73	0.32	0.32	52.4	1.52	-	-	-	56.29	-	-	
	8	-	0.82	0.17	0.15	54.1	0.87	-	-	-	56.11	-	-	
	9	-	0.72	0.16	0.17	53.9	1.02	-	-	-	55.97	-	-	
	10	-	1.02	0.17	0.22	54.1	0.98	-	-	-	56.49	-	-	
	11	-	0.01	0.10	0.03	55.3	0.43	-	-	-	55.90	-	-	
	12	-	0.05	0.13	0.03	55.3	0.65	-	-	-	56.16	-	-	
	13	-	0.08	0.13	0.01	55.3	0.54	-	-	-	56.06	-	-	
	14	-	0.41	0.16	0.04	54.7	0.76	-	-	-	56.07	-	-	
	15	-	0.42	0.14	0.10	54.6	0.87	-	-	-	56.13	-	-	
	16	-	2.28	0.17	0.34	52.3	1.41	-	-	-	56.50	-	-	
	17	-	1.61	0.25	0.13	53.0	1.41	-	-	-	56.40	-	-	
	18	-	0.79	0.20	0.10	53.8	1.09	-	-	-	55.98	-	-	
	19	-	0.75	0.18	0.14	54.4	0.43	-	-	-	55.90	-	-	
	20	-	1.87	0.15	0.23	52.9	1.52	-	-	-	56.67	-	-	
	21	-	0.43	0.09	0.10	54.3	0.87	-	-	-	55.79	-	-	
	22	-	0.56	0.09	0.13	54.3	1.09	-	-	-	56.17	-	-	
Means of Sample No. 1 ~ 22		43.42	0.75	0.16	0.12	54.28	0.78	-	-	-	99.51	-	-	
Composite Sample of No. 1 ~ 5		43.58	0.40	0.24	0.06	54.88	0.66	0.06	0.01	0.03	99.92	170	90	

Table 1-9 Chemical Analysis of Gua Panjang Limestone

Sample No.			Chemical Composition (%)										P_2O_5 (ppm)	Cl^- (ppm)	Note
			L.O.I.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Total			
Gua Panjang	A	1	42.49	1.18	0.55	0.12	53.69	0.53	0.02	0.01	0.10	98.69	5440	50	
		2	40.09	3.73	3.54	0.44	50.38	0.95	-	-	-	99.13	-	-	
		3	43.46	1.81	0.22	0.31	52.06	2.02	-	-	-	99.88	-	-	
		4	42.56	2.81	0.52	0.17	51.64	1.82	-	-	-	99.52	-	-	
		5	43.55	0.57	0.06	0.04	55.22	0.37	0.02	0.01	0.02	99.86	390	40	
		6	43.58	0.52	0.12	0.03	54.79	0.46	-	-	-	99.50	-	-	
		7	43.84	0.74	0.15	0.06	51.78	2.87	-	-	-	99.44	-	-	
		8	43.43	0.19	0.06	0.03	55.01	0.40	-	-	-	99.12	-	-	
		9	42.85	2.52	0.22	0.18	52.75	0.96	-	-	-	99.48	-	-	
		10	43.75	0.31	0.09	0.02	55.15	0.61	0.02	-	0.02	99.97	370	90	
		11	43.28	0.08	0.05	0.02	55.14	0.56	-	-	-	99.13	-	-	
		12	43.57	0.04	0.01	0.02	55.07	0.71	-	-	-	99.42	-	-	
		13	43.69	0.40	0.16	0.04	55.07	0.40	-	-	-	99.76	-	-	
		14	43.54	0.50	0.07	0.02	54.79	0.40	-	-	-	99.32	-	-	
		15	43.06	1.15	0.75	0.07	52.08	1.89	0.01	-	0.04	99.05	820	60	
		16	43.52	0.08	0.03	0.01	55.30	0.21	-	-	-	99.15	-	-	
		17	43.58	0.02	0.02	0.01	55.45	0.21	-	-	-	99.29	-	-	
		18	43.59	0.08	0.03	0.02	55.45	0.21	-	-	-	99.38	-	-	
		19	46.11	0.05	0.05	0.05	36.82	15.94	-	-	-	99.02	-	-	
		20	46.58	0.07	0.08	0.09	35.67	17.26	0.03	0.01	0.01	99.80	610	60	
		21	44.64	4.10	0.34	0.26	30.94	18.65	-	-	-	98.93	-	-	
	Means of Sample No. 1 ~ 21		43.56	1.00	0.34	0.10	51.15	3.21	-	-	-	99.36	-	-	
	Composite Sample of No. 1 ~ 21		43.39	0.92	0.34	0.10	51.83	2.77	0.05	0.01	0.05	99.46	2500	30	
	B	22	41.85	10.58	0.06	0.14	28.19	18.58	-	-	-	99.40	-	-	
		23	43.60	0.22	0.02	0.04	54.08	1.68	-	-	-	99.64	-	-	
		24	43.47	0.64	0.00	0.09	54.73	0.69	-	-	-	99.62	-	-	
		25	43.51	1.12	0.07	0.08	52.30	2.49	0.01	0.01	0.07	99.66	390	90	
		26	43.78	0.15	0.05	0.14	47.16	6.82	-	-	-	99.10	-	-	

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Sample No.			Chemical Composition (%)										P_2O_5 (ppm)	Cl^- (ppm)	Note
			L.O.I.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Total			
Gua Panjang	B	27	44.34	0.18	0.03	0.06	49.46	5.34	-	-	-	99.41	-	-	
		28	44.37	0.14	0.02	0.05	47.84	6.40	-	-	-	98.82	-	-	
		29	44.03	0.21	0.02	0.03	51.90	32	-	-	-	99.51	-	-	
		30	44.12	0.64	0.02	0.09	49.03	5.38	0.01	0.02	0.04	99.35	180	40	
		31	44.41	0.21	0.04	0.05	49.71	4.93	-	-	-	99.35	-	-	
		32	44.46	0.27	0.01	0.05	49.43	5.29	-	-	-	99.51	-	-	
		33	43.93	0.38	0.05	0.07	51.70	3.40	-	-	-	99.53	-	-	
		34	43.37	0.14	0.01	0.03	55.25	0.58	-	-	-	99.38	-	-	
		35	43.34	0.08	0.04	0.02	55.33	0.52	0.02	-	0.02	99.37	130	70	
		36	44.08	0.24	0.04	0.04	50.18	4.48	-	-	-	99.06	-	-	
		37	44.19	0.20	0.01	0.05	48.24	6.75	-	-	-	99.44	-	-	
		38	43.47	0.05	0.01	0.02	53.14	2.78	-	-	-	99.47	-	-	
		39	43.21	0.21	0.02	0.04	55.42	0.43	-	-	-	99.33	-	-	
		40	43.28	0.07	0.02	0.03	52.89	2.79	-	-	0.01	99.09	70	50	
		41	43.81	0.05	0.03	0.02	51.95	3.72	-	-	-	99.58	-	-	
		42	46.18	0.02	0.00	0.33	34.49	18.04	-	-	-	99.06	-	-	
		43	46.50	0.05	0.02	0.21	33.50	19.08	-	-	-	99.36	-	-	
	Means of Sample No. 22 ~ 43		44.01	0.72	0.03	0.08	48.91	5.61	-	-	-	99.36	-	-	
	Composite Sample of No. 22 ~ 43		44.34	0.49	0.11	0.07	49.97	4.87	0.04	trace	0.01	99.90	180	30	
	C	44	43.22	0.11	0.02	0.03	55.33	0.49	-	-	-	99.20	-	-	
		45	43.51	0.08	0.03	0.03	55.48	0.27	0.02	0.01	-	99.43	370	60	
		46	42.33	2.91	0.02	0.10	53.67	0.40	-	-	-	99.43	-	-	
		47	43.05	1.40	0.02	0.12	54.58	0.31	-	-	-	99.48	-	-	
		48	31.58	28.22	0.06	0.18	39.23	0.40	-	-	-	99.67	-	-	
		49	22.45	46.77	1.49	1.50	25.26	1.48	-	-	-	98.95	-	-	
		50	31.79	25.36	0.67	0.55	39.49	0.63	0.02	0.90	0.93	100.34	780	90	
		51	43.54	0.30	0.01	0.05	54.73	0.45	-	-	-	99.09	-	-	
		52	43.35	0.10	0.00	0.02	54.58	0.49	-	-	-	98.96	-	-	

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Sample No.			Chemical Composition (%)										P_2O_5 (ppm)	Cl^- (ppm)	Note
			L.O.I.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Total			
Gua Panjang	C	53	43.66	0.16	0.01	0.03	54.14	0.94	-	-	-	98.94	-	-	
		54	43.43	0.18	0.01	0.03	54.05	0.92	-	-	-	98.64	-	-	
		55	43.26	0.54	0.02	0.04	53.70	1.08	0.02	-	0.01	98.67	70	70	
		56	43.27	0.50	0.02	0.04	54.08	0.76	-	-	-	98.67	-	-	
		57	43.36	0.06	0.02	0.01	54.95	0.31	-	-	-	98.71	-	-	
		58	43.29	0.04	0.01	0.01	54.58	0.65	-	-	-	98.58	-	-	
		59	43.27	0.07	0.01	0.02	55.42	0.40	-	-	-	99.19	-	-	
		60	43.22	0.50	0.02	0.04	55.30	0.33	0.03	0.01	0.01	99.46	270	40	
		61	43.37	0.21	0.04	0.03	55.45	0.35	-	-	-	99.45	-	-	
		62	42.28	3.78	0.25	0.18	52.65	0.69	0.02	0.04	0.16	100.05	230	40	
		63	43.25	0.50	0.04	0.06	54.36	1.11	-	-	-	99.32	-	-	
		64	42.29	3.97	0.07	0.08	52.47	0.93	-	-	-	99.81	-	-	
		65	41.65	5.23	0.08	0.14	52.16	0.56	0.03	0.02	0.07	99.94	100	70	
		66	41.46	5.76	0.15	0.21	51.51	0.74	-	-	-	99.83	-	-	
		67	36.57	16.42	0.38	1.04	44.81	0.60	-	-	-	99.82	-	-	
		68	39.67	9.30	0.43	0.72	48.93	0.62	-	-	-	99.69	-	-	
		69	38.85	11.49	0.17	0.31	48.62	0.44	-	-	-	99.88	-	-	
	Means of Sample No. 41 ~ 69		40.81	6.31	0.16	0.21	51.13	0.63	-	-	-	99.25	-	-	
	Composite Sample of No. 44 ~ 69		40.28	6.21	1.11	0.26	50.43	0.56	0.04	0.07	0.17	99.63	280	50	
	D	70	43.08	2.19	0.07	0.14	52.95	1.14	0.04	0.03	0.03	99.67	110	40	
		71	43.53	0.35	0.14	0.03	55.15	0.38	-	-	-	99.58	-	-	
		72	43.40	0.63	0.23	0.07	54.85	0.46	-	-	-	99.64	-	-	
		73	43.56	0.51	0.15	0.06	55.11	0.36	-	-	-	99.75	-	-	
		74	43.74	0.12	0.05	0.03	55.38	0.34	-	-	-	99.66	-	-	
		75	43.39	0.63	0.20	0.05	54.96	0.41	0.02	0.02	0.02	99.70	200	60	
		76	43.72	0.33	0.14	0.04	55.30	0.34	-	-	-	99.87	-	-	
		77	42.29	2.61	0.74	0.26	53.04	0.43	-	-	-	99.37	-	-	
		78	43.30	0.71	0.22	0.08	54.94	0.29	-	-	-	99.54	-	-	
		79	43.43	0.75	0.13	0.05	54.55	0.54	-	-	-	99.45	-	-	
		80	42.79	2.00	0.56	0.15	53.65	0.52	0.03	0.04	0.10	99.84	160	140	
Means of Sample No. 70 ~ 80			43.29	0.98	0.24	0.09	54.53	0.47	-	-	-	99.60	-	-	
Composite Sample of No. 70 ~ 80			43.24	1.02	0.25	0.06	54.65	0.49	0.07	0.01	0.03	99.82	200	40	

Table 1-10 Chemical Analysis of Tanah Merah Clay

Sample No.		Moisture (%)	Chemical Composition (%)										P_2O_5 (ppm)	Cl^- (ppm)
			L.O.I.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Total		
West	26-1	10.8	6.84	64.68	19.75	7.10	0.25	0.13	0.02	0.16	0.85	99.78	-	-
	26-2	13.0	4.59	73.47	16.77	2.40	0.25	0.15	0.00	0.15	2.18	99.96	-	-
	26-3	18.6	8.31	53.60	19.75	15.55	0.25	0.15	0.02	0.20	2.17	100.00	-	-
	26-4	10.3	4.00	80.38	9.05	5.45	0.35	0.02	0.01	0.05	0.69	100.00	-	-
	26-5	16.6	6.20	68.68	14.77	8.54	0.27	0.03	0.03	0.09	1.36	99.97	-	-
	26-6	15.6	4.58	80.40	12.68	1.35	0.32	0.04	0.03	0.08	0.51	99.99	-	-
	26-7	21.5	10.35	50.64	25.69	11.60	0.25	0.04	0.04	0.16	1.23	100.00	-	-
	26-8	13.4	4.75	77.69	11.06	5.28	0.28	0.03	0.05	0.10	0.70	99.94	-	-
	26-9	17.2	5.40	77.95	12.10	3.76	0.30	0.02	0.05	0.07	0.35	100.00	-	-
	26-10	18.5	7.45	60.06	18.86	11.65	0.25	0.10	0.01	0.14	1.45	99.97	-	-
	26-11	14.1	6.77	66.73	11.58	14.00	0.44	0.00	0.04	0.14	0.24	99.94	-	-
	26-12	12.2	3.31	85.93	8.93	0.92	0.30	0.02	0.04	0.06	0.30	99.81	-	-
	26-13	13.2	3.55	84.31	10.70	0.68	0.23	0.02	0.01	0.07	0.42	99.99	-	-
	21-1	9.1	6.70	61.43	18.80	10.27	0.33	0.06	0.02	0.33	2.05	99.99	-	-
Means of Tanah Merah West		14.6	5.91	70.45	15.04	7.04	0.29	0.06	0.03	0.13	1.04	99.99	-	-
Composite Sample of Tanah Merah West		-	5.93	70.50	14.91	7.04	0.28	0.05	0.04	0.09	1.14	99.98	320	35
North	26-14	25.4	13.65	41.39	27.40	16.40	0.26	0.20	0.02	0.14	0.53	99.99	-	-
	26-15	27.4	13.88	40.29	27.96	16.62	0.30	0.24	0.04	0.14	0.52	99.99	-	-
Means of Tanah Merah North		26.4	13.76	40.84	27.68	16.51	0.28	0.22	0.03	0.14	0.52	99.98	-	-
Composite Sample of Tanah Merah North		-	13.76	40.86	27.68	16.50	0.28	0.25	0.03	0.13	0.50	99.99	600	58

Table 1-11 Chemical Analysis of Gua Musang Clay

Sample No.		Moisture (%)	Chemical Composition (%)										P_2O_5 (ppm)	Cl^- (ppm)
			L.O.I	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Total		
North East	25-1	25.9	9.25	52.59	27.04	7.96	0.32	0.22	0.02	0.05	2.52	99.97	-	-
	25-2	24.5	7.65	57.90	23.63	7.15	0.27	0.20	0.02	0.21	3.00	100.03	-	-
Means of Gua Musang North East		25.2	8.45	55.24	25.34	7.56	0.30	0.21	0.02	0.13	2.76	100.01	-	-
Composite Sample of Gua Musang North East		-	8.50	55.21	25.32	7.57	0.28	0.20	0.03	0.14	2.75	100.00	420	15
South	24-2	9.9	6.08	61.22	20.55	7.43	0.37	0.36	0.02	0.45	3.45	99.93	-	-
	24-3	29.5	11.94	55.36	24.33	3.09	0.44	1.48	0.02	0.22	3.12	100.00	-	-
	24-4	11.8	6.58	60.22	20.34	8.34	0.37	0.42	0.02	0.48	3.22	99.99	-	-
	24-5	12.3	1.74	87.10	6.54	2.21	0.37	0.31	0.03	0.02	1.67	99.99	-	-
	24-6	24.3	8.12	62.98	21.93	3.89	0.37	0.36	0.02	0.03	2.17	99.86	-	-
	24-7	22.8	7.85	55.82	23.94	8.18	0.39	0.11	0.02	0.13	3.46	99.90	-	-
	24-8	17.6	6.19	57.91	25.95	4.51	0.32	0.33	0.02	0.21	4.54	99.98	-	-
	24-9	17.8	6.13	64.78	19.11	5.71	0.37	0.11	0.02	0.17	3.59	99.99	-	-
	24-10	11.7	8.52	53.03	22.27	12.64	0.25	0.21	0.01	0.25	2.71	99.89	-	-
Means of Gua Musang South		17.5	7.02	62.05	20.55	6.22	0.36	0.41	0.02	0.22	3.10	99.95	-	-
Composite Sample of Gua Musang South		-	7.06	62.04	20.57	6.22	0.35	0.40	0.02	0.22	3.10	99.98	340	19
South	24-11	3.2	4.52	58.72	22.58	6.86	0.41	0.60	0.03	0.76	5.51	99.99	-	-
South	23-2	-	3.70	69.26	16.61	4.93	0.35	1.36	0.05	0.19	3.40	99.85	880	-
East	24-1-2	-	2.36	75.22	13.13	4.34	0.35	1.31	0.03	0.44	2.80	99.98	660	-
Means of Gua Musang South East		-	3.03	72.24	14.87	4.64	0.35	1.34	0.06	0.30	3.09	99.92	770	-

Table 1-12 Chemical Analysis of Jeli Clay

Sample No.		Moisture (%)	Chemical Composition (%)										P_2O_5 (ppm)	Cl^- (ppm)
			L.O.I.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Total		
Jeli	21-2	18.4	7.40	62.84	20.66	5.42	0.30	0.30	0.02	0.38	2.60	99.92	-	-
	21-3	22.2	5.70	61.50	25.27	2.10	0.21	0.20	0.02	0.45	4.50	99.95	-	-
	21-4	13.9	5.64	62.68	20.60	6.77	0.18	0.20	0.03	0.25	3.59	99.94	-	-
	21-5	13.5	5.90	58.58	22.60	7.94	0.18	0.25	0.00	0.24	4.17	99.86	-	-
	21-6	22.3	9.45	55.71	22.45	10.87	0.25	0.05	0.02	0.15	0.98	99.93	-	-
Means of Jeli Clay		18.1	6.82	60.26	22.32	6.62	0.22	0.20	0.02	0.29	3.17	99.92	-	-
Composite Sample of Jeli Clay		-	6.88	60.51	21.93	6.78	0.21	0.20	0.02	0.28	3.18	99.99	360	30

Table 1-13 Chemical Analysis of S. Kelantan Silica Sand

Sample No.	Moisture (%)	Chemical Composition (%)										P_2O_5 (ppm)	Cl^- (ppm)
		L.O.I.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Total		
27-1	3.1	0.54	90.96	4.24	0.62	0.34	0.00	0.00	0.59	2.70	99.99	-	65
27-2	1.3	0.69	90.08	4.85	0.79	0.35	0.00	0.00	0.60	2.53	99.89	-	-
27-3	0.3	0.65	92.51	3.60	0.85	0.42	0.00	0.02	0.44	1.50	99.99	200	-
27-4	2.7	0.50	89.84	5.13	0.65	0.42	0.00	0.00	0.63	2.80	99.97	200	39
Means of 27-1 ∿ 4	1.9	0.60	90.85	4.46	0.73	0.38	0.00	0.00	0.56	2.38	99.96	-	-
Means of 27-1, 4	2.9	0.52	90.40	4.69	0.64	0.38	0.00	0.00	0.61	2.75	99.99	-	-
Composite Sample of 27-1, 4	-	0.51	90.41	4.70	0.62	0.38	0.00	0.00	0.60	2.76	99.98	200	50

Table 1-14 Chemical Analysis of Bachok Silica Sand

Sample No.	Moisture (%)	Chemical Composition (%)										P_2O_5 (ppm)	Cl^- (ppm)
		L.O.I.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Total		
28-1	4.6	0.60	96.60	1.33	0.62	0.25	0.00	0.00	0.06	0.38	99.84	140	-
28-2	7.1	3.27	91.97	2.30	0.92	0.30	0.05	0.01	0.23	0.80	99.85	-	56
28-3	3.7	0.26	97.96	0.60	0.32	0.14	0.05	0.02	0.20	0.40	99.95	-	70
28-4	-	4.45	91.62	2.00	1.05	0.21	0.05	0.00	0.12	0.50	100.00	-	51
Means of 28-1 ∿ 4	5.1	2.14	94.53	1.56	0.73	0.22	0.04	0.01	0.15	0.52	99.90	-	-
Composite Sample of 28, 1 ∿ 4	-	2.03	94.78	1.55	0.60	0.23	0.04	0.01	0.15	0.54	99.93	150	60

Table 1-15 Chemical Analysis of Gua Musang and Bt. Kuang Silica Rock

Sample No.		Moisture (%)	Chemical Composition (%)										P_2O_5 (ppm)	Cl^- (ppm)
			L.O.I.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Total		
Gua Musang	23-1	-	0.98	92.30	3.71	1.55	0.29	0.48	0.00	0.14	0.55	100.00	-	-
	23-3	-	1.05	91.90	2.84	2.51	0.29	0.74	0.03	0.12	0.52	100.00	-	-
	24-1-1	-	1.26	89.06	4.65	2.73	0.28	0.76	0.01	0.26	0.98	99.99	-	-
Means of Gua Musang		-	1.10	91.09	3.73	2.26	0.29	0.66	0.01	0.17	0.68	99.99	-	-
Composite Sample of Gua Musang		-	1.11	91.09	3.75	2.23	0.28	0.69	0.01	0.16	0.67	99.99	400	39
Bt. Kuang	1-1	-	0.31	97.53	0.88	0.62	0.24	0.00	0.00	0.03	0.15	99.76	-	40
	1-2	-	0.18	97.27	1.04	0.66	0.28	0.00	0.00	0.02	0.19	99.64	-	-
Means of Bt. Kuang		-	0.24	97.40	0.96	0.64	0.26	0.00	0.00	0.02	0.16	99.68	-	-
Composite of Bt. Kuang		-	0.23	97.44	0.95	0.62	0.28	0.00	0.00	0.02	0.17	99.71	60	-

Table 1-16 Chemical Analysis of Temangan and Bt. Kuang Iron Ore

Sample No.		Moisture (%)	Chemical Composition (%)										P_2O_5 (ppm)	Cl^- (ppm)
			L.O.I.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Total		
Teman-gan	19-1	-	8.41	24.43	6.82	57.79	0.41	0.08	0.03	0.07	1.73	99.77	-	-
	19-2	-	10.72	11.29	0.77	76.50	0.37	0.11	0.00	0.04	0.16	99.96	-	-
	19-3	-	9.17	2.04	4.38	83.38	0.36	0.28	0.03	0.11	0.16	99.91	-	-
	19-4	-	10.25	2.17	0.35	86.24	0.09	0.24	0.04	0.05	0.09	99.52	-	-
	19-5	-	11.49	3.03	0.89	83.90	0.21	0.07	0.03	0.14	0.15	99.91	-	-
Means of Temangan		-	10.01	8.59	2.64	77.56	0.29	0.16	0.03	0.08	0.46	99.82	-	-
Composite sample of Temangan		-	10.00	8.61	2.62	77.60	0.30	0.15	0.02	0.09	0.43	99.82	440	16
Bt. Kuang	1-3	-	13.75	6.18	10.70	68.50	0.14	0.20	0.03	0.17	0.11	99.78	1,240	21

Table 1-17 Chemical Analysis of Bt. Lata Iron Ore

Sample No.		Moisture (%)	Chemical Composition (%)										P_2O_5 (ppm)	Cl^- (ppm)
			L.O.I.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Total		
Bt. Lata	1-4	-	11.65	8.30	7.60	68.89	0.80	1.41	0.11	0.08	1.01	99.85	8,520	-
	1-5	-	11.00	14.59	18.33	53.55	0.42	0.10	0.17	0.15	1.22	99.53	4,100	-
Means of Bt. Lata		-	11.33	11.45	13.00	61.22	0.61	0.78	0.14	0.11	1.12	99.76	6,310	-
Composite Sample of Bt. Lata		-	11.43	11.40	12.99	61.20	0.63	0.76	0.12	0.12	1.21	99.86	6,350	23

Table 1-18 Chemical Analysis of Gypsum

Sample No.	Moisture (%)	Chemical Composition (%)										P_2O_5 (ppm)	Cl^- (ppm)
		L.O.I.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Total		
Thai	2.2	21.67	3.92	0.11	0.10	30.32	0.00	43.67	0.03	0.15	99.97	120	-
Australia	-	21.08	0.08	0.02	0.02	32.56	0.00	46.17	-	-	99.93	-	-

Table 1-19 Chemical Analysis of Iron Slime *

Sample No.	Moisture (%)	Chemical Composition (%)										P_2O_5 (ppm)	Cl^- (ppm)
		L.O.I.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Total		
Iron Slime	2.2	12.82	14.29	18.70	53.45	0.42	0.00	0.17	0.03	0.12	100.00	9,040	-

* Iron slime is used as Iron source for cement manufacturing in Malaysia.

Table 1-20 Chemical Analysis of Coal Ash

Sample No.	Moisture (%)	Chemical Composition (%)										P_2O_5 (ppm)	Cl^- (ppm)
		L.O.I.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Total		
Australia	-	-	68.6	24.0	2.7	0.7	0.6	0.3	0.5	1.1	98.5	-	-

2. Physical Properties

2-1 Specific gravity

The samples are ground by a vibration mill to 100 % passing through the 149μm sieve.

Then the specific gravity of samples is measured with a pycnometer using water at 20±1°C.

The specific gravity is calculated by the following equation.

$$\rho = \frac{(W_2 - W_0) \cdot \rho s}{(W_2 - W_0) - (W_1 - Ws)}$$

where,

W_0	:	weight of pycnometer
Ws	:	weight of pycnometer filled up with water
W_1	:	weight of pycnometer filled up with sample and water
W_2	:	weight of pycnometer filled up with sample
ρs	:	specific gravity of water at 20°C

The results of specific gravity are shown in Table 2-1.

2-2 Apparent Specific Gravity

The apparent specific gravity of samples under saturated surface dry condition (with dried surface) is measured by weighing both in air and water. The results are shown in Table 2-2.

Silica sand figures show a bulk density at the condition of being dried up to equilibrium.

Table 2-1 Test Results of Specific Gravity

Sample		Sample No.	Specific Gravity
Raw Materials	Sampling Area		
Limestone	Gua Panjang		2.69
			2.69
	Gua Musang		2.71
Clay	Tanah Merah	26-1 ∿ 13 and 21-1 Mixing	2.40
		26-14, 15 Mixing	2.65
	Gua Musang	25-1	2.65
		24-2 ∿ 10 Mixing	2.63
		23-2	2.64
Silica Sand	S. Kelantan	27-3	2.62
		27-4	2.69
	Bachok	28-1	2.61
		28-2	2.61
Silica Rock	Gua Musang	23-1, 3 and 24-1-1 Mixing	2.65
	Tanah Merah	31-1	2.68
Iron Ore	Bt. Lata	1-4	3.75
		1-5	3.42
	Temangan	19-1 ∿ 5 Mixing	3.93
Granite	Machang		2.59

Table 2-2 Test Results of Apparent Specific Gravity

Sample			Sample No.		Apparent Specific Gravity
Raw Materials	Sampling Area				
Limestone	Gua Panjang		White Limestone	1	2.69
				2	2.74
				3	2.70
				4	2.69
			Means		2.70
			Black Limestone	1	2.62
				2	2.66
			Means		2.64
Clay	Tanah Merah		26-1		1.92
			26-7		1.76
			26-11		2.44
			26-14, 15 Mixing		2.07
	Gua Musang	South	24-5		2.22
			24-6		1.75
			24-9		2.42
			24-10		2.08
		North East	25-1		2.11
		South East	23-1, 3 and 24-1-1 Mixing		2.58
			23-2		2.50
	Jeli		21-2		1.88
			21-4		2.38
Silica Sand	S. Kelantan		27-4		1.53 *
	Bachok		28-1		1.30*
			28-2		1.15*
Silica Rock	Bt. Kuang		1-1, 2 Mixing		2.53
Iron Ore	Temangan Mine		19-4		3.68
Granite	Machang		J.K.R. Mine	1	2.55
				2	2.53
				3	2.55
				4	2.58
				5	2.56
				6	2.53
			Means		2.55

* The test results are indicated in unit volume weight in absolute dry contition. (Kg/ℓ)

2-3 Particle size distribution

The particle size distribution of silica sand is shown in Table 2-3.

2-4 Water Absorption, Compressive Strength, Soundness and Velocity Propagation

The samples are weighed both in wet and dry conditions and the water absorption is calculated by the following equation.

$$Q\,(\%) = \frac{Ws - Wd}{Wd} \times 100$$

where,

Q : water absorption
Ws : weight of sample in wet condition
Wd : weight of sample in dry condition

The test specimens (25 mm dia x 50 mm length) prepared from the stone samples are compressed to measure the compressive strength using a 10 ton test machine.

The soundness of the sieved samples, which are 5-2.5 mm, 2.5 - 1.2 mm and 1.6 - 0.6 mm, is measured in Na_2SO_4 solution.

The P and S wave velocities of the test specimens (25 mm dia. x 50 mm length) are measured in the wet condition by the Ultra Sonic Propagation Meter.

These results are shown in Table 2-4.

Table 2-3 Test Results of Sieve Analysis of Silica Sand

Sample		Sample No.	Weight percent of passing Sieve (wt. %)								
			40mm	20mm	10mm	5mm	2.5mm	1.2mm	0.6mm	0.3mm	0.15mm
Silica Sand	S. Kelantan	27-1	-	-	100	98.2	84.3	48.2	8.9	0.5	0.1
		27-2	100	94.6	81.0	58.2	31.7	11.7	1.5	0.6	0.4
		27-3	100	74.1	43.5	35.2	26.4	17.5	6.7	1.5	0.8
		27-4	-	100	94.4	92.0	82.2	57.4	24.2	5.3	0.7
	Bachok	28-1	-	-	-	-	100	99.8	89.6	37.5	2.2
		28-2	-	-	-	-	100	99.8	89.4	28.4	1.2
		28-3	-	-	-	100	98.2	93.2	71.2	20.5	0.7

Table 2-4 Test Results of Water Absorption, Compressive Strength, Soundness and Velocity Propagation.

Item	Sample		Water Absorption (%)	Compressive Strength (Kgf/cm^2)	Soundness (%)	Velocity Propagation (m/sec)	
						P Wave	S Wave
Limestone Gua Panjang	White	1	0.15	1,150	0.9	6,150	4,100
		2	0.00	1,600		6,350	3,860
		3	0.00	1,580		6,250	3,180
		4	0.00	1,020		6,280	3,840
	Means		0.04	1,340	-	6,260	3,750
	Black	1	0.30	920	0.8	5,830	3,480
		2	0.31	1,000		5,850	3,350
	Means		0.31	960	-	5,840	3,420
Granite (Machang)	J.K.R. Mine	1	0.45	2,280	1.5	5,470	2,880
		2	0.47	1,930		5,440	3,290
		3	0.47	2,140		5,400	2,870
		4	0.48	2,350		5,560	3,450
		5	0.33	2,440		5,500	2,860
		6	0.17	2,420		5,460	3,460
	Means		0.40	2,260	-	5,470	3,140

3. X-ray Diffraction Analysis

The samples are pulverized finely with a vibration mill and analized by the automatic recording X-ray diffractmeter (Rigaku Denki Geigerflex D-2).

The operating conditions are shown below.

Target	Cu
Filter	Graphite Monochrometer
Voltage	40 KVP
Current	20 mA
Count full scale	1000 or 2000
Divergence slit	1°
Scatter slit	1°
Receiving slit	0.3°
Scanning speed	2°/min.
Chart speed	20 mm/min.

The minerals determined by X-ray diffraction are summerized in Table 3-1.

The X-ray diffraction patterns recorded are shown in Fig. 3-1 ∿ Fig. 3-20.

Table 3-1 Results of X-ray Diffraction Analysis

Sample Item	Sample Sampling Area		Sample No.	X-ray Diffraction recognized minerals
Lime-stone	Gua Selir		G-S-3	C (D)
	Dabong	Gua Tembakau	G-T-4	C
		Gua Ikan	G-I-2	C (D)
	Gua Panjang	B	G-M-24	C (D)
		B	G-M-42	D C
		C	G-M-63	C (D)
Clay	Tanah Merah	West	21-1	Q H K
			26-1	Q (M*) (K)
			26-6	Q (K)
			26-7	K Q ((M*))
			26-12	Q K
			26-13	Q K
		North	26-14	(Q) (K) ((M*))
	Jeli		21-2	Q (K) ((M*))
			21-3	Q M* (K)
			21-5	Q M* (K)
	Gua Musang	North East	25-1	Q K (M*)
		South	24-2	Q M* (K) F(?)
			24-3	Q (M*) ((K))
			24-5	Q ((M*))
			24-9	Q (M*) (K)
			24-10	Q (M*) (K) F(?)
			24-11	Q M* ((K))
		South East	23-2	Q (M*) (K) Mo(?)
			24-1-2	Q (M*) (K) Mo(?)
Silica Sand	S. Kelantan		27-3	Q ((K)) ((M*))
			27-4	Q F
	Bachok		28-1	Q F(?)
			28-2	Q
Silica Rock	Gua Musang	South East	23-3	Q (K) ((M*))
	Bt. Kuang		1-1	Q

—— Continued ——

Iron Ore	Bt. Lata	1-4	Go ((M*))
		1-5	(He) ((K))
	Temangan Mine	19-1	Go Q
		19-2	Go
		19-3	(Go)
		19-4	Go
		19-5	Go
	Bt. Kuang	1-3	Go ((K))
Gypsum	Thai		G
Iron Slime	Perak Iron Mining Co.		(He) ((Mg))

Note: (1)

Sign	Mineral	Molecular formula
C,	Calcite	$CaCO_3$
D,	Dolomite	$CaCO_3 \cdot MgCO_3$
F,	Feldspar	$R_2O \cdot Al_2O_3 \cdot 6SiO_2$
G,	Gypsum	$CaSO_4 \cdot 2H_2O$
Go,	Goethite	$Fe_2O_3 \cdot H_2O$
H,	Halloysite	$Al_2O_3 \cdot 2SiO_2 \cdot 4H_2O$
He,	Hematite	Fe_2O_3
K,	Kaolinite	$Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$
M,	Muscovite	$K_2O \cdot 3Al_2O_3 \cdot 6SiO_2 \cdot 2H_2O$
Mo,	Montmorillonite	$Al_2O_3 \cdot 4SiO_2 \cdot 6H_2O$
Mg,	Magnetite	Fe_3O_4
Q,	Quartz	SiO_2
M*	Muscovite or Halloysite	

(2) It was difficult to distinguish between the minerals of Halloysite and Muscovite by X-ray diffraction pattern except for Sample No. 21-1 and 26-1.

(3) Underlined minerals are recognized as minerals with strong intensity in the diffraction patterns, minerals in ( ) are with weak intensity and those in (( )) are with very weak one.

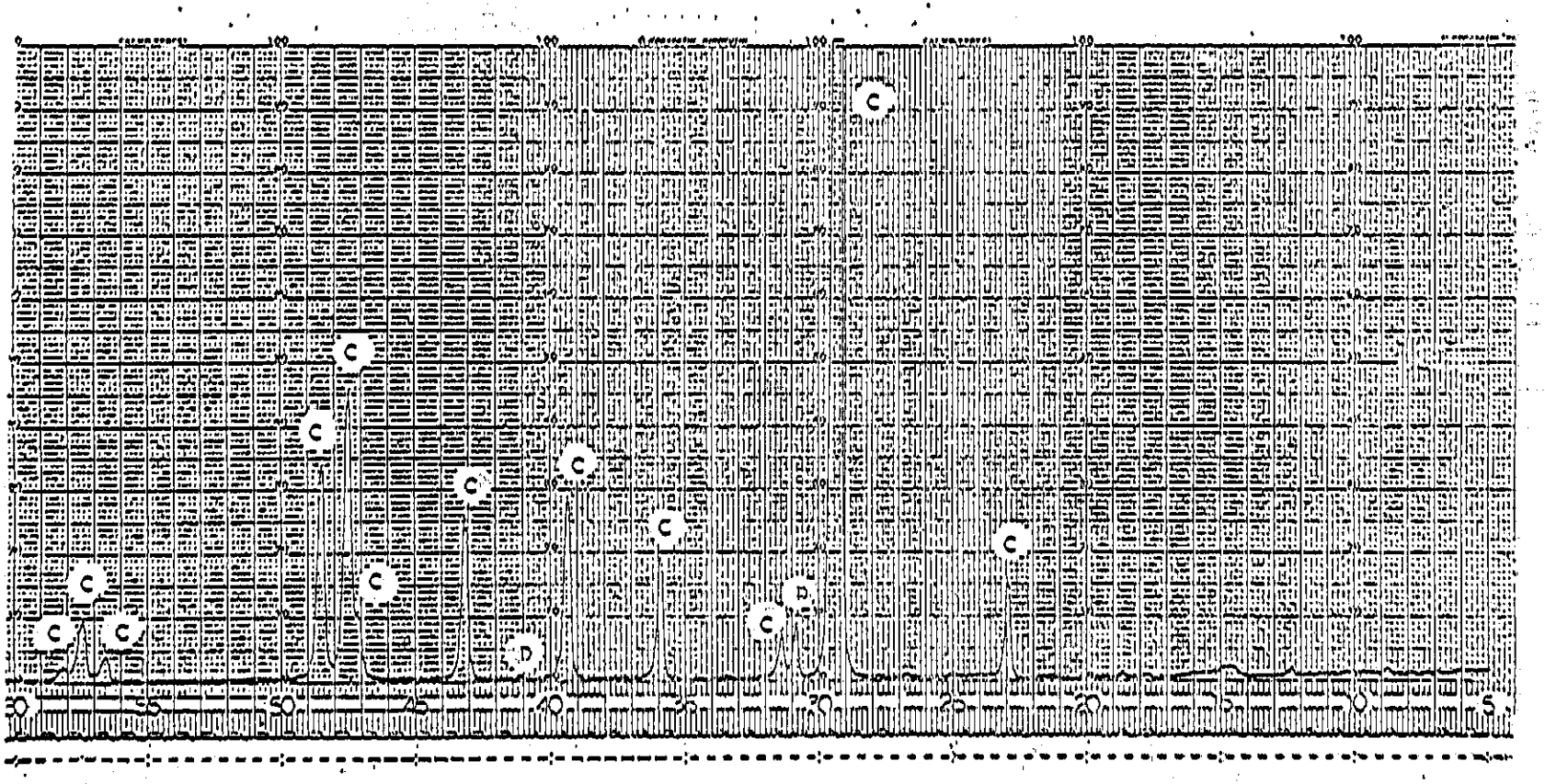


Fig. 3-1 Gua Setir Limestone (G-S-3)

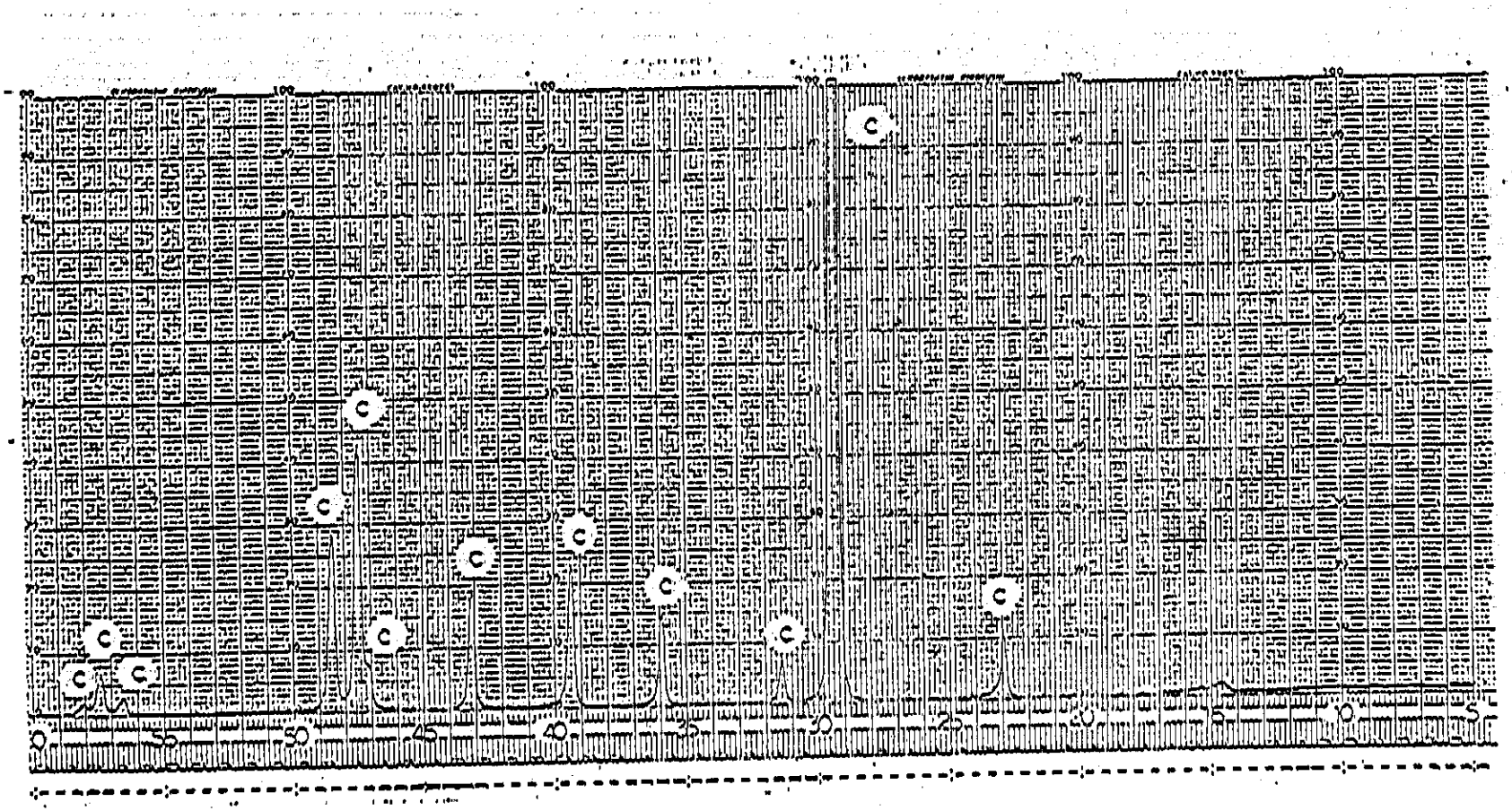


Fig. 3-2 Gua Tembakau Limestone (G-T-4)

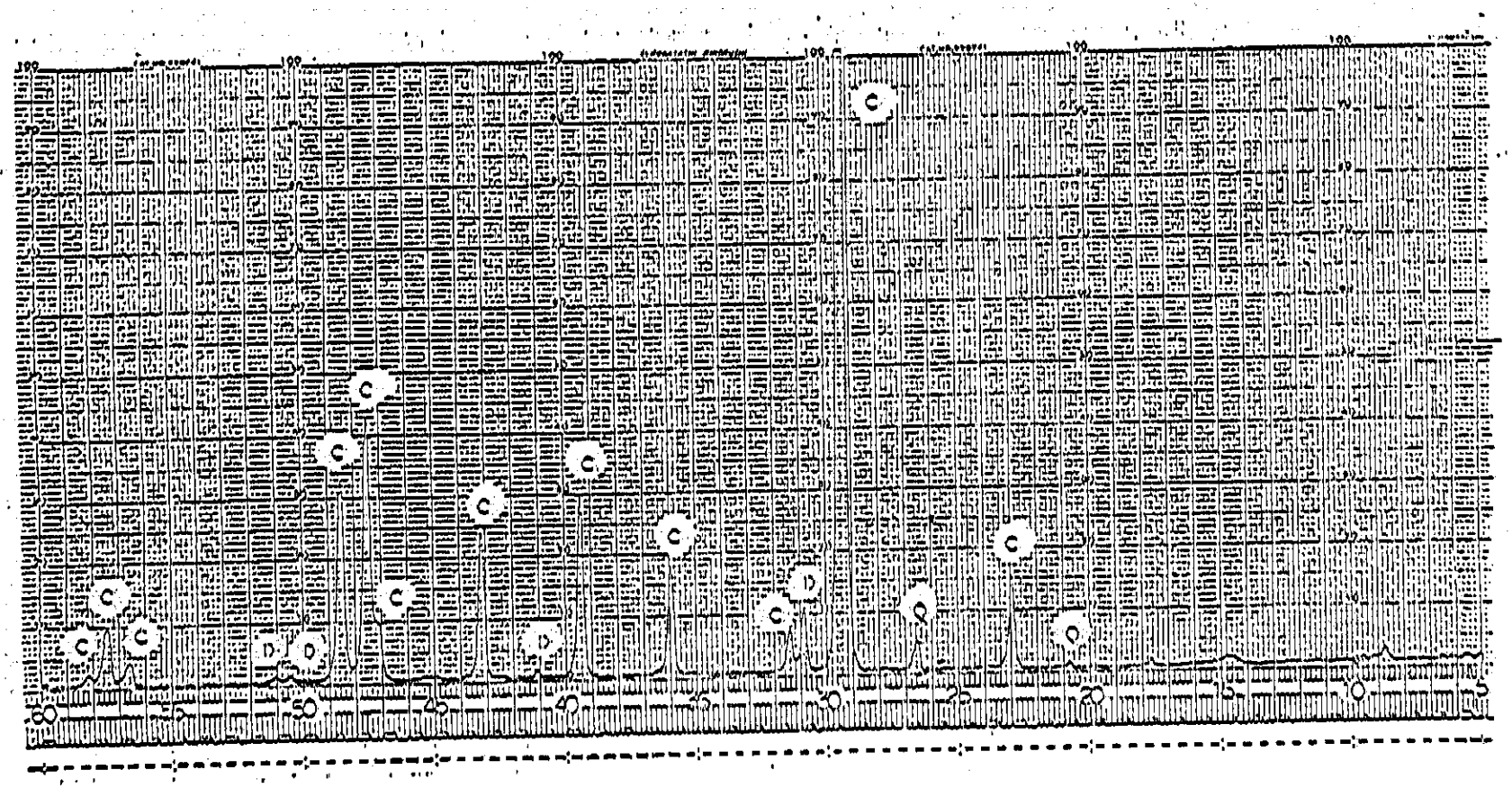


Fig. 3-3 Gua Ikan Limestone (G-I-2)

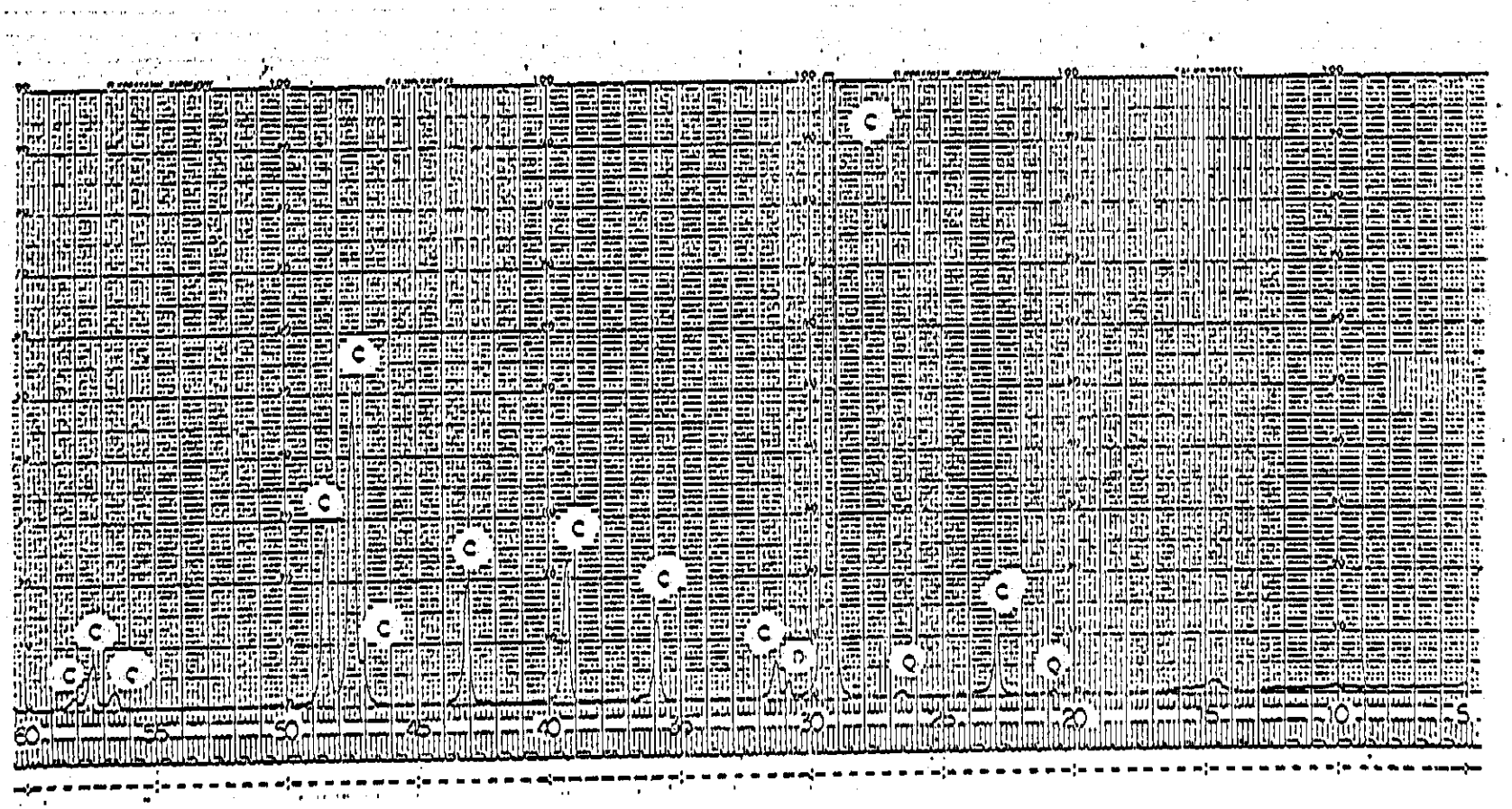


Fig. 3-4 Gua Panjang Limestone (G-M-24)

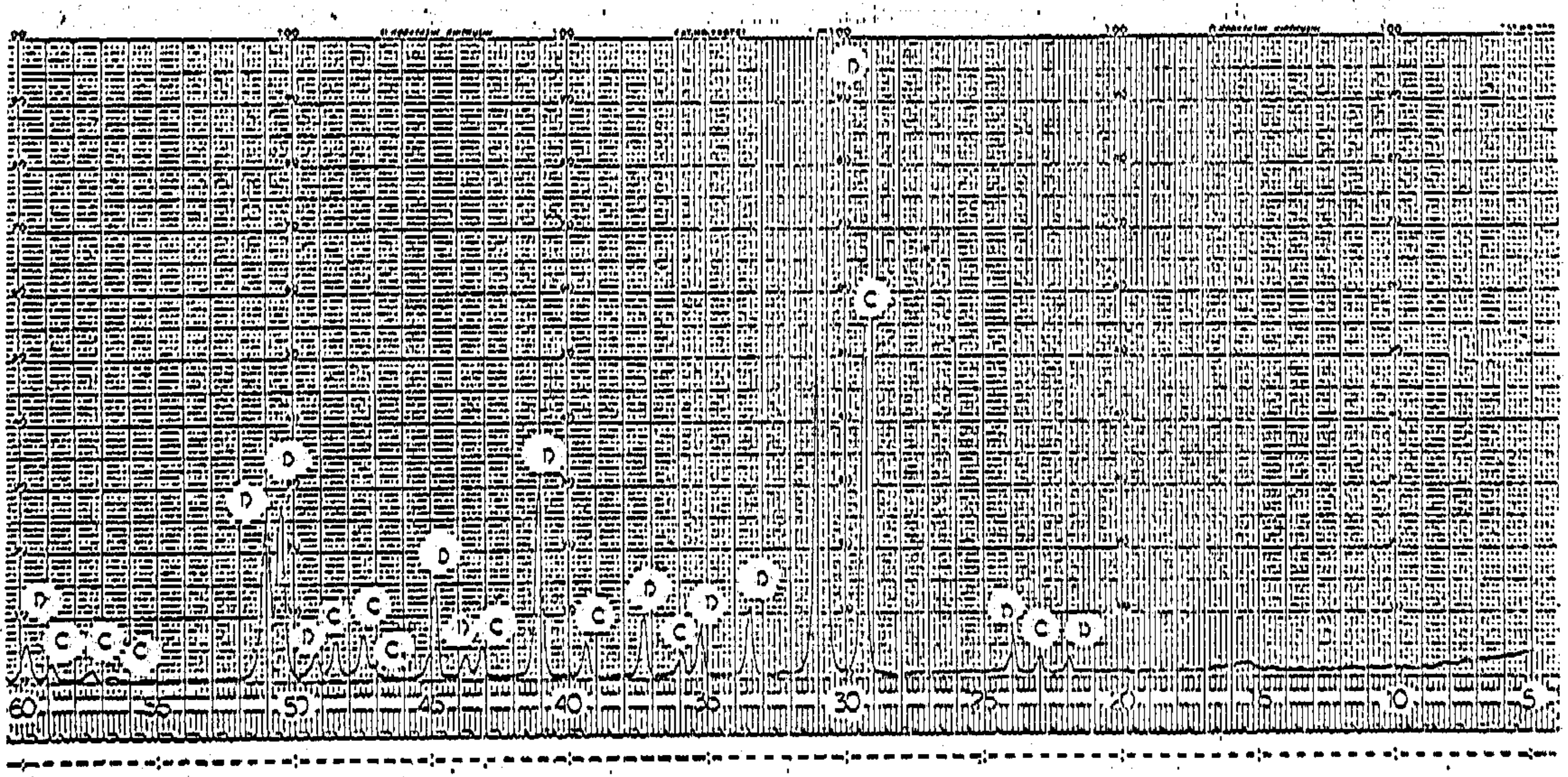


Fig. 3-5 Gua Panjang Calcitic Dolomite (G-M-42)

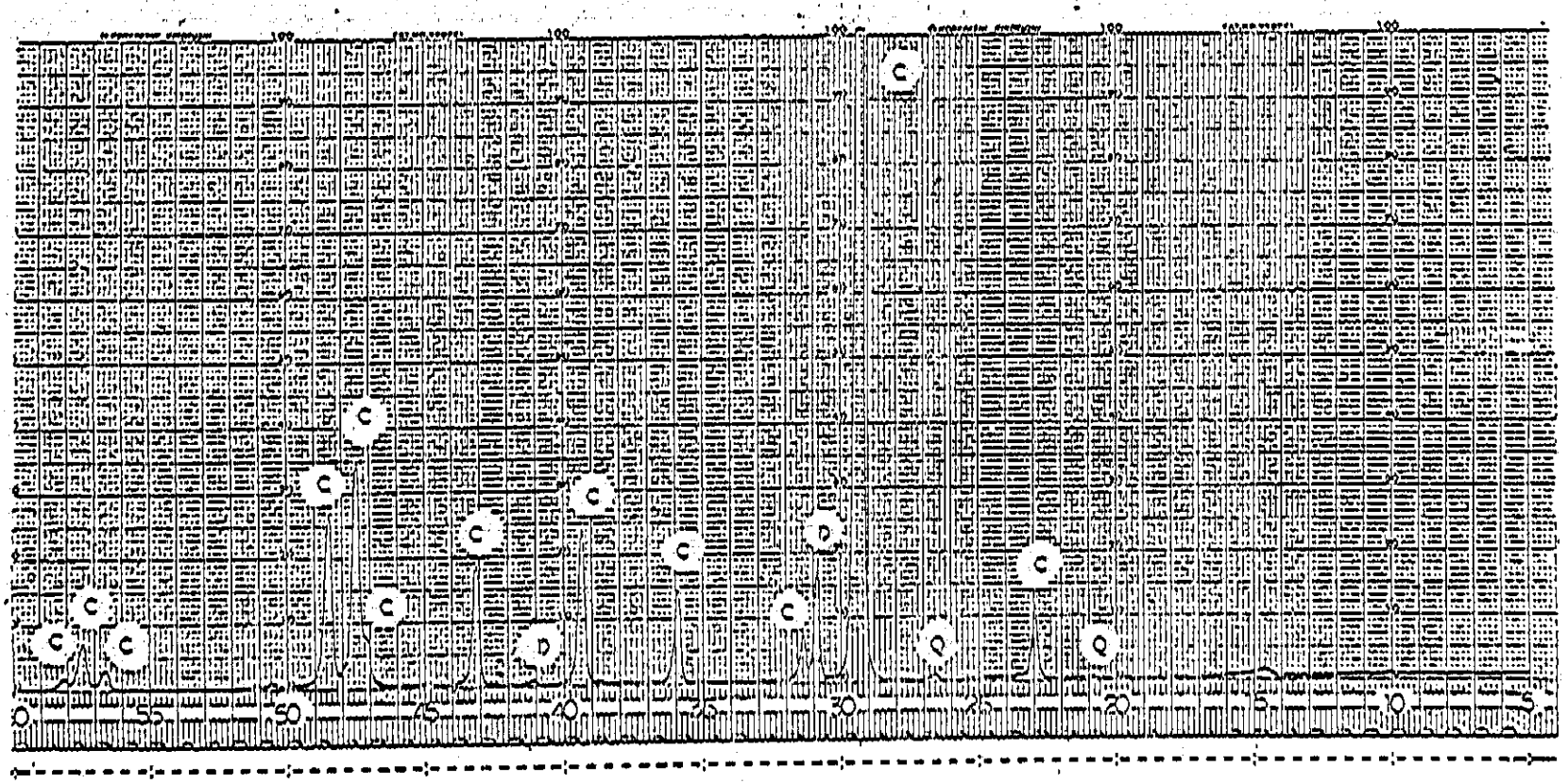


Fig. 3-6 Gua Panjan Limestone (G-M-63)

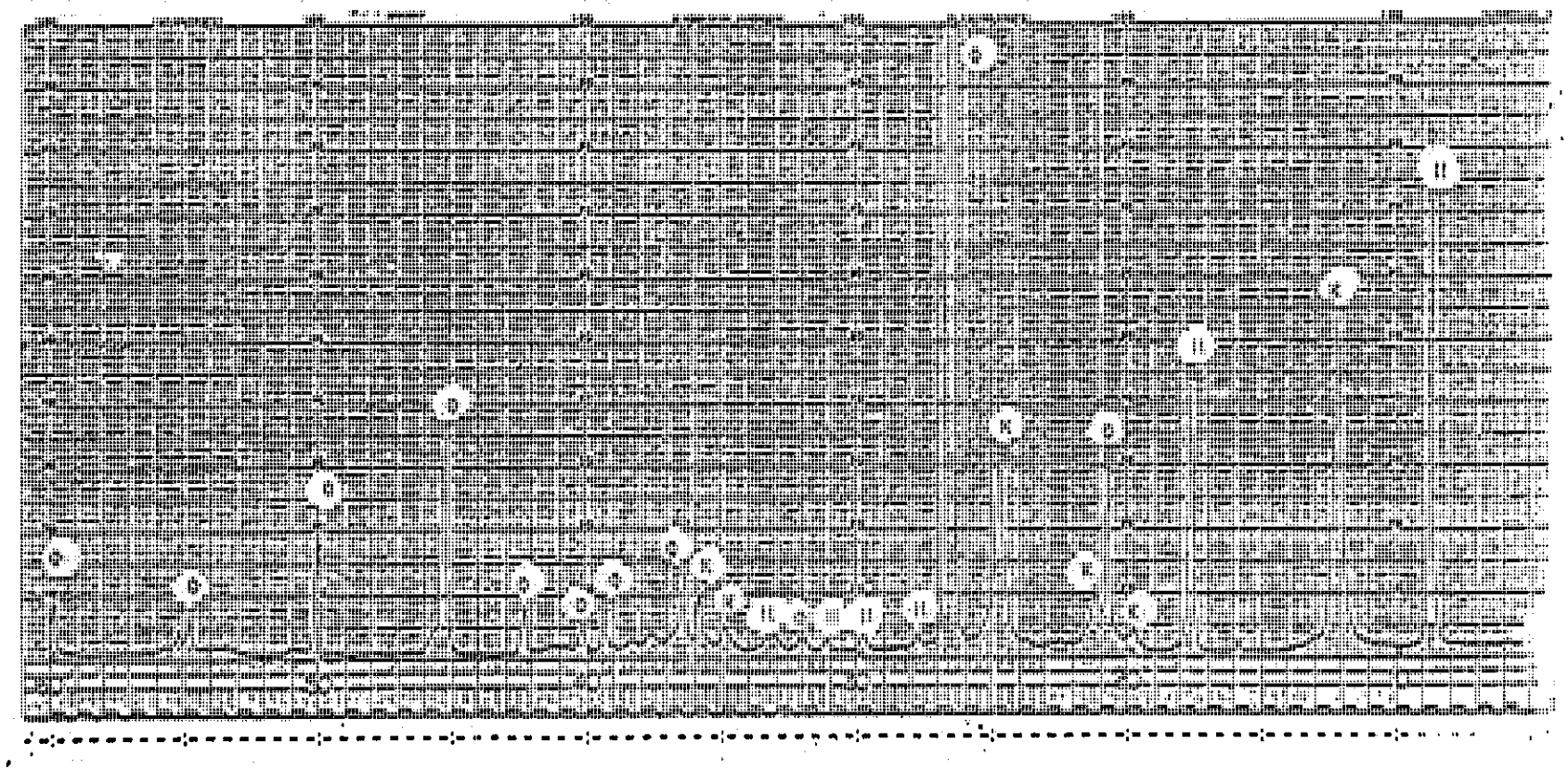


Fig. 3-7 Tanah Merah Clay Sample No. 21-1

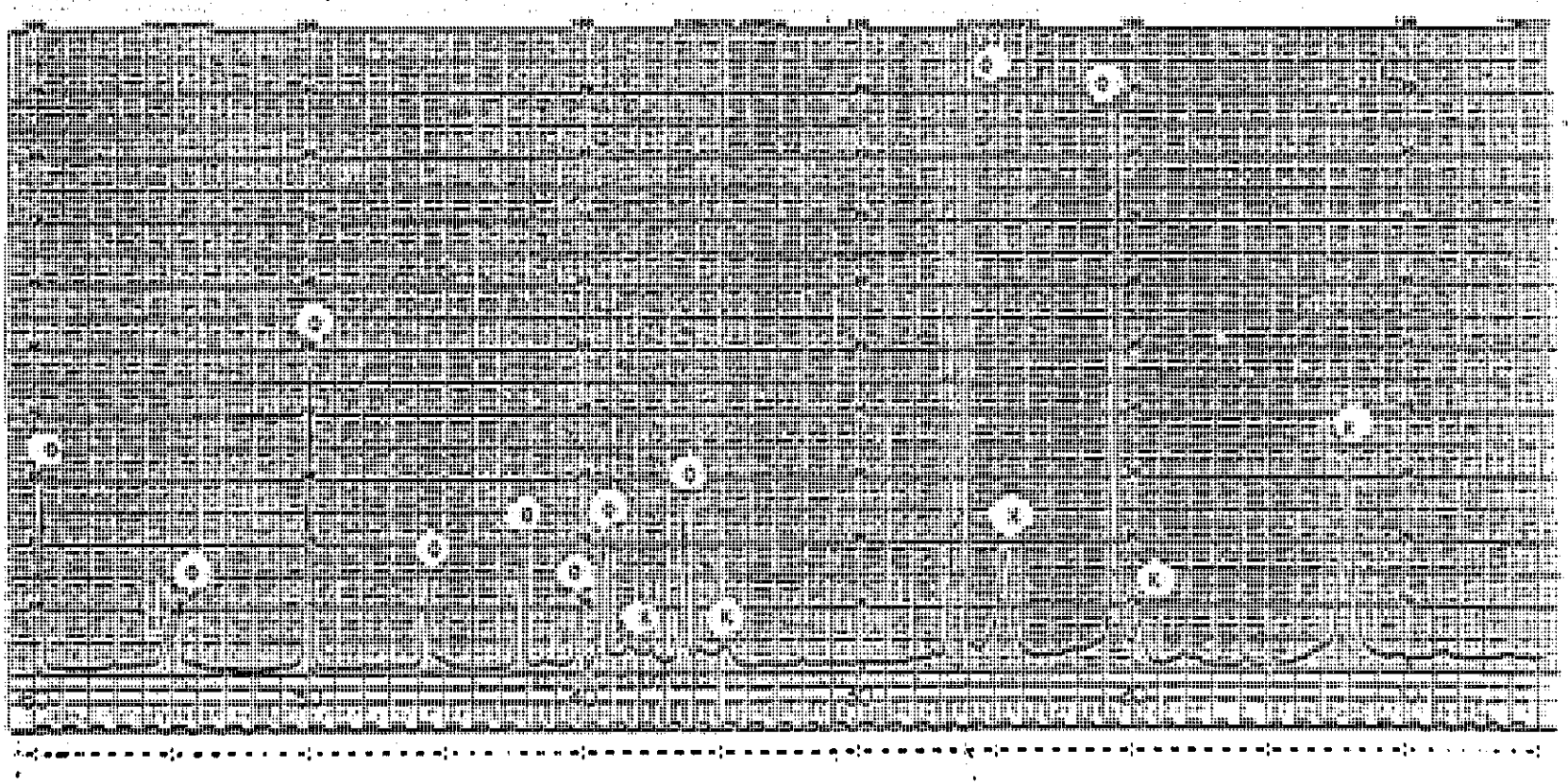


Fig. 3-8 Tanah Merah Clay Sample No. 26-6

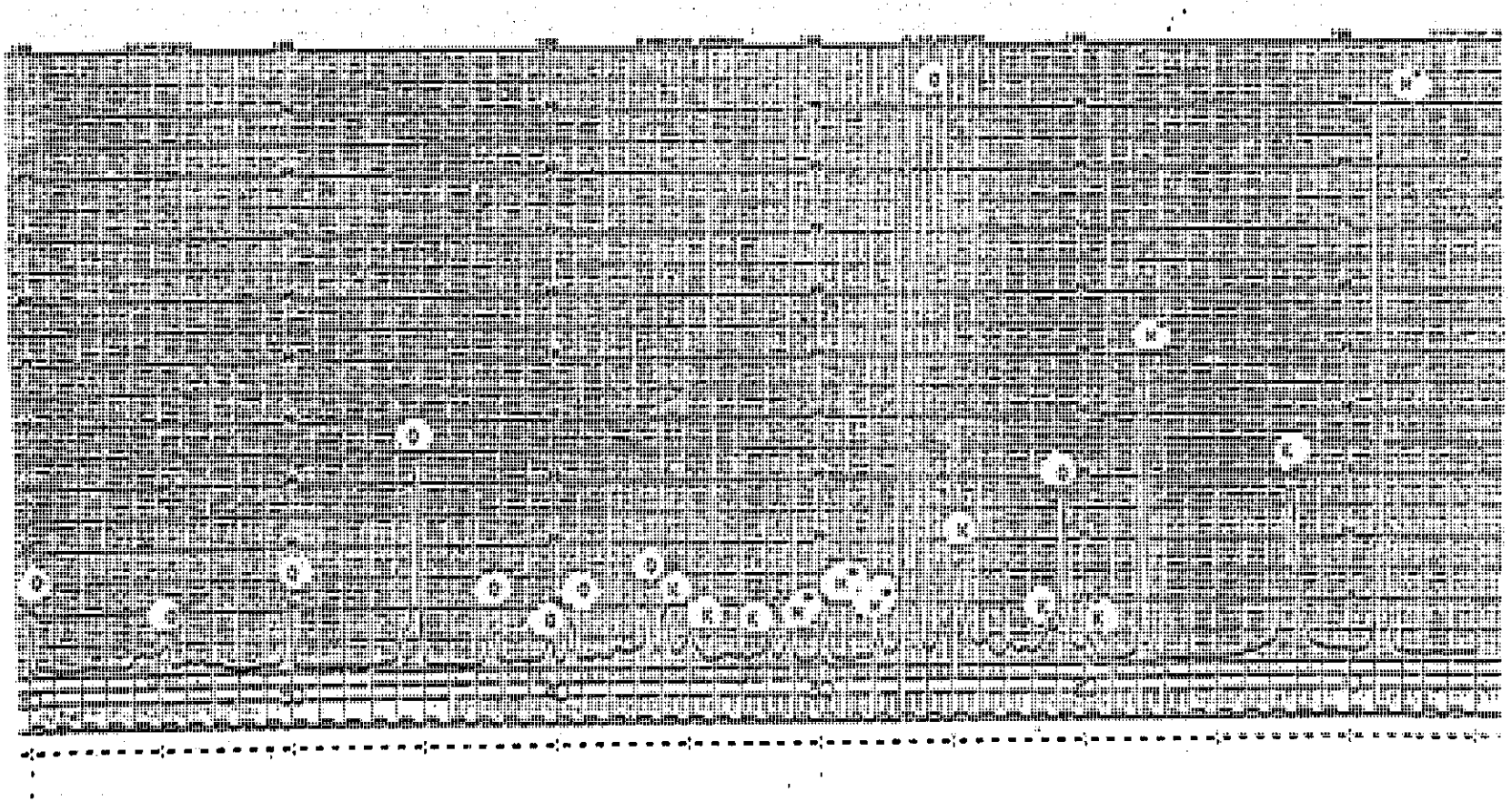


Fig. 3-9 Jeli Clay Sample No. 21-5

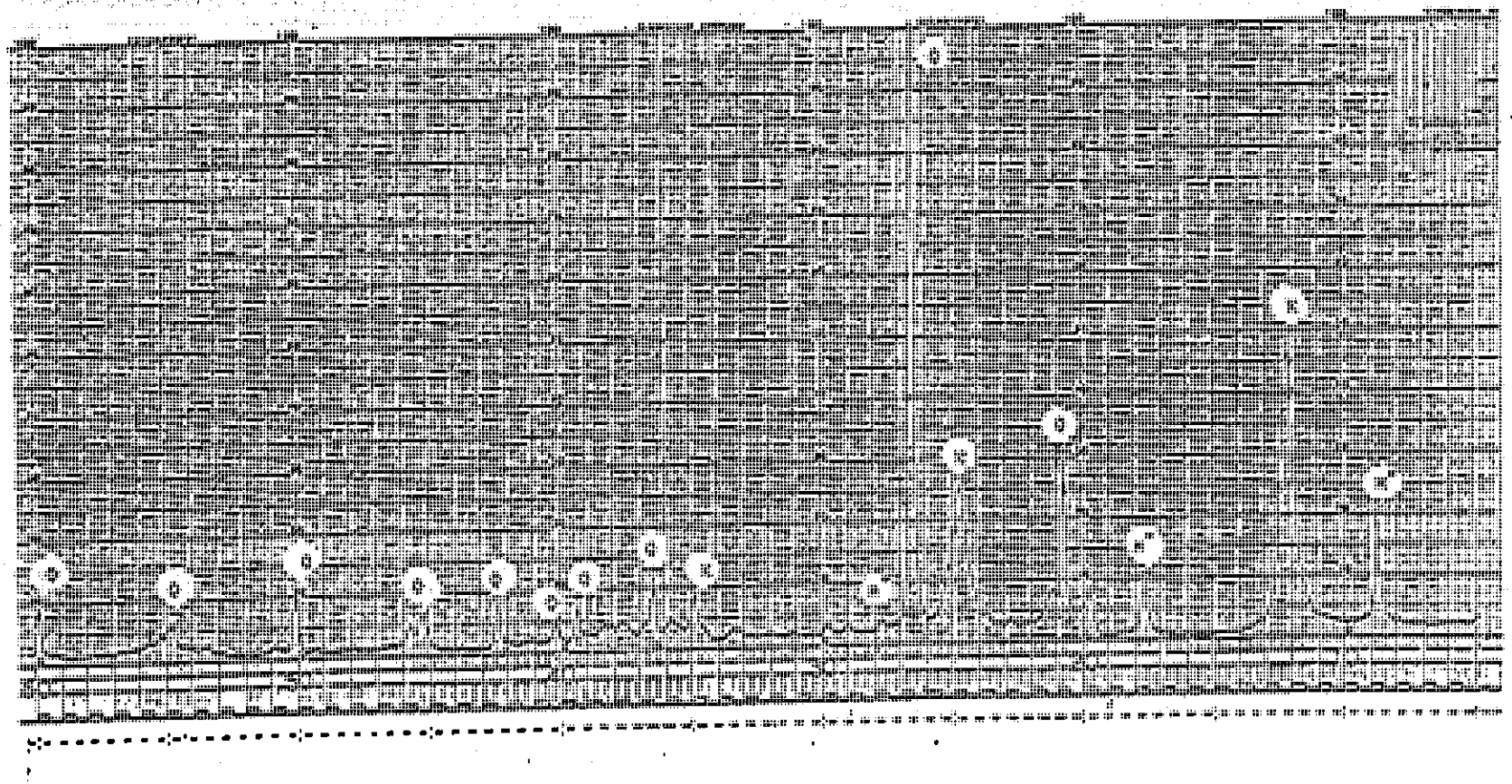


Fig. 3-10 Gua Musang Clay Sample No. 25-1
(North East)

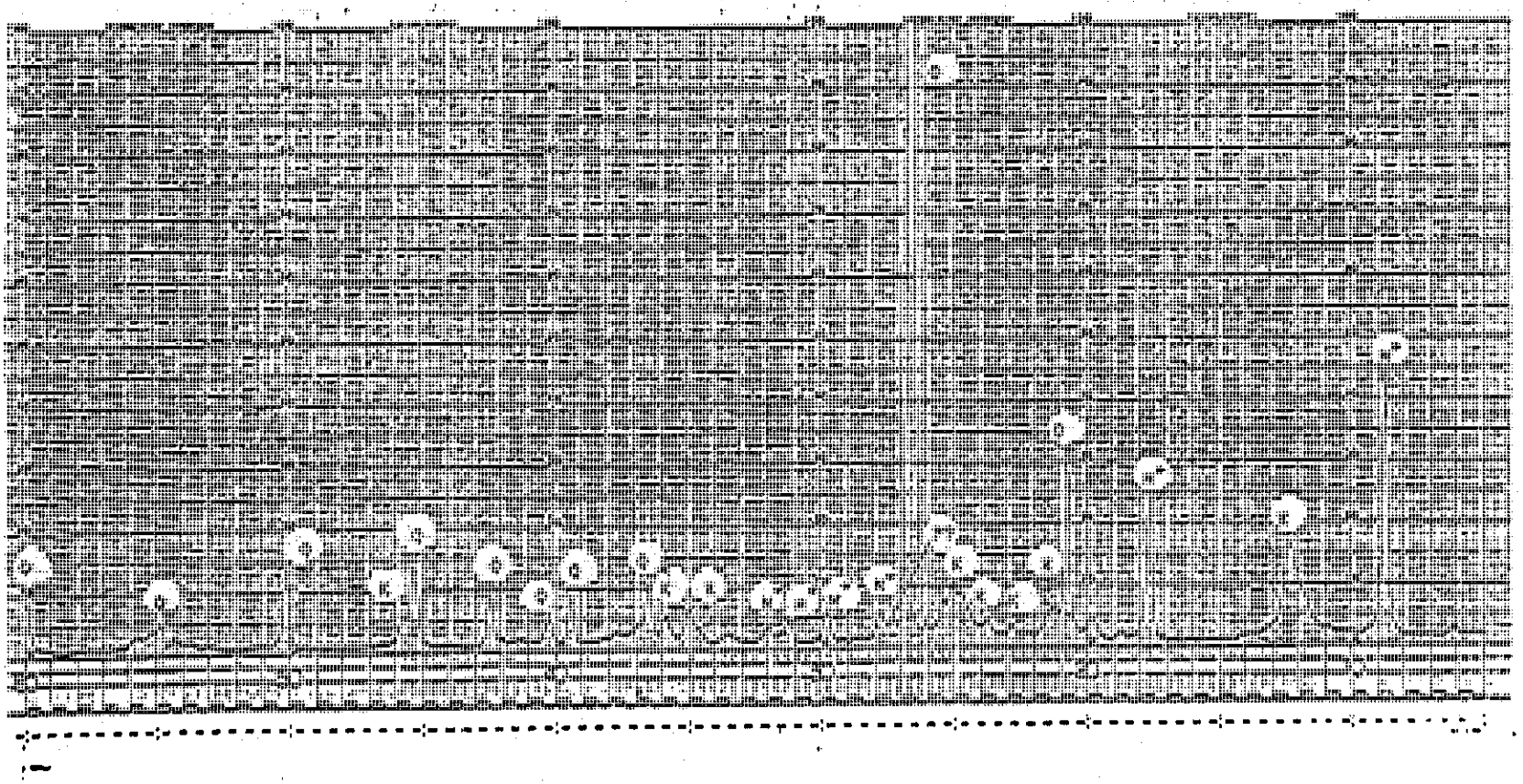


Fig. 3-11 Gua Musang Clay Sample No. 24-2
(South)

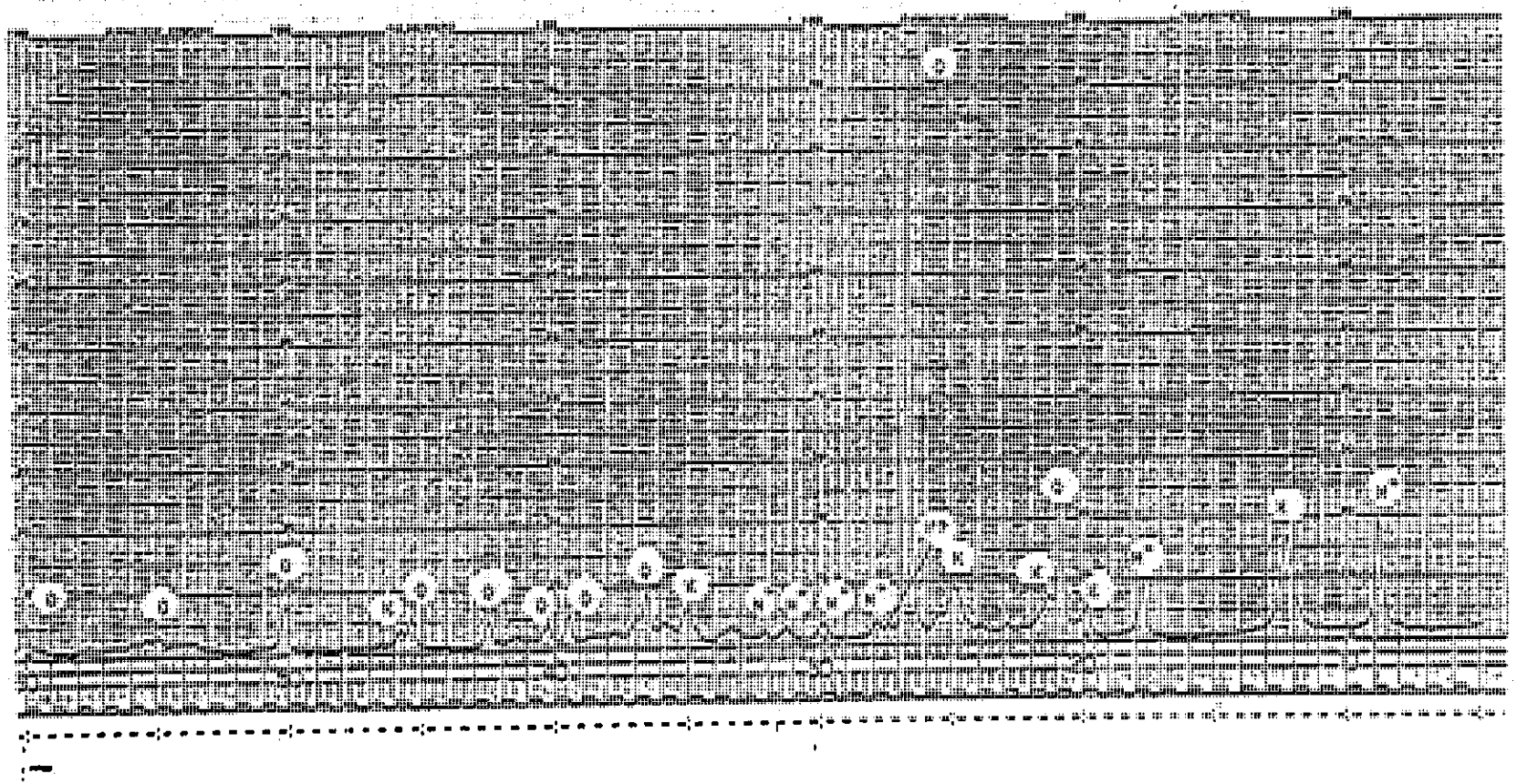


Fig. 3-12 Gua Musang Clay Sample No. 24-10
(South)

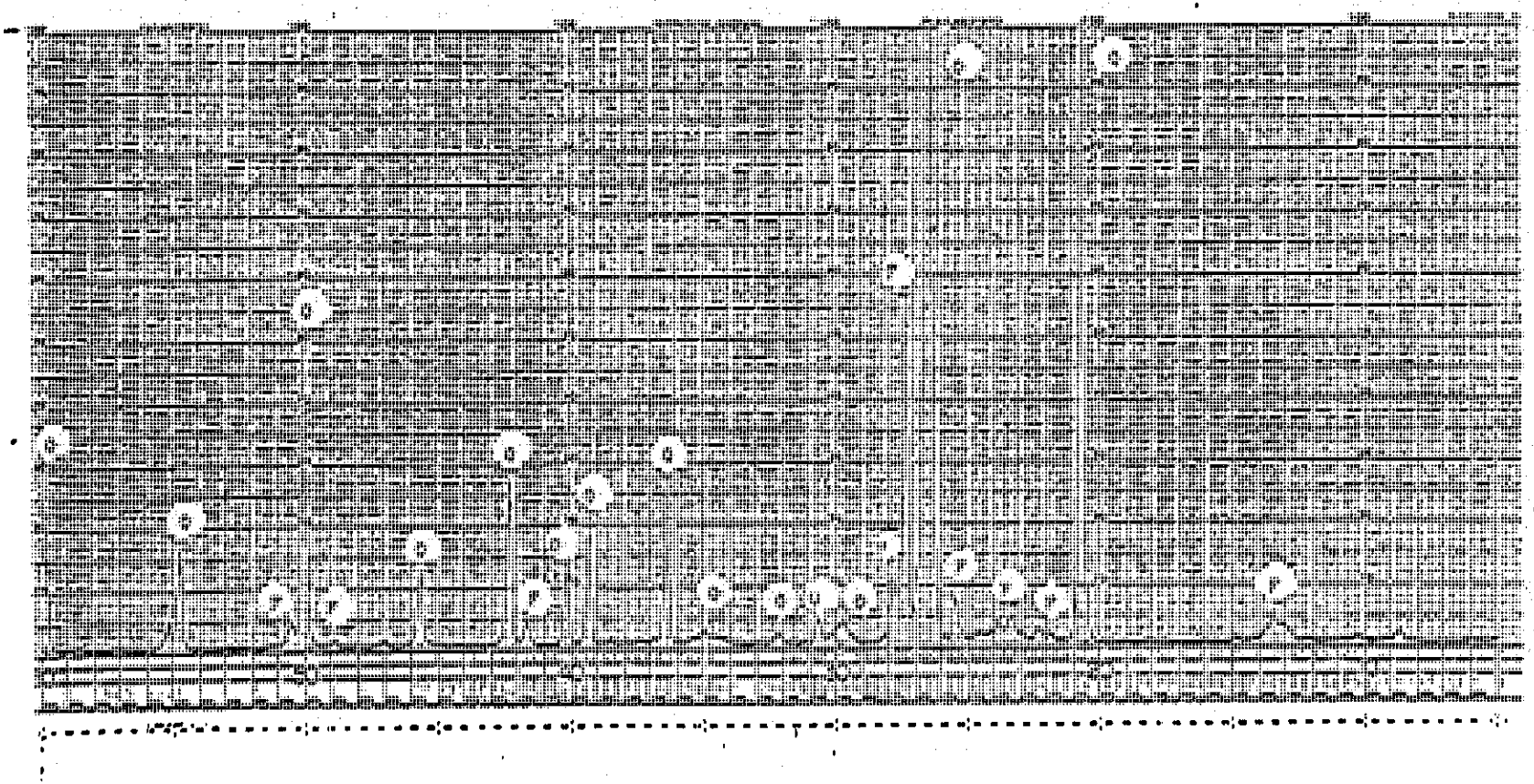


Fig. 3-13 S. Kelantan Silica Sand Sample No. 27-4

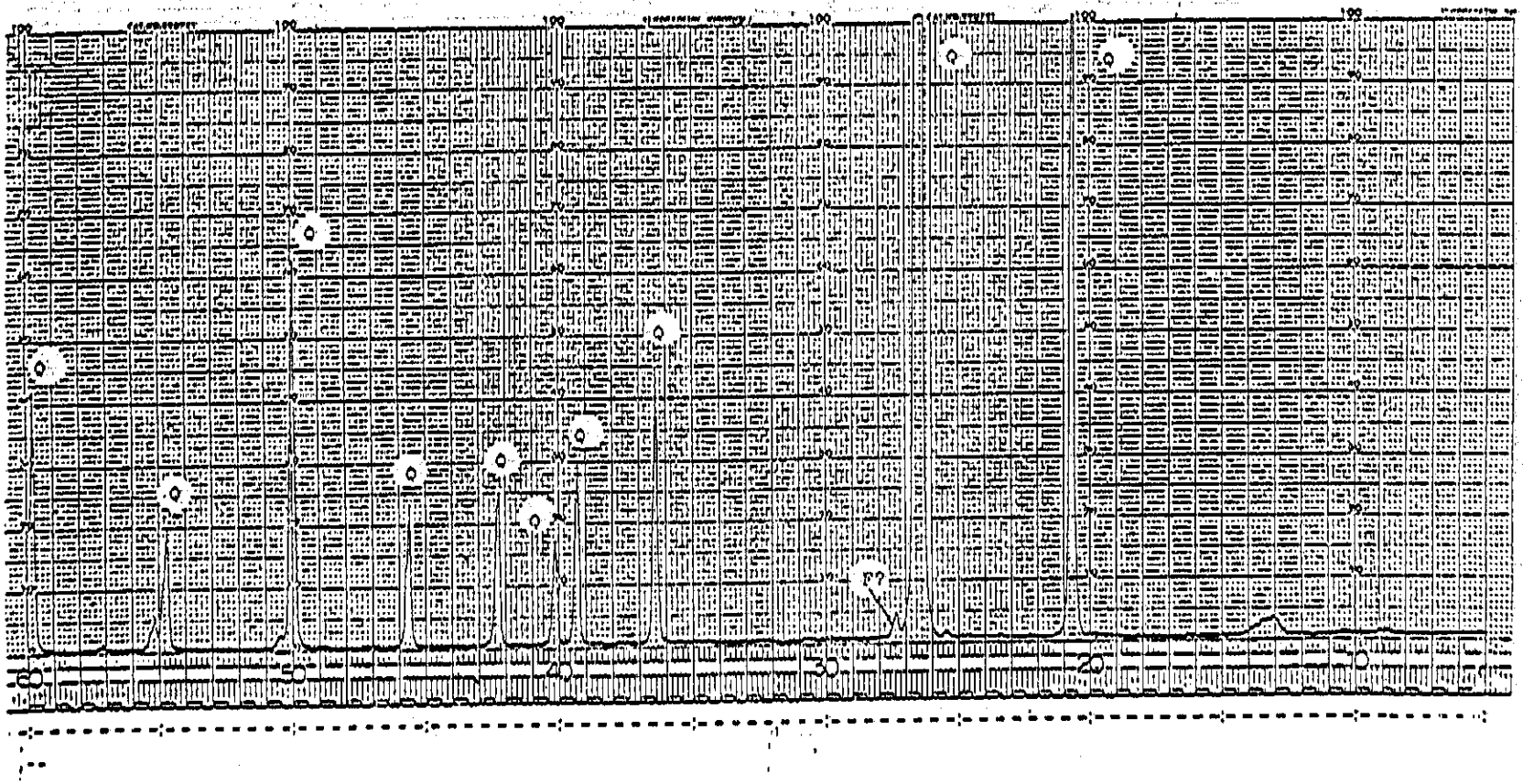


Fig. 3-14 Bachok-Silica Sand Sample No. 28-1

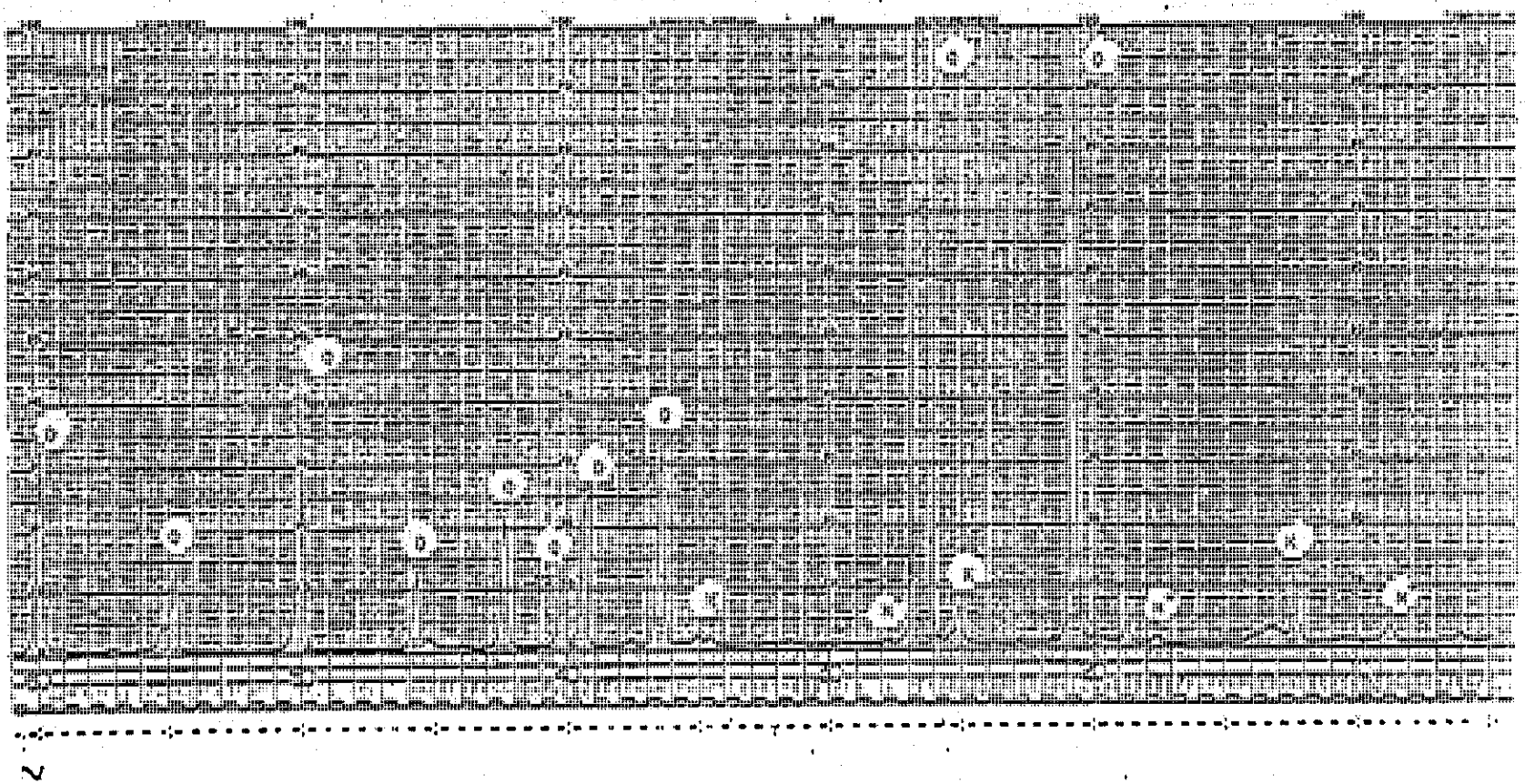


Fig. 3-15 Gua Musang Silica Rock Sample No. 23-3
(South East)

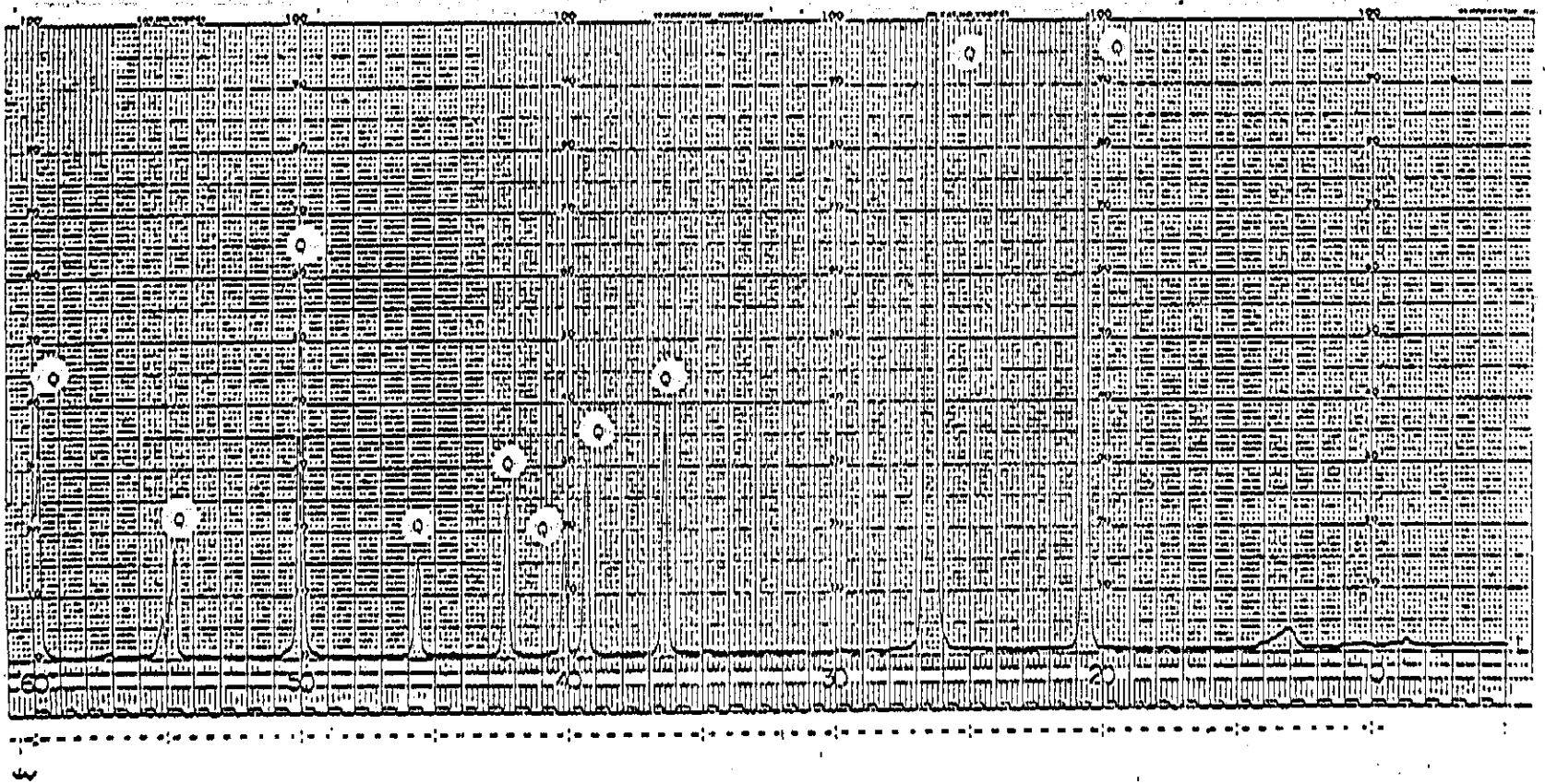


Fig. 3-16 Bt. Kuang Silica Rock Sample No. 1-1

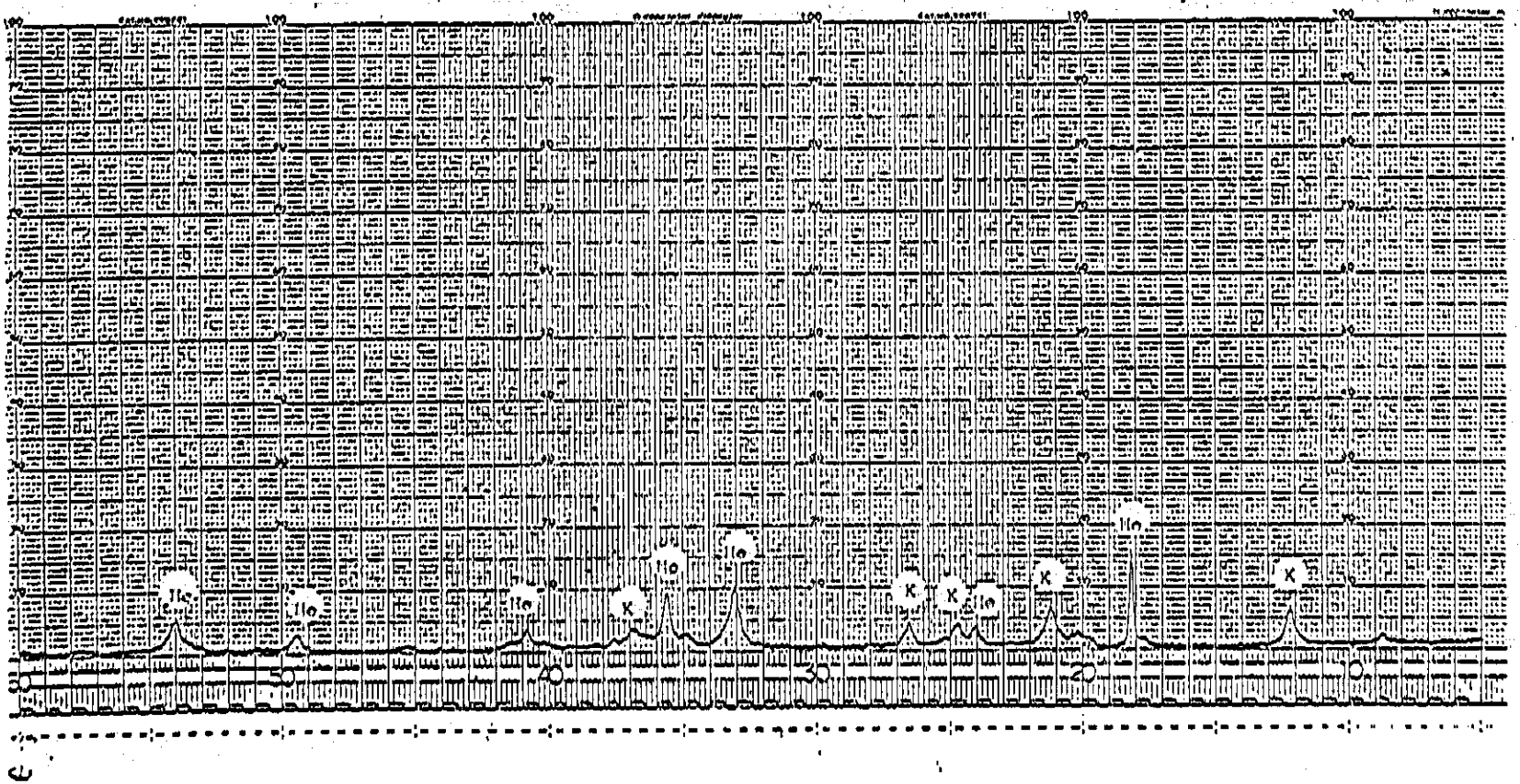


Fig. 3-17 Bt. Lata Iron Ore Sample No. 1-S

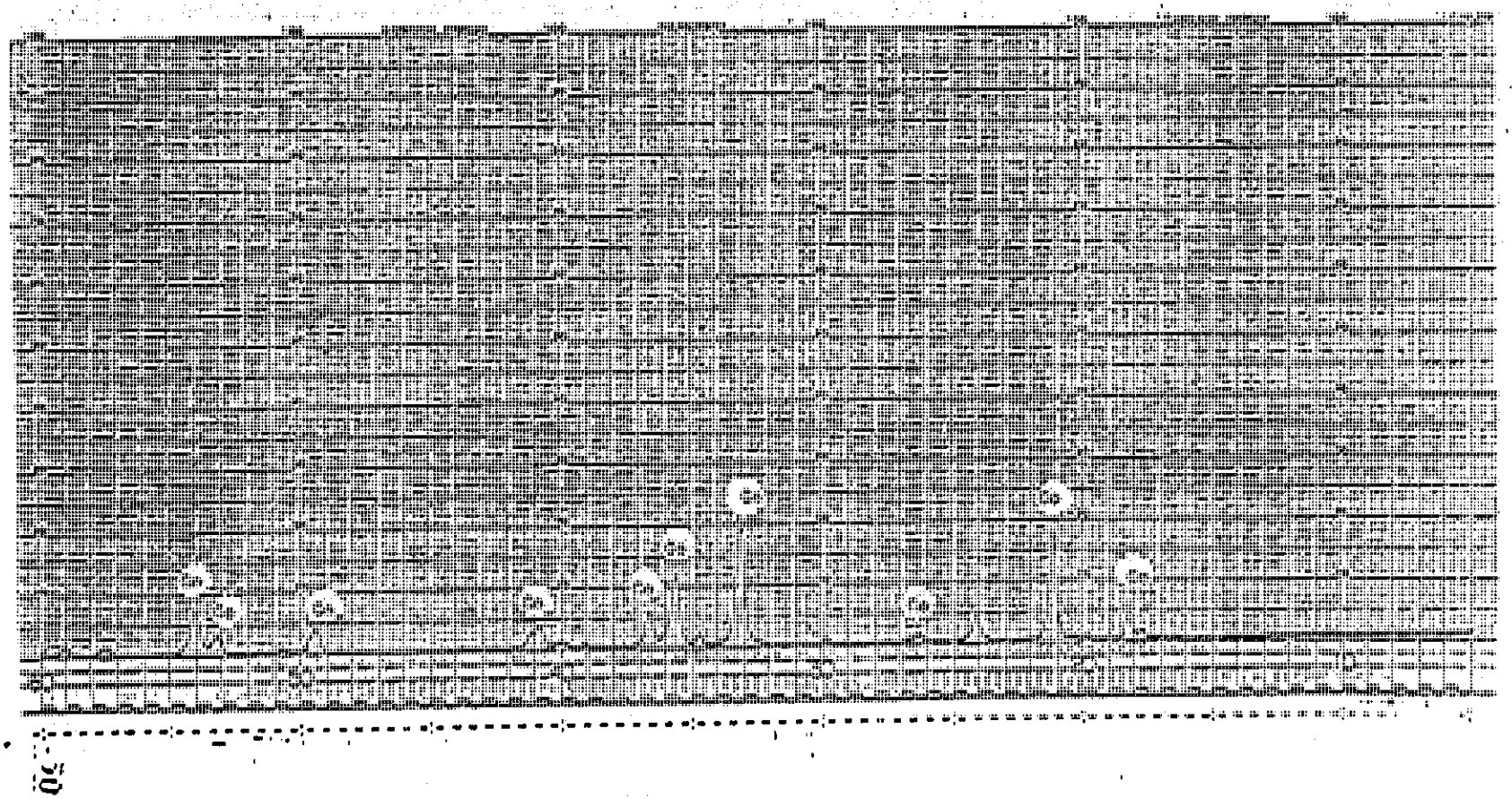


Fig. 3-18 Temangan Iron Ore Sample No. 19-3

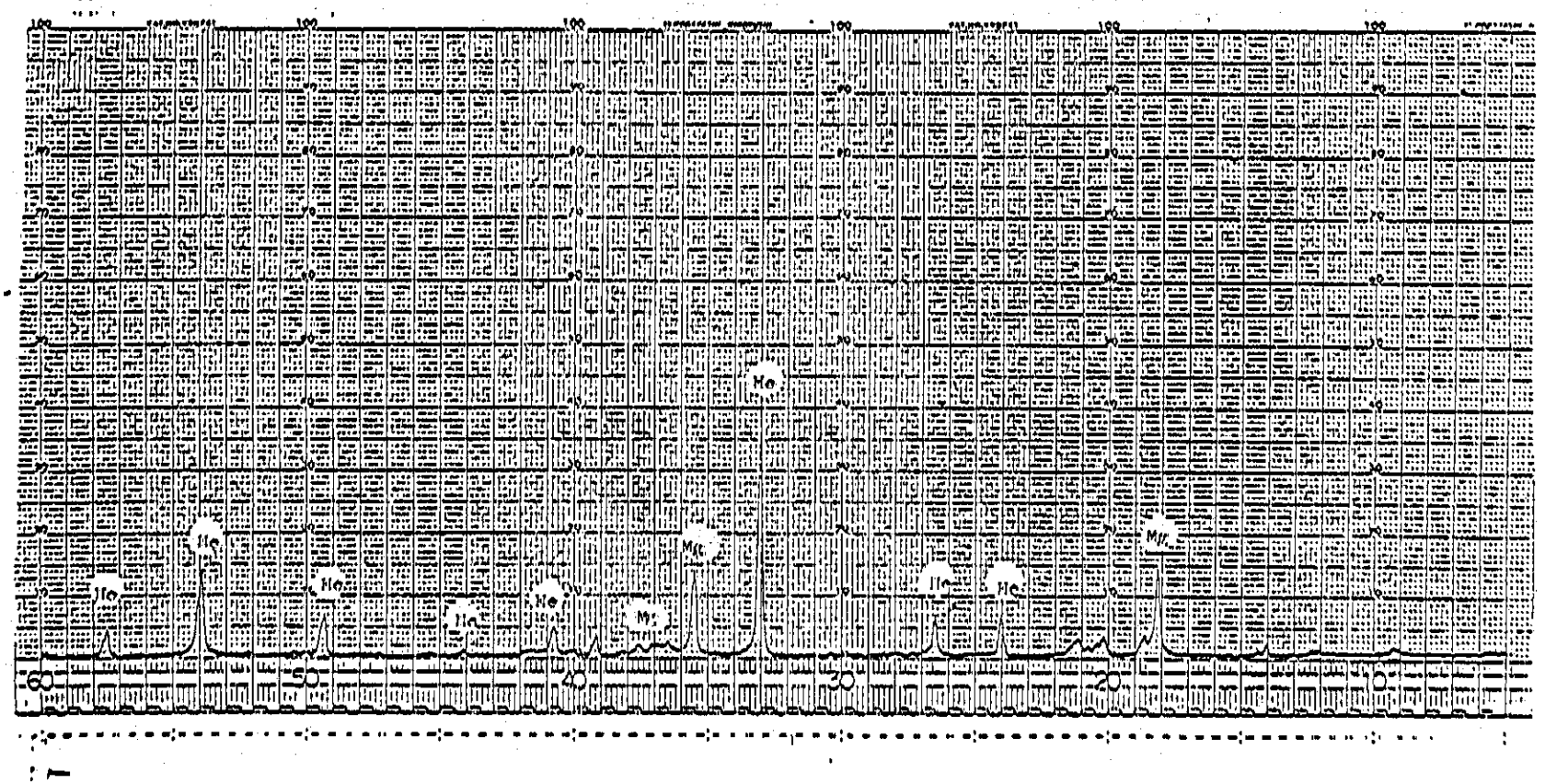


Fig. 3-19 Iron Slime (Perak Iron Mining Co.)

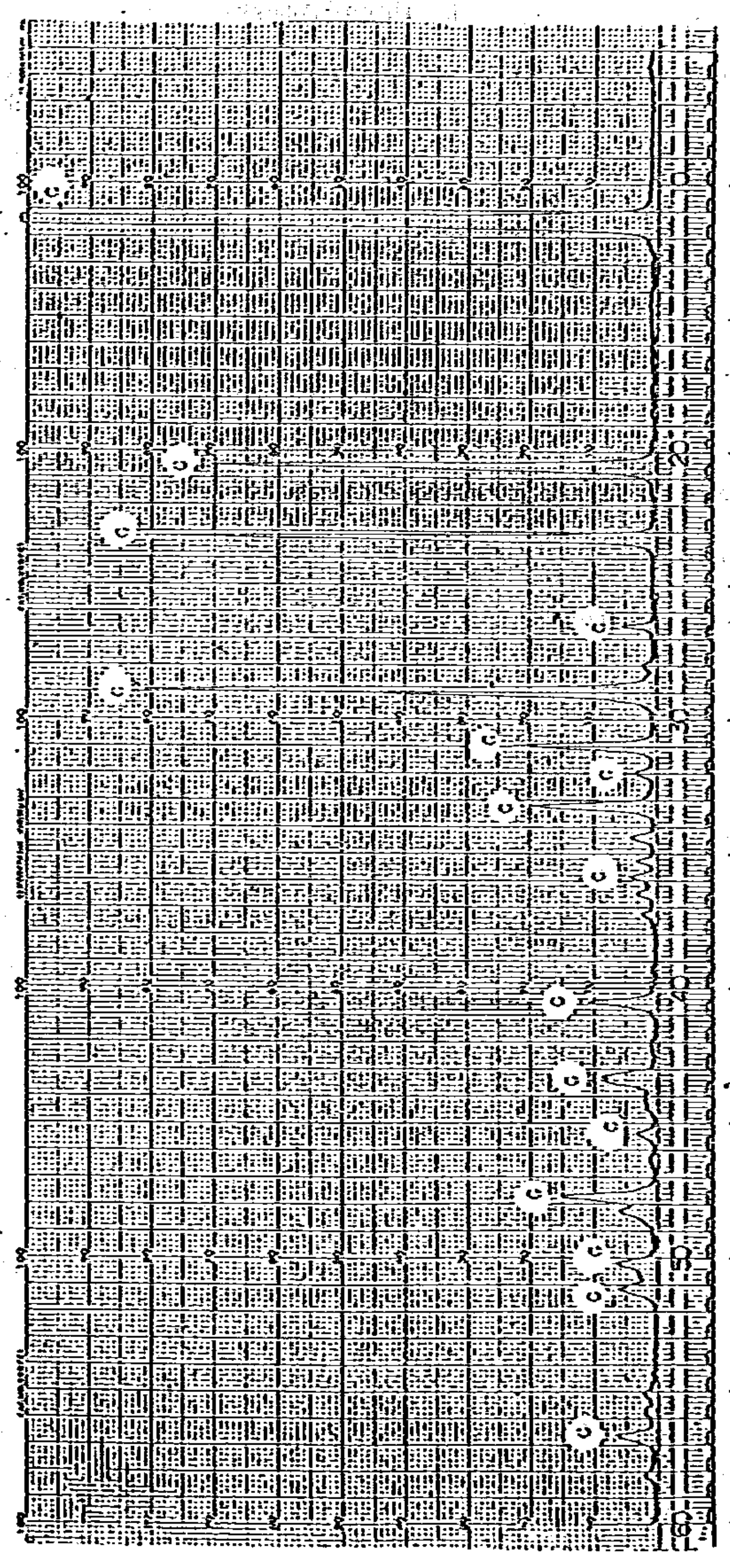


Fig. 3-20 Gypsum (Thai)

4. Thermal Analysis

The samples are ground to the fineness passing through the 149 μm sieve, then dried at 105°C for 24 hours. The pre-treated samples are analyzed by 8076 D-1 (Rigaku Denki). The operating conditions are as follows.

Temperature rate	20°C/min.
Temperature Sensitivity	20 mV
DTA sensitivity	±100μV
TGA sensitivity	20 mg full scale
Chart speed	5 mm/min.
Thermocouple	Pt-PtRh (13%)
Carrier gas	Air
Sample size	41 ∿ 44 mg

The typical patterns of thermal analysis are shown in Fig. 4-1 and Fig. 4-2.

The thermal properties determined by DTA are shown in Fig. 4-3.

The losses of samples determined by TG are shown in Fig. 4-4.

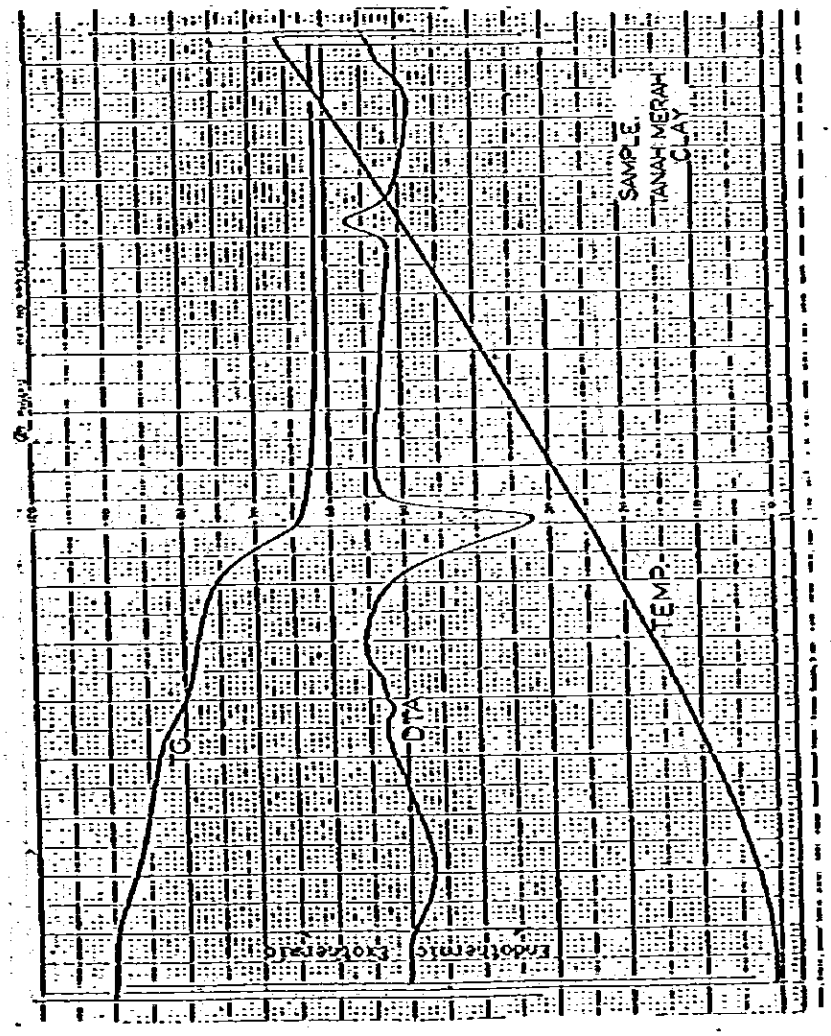


Fig. 4-1 Chart of Thermal Analysis

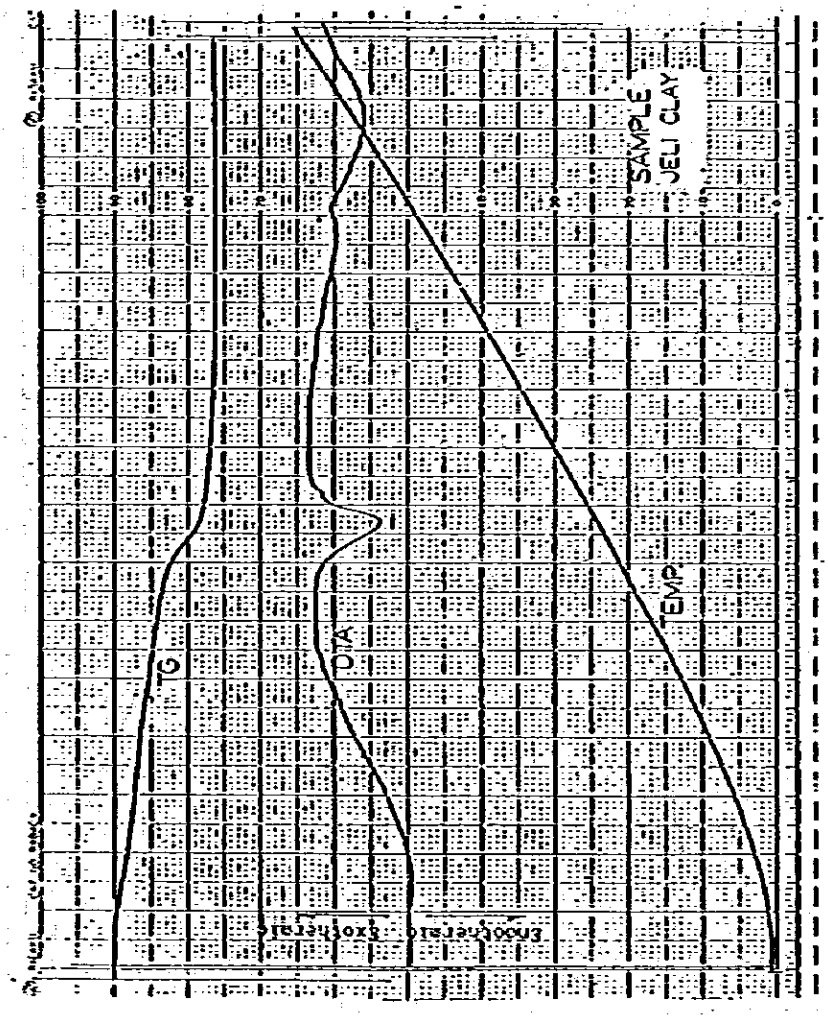


Fig. 4-2 Chart of Thermal Analysis

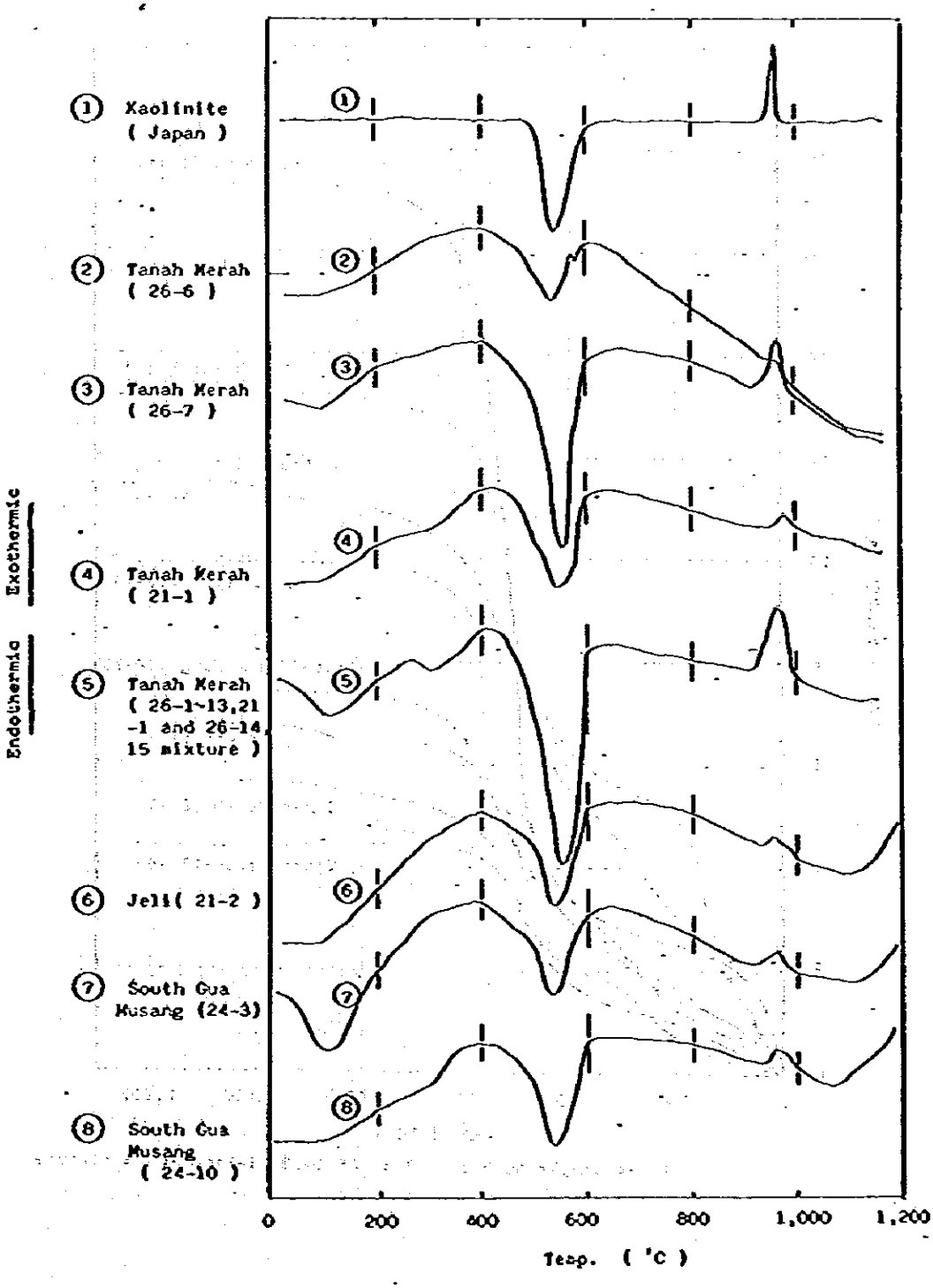


Fig. 4-3 D.T. Analysis

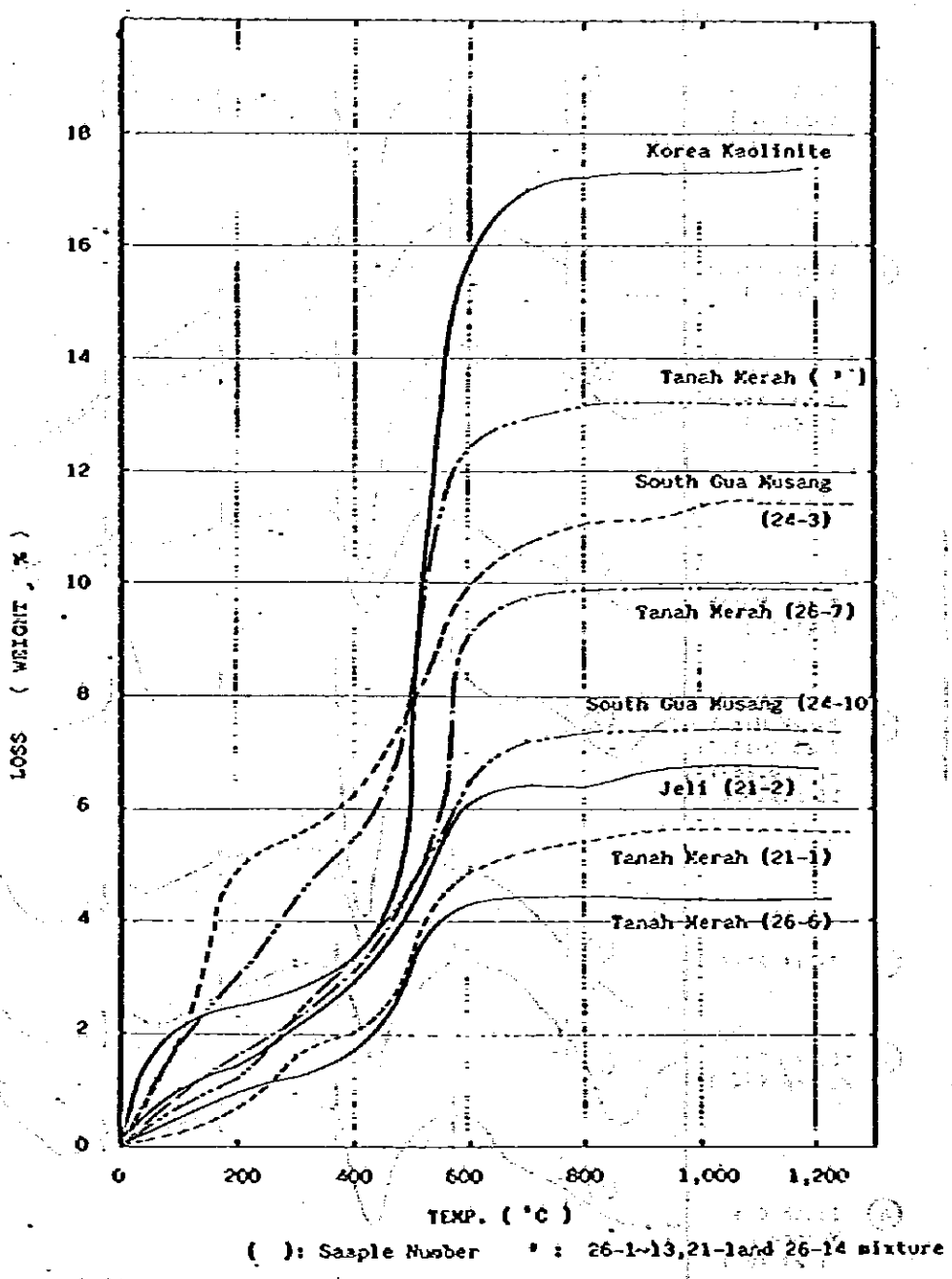


Fig. 4-4 T.G Analysis

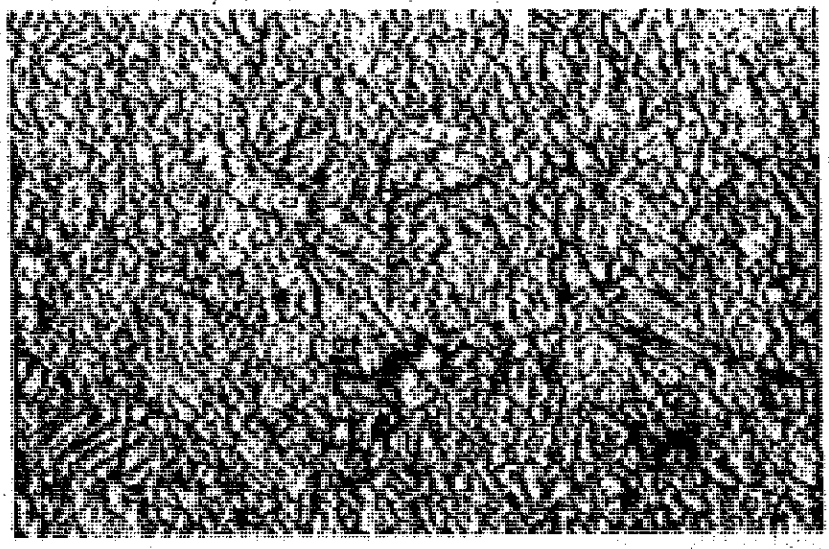
5. Microscopic Observation

The 30 μm specimens prepared from the collected samples are observed under a polarizing microscope. The results are summerized in the list below and the photographs are shown in Photo 5-1 ∿ 5-12.

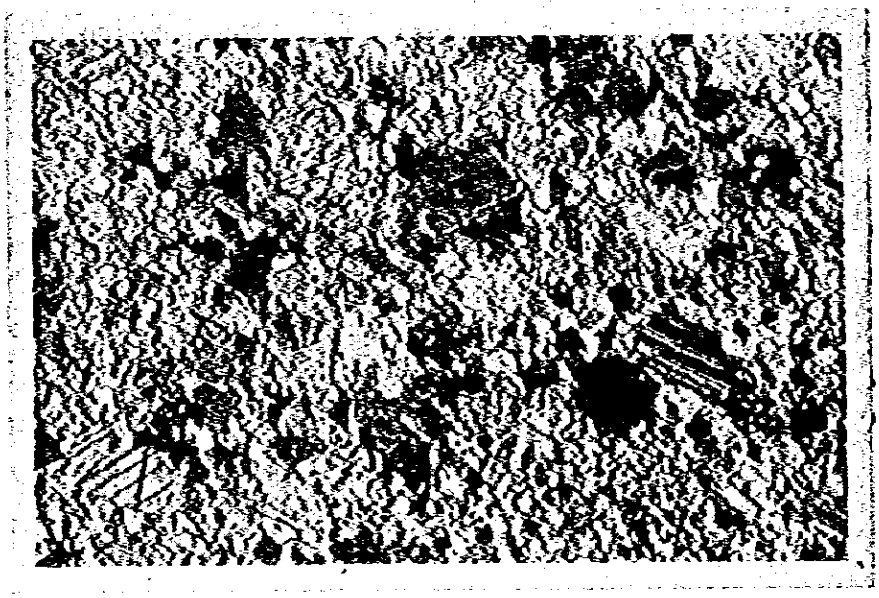
Test result of Microscopic Observation

Name of Sample	Sample No.	Minerals Observed	Size of Crystals
Gua Setir Limestone	GS-1	Calcite	Calcite; about 10 ∿ 200μm
Limestone near Dabong	GI-2	Calcite, Quartz (a little)	Calcite; 10 ∿ 200 μm Quartz; about 200 μm
	GI-5	Calcite, Quartz (a little)	Calcite; 10 ∿ 200 μm Quartz; about 100μm
	GT-2	Calcite, Pyrite (a little)	Calcite; about 10μm Pyrite; about 10μm
Gua Panjang Limestone	GP-20	Calcite	Calcite; about 30 ∿ 100μm
	GP-43	Dolomite	Dolomite; 100 ∿ 200μm
	GP-60	Calcite Quartz (a little) Pyrite (a little)	Calcite; about 10μm Quartz; about 100μm Pyrite; about 20μm
Silica rock	1-1	Quartz Calcite	Quartz; 30 ∿ 100μm
	23-3	Quartz Feldspar	Quartz; 20 ∿ 200μm Feldspar; 100μm
Shale	24-4	Quartz Mica Clay	Quartz; Mica; } less than 10μm Clay;
Granite	27-4	Quartz, Biotite Potassium Feldspar	Quartz; 400 ∿ 1000μm Biotite; 100μm

Photo 5-1 Gua Setir Limestone (Sample No. GS-1)



Open Nicol

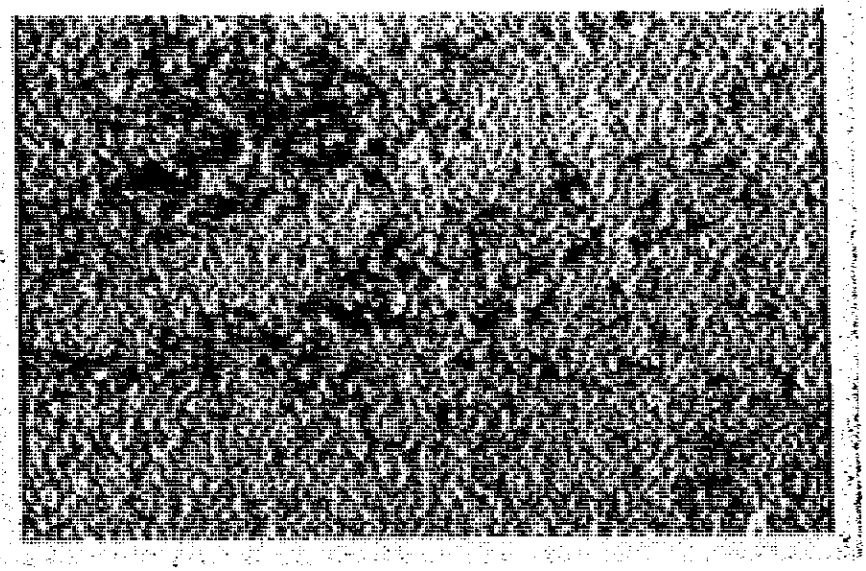


Close Nicol

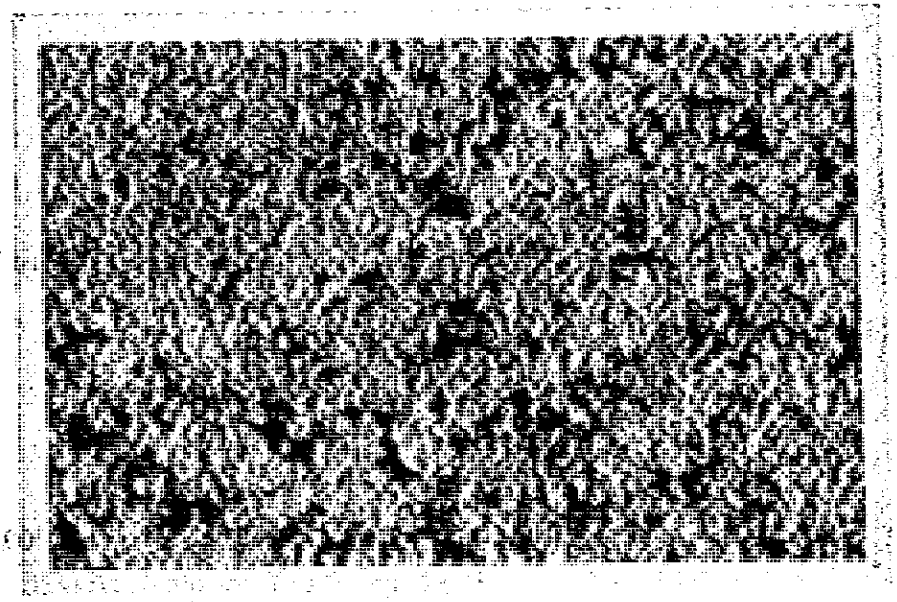
200μm

Only calcite crystals are observed. The sample consists of microcrystaline limestone which size are 10 - 200 μm approximately.
Many lines of cleavage are observed.

Photo 5-2 Gua Ikan Limestone (Sample No. GI-2)



Open Nicol

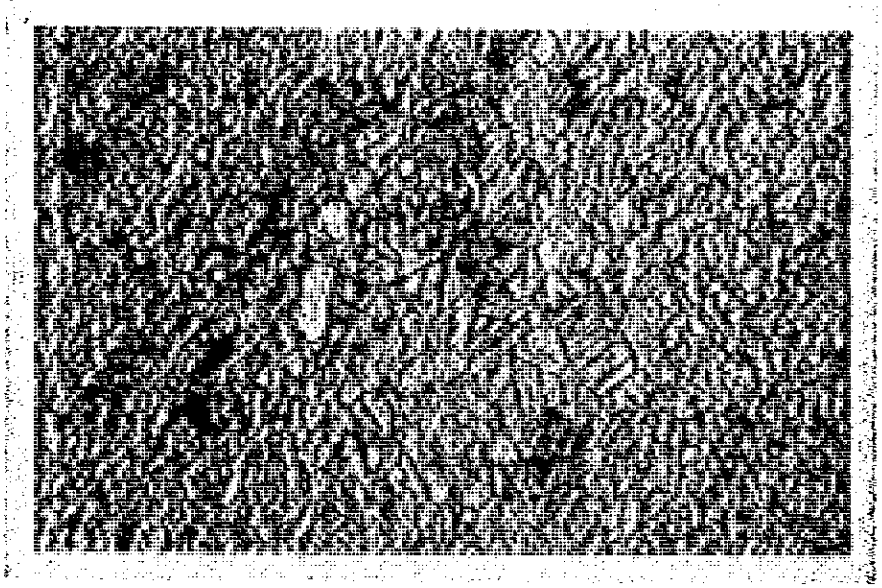


Cross Nicol

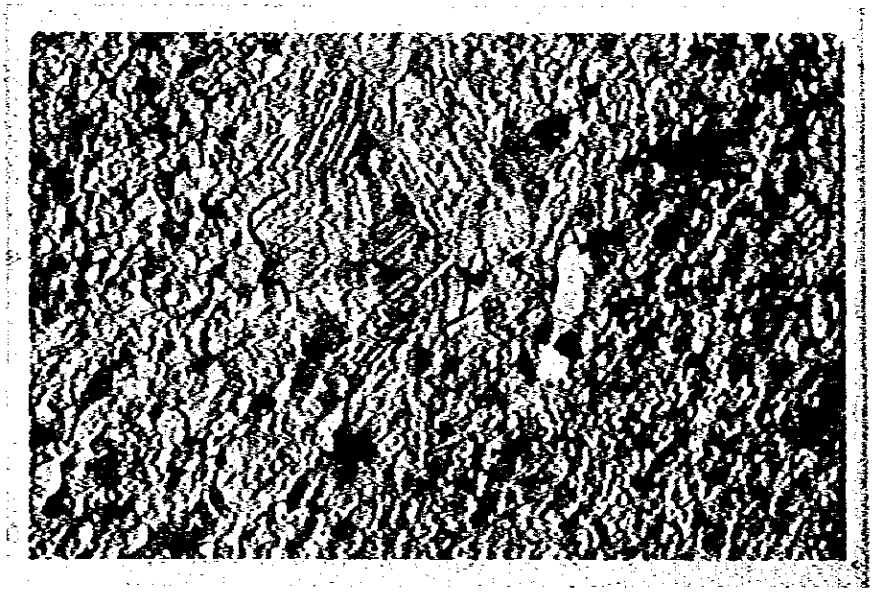
200μm

A large quantity of calcite crystals and a small quantity of rubbly quartz crystals are observed. The size of calcite crystals varies from 10 μm to 200μm, most of them are arround 50μm. That of quartz crystals is around 200μm.
The lines of cleavage are observed.

Photo 5-3 Gua Ikan Limestone (Sample No. GI-5)



Open Nicol



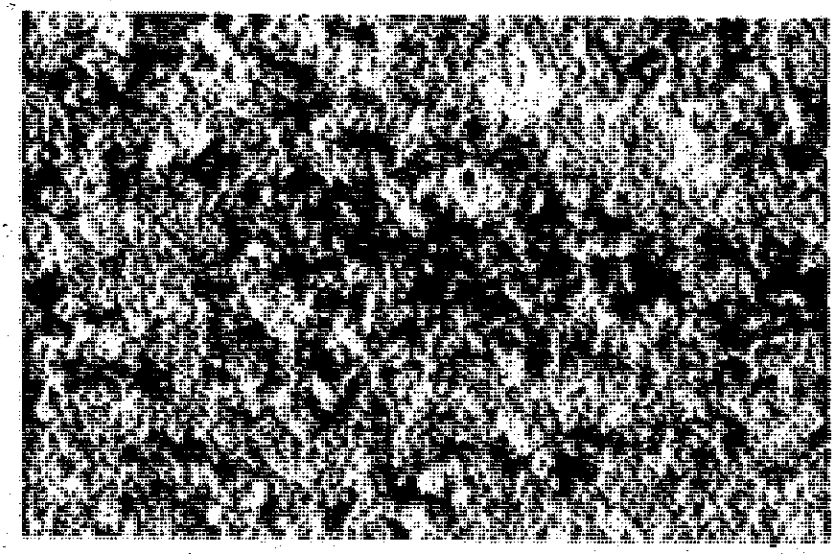
Cross Nicol

200μm

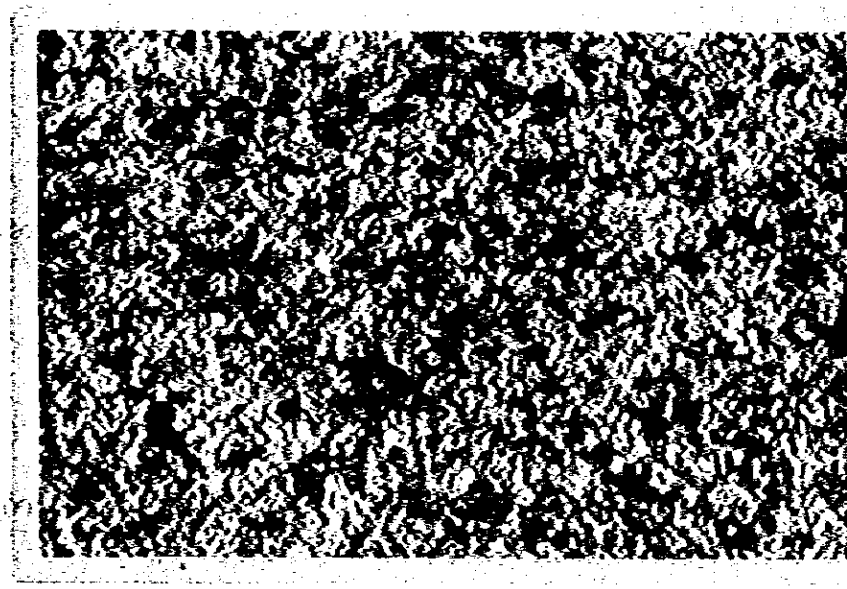
A many quantity of calcite crystals and a small quantity of rubbly quartz crystals are observed.

The size of calcite crystals varies from 10μm to 200μm, most of them are around 50μm. That of quartz crystals is around 100μm.
The quartz crystals are nearly arranged in a layer. Many lines of cleavage are observed on the calcite crystal.

Photo 5-4 Gua Tembakan Limestone (Sample No. GT-2)



Open Nicol

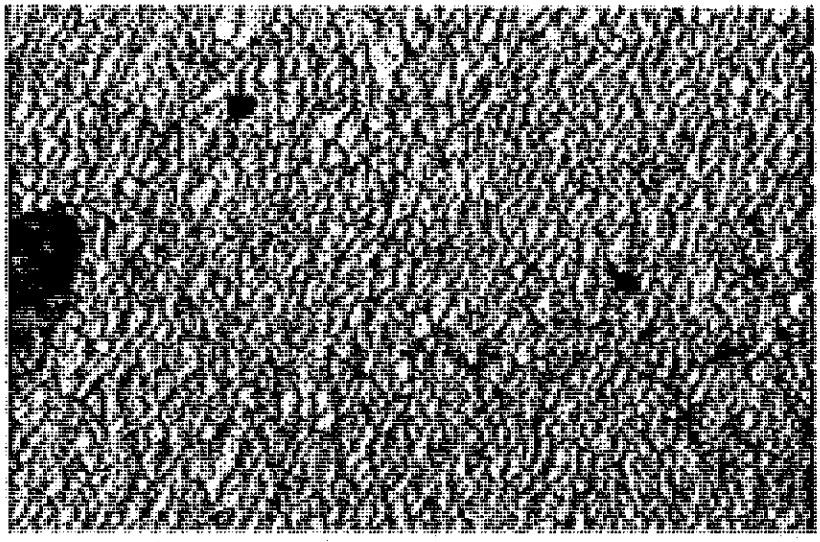


Cross Nicol

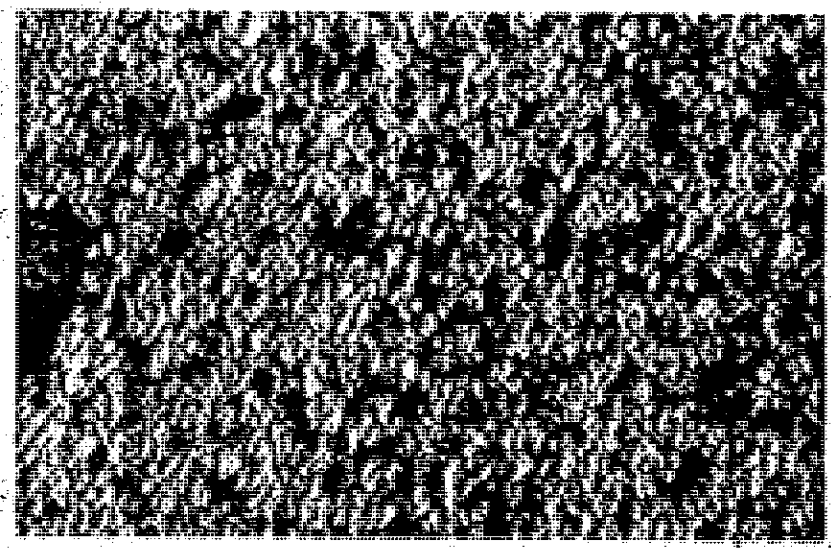
200μm

A large quantity of calcite crystals and a small quantity of iron ore which seems as pyrite are observed. Light brown particles of clay are observed under the open nicol. The calcite crystales of clay are observed under the open nicol. The calcite crystals are around 10μm in size and are equigranular microcrystal line.
Many lines of cleavage are observed.

Photo 5-5 Gua Panjang Block A Limestone (Sample No. GP-20)



Open Nicol

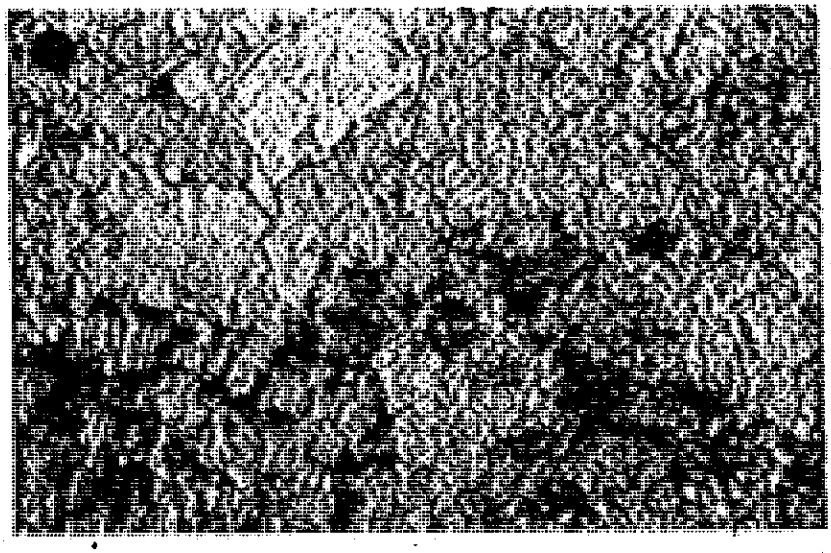


Cross Nicol

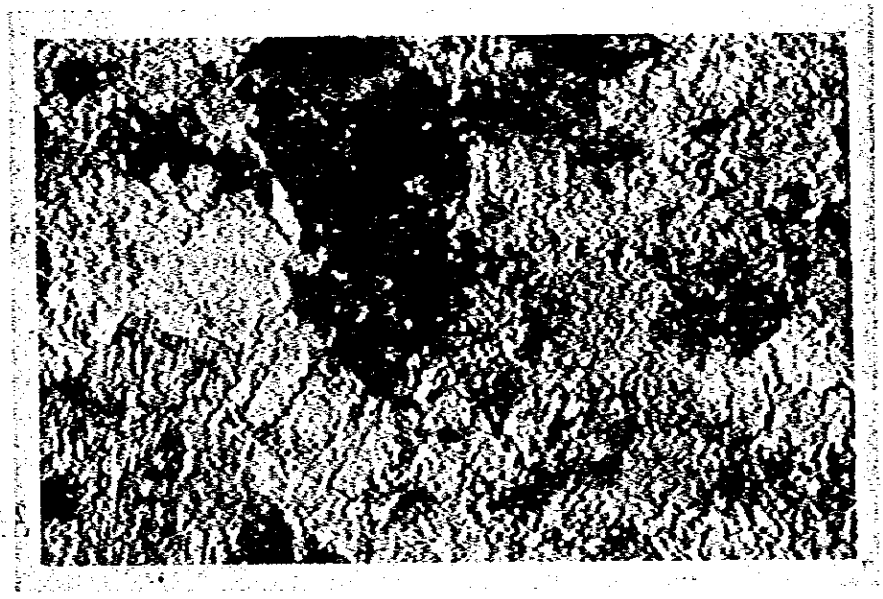
200μm

Only calcite crystals are observed. The size of calcite crystals varies from 30μ m to 100μm. Many lines of cleavage are observed.

Photo 5-6 Gua Panjang Block B Limestone (Sample No. GP-43)



Open Nicol

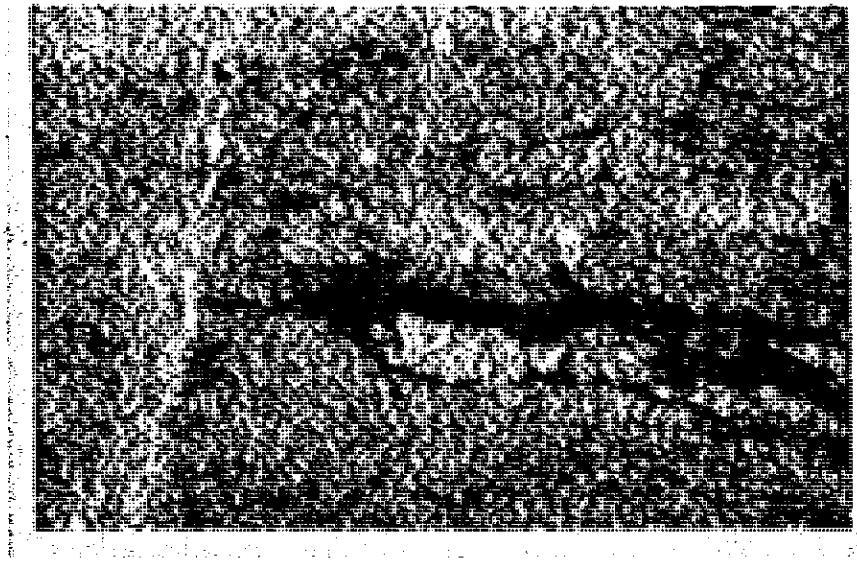


Cross Nicol

200μm

Many dolomite crystals are observed. The size of dolomite crystals varies from 100μm to 200μm. Many lines of cleavage are observed as the calcite crystal.

Photo 5-7 Gua Panjang Block C Limestone (Sample No. GP-60)



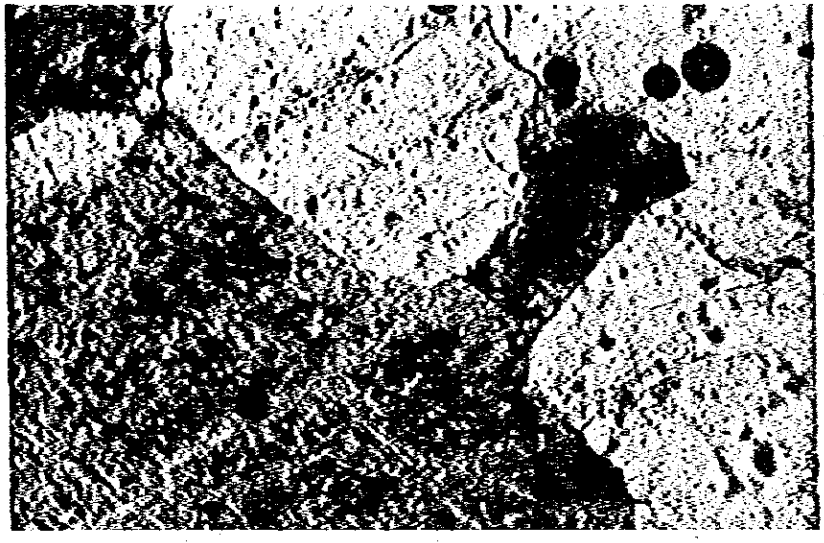
Open Nicol

Cross Nicol

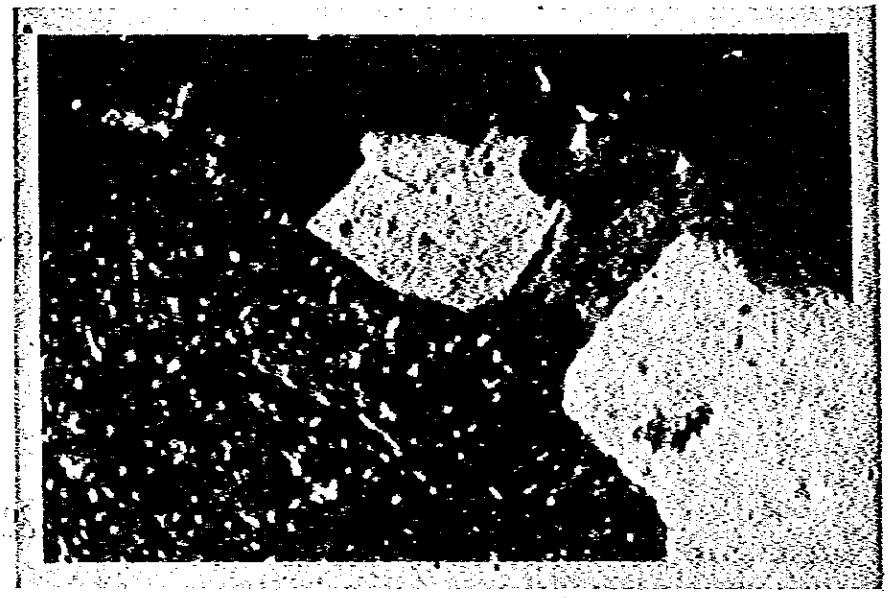
200μm

A large quantity of calcite crystals and a small quantity of rubbly quartz, line particle of pyrite and clay are observed. The size of calcite crystal is around 10μm. The size of quartz is around 10μm and is arranged in a layer. The pyrite and clay are distributed in a layer just as quartz and their size is around 20μm.

Photo 5-8 Granite



Open Nicol

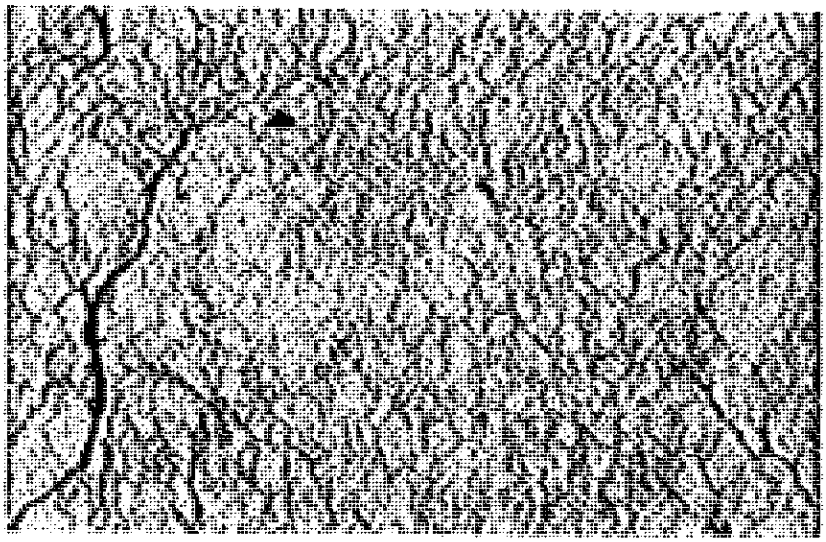


Cross Nicol

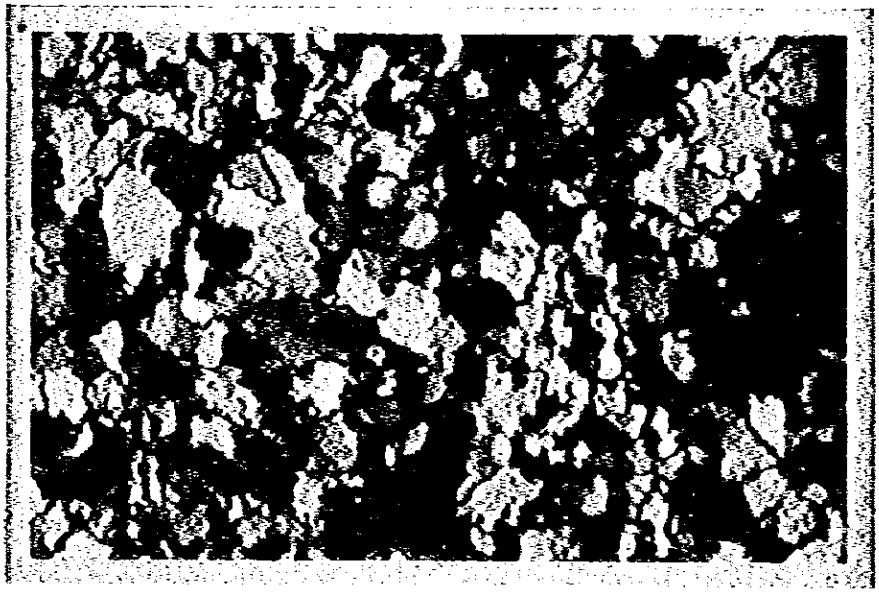
200μm

A large quantity of quartz and orthoclase and a small quantity of biotite are observed. Their size varies from 400μm to 1000μm.

Photo 5-9 Bt. Kuang Silica Rock (Sample No. 1-1)



Open Nicol

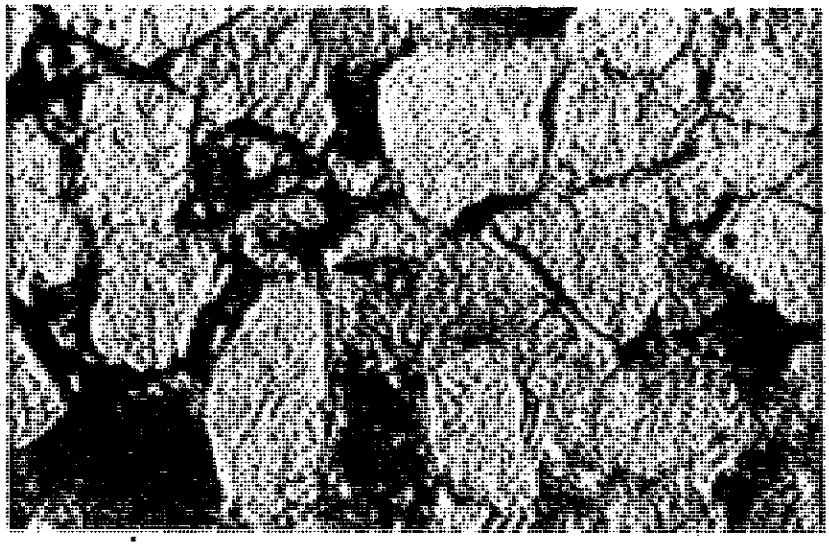


Cross Nicol

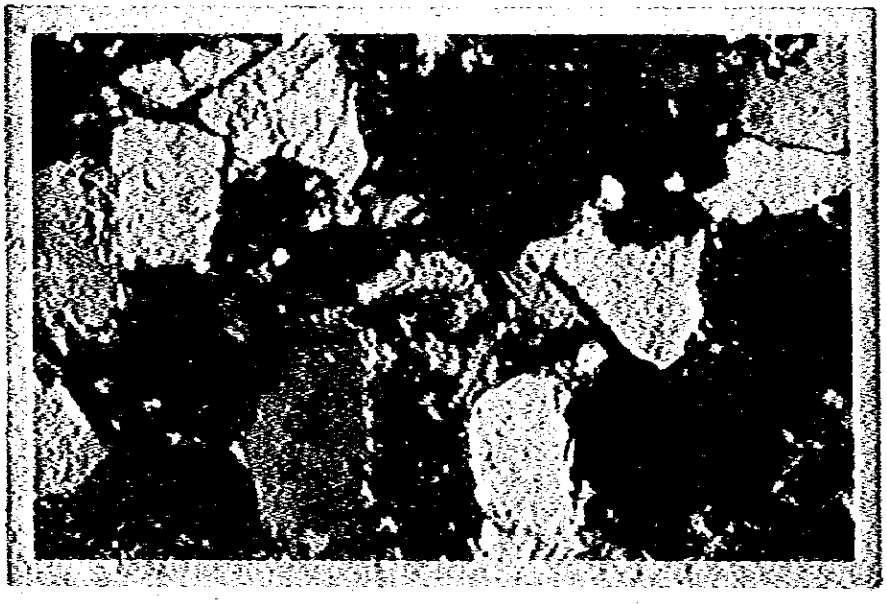
200μm

The sample is composed of a large quantity of quartz crystals. The size of quartz crystals varies from 30μm to 100μm.
The vein of calcite (10μm width) is observed among quartz crystals.

Photo 5-10 Gua Musang Sand Stone (Sample No. 23-3)



Open Nicol

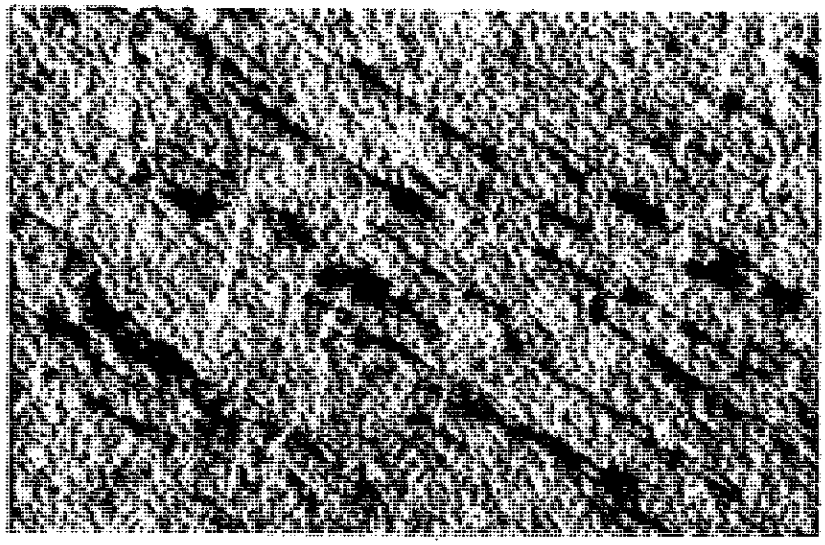


Cross Nicol

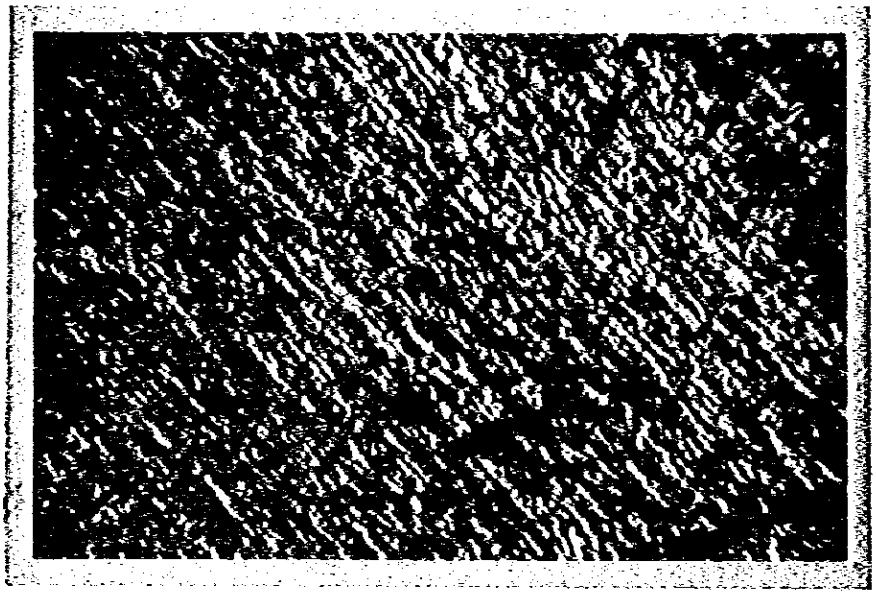
200μm

The quartz crystals of less than 200μm in size are observed in clay.
The silica sand particles are mainly composed of quartz and partly composed of orthoclase.
The quartz crystals look almost square.

Photo 5-11 Gua Musang Shale (Sample No. 24-4)



Open Nicol

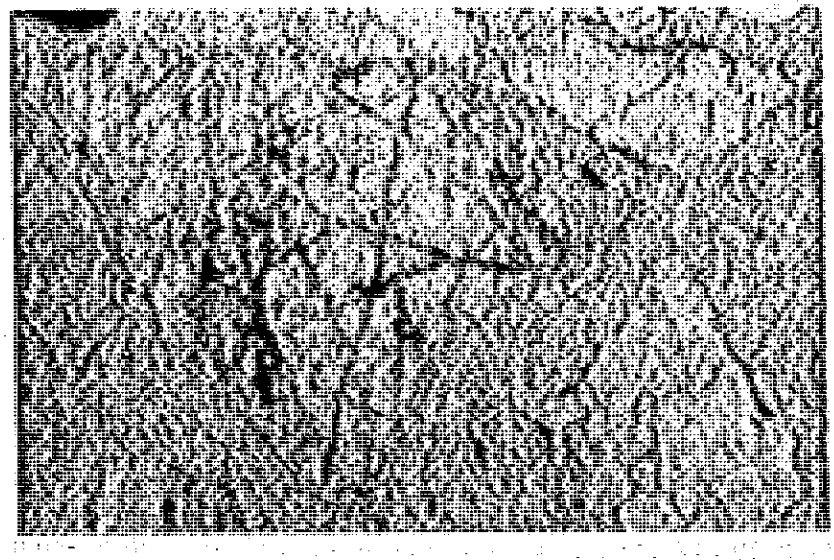


Cross Nicol

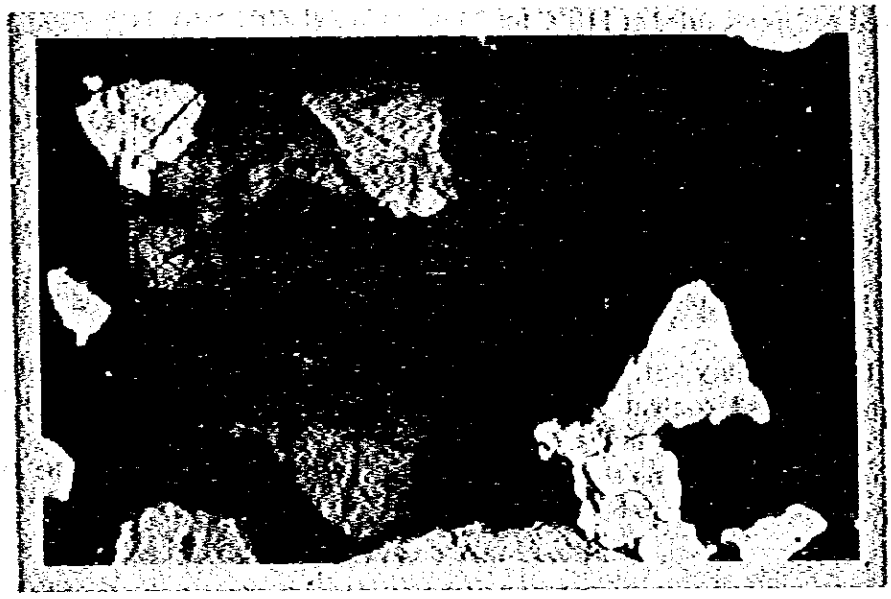
200μm

The sample is composed of fine quartz, mica and clay around 10μm in size.
The Schistosity is well observed.

Photo 5-12 Sg. Kelantan River Sand (Sample No. 27-4)



Open Nicol



Cross Nicol

200μm

The sample is composed of a large quantity of quartz particles and a small quantity of feldspar. Each particles look almost round.

6. Burnability Test

The burnability test of the raw meal prepared from the raw materials at Jeli, Tanah Merah and Gua Musang are carried out in the purpose of manufacturing ordinary portland cement. For a reference, the raw meal generally used in Japanese cement industry is tested.
The mixing proportion of raw materials and the Moduli of clinker for the test are shown in Table 6-1. The chemical composition of raw materials used is listed in Table 6-2 (Malaysia) and Table 6-3 (Japan).
The procedure of test is as follows.

a) Each raw materials is crushed to the fineness passing through 5 mm sieve with a Laboratory jaw crusher.

b) Crushed raw materials are mixed according to the specified mixing proportion (Table 6-1).

c) Mixed raw materials are ground finely to 14±1% residues by 88μm sieve with a vibration mill.

d) After adding 20 wt% of water, the raw meal is formed into pellets of about 7 mm in diameter.

e) Formed pellets are dried at 110°C for 24 hours in a electric oven.

f) The dried pellets are slowly put into an electric furnace for 15 minutes, and burnt at the center of the furnace for 20 minutes at the temperature of 1350, 1400 and 1450°C respectively.

g) The burnt pellets are taken out from the furnace and cooled at a room temperature.

The flow chart of burnability test is shown in Fig. 6-1. The fineness and grinding time of raw meal is shown in Table 6-4.
As the results of the burnability test, the chemical composition and moduli of clinkers are shown in Table 6-5. The free lime content of clinkers is shown in Table 6-6. The X-ray diffraction patterns of burnt clinkers are shown in Fig. 6-2 and 6-3.
These results show that there are no significant difference between the clinkers. The Japanese raw meal may have more difficulty to burn.

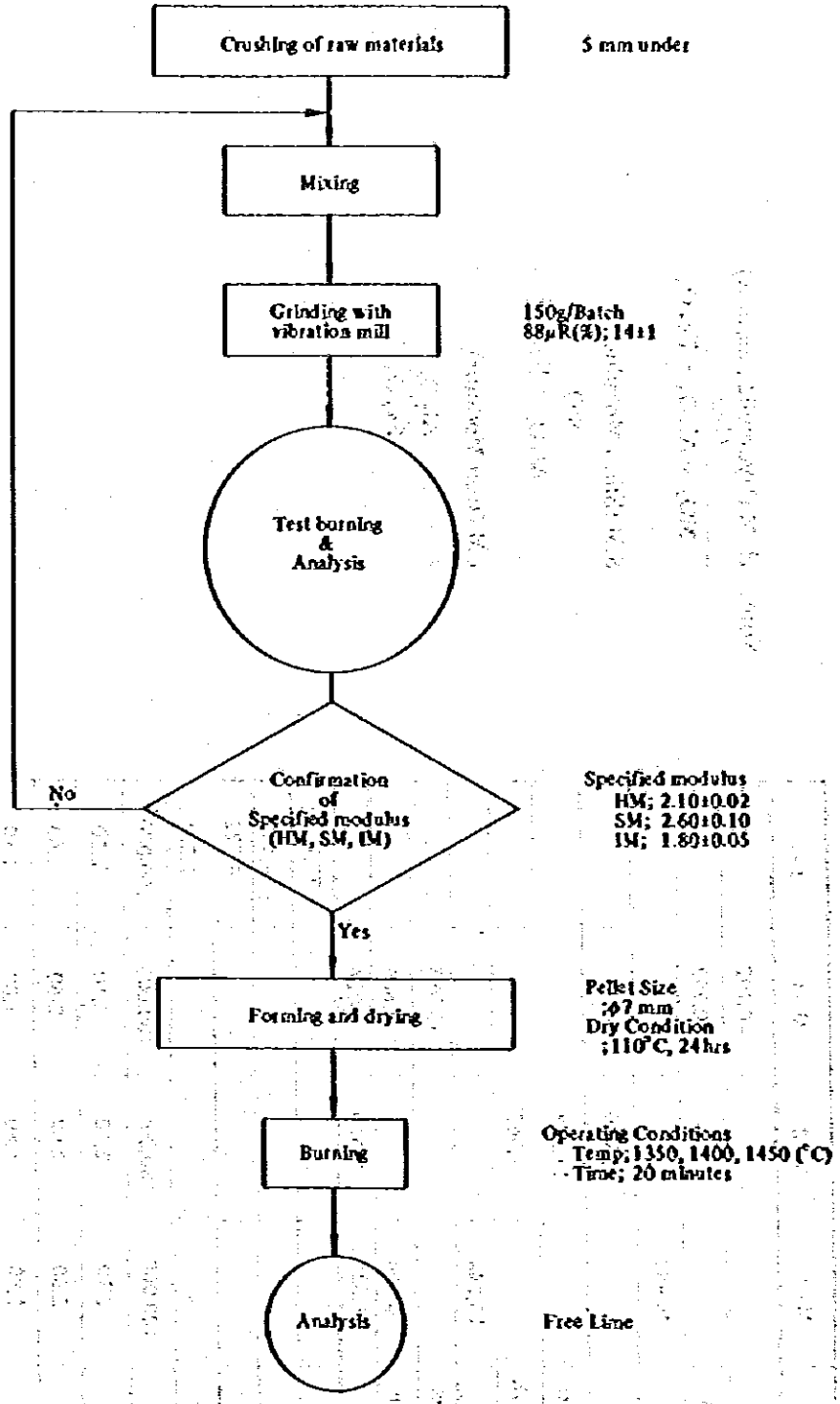


Fig. 6-1 Flow Chart of Testing Burnability

Table 6-1 Mixing Proportion of Raw Material and Moduli of Clinker Sample

Combination				M-1	M-2	M-3	J-1
Lime-stone	(1)	Gua Musang	C			40.793	
	(2)		D			40.793	
	(3)	Jeli		78.457			
	(4)	Dabong			80.449		
Clay	(1)	Tanah Merah	West		17.578		
	(2)		North		1.363		
	(3)	Jeli		13.244			
	(4)	Gua Musang				13.083	
Silica Sand		S. Kelantan		6.664		3.605	
Iron Ore		Bt. Lata		1.635	0.610	1.726	
Japanese Limestone							77.782
Japanese Clay							16.445
Japanese Silica Stone							4.522
Japanese Copper Slag							1.251
Total				100.000	100.000	100.000	100.000
Moduli of Clinker Sample		H.M.		2.10	2.10	2.10	2.10
		S.M		2.60	2.60	2.60	2.60
		I.M		1.80	1.80	1.80	1.80

Note; H. M (Hydraulic modulus)

$$= \frac{CaO}{SiO_2 + Al_2O_3 + Fe_2O_3}$$

S.M (Silica Modulus)

$$= \frac{SiO_2}{Al_2O_3 + Fe_2O_3}$$

I.M (Iron Modulus)

$$= \frac{Al_2O_3}{Fe_2O_3}$$

Table 6-2 Chemical Composition of Raw Material Samples used for Burnability Test (Malaysian Raw Material Samples)

Sample		Item	Chemical Composition (wt % in dry basis)									
			L.O.I.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Total
Limestone	(1)	Gua C	40.28	6.71	1.11	0.26	50.43	0.56	0.04	0.07	0.17	99.63
	(2)	Musang D	43.24	1.02	0.25	0.06	54.65	0.49	0.07	0.01	0.03	99.82
	(3)	Jeli	43.93	0.24	0.17	0.05	53.51	1.92	0.02	0.01	0.02	99.87
	(4)	Dabong	42.80	1.96	0.66	0.21	52.86	1.15	0.04	0.05	0.09	99.82
Clay	(1)	Tanah Merah West	5.93	70.50	14.91	7.04	0.28	0.05	0.04	0.09	1.14	99.98
	(2)	Tanah Merah North	13.76	40.86	27.68	16.50	0.28	0.25	0.03	0.13	0.50	99.99
	(3)	Jeli	6.88	60.51	21.93	6.78	0.21	0.20	0.02	0.28	3.18	99.99
	(4)	Gua Musang	7.06	62.04	20.57	6.22	0.35	0.40	0.02	0.22	3.10	99.98
Silica Sand		S. Kelantan	0.51	90.41	4.70	0.62	0.38	0.00	0.00	0.60	2.76	99.98
Iron Ore		Bt. Lata	11.43	11.40	12.99	61.20	0.63	0.76	0.12	0.12	1.21	99.86

Table 6-3 Chemical Composition of Raw Material Samples Used for Burnability Test (Japanese Raw Material Samples)

Sample	Item	Chemical Composition (wt % in dry basis)								
	L.O.I.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Total
Japanese Limestone	43.68	0.47	0.11	0.06	54.65	0.30	0.01	0.01	0.01	99.30
Japanese Clay	8.38	59.17	20.41	6.34	0.70	1.45	0.00	0.34	3.15	99.94
Japanese Silica Stone	1.29	92.67	2.80	1.52	0.28	0.20	0.00	0.12	0.68	99.56
Japanese Copper Slag	+4.09	27.86	4.50	68.25	0.84	0.61	0.04	0.10	0.02	98.13

Table 6-4 Fineness and Grinding Time of Raw Meal

Combination	Fineness, (wt %) (Residue on 88μ Sieve)	Grinding Time (Sec.)
M-1	13.3	65
M-2	14.0	60
M-3	13.6	67
J-1	14.1	62

Table 6-5 Chemical Composition and Moduli of Clinkers

Combination	Chemical Composition (wt. % in dry basis)						Moduli of Clinker			
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Total	H.M	S.M	I.M	L.S.F
M-1	22.36	5.57	3.06	65.10	2.74	98.83	2.10	2.59	1.82	0.913
M-2	22.72	5.60	3.10	66.32	1.21	98.95	2.11	2.61	1.81	0.916
M-3	22.88	5.68	3.14	66.42	0.65	98.77	2.09	2.59	1.81	0.911
J-1	22.70	5.64	3.11	66.45	0.73	98.63	2.11	2.59	1.81	0.918

Table 6-6 Free Lime Content of Clinker

Burning Temp. / Combination	Free Lime Content of Clinker (%)		
	1350°C	1400°C	1450°C
M–1	5.0	3.0	1.5
M–2	5.3	3.1	1.5
M–3	5.5	3.1	1.4
J–1	6.0	3.4	1.7

Note; The free lime content of clinker corresponds to the quantity of uncombined CaO. If the free lime content of clinker prepared and burnt under the same condition is higher than the others, the burnability of the clinker is judged to be inferior as compared with the others.

A : Alit $3CaO \cdot SiO_2$

B : Belit $2CaO \cdot SiO_2$

CA : Calcium Aluminate $3CaO \cdot Al_2O_3$

F : Felite $4CaO \cdot Al_2O_3 \cdot Fe_2O_3$

CaO : Calcium Oxide

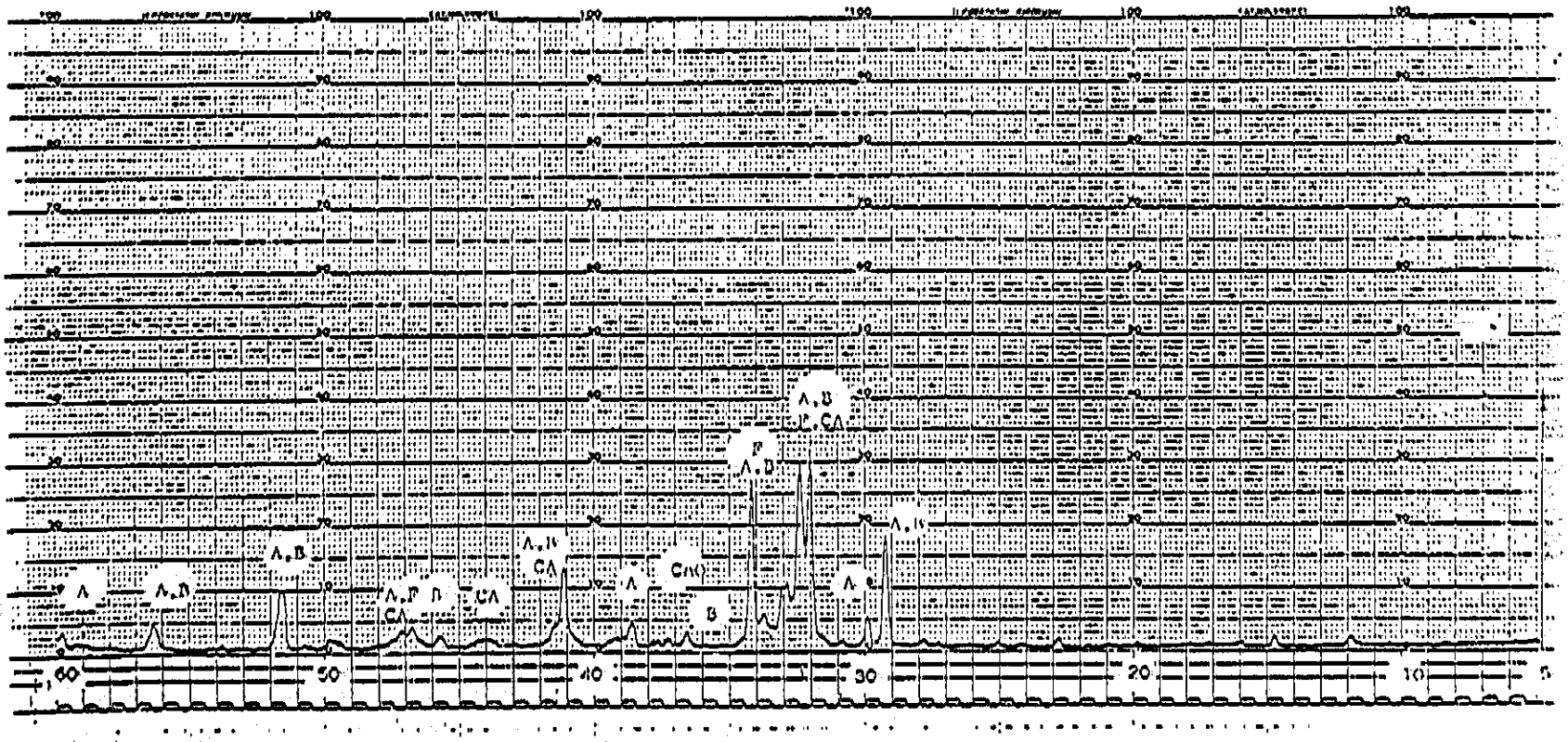


Fig. 6-2 X-ray analysis of test burned clinker (J-1)

The letter means the same as Fig. 6-2

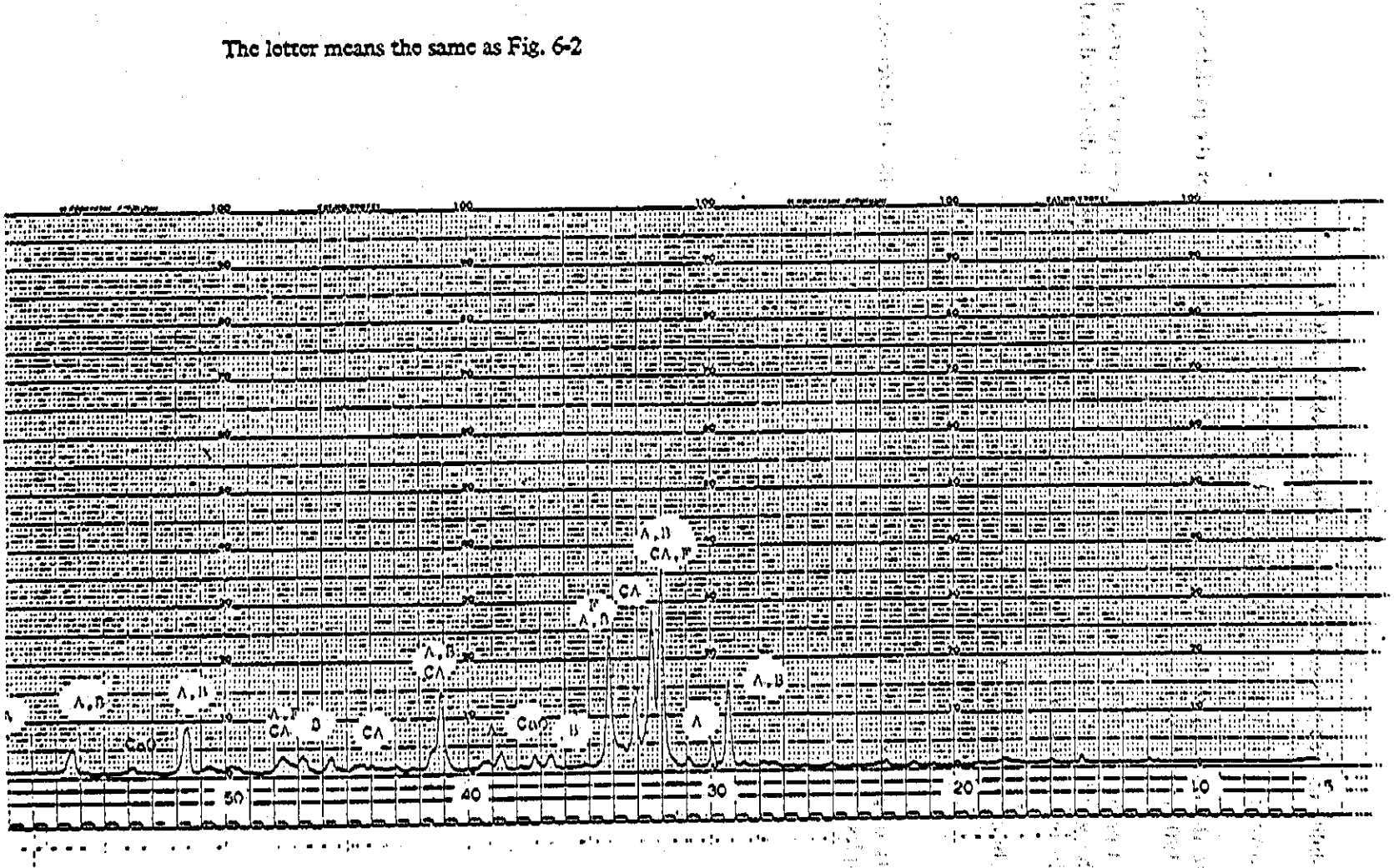


Fig. 6-3 X-ray analysis of test burned clinker (M-3)

7. Grindability Index (GI)

The grindability index test is carried out according to ASTM D409.

The hardgrove grindability machine is shown in Fig. 7-1.

To prepare the testing samples, the raw material is ground and sieved to get the particle size between 1190 μm and 590μm.

The 50g of prepared sample is fed into the machine, then 64 lb of weights are set on the vertical shaft. The grinding element is rotated up to 60 revolutions. The sample is discharged and weighed the residues (w)g of 74μm sieve.

The grindability index is calculated by the following equation.

$$GI = 13 + 6.93\,(50\text{-}w)$$

The results of grindability index are shown in Fig. 7-2. These are no significant differences in the samples.

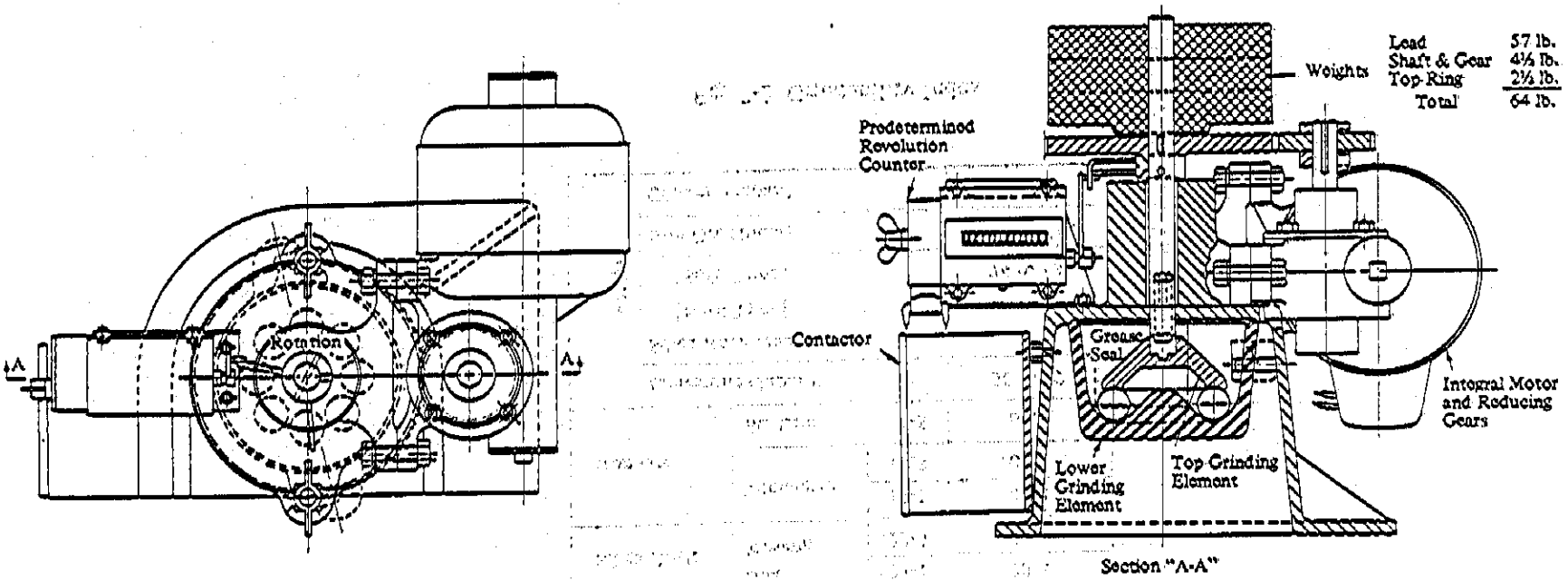


Fig. 7-1 Hardgrove Grindability Machine (Specified by ASTM D409)

Sample			Grindability Index
Name	Area	No.	
Limestone	Gua Panjang		73.7
Silica Sand	S. Kelantan	27-3	43.1
Silica Rock	Gua Musang	23-1	78.8
		23-3	45.5
Iron Ore	Temangan	19-1	45.4
		19.3	108.5
	Bt. Lata	6-5	68.3
Reference	Limestone (Japan)		30 ~ 92
	Silica Rock (Japan)		
	[Hard Type]		28 ~ 50
	[Soft Type]		74 ~ 130
	Iron Ore (India)		66 ~ 118
	Clinker (Japan)		39 ~ 68

Fig. 7-2 Grindability Index

8. Grindability Test (Work Index)

The grindability test is carried out according to JIS M4002, since the closed circuit mill is adopted in the cement plant.

The mixing proportion of raw materials is shown in Table 8-1 to aim the moduli of clinker listed below.

H.M	2.10
S.M	2.60
I.M	1.80
L.S.F	0.913

The specification of ball mill is described below and the outline of the mill is shown in Fig. 8-1.

Inside diameter of the mill	305 mm
Inside length of the mill	305 mm
Revolution	70 r.p.m.

The grinding steel balls are specified as below. The total weight of the balls are not less than 19.5 kg.

Test ball

Diameter (mm)	Quantity (pieces)
36.5	43
30.2	67
25.4	10
19.1	71
15.9	94
Total	285

The procedure of the test is shown in Fig. 8-2.

The raw materials are ground to pass through 3360μm sieve with a laboratory crusher. Then measure the particle size distribution to determine under size of P_1 (μm) and 80% particle size F (μm).

In this case, P_1 is 88μm.

a) Measure the weight (Wg) of 700 ml volume sample and charge this into the mill with the steel ball and then operate the mill.

b) After rotating the mill 100 times, screen all the ground material by P_1 (μm) sieve and measure over size A(g).

c) Calculate Gbp from under size of P_1 (μm) and estimate the revolution of next trial so as to reach 250% of the circulating rate.

Gbp(g); under size of P_1 (μm) produced by one rotation

d) Add the new prepared sample of the same weight as the under size of P_1 (μm), to the over size A(g) and charge into the mill.

e) Operate the mill by the estimated revolutions in c).

f) Repeat the procedure of c) to e) untill the circulating rate reaches steady state at about 250%.
Calculate the average value of $\overline{Gbp}$ from the last three trials.

g) Measure the particle size distribution of under size product of P_1 sieve obtained in f) and calculate 80% of particle size of P (μm).

h) Work Index is calculated by the following equation.

$$\text{Work Index} = \frac{44.5}{P_1^{0.23} \times \overline{Gbp}^{0.82} \left(\frac{10}{\sqrt{P}} - \frac{10}{\sqrt{F}} \right)} \times 1.10$$

The results are shown in Table 8-2. There are no significant differences among the results. It can be assumed from the results that the electric consumption for raw material reduction is the same as the Japanese cement industries.

Table 8-1 Mixing Proportion of Raw Materials for Testing of Grinding Work Index

Sample of Raw Materials		Mixing Proportion (%)
Limestone	Dabong	80.449
Clay	Tanah Merah (West)	17.578
	Tanah Merah (North)	1.363
Iron Ore	Bt. Lata	0.610
Total		100.000

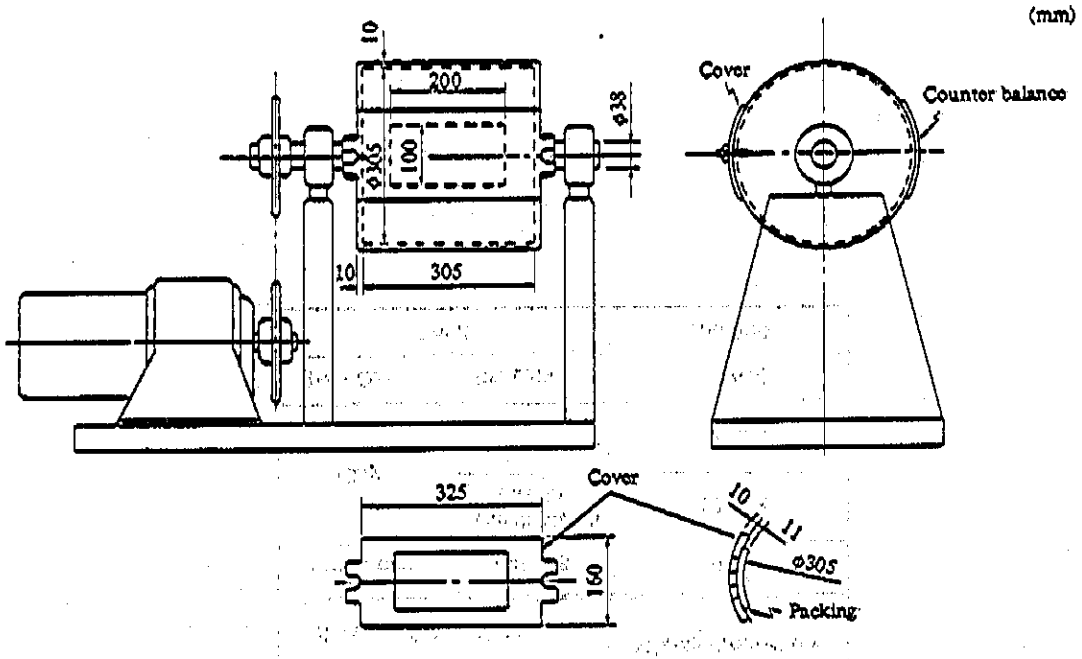


Fig. 8-1 Ball Mill for Grindability Test

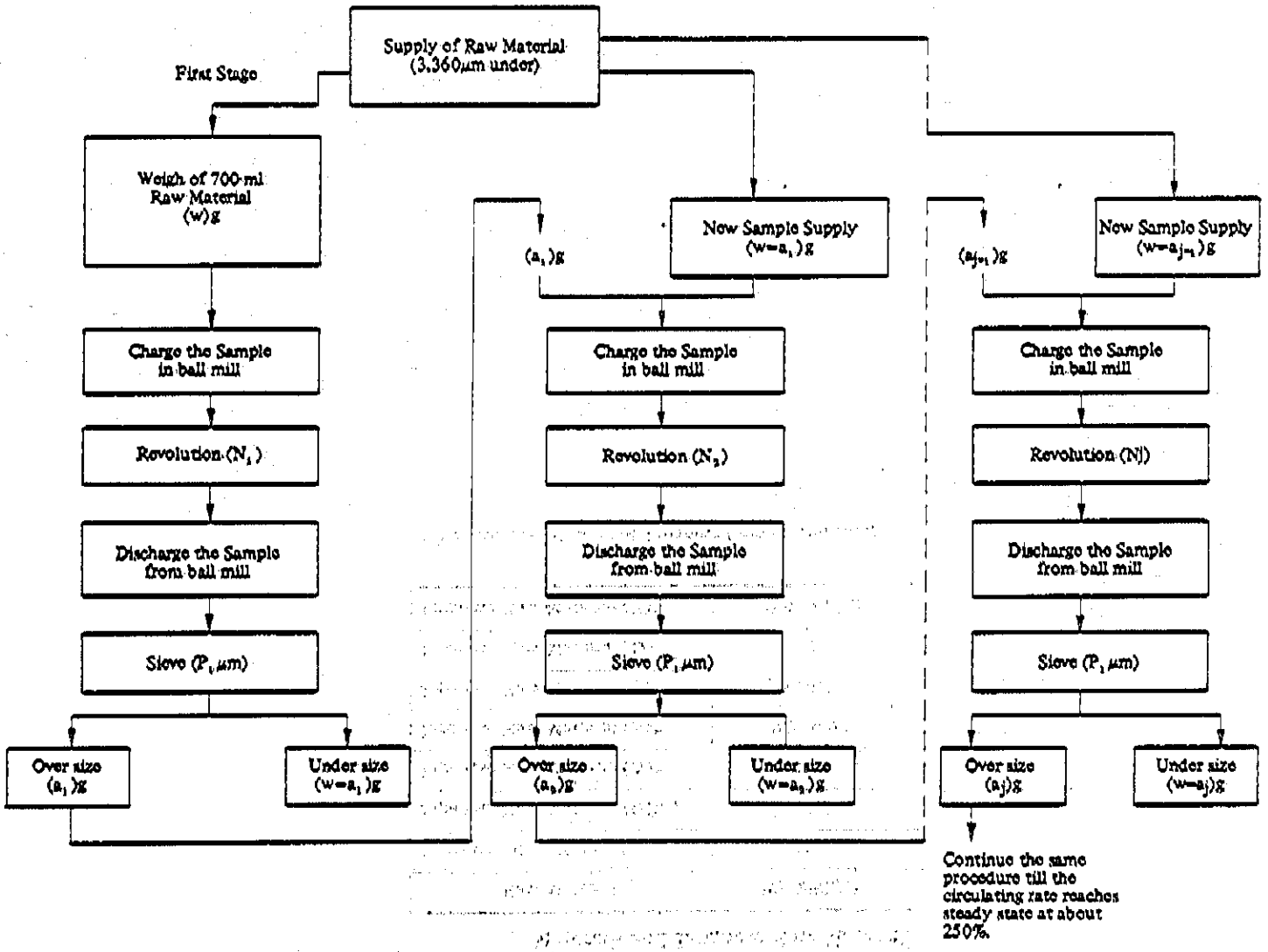


Fig. 8-2 Flow Chart of Testing of Grinding Work Index

Table 8-2 Work Index (Wi) of Malaysian Raw Materials and Japanese Raw Materials

Raw Materials	Wi (kWh/t)
Malaysian Raw Material	10.5
Japanese Raw Material (UBE)	11.3
Japanese Raw Material (A)*	12.5
Japanese Raw Material (B)*	9.3 ~ 9.8
Japanese Raw Material (C)*	10.2
Japanese Raw Material (D)*	12.9
Japanese Raw Material (E)*	9.4 ~ 11.2

* Typical Test Results of Japanese Cement Industries.