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EXPLORATION LICENCE 4/61

WEST COAST, TASMANIA

APPENDICES 192
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QUARTERLY RESUME

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Appendix 1: Canterford, J.H., et al, "Production of Magnesia from Savage River Magnesite (Progress Report No. 12)", CSIRO Institute of Energy and Earth Resources, Division of Mineral Chemistry, April 1984.

Appendix 2: Frost, M.T., et al, "An Evaluation of the Main Creek Magnesite Deposit; I. An Assessment of Ore Grades and Reserves Based on Recent Exploration", CSIRO Institute of Energy and Earth Resources, Division of Mineral Chemistry, June 1984.

Appendix 3: Diamond Laboratory Services Pty. Ltd, "Heavy Mineral Concentrate Analysis, Examination for Kimberlitic Mineral Indicator Grains", 19 April 1984.

1. SUMMARY

Field work on the area was continuous during the quarter under review.

During the quarter, activities were concentrated on the:

- completion of track construction;
- cutting of foot tracks to provide exploration access in the central portion of the licence area;
- cutting of grids for soil sampling in the central/western portion of the licence area;
- cutting of Specimen Reef diamond drill core in readiness for analysis;
- stream sediment sampling of the central and southern portions of the licence area for gold, base metals and diamonds with helicopter retrieval;
- further metallurgical testwork by the CSIRO of the Main Creek magnesite resource;
- a review by our consultant geologist, Mr Peter Forwood, of the Exploration Licence;
- an assessment of ore grades and reserves based on recent exploration of the Main Creek magnesite resource; and
- the preparation of the annual exploration report.

2. PERSONNEL

IMI's exploration personnel who were engaged on the area during the quarter included:

Henry Shannon, Senior Field Geologist

Bruce Penny, Project Geologist

Luke Vanzino, Field Geologist

Peter Cover, Field Foreman

Bonny Green, Field Assistant

Casual field assistants.

Contractors engaged on the area during the quarter included:

- Analabs - Assays
- CSIRO - Geostatistical analysis
- Diamond Laboratory Services Pty Ltd - Heavy mineral concentrate analysis
- John Dart - Line cutting
- John Dicker Investments Pty Ltd - Earthmoving and track clearance
- Peter Forwood - Consulting Geologist
- Hookway Aviation - Helicopter Access.

3. EXPLORATION - MINERALS AND GEMSTONES

Details of the current quarter's exploration will be included in the annual exploration report.

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APPENDIX I

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CSIRO

Institute of Energy and Earth Resources

Division of Mineral Chemistry

PRODUCTION OF MAGNESIA FROM SAVAGE RIVER MAGNESITE

(PROGRESS REPORT NO. 12)

J.H. Canterford, P.T.L. Koh, C. Moorrees,
and G. Tsambourakis

April 1984

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PRODUCTION OF MAGNESIA FROM SAVAGE RIVER MAGNESITE
(PROGRESS REPORT NO. 12)

INTRODUCTION

With the exception of some limited calcination/leaching studies using feeds with different magnesite:dolomite ratios carried out in the early stages of this project [1-3], virtually all experimental work has been carried out with calcines derived from magnesite-rich ore [4-18]. An important result of the studies using feeds with different magnesite:dolomite ratios was that the optimum calcination temperature was very much dependent on this magnesite:dolomite ratio. For a number of reasons it was then concluded that in a commercial operation, actual processing conditions should be those relevant to magnesite and so the feed should have a minimum dolomite content.

Figures 1 and 2 clearly illustrate the reasons why the operating calcination conditions should be those that are optimum for magnesite. The data have been taken from previously reported data [2,3] for high-magnesite (MAG 3) and high-dolomite (MAG 1) samples. The mineralogical composition (%) of these samples was deduced to be as follows.

	<u>MAG 3</u>	<u>MAG 1</u>
Magnesite	75.0	6.7
Dolomite	15.9	78.8
Siderite	3.6	1.8
Calcite	0.5	4.1
Balance	5.0	8.6

For a retention time of 1 h, the optimum calcination conditions were found to be 970° and 700°C for MAG 1 and MAG 3, respectively. Apart from increasing the amount of magnesium recovered by using a high-magnesite feed, such a feed has the advantage of requiring a lower energy consumption because of the lower calcination temperature. Moreover, the amount of solids that have to be discarded when separating the leachate from the leach residue is also reduced.

While it is possible to upgrade a magnesite ore contaminated with dolomite by physical beneficiation techniques, a somewhat simpler approach involves selective mining of the orebody. This could only be carried out successfully on a commercial scale if the dolomite occurred as quite separate and easily recognized beds, pockets, lenses, etc. This approach can only be considered at this stage of the development of the Savage River deposit if the detailed geology and mineralogy of the deposit can be established. This detailed information is now being obtained [19-21]. The most recent, and presently ongoing, study is a detailed analysis of two recently obtained diamond-drill cores.

Associated with this detailed mineralogical examination, it was decided to carry out calcination and leaching tests on selected samples of one of these cores - in this case MC 28. This report gives details of these calcination and leaching tests. The conditions were chosen on the basis of the following points.

- Calcination would be carried out at 700°C for 1 h, that is, at the optimum conditions for magnesite-rich ore.
- Leaching would be carried out under two sets of conditions. The first, Set A, are those that have been used to compare the reactivities of a number of different calcines, and the second, Set B, are those that have been shown [6,14] to reduce the amount of undesirable iron dissolution.

<u>Set A</u>	<u>Set B</u>
3% solids	2% solids
15.5°C	45.0°C

Common leaching conditions are 0.5 h slake at the leaching temperature, 100 psig carbon dioxide and 1200 rpm.

EXPERIMENTAL

Ten segmented samples of core MC 28 were selected for examination - these ranged from high-magnesite through to high-dolomite, as deduced from the drilling log. Each sample was crushed to 100% -1 mm and thoroughly blended. Riffled samples were collected for detailed

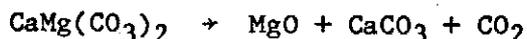
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mineralogical analysis by M.T. Frost, and for chemical and mineralogical analysis, calcination and leaching in this part of the overall programme. All of the experimental techniques used were the same as those used for previously reported data.

RESULTS AND DISCUSSION

Tables 1 and 2 give details of the magnesite-dolomite samples - core intervals, mineralogy and chemical composition. Figures 3-12 give the X-ray diffraction patterns of these samples. The chemical compositions and patterns clearly indicate that although magnesite and dolomite are present in each sample, the proportions of magnesite and dolomite vary significantly. Thus, in sample MC 28/37 (Fig. 9), the carbonate phase is predominantly dolomite, whereas in sample MC 28/51 (Fig. 11), it is magnesite. The X-ray diffraction data are also useful in that they demonstrate that quartz and talc are the most common gangue minerals, while many samples also contain a small amount of free calcite. Such conclusions cannot be drawn from the chemical compositions.

Table 3 gives the chemical compositions of the products formed after calcination at 700°C for 1 h in an electrically heated muffle furnace. Also included are the weight losses on ignition. The data clearly indicate that complete decomposition of the carbonate phases has not occurred. This is consistent with the known decomposition temperatures of calcite, dolomite and magnesite. The X-ray diffraction patterns of the calcines (Figs. 3-12) indicate that in each case the magnesite has been decomposed to periclase (magnesium oxide). In each case, the calcine has a greater calcite (CaCO₃) content than the original magnesite-dolomite ore, indicating that the first stage of dolomite decomposition



had occurred to a greater or lesser extent. As expected, no iron-rich phase could be identified in the calcines.

The leaching results are presented in Tables 4-14 and Figs. 3-27. The results can be summarized in the following terms.

- There is considerable variation in the magnesium concentration of the leach liquor, the magnesium leaching kinetics and the percentage of magnesium extracted.
- There are no significant differences in magnesium extraction from each sample for the two sets of leaching conditions.* However at the lower pulp density and higher leaching temperature, the magnesium leaching kinetics are substantially increased while there is a significant reduction in the amount of iron dissolution. These results are consistent with previously reported data.
- When leaching at 3% solids and 15.5°C, all calcines yield leach liquors that would ultimately yield magnesia products with >0.05% Fe₂O₃. The ore sample with the highest magnesite content, and thus the calcine with the highest crude magnesia content, MC 28/51, would yield a final product with >0.9% Fe₂O₃. If the pulp density and leaching temperature are reduced and increased to 2% solids and 45.0°C, respectively, all samples but MC 28/51 would yield products with <0.05% Fe₂O₃.
- There is considerable variation in the magnesium concentration (g/litre) at the end of the 2-h leaching period.

<u>3% solids, 15.5°C</u>	<u>2% solids, 45.0°C</u>
0.71-13.16	0.48-9.06

Such a variation would be commercially unacceptable, indicating that the magnesite-dolomite ore, as well as the crude calcine, must be thoroughly blended to ensure that the leachate concentration falls within a narrow range.

- As expected, the magnesium concentration of the leachate and the magnesium extraction at the end of the 2-h leach period both increase as the following properties of the ore/calcine increase. (Figs. 23-26).

- A Calcine MgO content
- B Ore composition (mole MgO-mole CaO)
- C Calcine composition (mole MgO-mole CaO)

*At the completion of the 2 h leach period, Mg extractions at the lower temperature/higher pulp density are slightly lower than those obtained at 45°C and 2% solids. This is because reaction is still occurring after 2 h when leaching at 15.5°C and 3% solids.

There is not a direct correlation between the variables; the results obtained with samples MC 28/34 and MC 28/46 tend to be lower and higher, respectively, than might be expected. Although correlation with calcine composition is expressed as mole MgO-mole CaO (factor C), since this is an expression of the amount of leachable magnesia (total magnesia less MgO present as undecomposed dolomite), it can only be deduced after calcination. Thus, a correlation that can be derived directly from analysis of the ore will be more useful in determining what type of ore (principally the magnesite-to-dolomite ratio) should be processed, and the amount of blending required - see Figs. 25 and 27. Moreover, the expected composition of leach liquors derived from a range of samples using different leaching conditions can also be deduced - see Fig. 27. Such information is essential for the design and operation of the post-leaching circuit.

CONCLUSIONS

Analysis of previously obtained data for high-magnesite ore [MAG 3] and high-dolomite ore [MAG 1] indicates that the feed for the calcination/carbon dioxide leach process should have as high a magnesite content as possible, and that the feed should be calcined using the optimum conditions for the magnesite component of the feed.

Leaching tests on calcines derived from a range of ores with different magnesite/dolomite ratios clearly indicate the calcination/carbon dioxide leach process can be applied to a wide range of feeds. In order to eliminate variations in leaching efficiency, and more importantly to produce a leach liquor of "constant" composition, the feed must be as uniform in composition as possible. As pointed out in the introduction, this could be achieved by either selective mining or physical beneficiation of the mined ore.

ACKNOWLEDGEMENT

Chemical analyses of the ores and calcines were carried out by the Analytical Services Group under the direction of Mr P. Strode; their assistance is gratefully acknowledged.

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Table 1. Sample details.

Sample	Core interval (m)	Mineralogy
MC 28/2	54.0-54.4	Magnesite, dolomite, quartz, talc
MC 28/5	57.0-57.4	Magnesite, dolomite, calcite, quartz
MC 28/10	63.0-63.4	Magnesite, dolomite, talc
MC 28/25	81.0-81.4	Magnesite, dolomite, talc
MC 28/27	83.0-83.4	Magnesite, dolomite, calcite, talc
MC 28/34	95.0-95.4	Magnesite, dolomite, quartz, talc
MC 28/37	105.6-105.9	Magnesite, dolomite, quartz
MC 28/46	143.0-143.65	Magnesite, dolomite, quartz
MC 28/51	153.0-153.65	Magnesite, dolomite, calcite, quartz
MC 28/58	163.0-163.65	Magnesite, dolomite, calcite, quartz

Table 2. Chemical composition (%) of ore samples.

Sample	MgO	CaO	FeO	CO ₂	SiO ₂	Total
MC 28/2	35.0	12.1	1.54	47.4	2.20	98.24
MC 28/5	34.5	11.0	3.03	46.9	3.49	98.92
MC 28/10	37.3	7.41	2.12	45.8	6.50	99.13
MC 28/25	22.6	27.4	1.03	46.7	2.35	100.08
MC 28/27	34.7	11.8	1.56	48.6	1.82	98.48
MC 28/34	36.0	9.19	2.88	43.8	7.02	98.89
MC 28/37	23.1	26.7	1.12	44.9	3.12	98.94
MC 28/46	24.2	24.5	2.28	48.8	0.75	100.53
MC 28/51	42.0	1.93	3.91	51.8	0.77	100.41
MC 28/58	36.7	6.67	2.34	50.1	2.36	99.49

Table 3. Chemical composition (%) of calcines and weight loss (%) on calcination.

Sample	MgO	CaO	Fe ₂ O ₃	CO ₂	SiO ₂	Total	LOI
MC 28/2	53.9	17.3	2.35	22.4	2.57	98.52	31.2
MC 28/5	54.9	15.2	5.15	20.5	2.59	98.34	37.2
MC 28/10	61.8	11.3	3.59	18.7	2.82	98.21	38.4
MC 28/25	31.3	29.7	1.24	34.6	2.22	99.06	8.01
MC 28/27	53.2	17.2	2.56	22.8	3.04	98.80	33.2
MC 28/34	56.6	11.4	4.09	20.7	6.50	99.29	26.9
MC 28/37	31.4	29.4	1.33	33.3	2.59	98.02	7.80
MC 28/46	29.7	28.5	2.92	37.7	0.39	99.21	15.4
MC 28/51	84.2	2.41	8.02	3.92	1.50	100.05	48.7
MC 28/58	55.9	8.59	3.36	26.9	3.61	98.36	38.1

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Table 4. Autoclave leach test results.

Sample: MC 28/2 - 53.9% MgO, 17.3% CaO, 2.35% Fe₂O₃, 2.57% SiO₂,
22.4% CO₂, 98.5% total

Leaching conditions: 0.5 h slake at leach temperature
100 psig carbon dioxide
1200 rpm

Time (h)	Concentration (g/litre)			
	3% solids, 15.5°C		2% solids, 45.0°C	
	Mg	Fe	Mg	Fe
0.08	1.50	0.002	2.45	0.004
0.25	3.51	0.004	3.23	0.003
0.50	4.89	0.005	3.60	0.001
0.75	5.38	0.007	3.74	0.000
1.00	5.54	0.007	3.74	0.000
1.50	5.55	0.007	3.74	0.000
2.00	5.56	0.007	3.74	0.000
Mg extraction (%)	57.0		57.5	
[Fe×100/Mg]	0.126		0.000	

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388019

Table 5. Autoclave leach test results.

Sample: MC 28/5 - 54.9% MgO, 15.2% CaO, 5.15% Fe₂O₃, 2.59% SiO₂,
20.5% CO₂, 98.4% total

Leaching conditions: 0.5 h slake at leach temperature
100 psig carbon dioxide
1200 rpm

Time (h)	Concentration (g/litre)			
	3% solids, 15.5°C		2% solids, 45.0°C	
	Mg	Fe	Mg	Fe
0.08	1.25	0.002	2.64	0.001
0.25	3.16	0.005	3.76	0.001
0.50	4.75	0.008	4.41	0.001
0.75	5.66	0.010	4.75	0.001
1.00	6.09	0.015	4.88	0.001
1.50	7.01	0.020	5.00	0.001
2.00	7.51	0.023	5.08	0.001
Mg extraction (%)	75.6		76.7	
[Fe×100/Mg]	0.306		0.020	

019

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Table 6. Autoclave leach test results.

Sample: MC 28/10 - 61.8% MgO, 11.3% CaO, 3.59% Fe₂O₃, 2.82% SiO₂,
18.7% CO₂, 98.2% total

Leaching conditions: 0.5 h slake at leach temperature
100 psig carbon dioxide
1200 rpm

Time (h)	Concentration (g/litre)			
	3% solids, 15.5°C		2% solids, 45.0°C	
	Mg	Fe	Mg	Fe
0.08	1.06	0.000	2.90	0.003
0.25	2.75	0.003	3.80	0.003
0.50	5.04	0.009	4.42	0.003
0.75	6.25	0.012	4.88	0.003
1.00	6.66	0.015	5.07	0.003
1.50	7.17	0.018	5.09	0.002
2.00	7.47	0.020	5.10	0.002
Mg extraction (%)	66.9		68.5	
[Fe×100/Mg]	0.268		0.039	

Table 7. Autoclave leach test results.

Sample: MC 28/25 - 31.3% MgO, 29.7% CaO, 1.24% Fe₂O₃, 2.22% SiO₂,
34.6% CO₂, 99.1% total

Leaching conditions: 0.5 h slake at leach temperature
100 psig carbon dioxide
1200 rpm

Time (h)	Concentration (g/litre)			
	3% solids, 15.5°C		2% solids, 45.0°C	
	Mg	Fe	Mg	Fe
0.08	0.15	0.000	0.59	0.001
0.25	0.40	0.001	0.62	0.001
0.50	0.74	0.001	0.62	0.000
0.75	1.00	0.001	0.62	0.000
1.00	1.00	0.002	0.62	0.000
1.50	1.00	0.002	0.62	0.000
2.00	1.00	0.002	0.62	0.000
Mg extraction (%)	17.6		16.4	
[Fe×100/Mg]	0.200		0.000	

021

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Table 8. Autoclave leach test results.

Sample: MC 28/27 - 53.2% MgO, 17.2% CaO, 2.56% Fe₂O₃, 3.04% SiO₂,
22.8% CO₂, 98.8% total

Leaching conditions: 0.5 h slake at leach temperature
100 psig carbon dioxide
1200 rpm

Time (h)	Concentration (g/litre)			
	3% solids, 15.5°C		2% solids, 45.0°C	
	Mg	Fe	Mg	Fe
0.08	1.45	0.000	2.55	0.001
0.25	2.90	0.001	3.66	0.001
0.50	4.24	0.002	4.04	0.001
0.75	4.62	0.004	4.18	0.001
1.00	5.19	0.006	4.20	0.001
1.50	5.91	0.007	4.23	0.001
2.00	6.30	0.008	4.24	0.001
Mg extraction (%)	65.4		66.0	
[Fe×100/Mg]	0.127		0.024	

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Table 9. Autoclave leach test results.

Sample: MC 28/34 - 56.6% MgO, 11.4% CaO, 4.09% Fe₂O₃, 6.50% SiO₂,
20.7% CO₂, 99.3% total

Leaching conditions: 0.5 h slake at leach temperature
100 psig carbon dioxide
1200 rpm

Time (h)	Concentration (g/litre)			
	3% solids, 15.5°C		2% solids, 45.0°C	
	Mg	Fe	Mg	Fe
0.08	0.45	0.000	1.36	0.000
0.25	1.40	0.001	1.90	0.001
0.50	2.13	0.002	2.37	0.001
0.75	2.83	0.002	2.53	0.001
1.00	3.44	0.003	2.59	0.000
1.50	3.76	0.004	2.60	0.000
2.00	3.76	0.004	2.62	0.000
Mg extraction (%)	38.6		38.4	
[Fe×100/Mg]	0.106		0.000	

023

388024

Table 10. Autoclave leach test results.

Sample: MC 28/37 - 31.4% MgO, 29.4% CaO, 1.33% Fe₂O₃, 2.59% SiO₂,
33.3% CO₂, 98.0% total

Leaching conditions: 0.5 h slake at leach temperature
100 psig carbon dioxide
1200 rpm

Time (h)	Concentration (g/litre)			
	3% solids, 15.5°C		2% solids, 45.0°C	
	Mg	Fe	Mg	Fe
0.08	0.48	0.002	0.25	0.000
0.25	0.58	0.002	0.35	0.000
0.50	0.65	0.002	0.46	0.000
0.75	0.71	0.002	0.48	0.000
1.00	0.71	0.002	0.49	0.000
1.50	0.71	0.002	0.49	0.000
2.00	0.71	0.002	0.48	0.000
Mg extraction (%)	12.5		12.7	
[Fex100/Mg]	0.282		0.000	

Table 11. Autoclave leach test results.

Sample: MC 28/46 - 29.7% MgO, 28.5% CaO, 2.92% Fe₂O₃, 0.39% SiO₂,
37.7% CO₂, 99.2% total

Leaching conditions: 0.5 h slake at leach temperature
100 psig carbon dioxide
1200 rpm

Time (h)	Concentration (g/litre)			
	3% solids, 15.5°C		2% solids, 45.0°C	
	Mg	Fe	Mg	Fe
0.08	0.00	0.000	0.20	0.000
0.25	0.24	0.000	0.68	0.000
0.50	0.98	0.000	1.23	0.000
0.75	1.42	0.001	1.40	0.000
1.00	1.68	0.001	1.40	0.000
1.50	1.90	0.001	1.40	0.000
2.00	2.02	0.001	1.40	0.000
Mg extraction (%)	37.6		39.1	
[Fe×100/Mg]	0.050		0.000	

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Table 12. Autoclave leach test results.

Sample: MC 28/51 - 84.2% MgO, 2.41% CaO, 8.02% Fe ₂ O ₃ , 1.50% SiO ₂ , 3.92% CO ₂ , 100.1% total					
Leaching conditions: 0.5 h slake at leach temperature 100 psig carbon dioxide 1200 rpm					
	Concentration (g/litre)				
	3% solids, 15.5°C		2% solids, 45.0°C		
Time (h)	Mg	Fe	Mg	Fe	
0.08	2.22	0.002	4.99	0.004	
0.25	6.03	0.013	6.63	0.007	
0.50	8.32	0.033	7.60	0.009	
0.75	9.60	6.053	8.19	0.013	
1.00	10.35	0.073	8.61	0.015	
1.50	12.15	0.112	9.00	0.015	
2.00	13.16	0.149	9.06	0.015	
Mg extraction (%)	86.4		89.2		
[Fe×100/Mg]	1.13		0.166		

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Table 13. Autoclave leach test results.

Sample: MC 28/58 - 55.9% MgO, 8.59% CaO, 3.36% Fe₂O₃, 3.61% SiO₂,
26.9% CO₂, 98.4% total

Leaching conditions: 0.5 h slake at leach temperature
100 psig carbon dioxide
1200 rpm

Time (h)	Concentration (g/litre)			
	3% solids, 15.5°C		2% solids, 45.0°C	
	Mg	Fe	Mg	Fe
0.08	1.20	0.000	2.79	0.001
0.25	2.51	0.003	3.82	0.002
0.50	3.94	0.005	4.55	0.002
0.75	4.83	0.008	4.81	0.002
1.00	5.86	0.013	4.95	0.001
1.50	6.90	0.018	5.08	0.001
2.00	7.32	0.020	5.12	0.001
Mg extraction (%)	72.4		76.0	
[Fex100/Mg]	0.273		0.014	

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Table 14. Approximate Fe_2O_3 content (%) of MgO produced from leach liquors.*

Sample	3% solids, 15.5°C	2% solids, 45.0°C
MC 28/2	0.10	0
MC 28/5	0.28	0.02
MC 28/10	0.22	0.04
MC 28/25	0.16	0
MC 28/27	0.11	0.02
MC 28/34	0.10	0
MC 28/37	0.16	0
MC 28/46	0.05	0
MC 28/51	0.93	0.15
MC 28/58	0.22	0.02

*After 2 h leach period, assuming complete recovery of Mg and Fe.

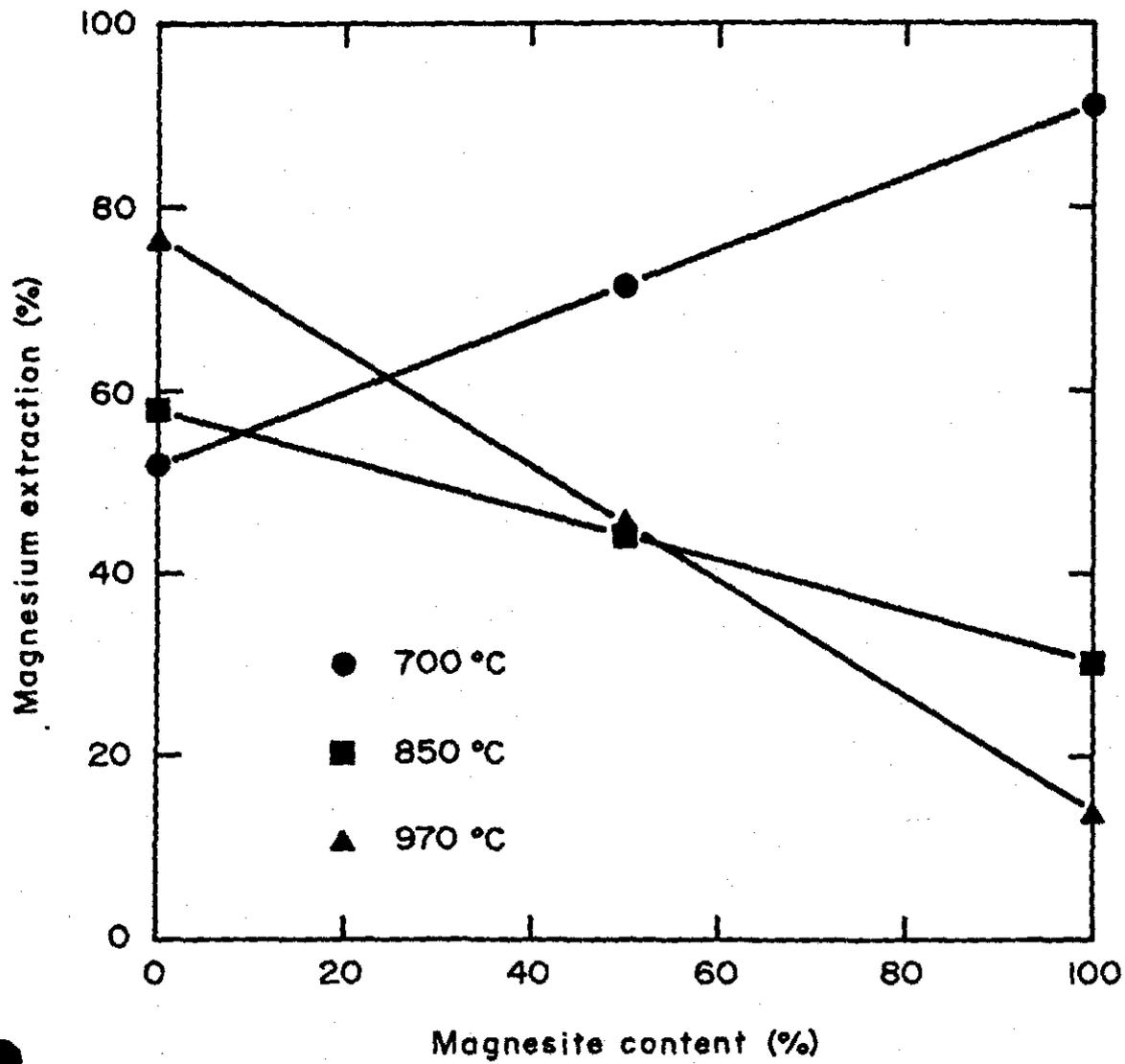


Fig. 1. Magnesium extraction as a function of magnesite content of feed at several calcination temperatures.

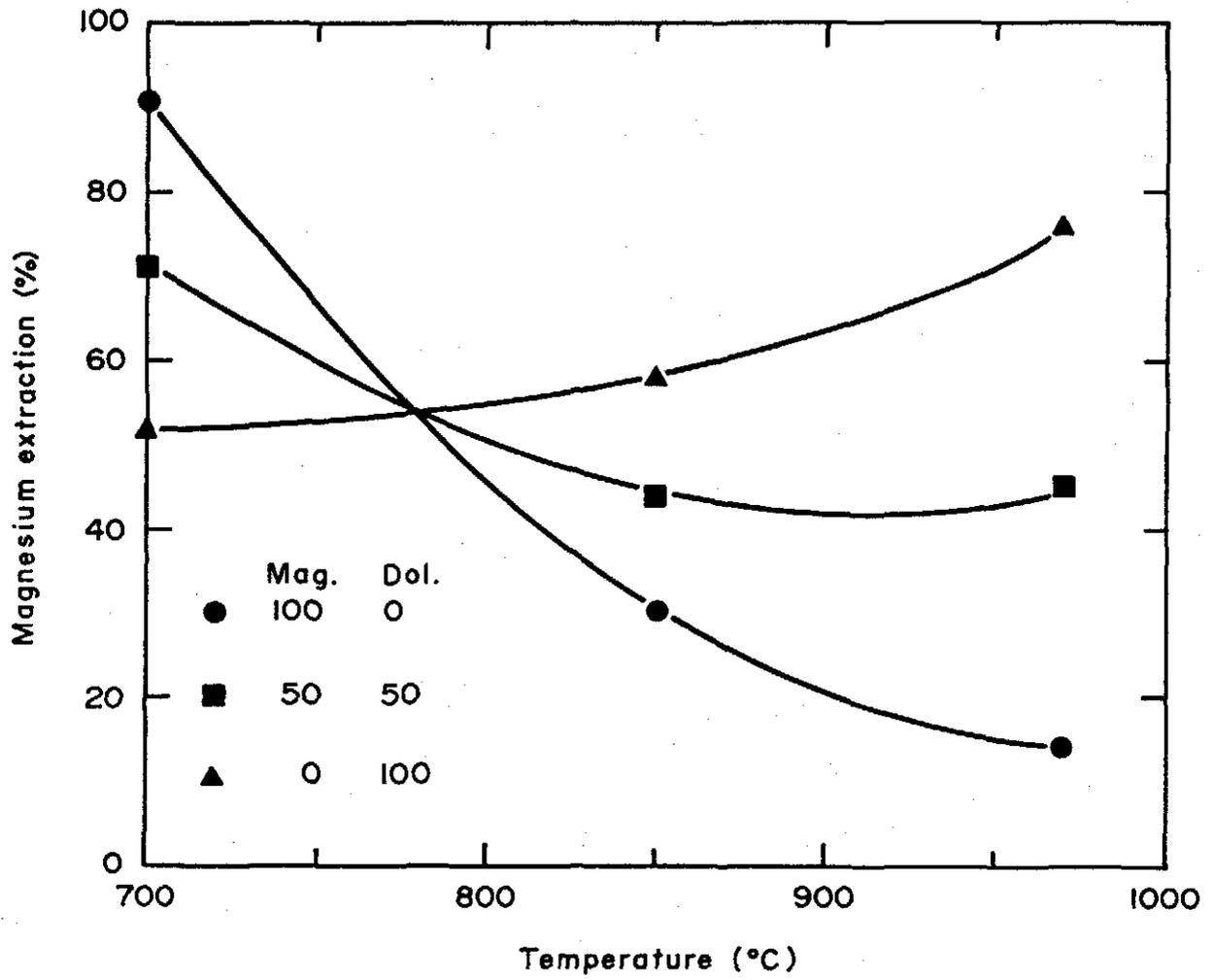


Fig. 2. Magnesium extraction as a function of calcination temperature for several feed compositions.

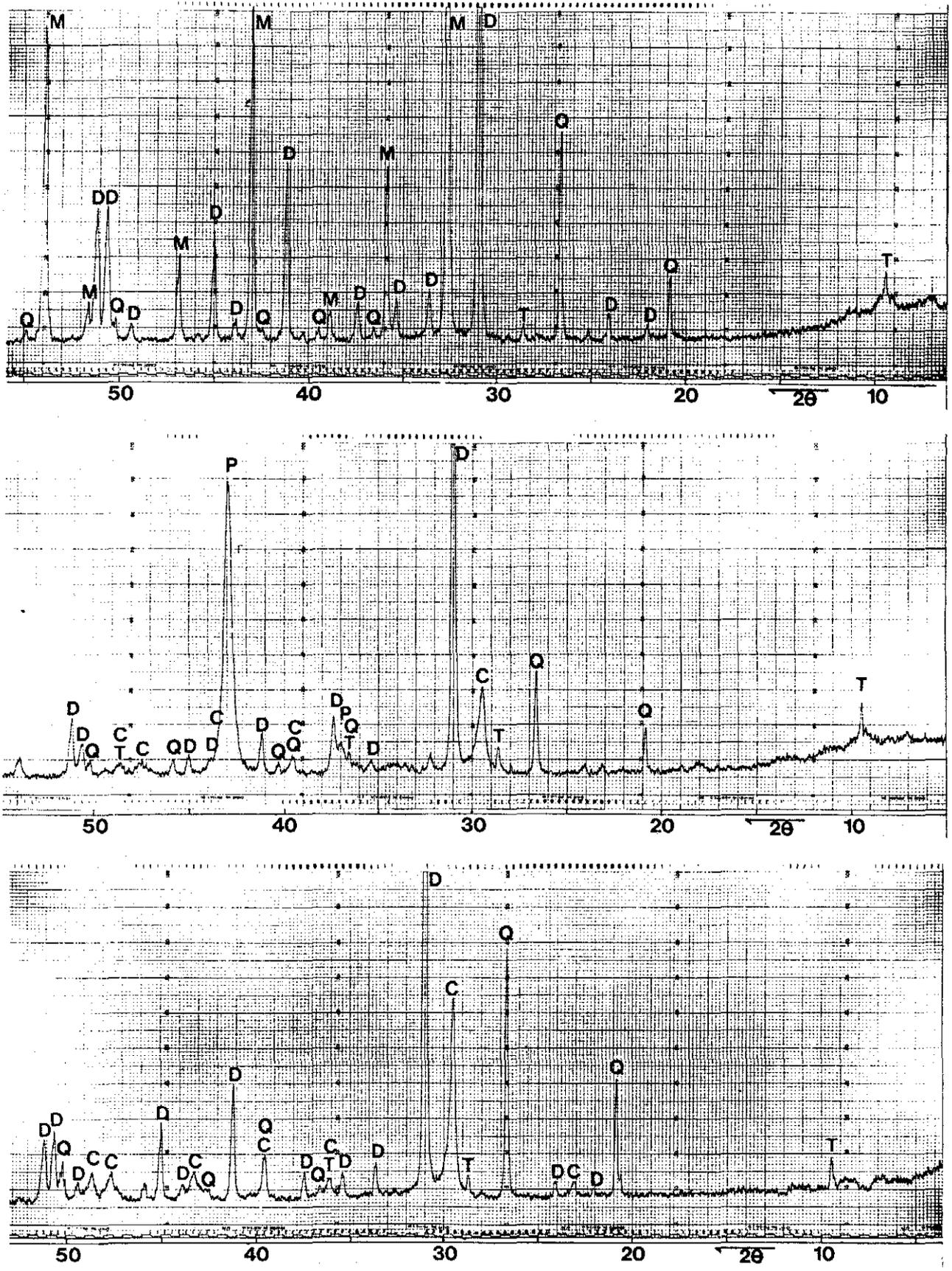


Fig. 3. XRD patterns of sample MC 28/2 (upper), calcine (centre) and leach residue (lower). C = calcite, D = dolomite, M = magnesite, P = periclase, Q = quartz, T = talc.

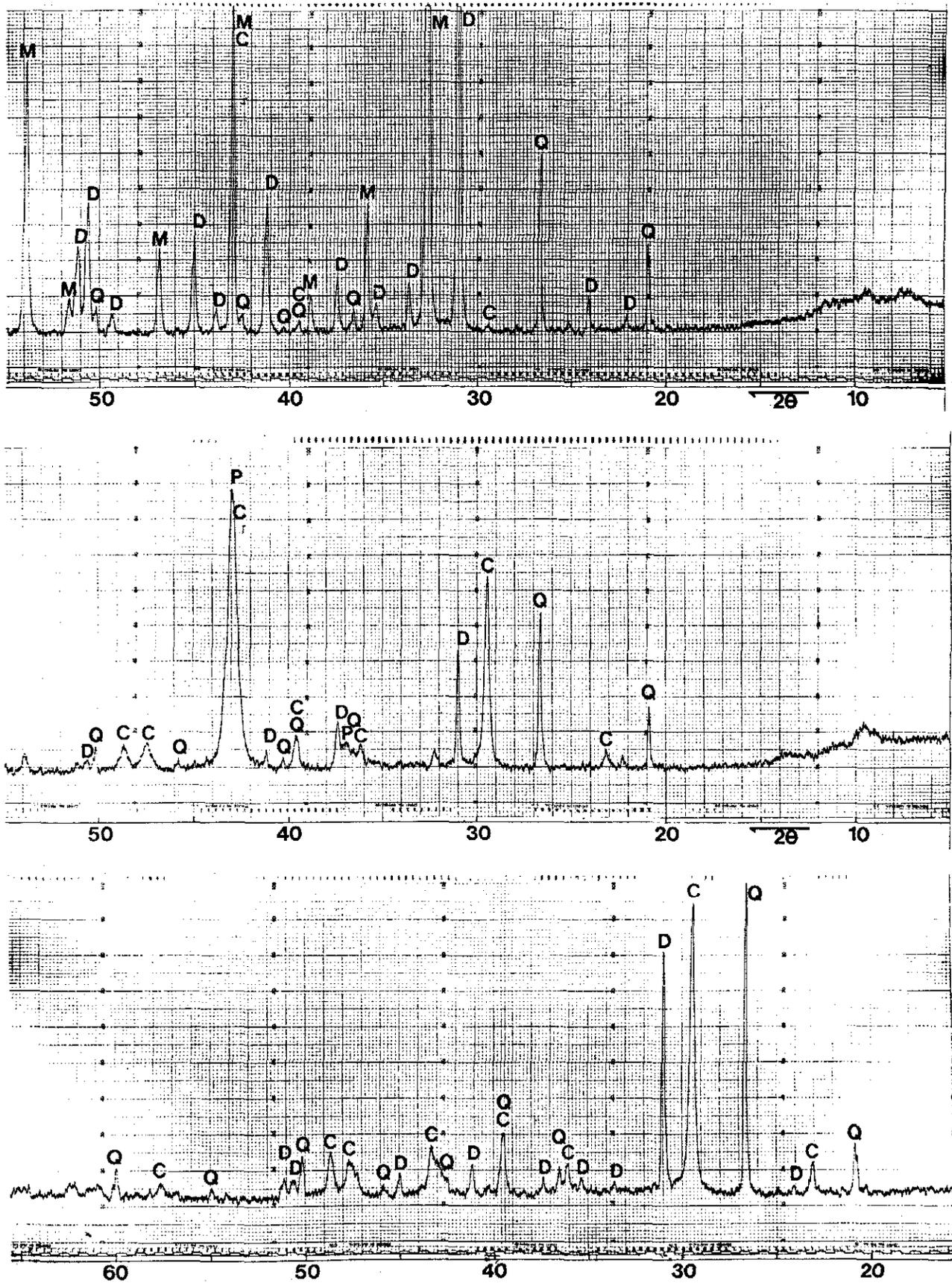


Fig. 4. XRD patterns of sample MC 28/5 (upper), calcine (centre) and leach residue (lower). C = calcite, D = dolomite, M = magnesianite, P = periclase, Q = quartz.

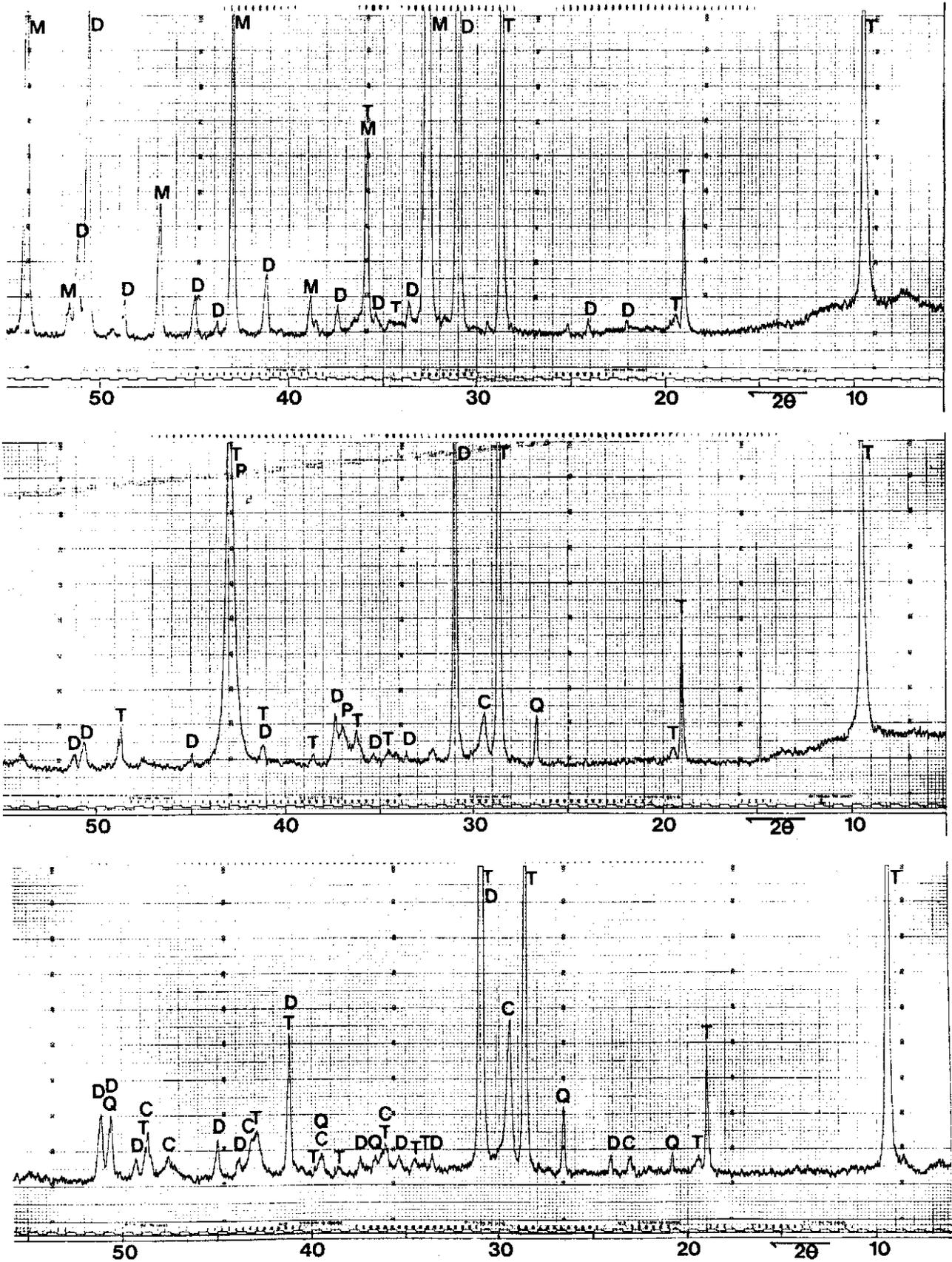


Fig. 5. XRD patterns of sample MC 28/10 (upper), calcine (centre) and leach residue (lower). C = calcite, D = dolomite, M = magnesite, P = periclase, Q = quartz, T = talc.

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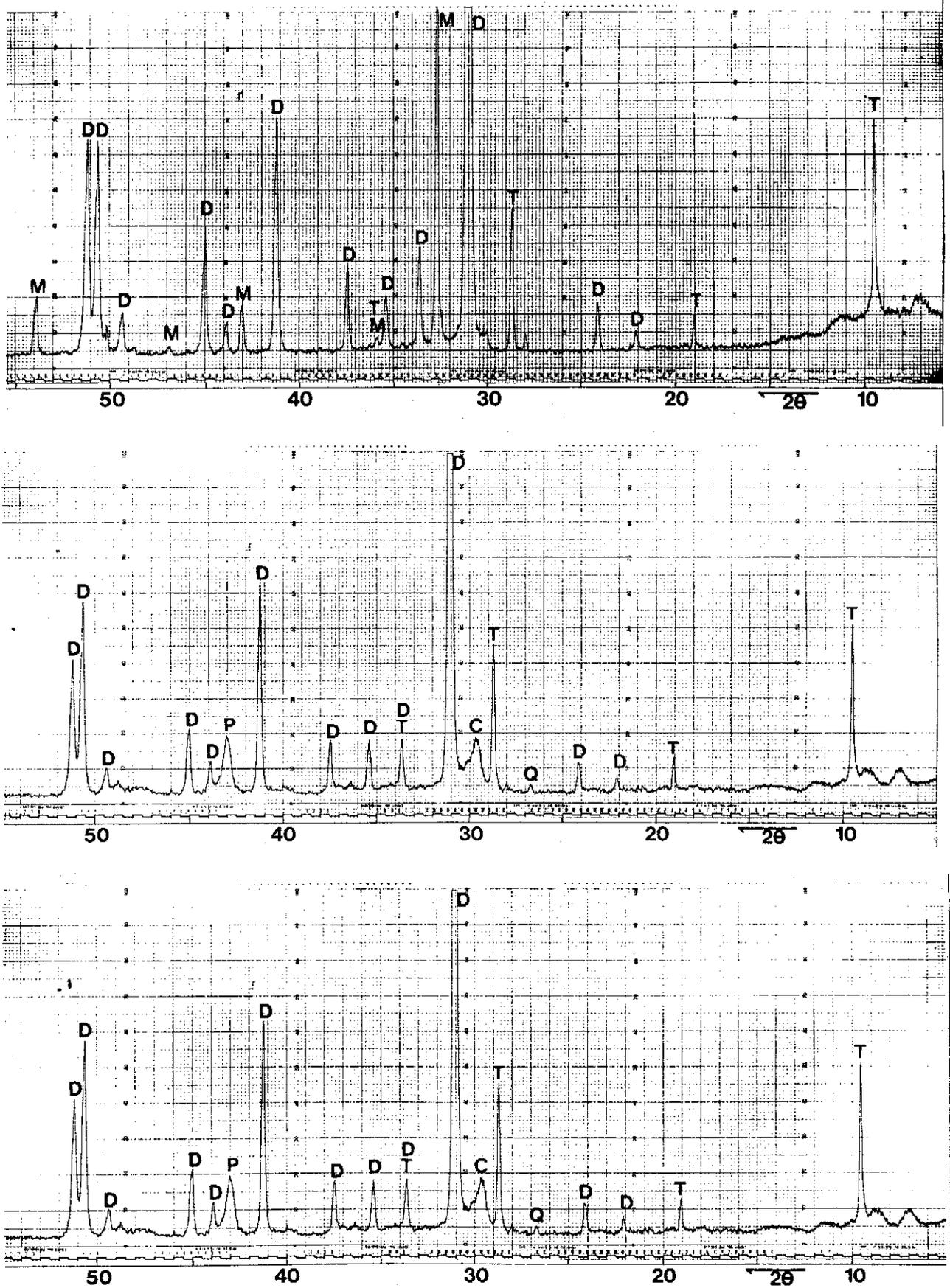


Fig. 6. XRD patterns of sample MC 28/25 (upper), calcine (centre) and leach residue (lower). D = dolomite, M = magnesite, P = periclase, Q = quartz, T = talc.

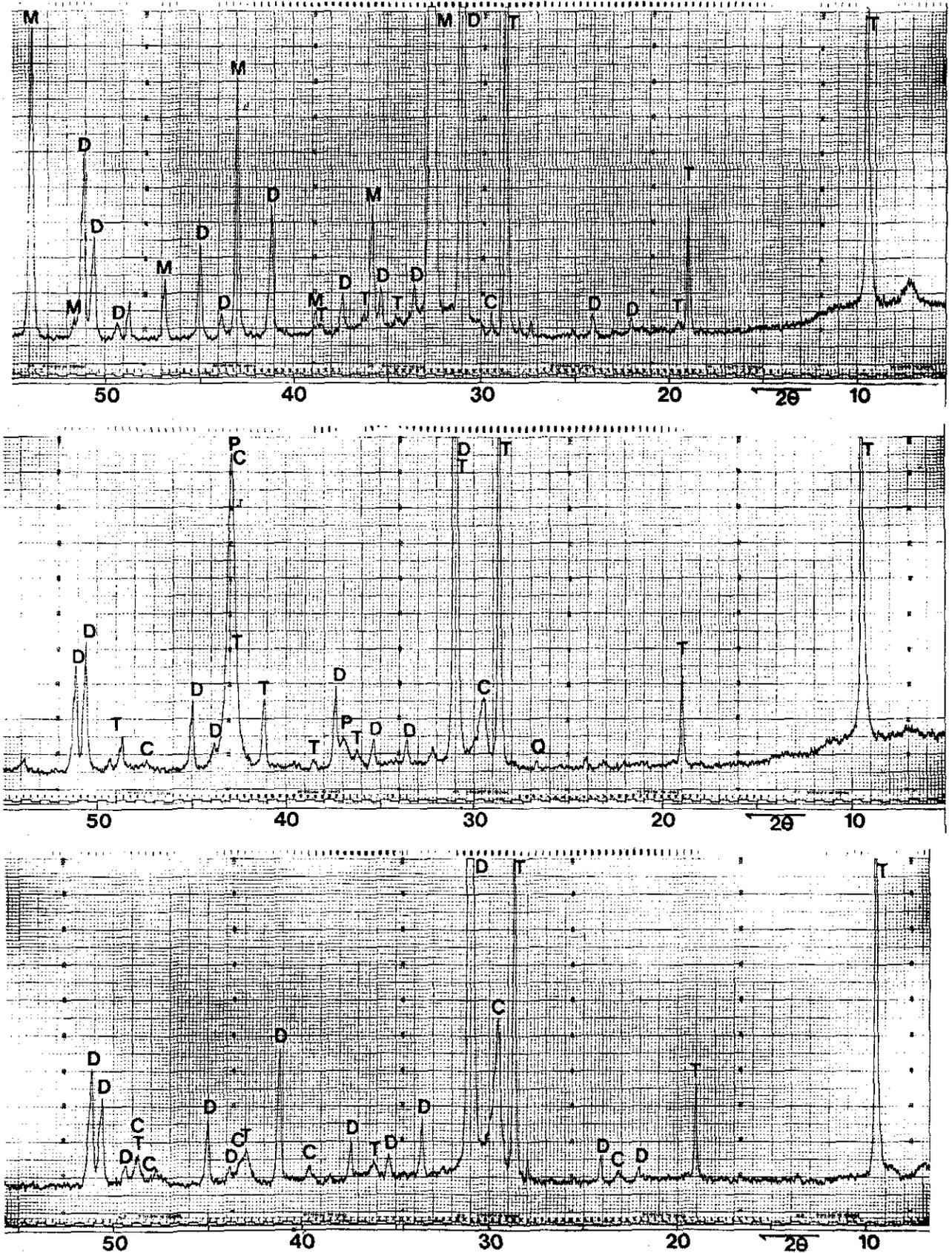


Fig. 7. XRD patterns of sample MC 28/27 (upper), calcine (centre) and leach residue (lower). C = calcite, D = dolomite, M = magnesite, P = periclase, Q = quartz, T = talc.

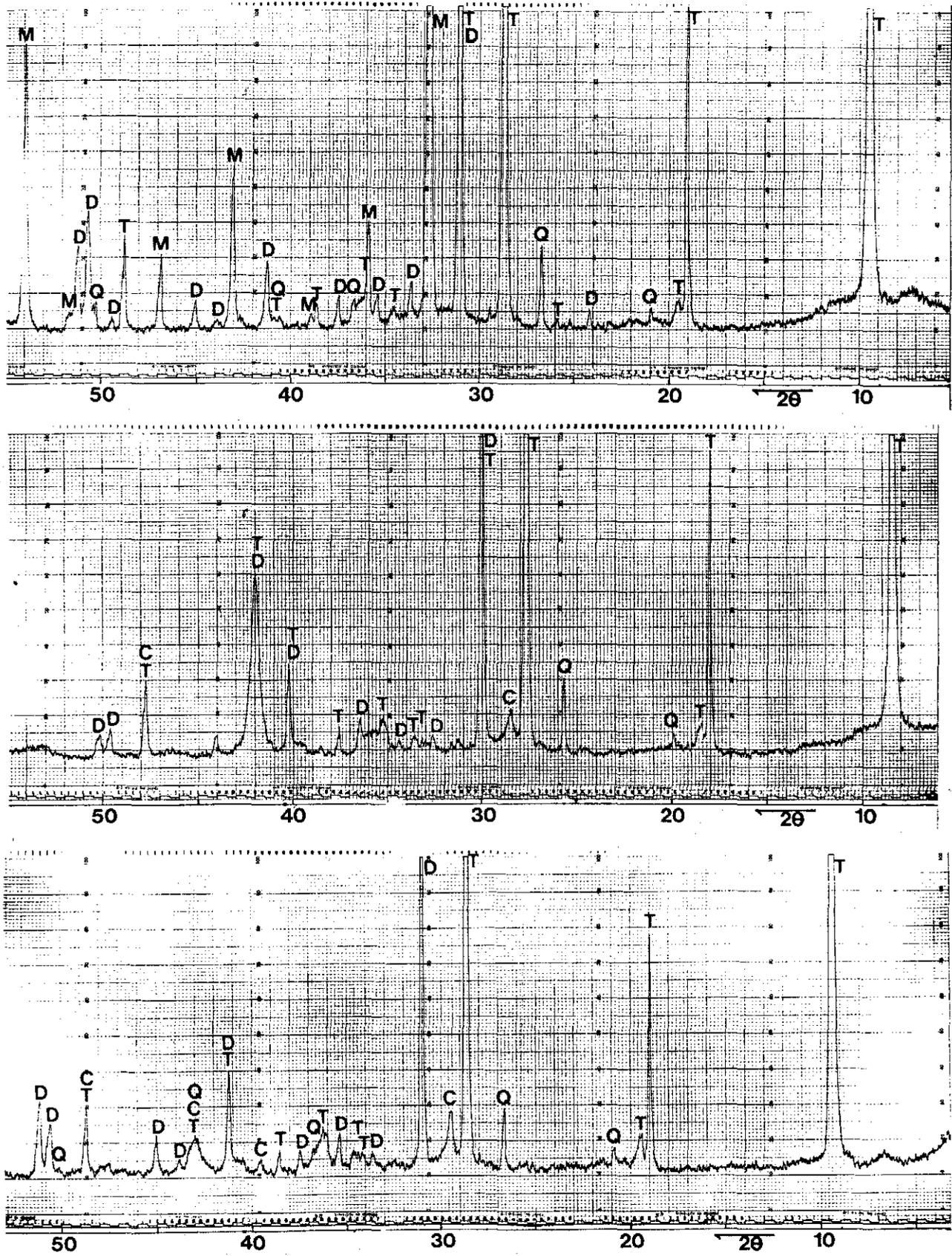


Fig. 8. XRD patterns of sample MC 28/34 (upper), calcine (centre) and leach residue (lower). C = calcite, D = dolomite, M = magnesite, P = periclase, Q = quartz, T = talc.

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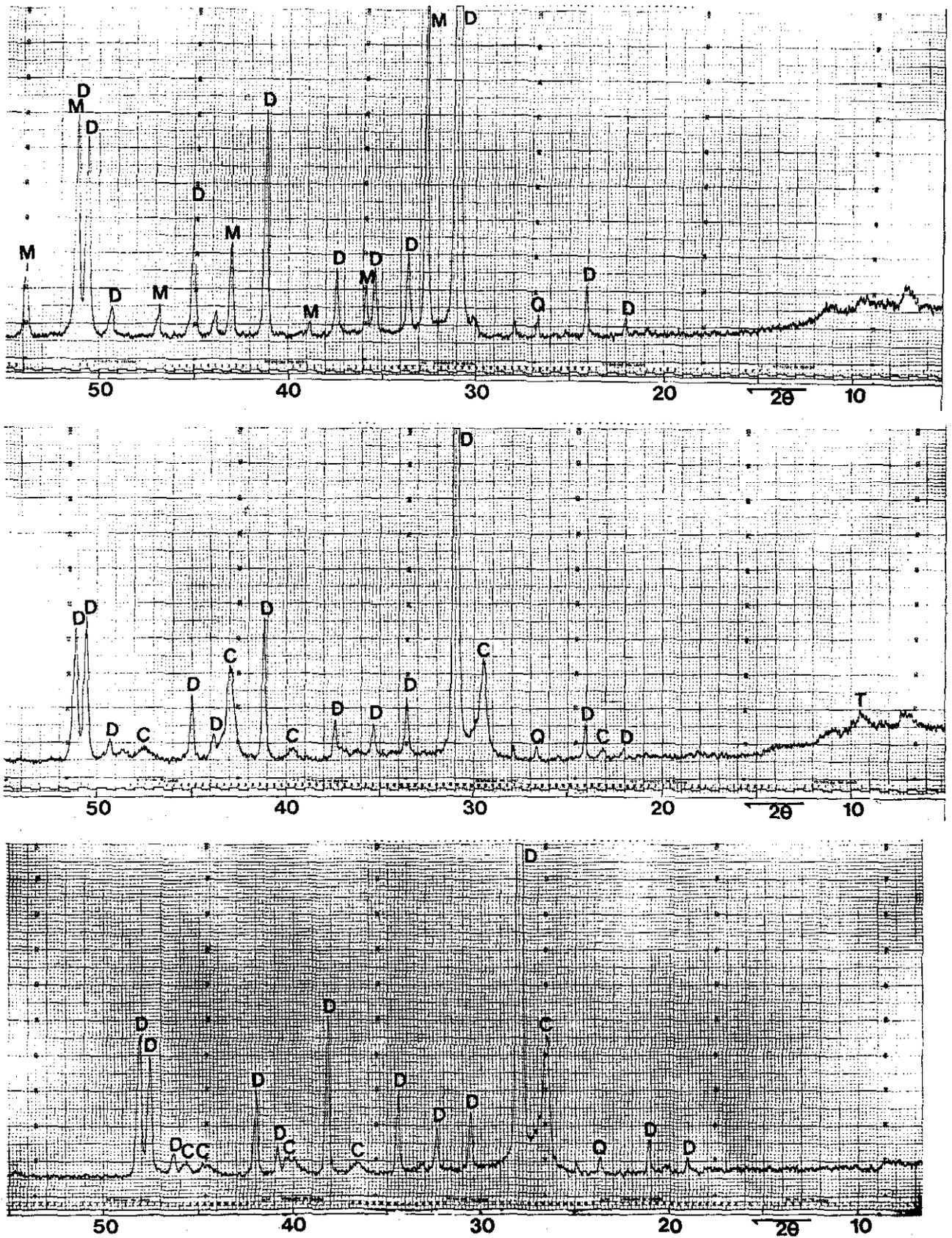


Fig. 10. XRD patterns of sample MC 28/46 (upper), calcine (centre) and leach residue (lower). C = calcite, D = dolomite, M = magnesian, P = periclase, Q = quartz.

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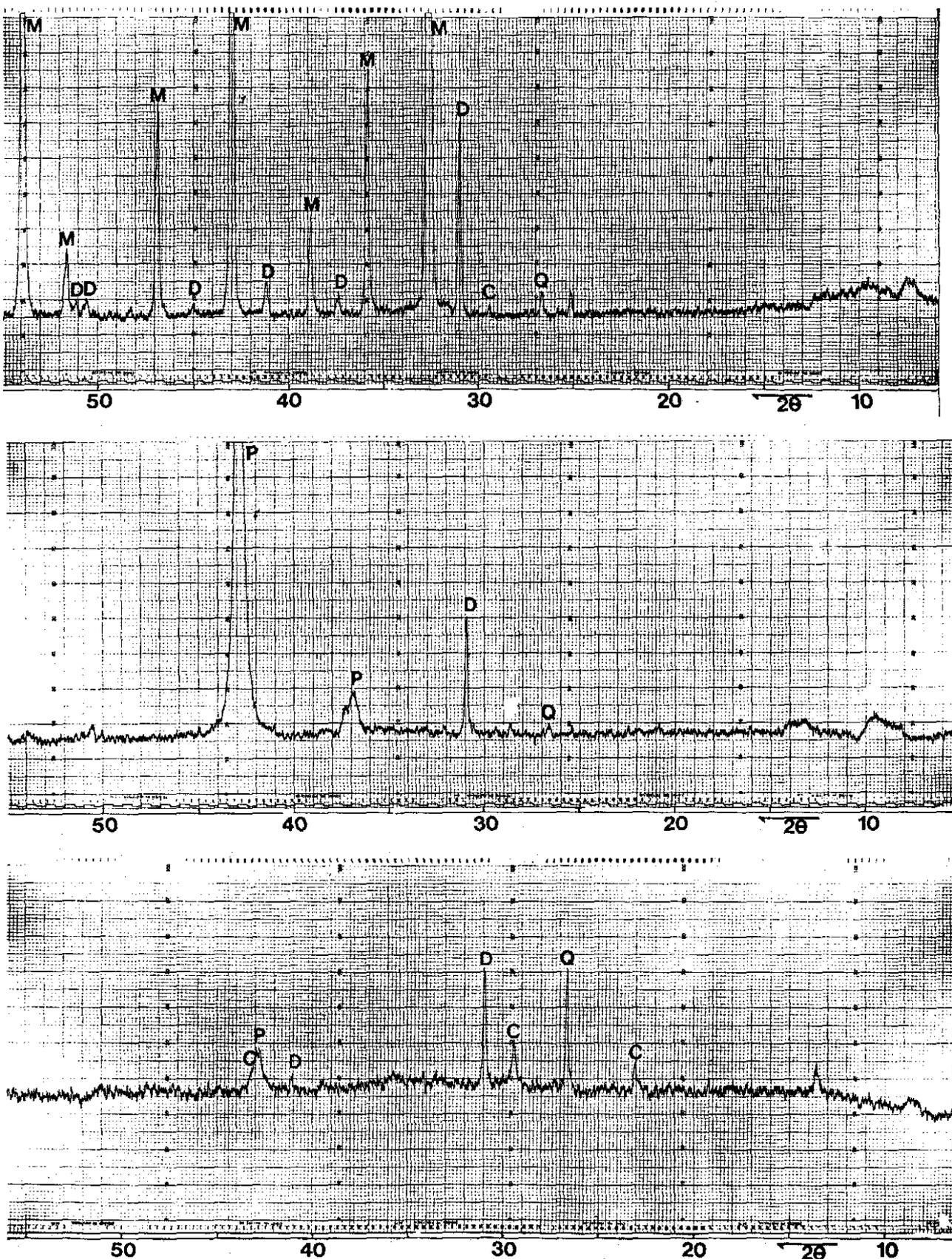


Fig. 11. XRD patterns of sample MC 28/51 (upper), calcine (centre) and leach residue (lower). C = calcite, D = dolomite, M = magnesite, P = periclase, Q = quartz.

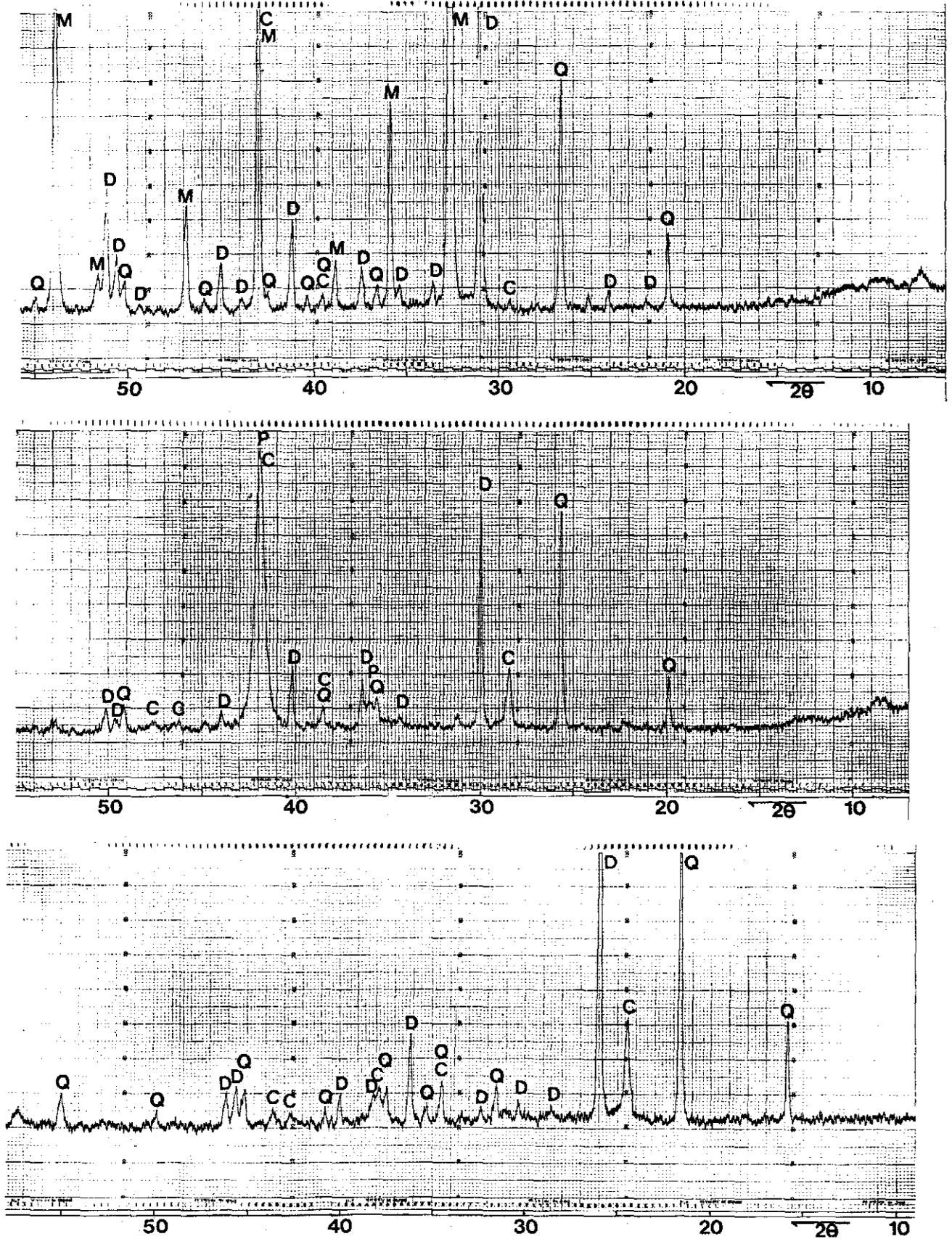


Fig. 12. XRD patterns of sample MC 28/58 (upper), calcine (centre) and leach residue (lower). C = calcite, D = dolomite, M = magnesite, P = periclase, Q = quartz.

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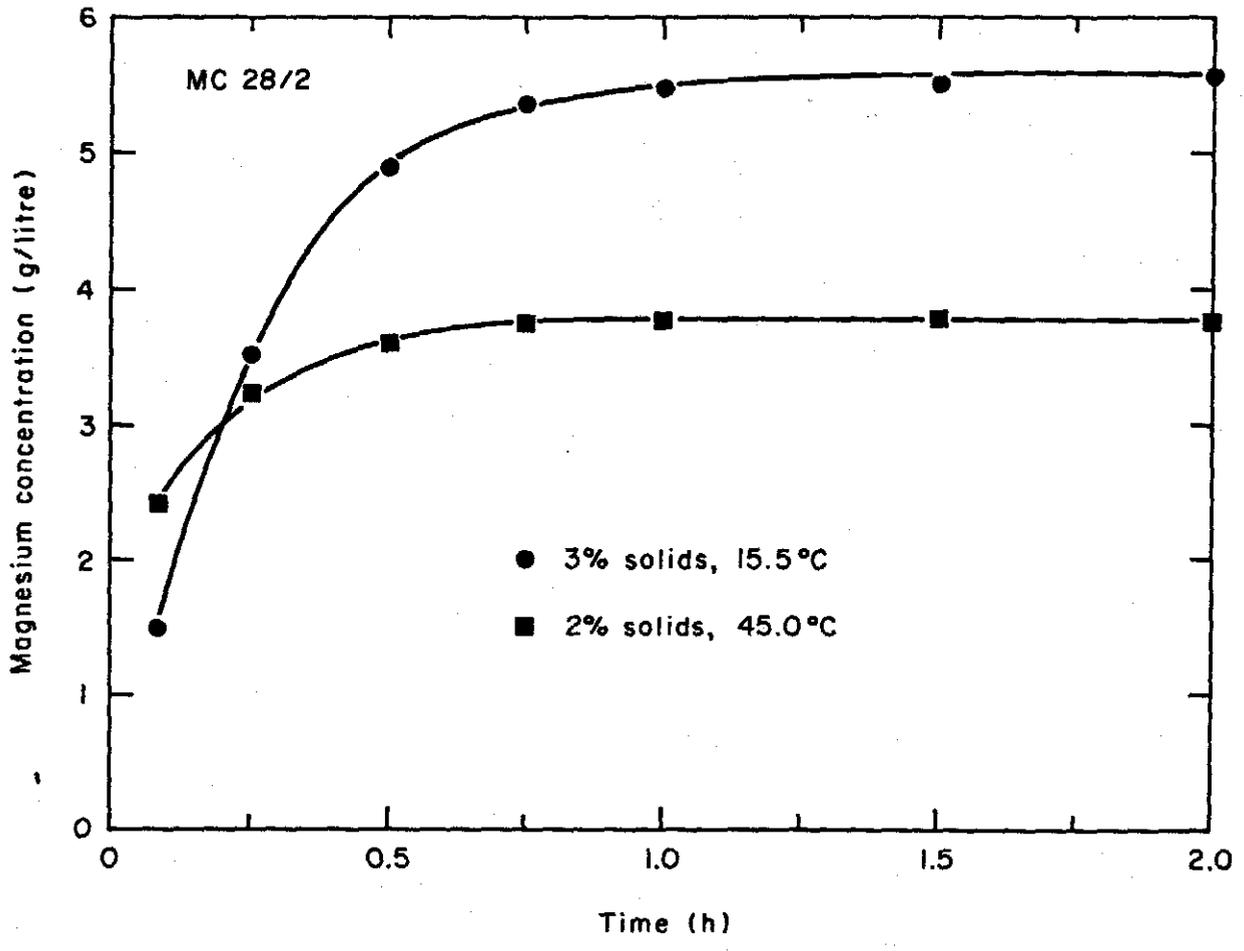


Fig. 13. Sample MC 28/2 - leach data.

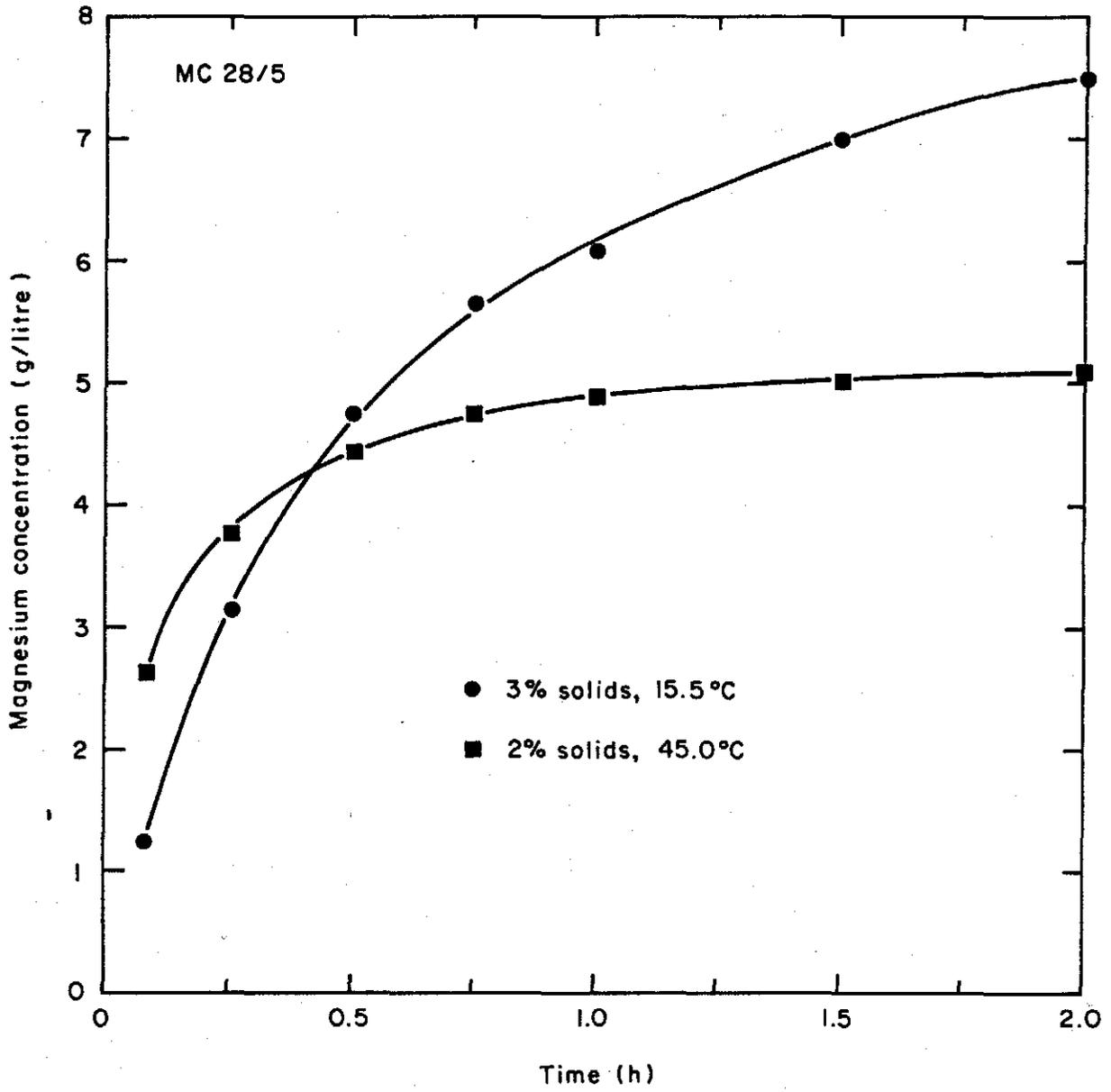


Fig. 14. Sample MC 28/5 - leach data.

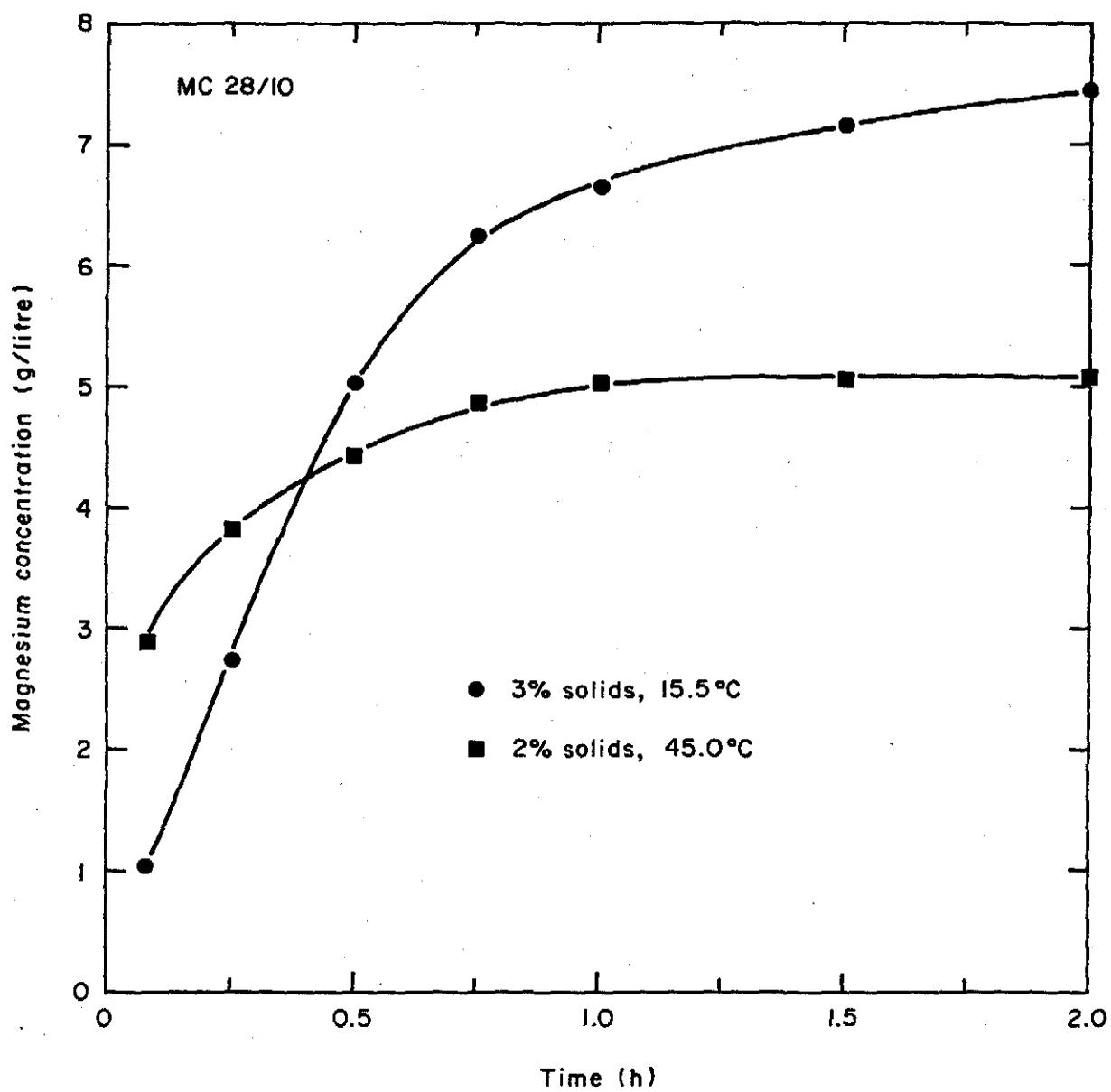


Fig. 15. Sample MC 28/10 - leach data.

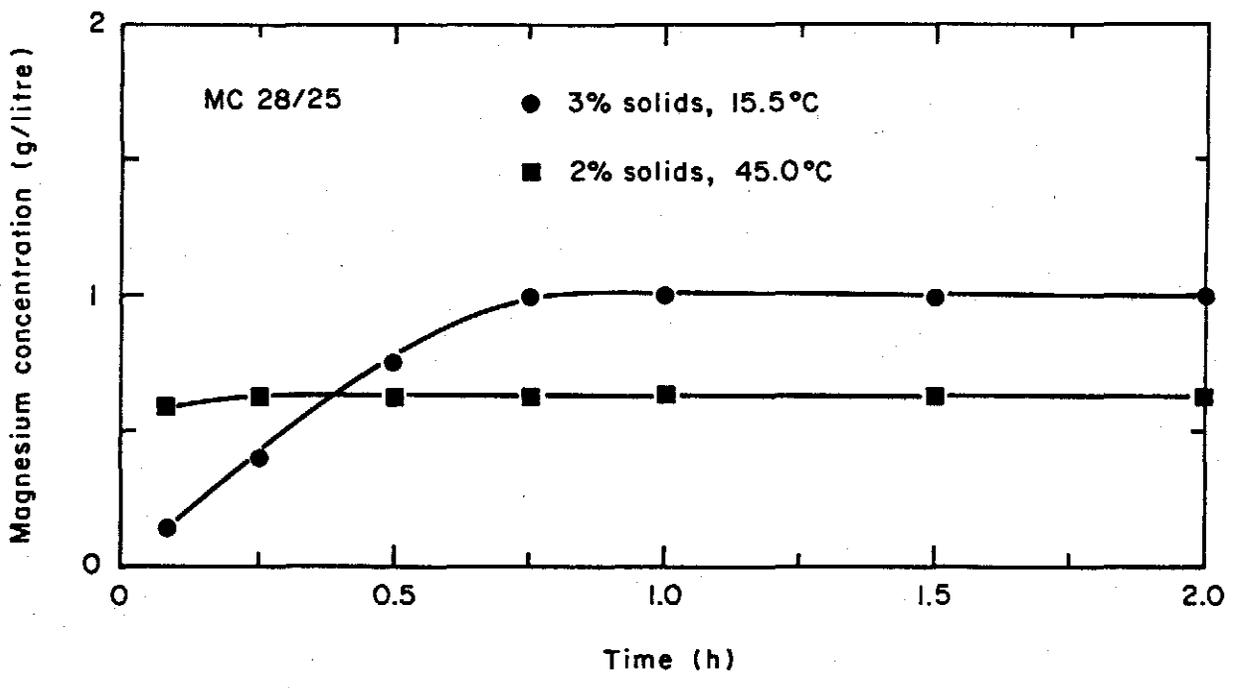


Fig. 16. Sample MC 28/25 - leach data.

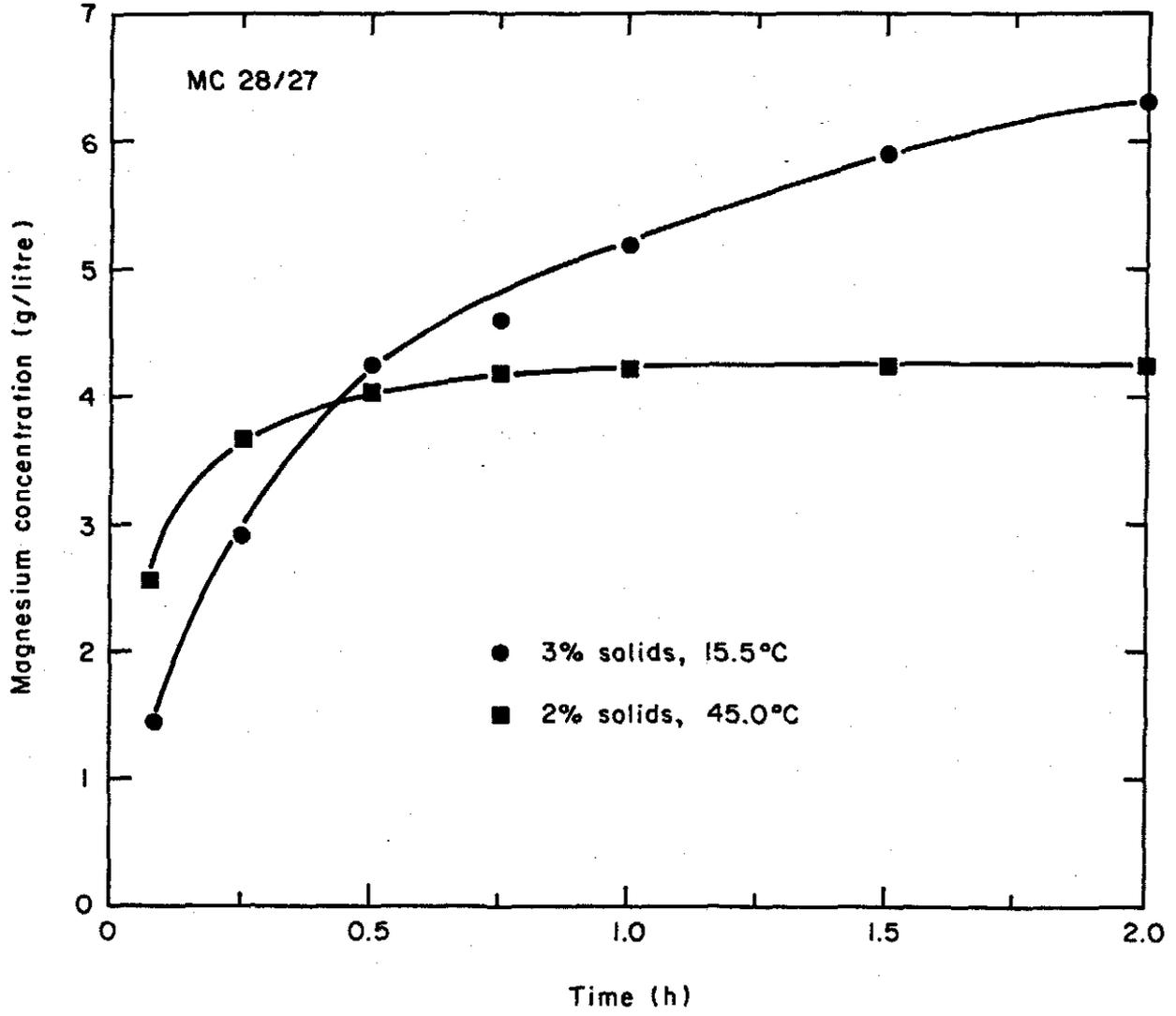


Fig. 17. Sample MC 28/27 - leach data.

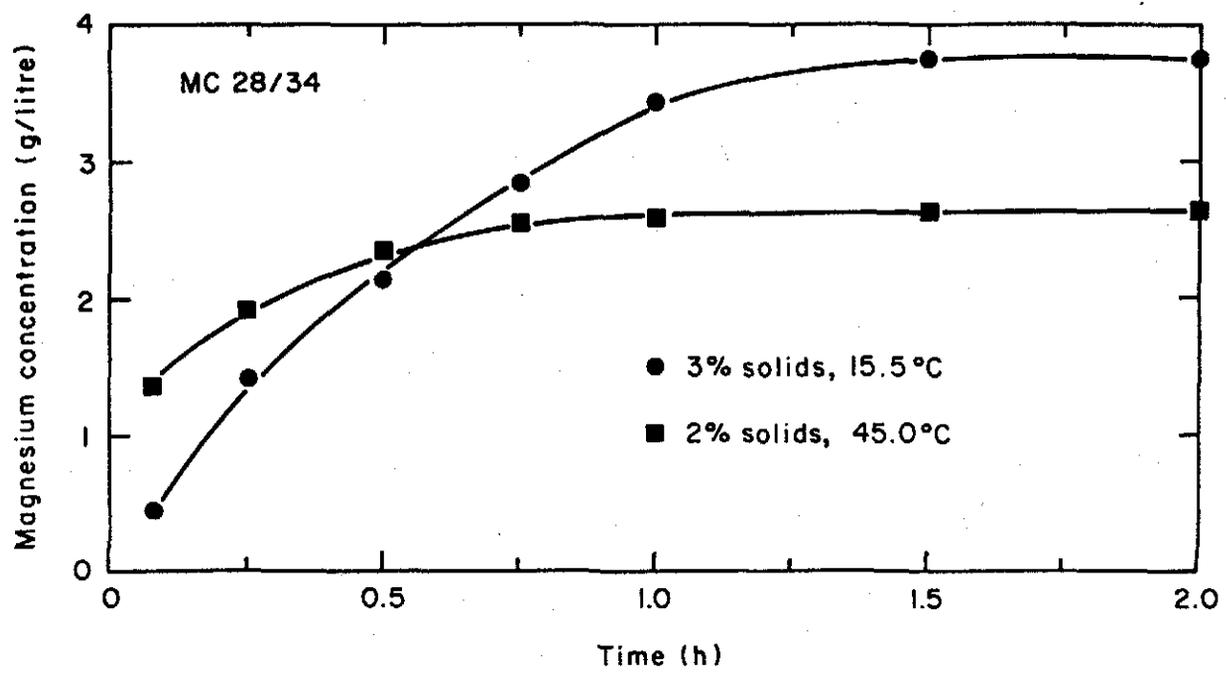


Fig. 18. SAMPLE MC 28/34 - leach data.

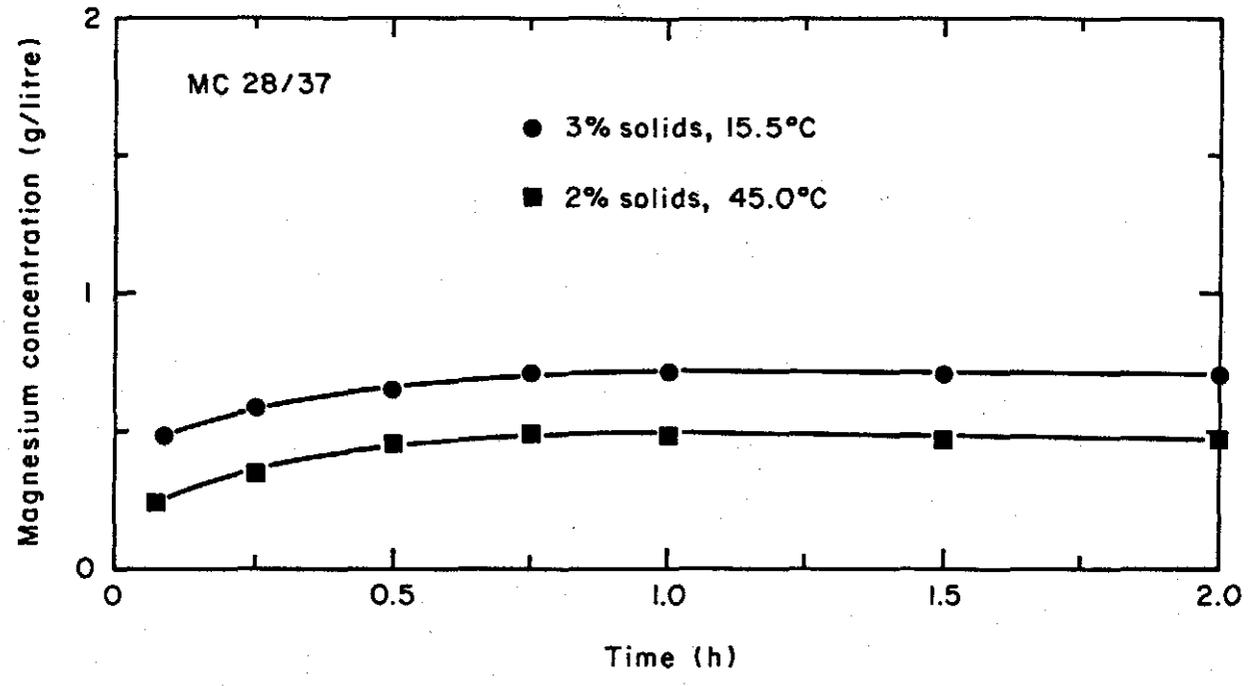


Fig. 19. Sample MC 28/37 - leach data.

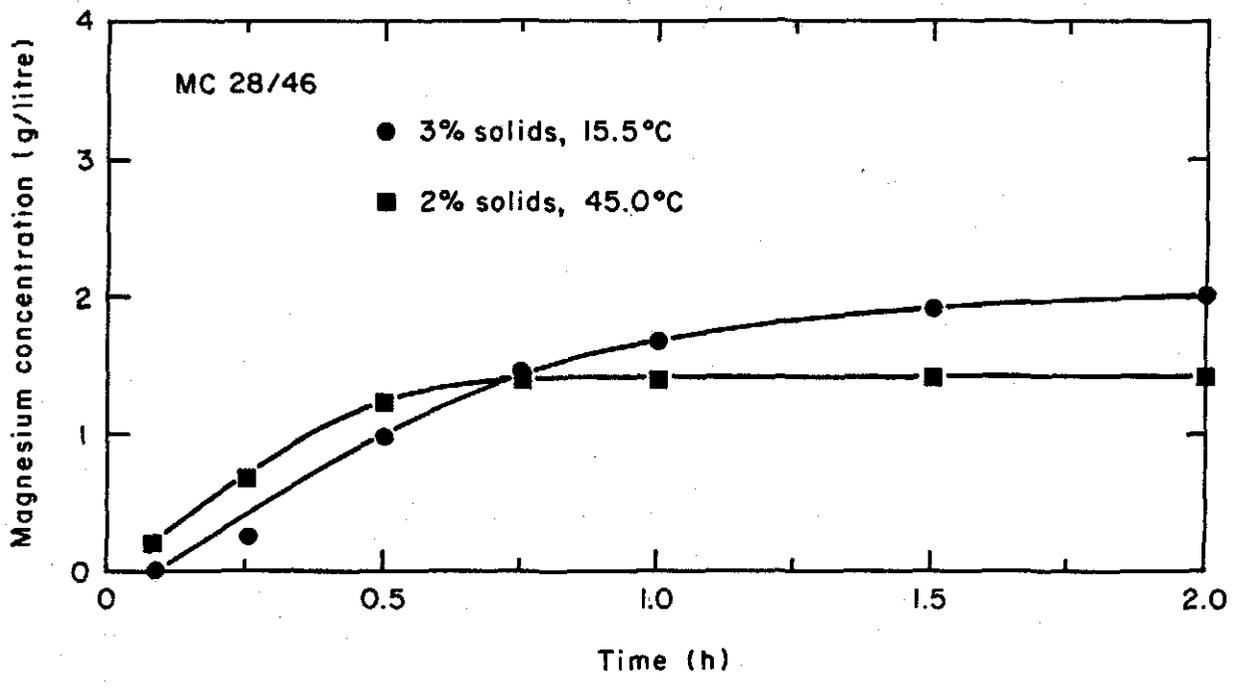


Fig. 20. Sample MC 28/46 - leach data.

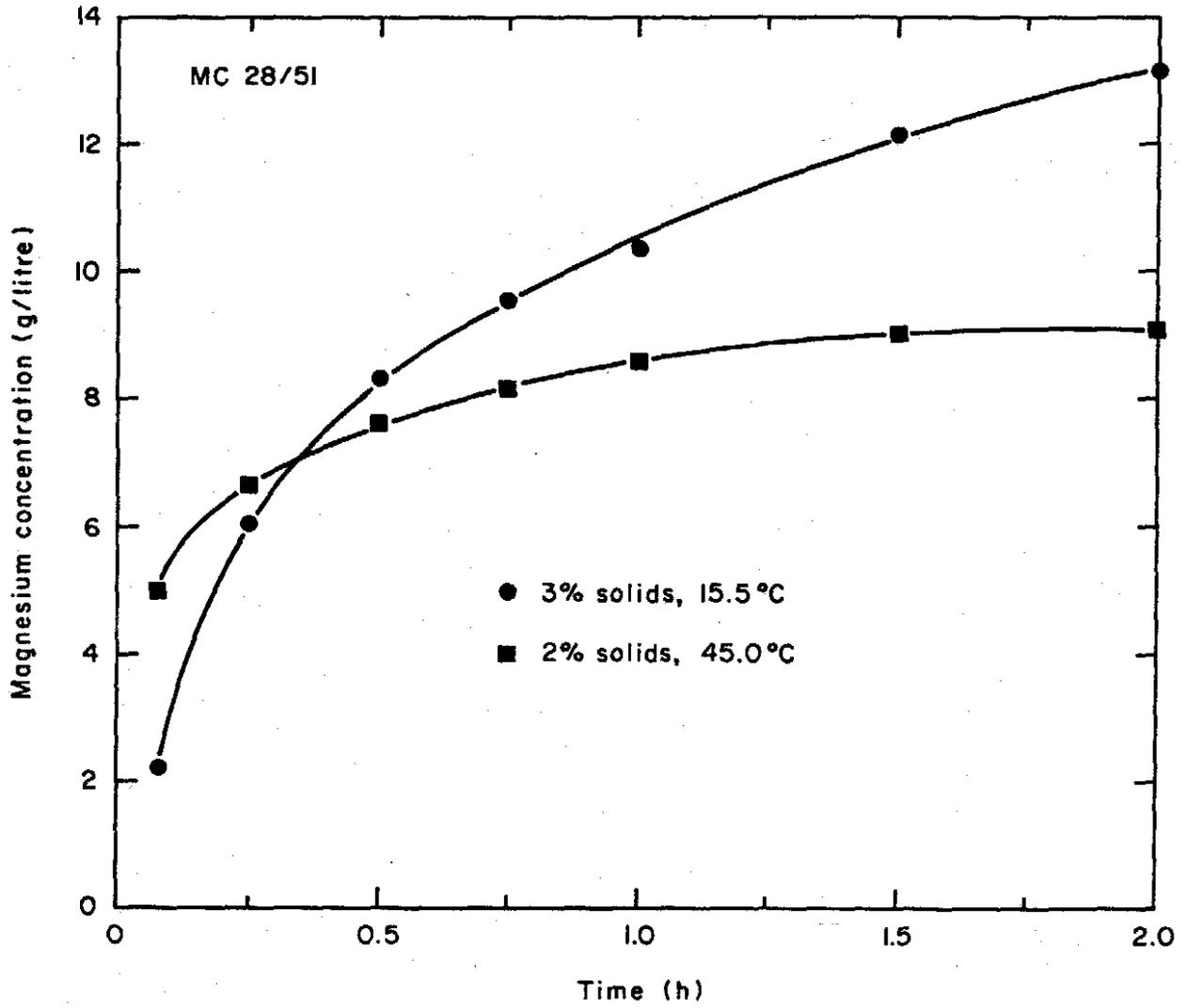


Fig. 21. Sample MC 28/51 - leach data.

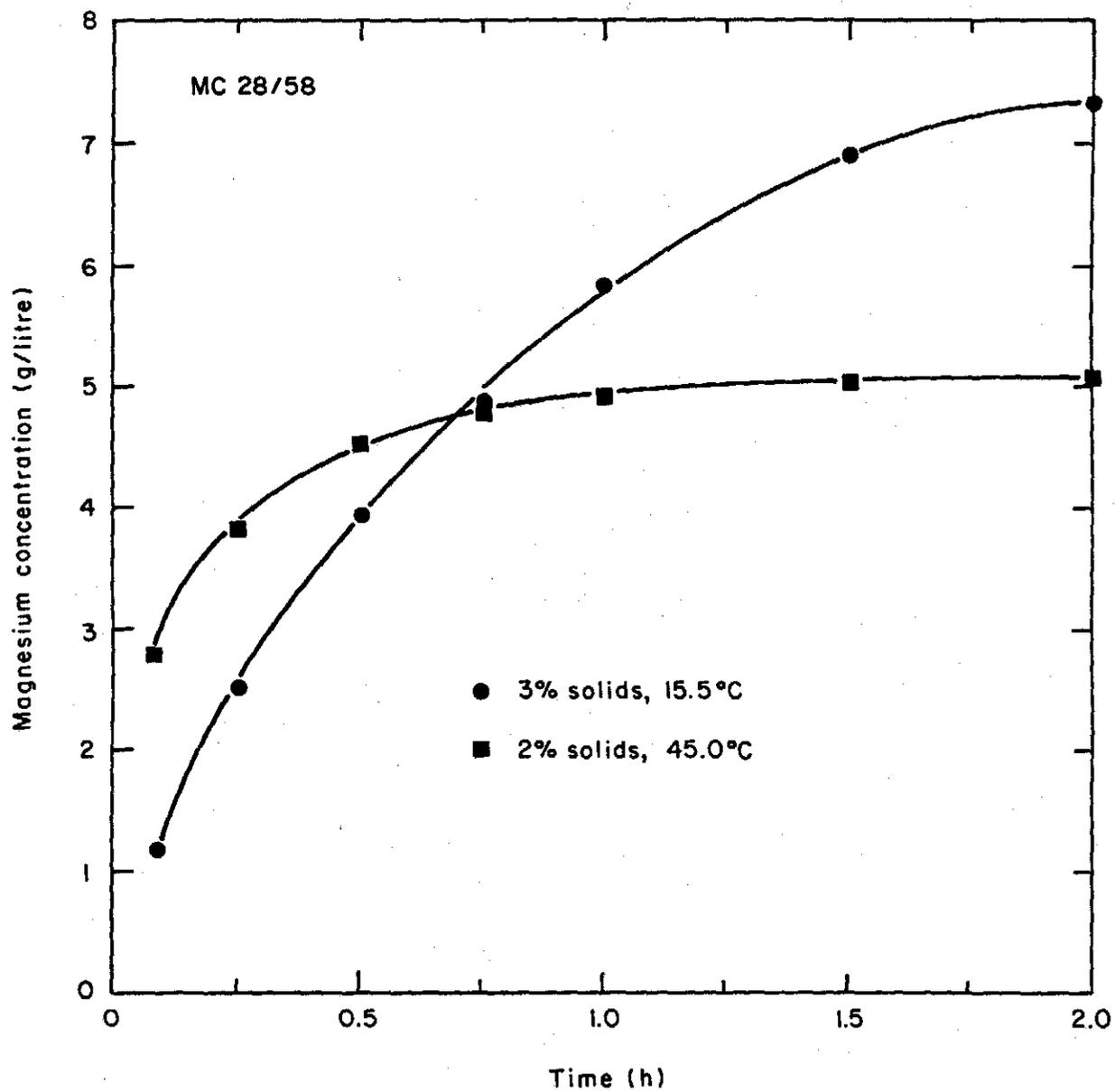


Fig. 22. Sample MC 28/58 - leach data.

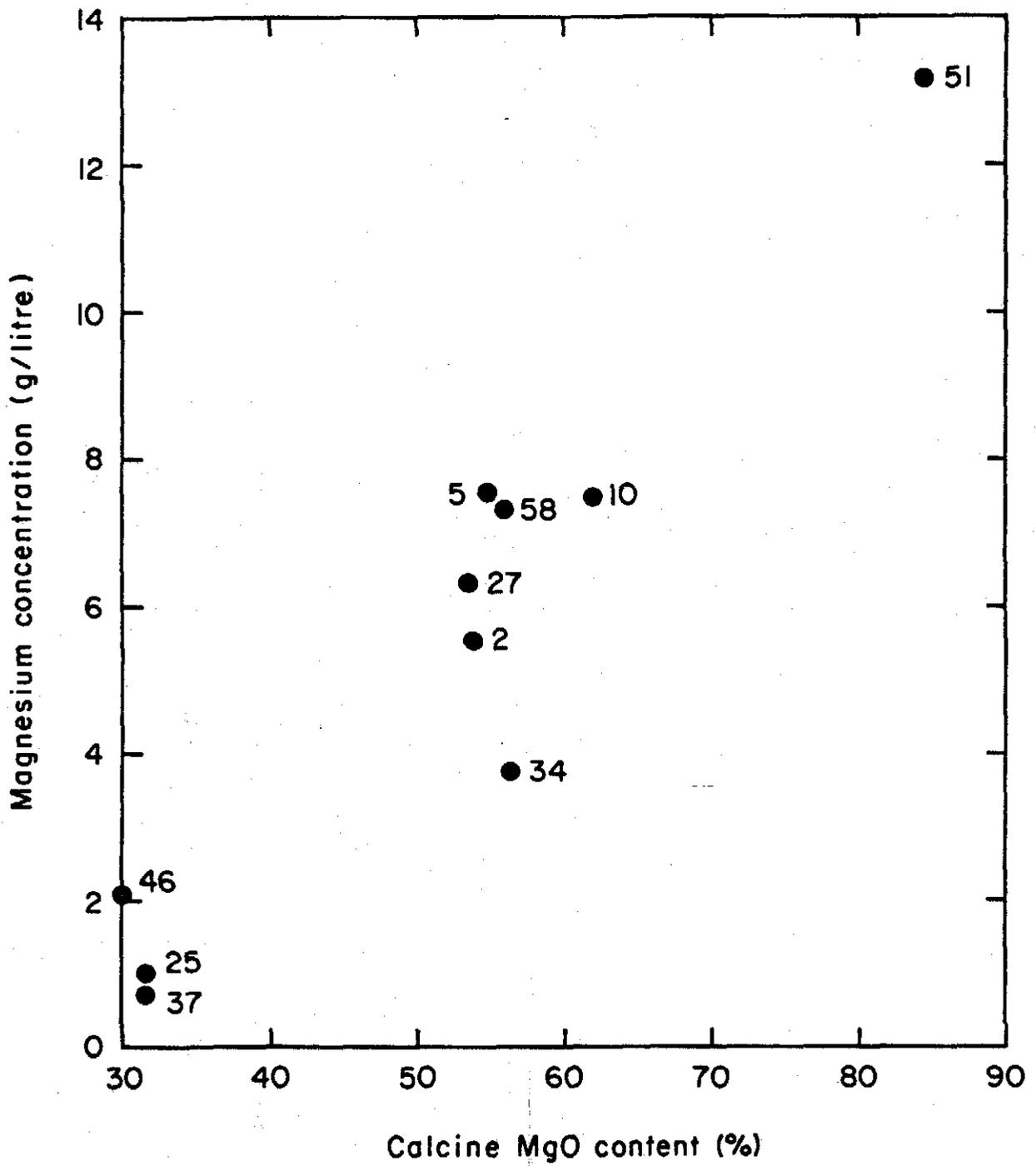


Fig. 23. Magnesium concentration as a function of calcine MgO content (leach at 3% solids, 15.5°C)

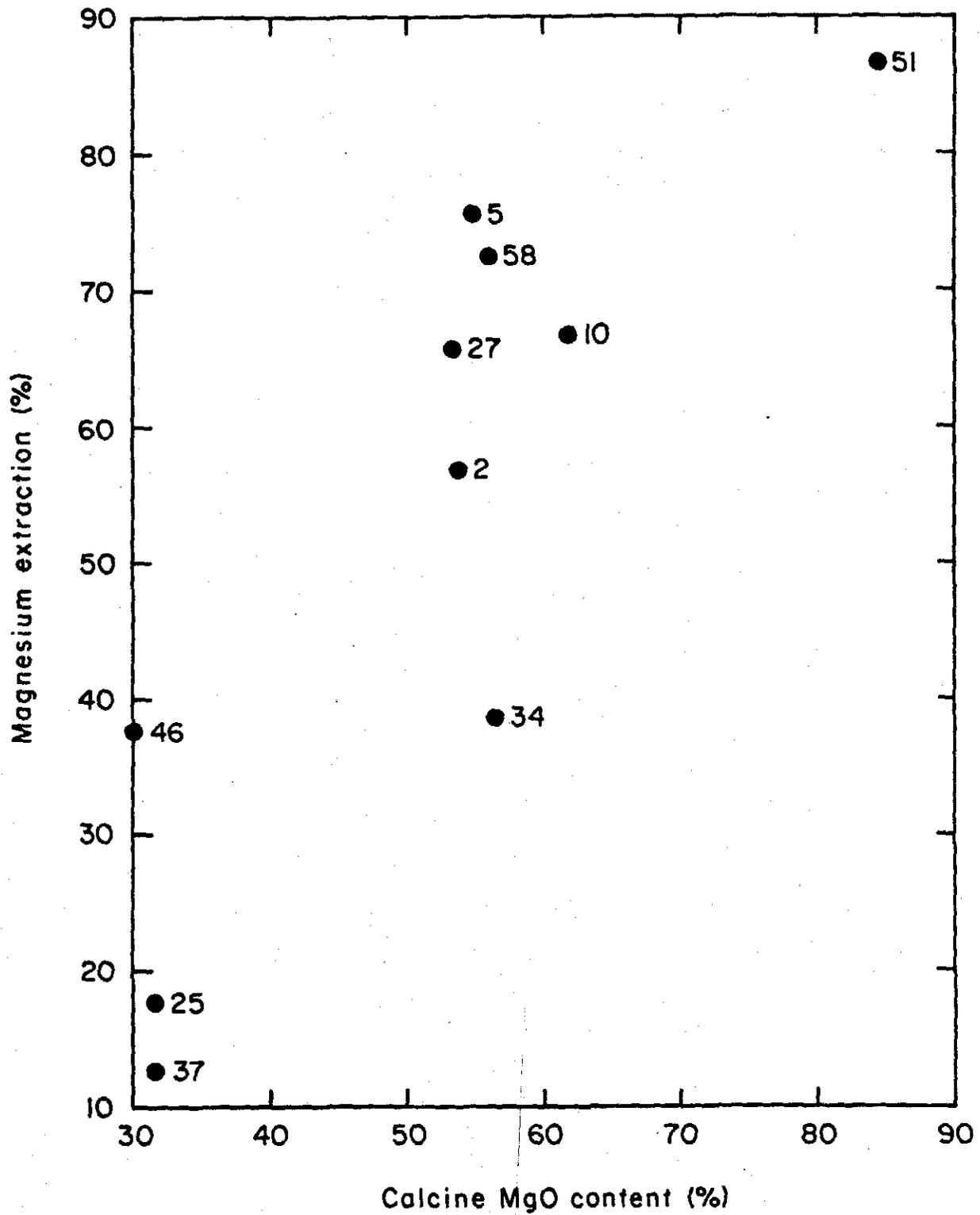


Fig. 24. Magnesium extraction as a function of calcine MgO content (leach at 3% solids, 15.5°C).

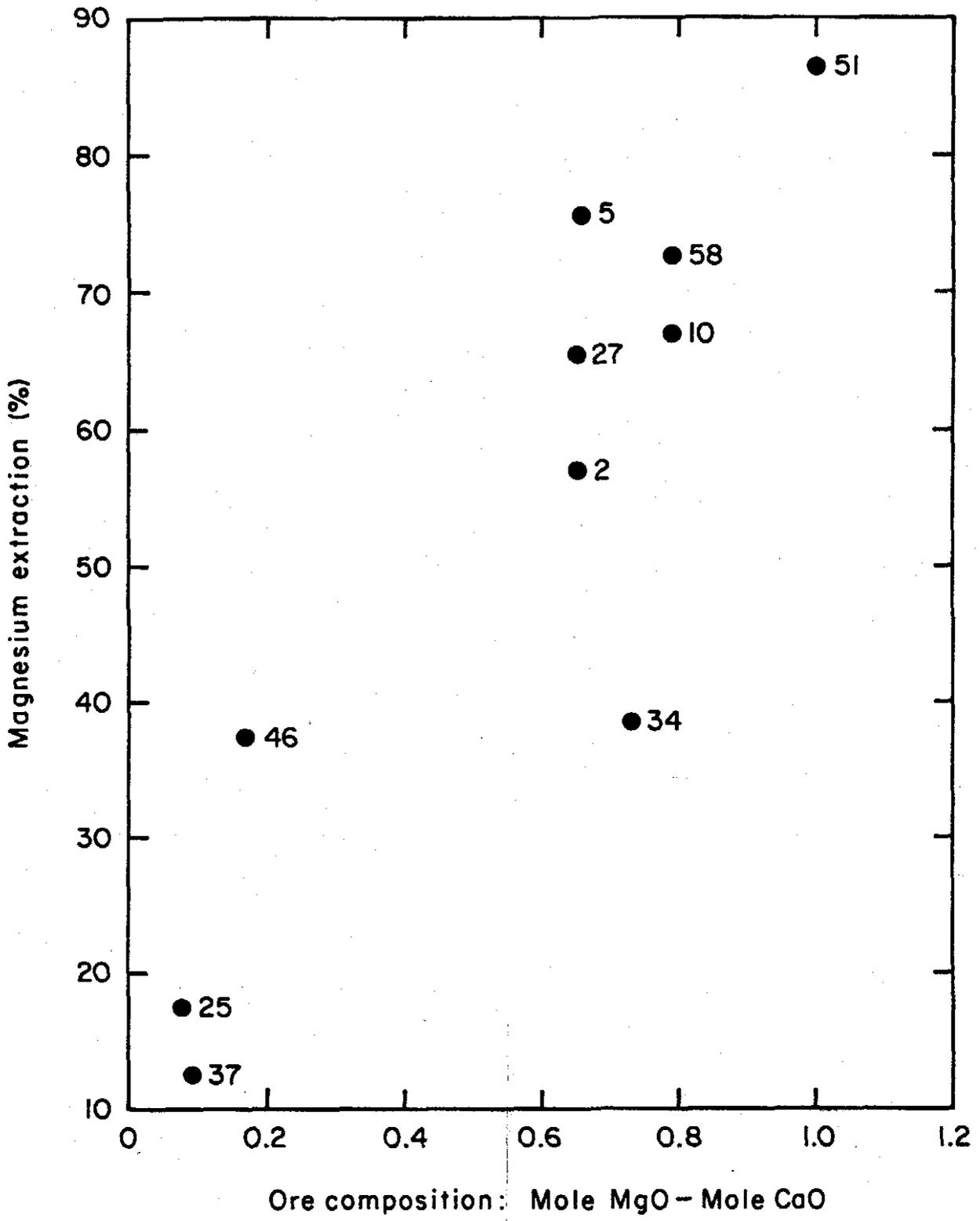


Fig. 25. Magnesium extraction as a function of ore composition [mole MgO-mole CaO] (leached at 3% solids, 15.5°C).

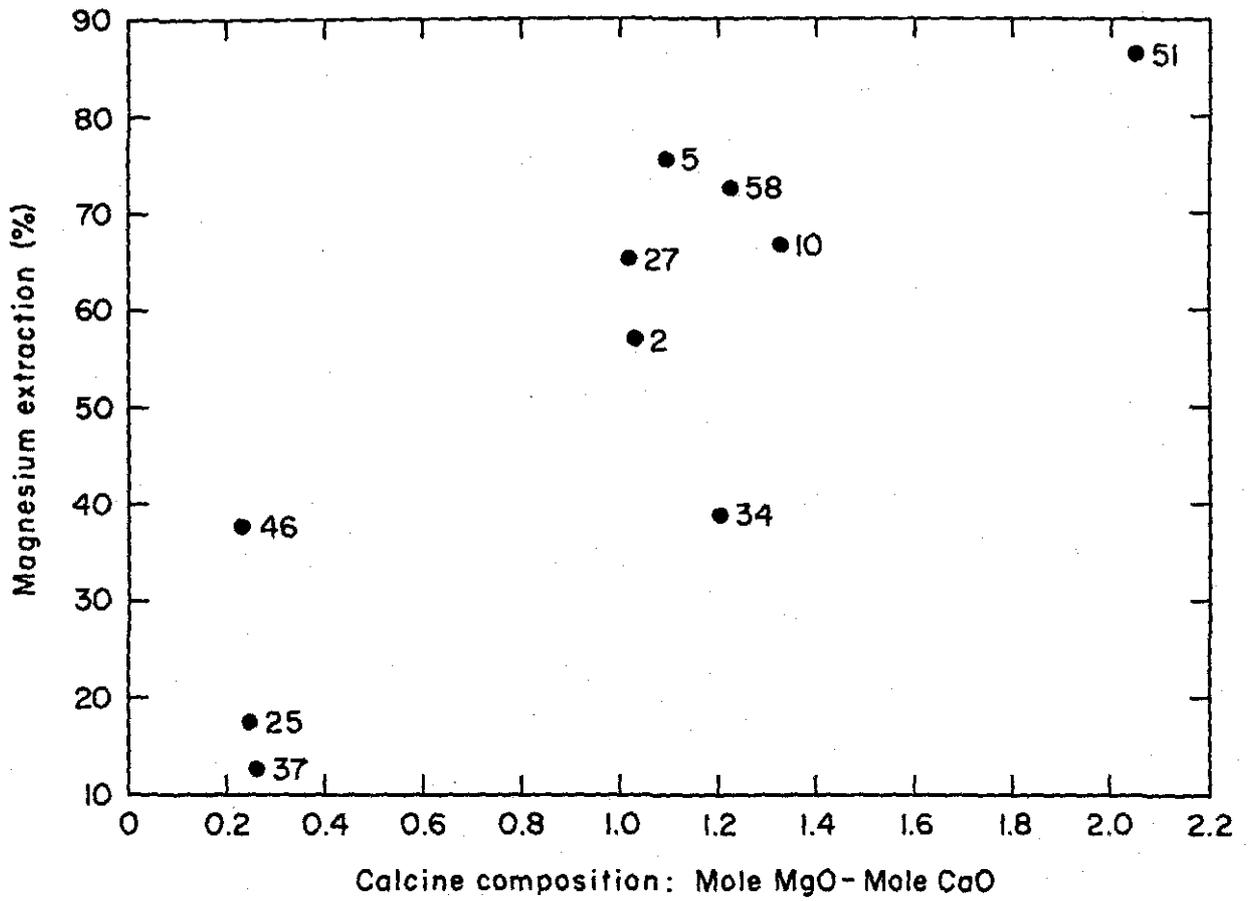


Fig. 26. Magnesium extraction as a function of calcine composition [mole MgO-mole CaO] (leached 3% solids, 15.5°C).

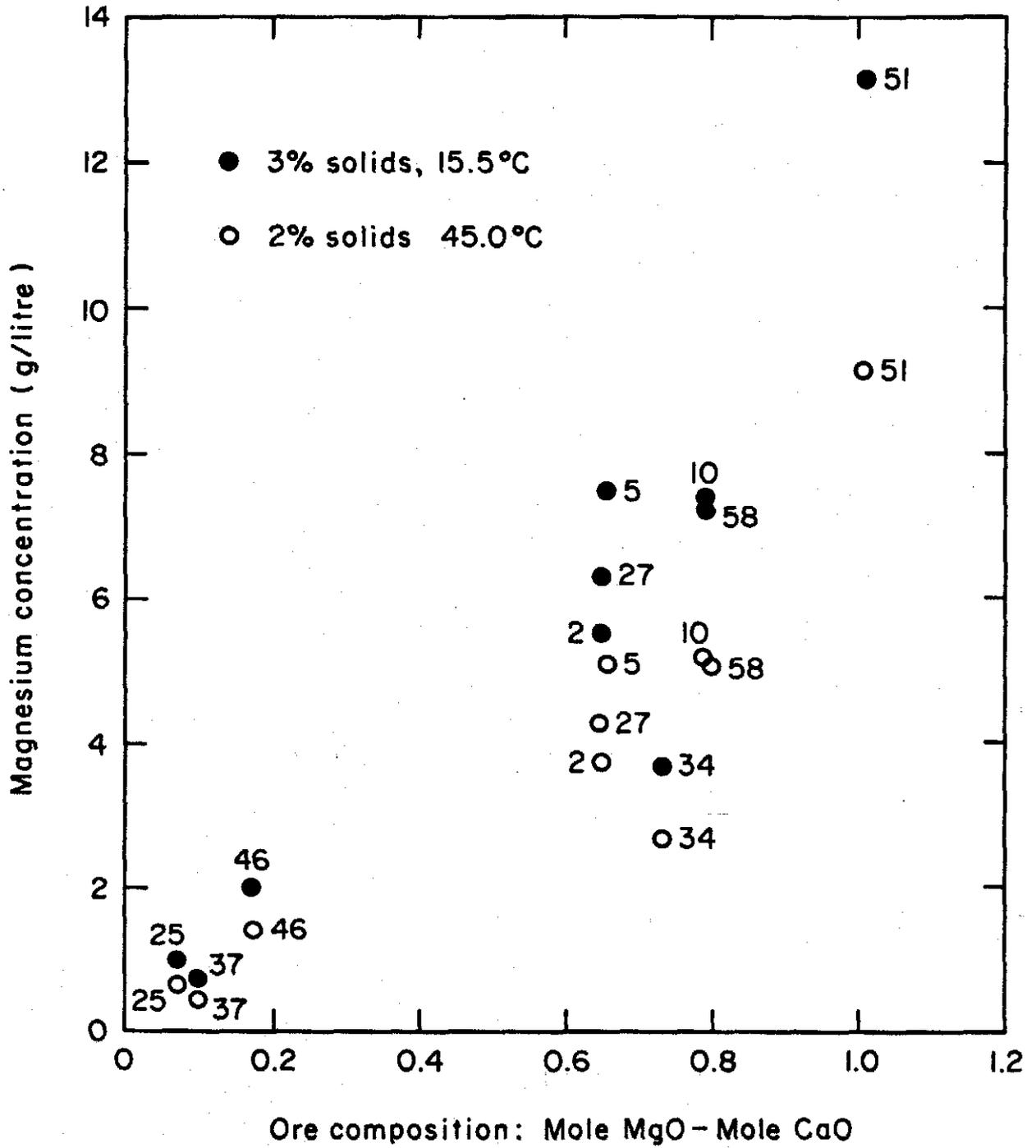


Fig. 27. Magnesium concentration as a function of ore composition (mole MgO-mole CaO) .

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APPENDIX II

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Division of Mineral Chemistry

AN EVALUATION OF THE MAIN CREEK MAGNESITE DEPOSIT

I. AN ASSESSMENT OF ORE GRADES AND RESERVES
BASED ON RECENT EXPLORATION

M.T. Frost, M. McCallum and C.M. MacCrae

June 1984

Mineral Chemistry Communication

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AN EVALUATION OF THE MAIN CREEK MAGNESITE DEPOSIT.

I. AN ASSESSMENT OF ORE GRADES AND RESERVES
BASED ON RECENT EXPLORATION.

ABSTRACT

A quantitative mineralogical analysis was made of 155 samples from DDH MC27, which was sunk about 2 km north of DDH MC1, and 58 samples from DDH MC28, which was sunk halfway between DDH MC1 and DDH MC27. A much higher grade of ore was found from samples taken from DDH MC27 compared with that from DDH MC28. Ninety-two metres of high-grade ore was found in samples from DDH MC27 whereas most of the carbonate found in samples from DDH MC28 was dolomite-rich and the amount of quartz and talc was significantly higher. Only 12% of samples from DDH MC28 contained more than 80% magnesite, compared with 76% in the case of DDH MC27, and most of these high grades were found at the base of the borehole. It is considered most likely that the main magnesite zones were not reached until near the end of the hole. The samples from DDH MC27 contain as much or more magnesite as that found in DDH MC1. Further drilling is recommended to confirm that the deposit is continuous from the area about DDH MC27 southwards to DDH MC2, and also to investigate the extent of the orebody about Bowry Creek.

1. INTRODUCTION

The evaluation of the Main Creek magnesite deposit has been progressing steadily for many years. Initially, Industrial and Mining Investigations sunk two boreholes (MC1 and MC2) and studies of core samples and surface mapping formed the basis of an earlier report [1]. In 1983 two further boreholes were sunk, and a more detailed surface geological survey was carried out by H. Shannon, Chief Geologist for Industrial and Mining Investigations. This work showed that the carbonate extended at least 2 km northwest along strike from DDH MC1 and that

extensive deposits of magnesite most likely occurred south of DDH MC2 about Bowry Creek. Figure 1 shows details of the surface mapping and the positions of all four diamond drill holes. Mineralogical data defining the grade of the magnesite from the two recently drilled boreholes are presented in this report. The report concentrates on the variations in the proportions of magnesite and the other minerals from regularly and frequently sampled core. A second report, to be issued soon, will include geochemical data of the minerals present and in particular will report on the amount of Fe in solid solution in the magnesite from the same set of samples. A third study now under way by personnel from the Division of Mathematics and Statistics will analyse these data statistically. Their methods of analysis are still being determined. The problems encountered in evaluating this type of ore are less straightforward than those found when dealing with continuously varying deposits. In this deposit magnesite occurs within distinct zones, which are distributed irregularly between bands of schist, and which are also of variable thickness.

2. EXPERIMENTAL DETAILS

Core was sampled every metre through the carbonate-rich zones and less frequently through the bands of schist and amphibolites. About 60 cm of core from each sample was halved and one-half halved again. One of the two resulting quarters was crushed in a hammer crusher and a 3 g sample of crushed ore (<1 mm.) was split carefully from the total sample, mounted in resin and polished. The proportions by volume of each phase were determined by either point counting using a scanning electron microscope or by a semi-automatic method in which phases are distinguished by their backscattered-electron and X-ray signals [2]. To investigate the variations introduced through sampling and sample preparation, one sample from DDH MC28 was prepared nine times. The results of careful point counting of all nine samples are shown in Table 1. The results show very satisfactory standard deviations of about 4% for dolomite and magnesite at the 40-50% level, and 25% for quartz at the 10% level. Altogether, 212 samples of carbonate-rich rock were examined. Modal analyses for carbonate-poor rocks, schists and amphibolites were obtained by point counting.

3. RESULTS

The sequence of rocks that both drill holes pass through consists of alternating carbonate and schist bands. Magnesite is usually the most abundant carbonate, although some bands very rich in dolomite are also present. Traces of calcite also occur but these are rare. Quartz and talc are found associated with the carbonate-rich zones. Minor hematite, pyrite and apatite are also recorded.

The schists contain typically quartz (10%), chlorite (50%), albite (30%) and K-felspar (10%), with minor hematite and pyrite. These rocks will be studied in more detail when further samples have been supplied.

Modal analyses of every sample of carbonate-rich rocks and for some schists for DDH MC 27 and MC28 are given in Tables 2 and 3 respectively. The distribution of magnesite, dolomite, quartz and talc (DDH MC28 only), are illustrated in Figs. 2 and 3 and emphasise the far superior grade of ore found in samples from DDH MC27 compared with those from DDH MC28. Forty-one per cent of samples from DDH MC27 contain more than 90% magnesite and 76% of samples contain more than 80%. These figures are obtained from samples whose total carbonate exceeds 30%. In contrast, only about 4% of samples from DDH MC28 contain more than 90% magnesite. Magnesite grades from the latter borehole show a very flat distribution, with no significant maximum at any value over the whole range of magnesite grades. Quartz and talc are found in significant proportions with 29% of samples containing more than 5% quartz and talc. More importantly, 38% of all carbonate-rich samples contain over 40% dolomite. In contrast, the distribution of grades in samples from DDH MC27 shows a marked peak at 90% magnesite and only 19% of samples contain more than 40% of dolomite. The proportions of quartz and silicates are very low, with only three samples from DDH MC27 containing 5% or more silicates. Twenty-four per cent of samples contain less than 1% of quartz and 38% contain less than 2%.

The much wider spread of carbonate compositions and the high and variable amounts of silicates present in carbonate-rich samples of DDH MC28 are illustrated in Fig. 4. Many rock compositions plot near the centre of the magnesite-dolomite-quartz projection and there are very few $MgCO_3$ -rich samples. In contrast, a much narrower distribution is shown in Fig. 5 in which data for DDH MC27 are presented. Most

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compositions occur close to the magnesite-dolomite boundary and Mg CO₃-rich compositions are very numerous.

The variation of grade along the boreholes is important as it provides information concerning reserves and the location of high-grade ore. Figure 6 illustrates the variation of magnesite, dolomite, quartz and talc through DDH MC28. The first 80 m of this borehole consists of poor-grade magnesite (40-60%) alternating with sometimes substantial bands of carbonate rich in dolomite and bands of schist. It is only after the major schist sequence between 120 and 138 m that the grade improves to 80% magnesite and above. Notice that when talc is found in significant amounts, quartz is very low and vice versa. Quartz and talc do not co-exist together at equilibrium at any temperature or CO₂ pressure for, as temperature rises at a given CO₂ content, quartz gives way to talc, i.e.

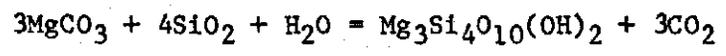


Figure 7 more clearly shows how magnesite grade is related to depth and to other rock types. One important feature that is illustrated is the relatively rapid changes in grade between schist bands. The latter could be discarded selectively, but the bands of dolomite-rich carbonates would present mining difficulties, because of their intimate association with the magnesite-rich material. In some cases (e.g., at 71-78 m), dolomite-rich zones are found to occur close to the schists, with much higher grade magnesite occurring in the central regions between neighbouring schists.

The variation of grade measured through DDH MC27 is illustrated in Figs. 8 and 9. Figure 8 shows specifically how magnesite, dolomite and quartz vary with depth. Talc was only found in significant proportions in a narrow zone between 286 and 297 m and was not included in Fig. 8. Figure 9 demonstrates the variation in rock types and how the major zones can be identified.

33 - 77 m	High-grade magnesite
78 - 111 m	Schist with minor carbonates
112 - 119 m	High-grade magnesite
120 - 128 m	Schist
129 - 142 m	High-grade magnesite

143 - 189 m	More dolomite-rich carbonates with less frequent magnesite-rich bands.
190 - 273 m	Schist.
274 - 297 m	Moderately high-grade magnesite.
298 - 312 m	Schists with minor magnesite bands.
313 - 326 m	High-grade magnesite.
326 - 363 m	Schist.

The analytical data for DDH MC27 can be summarised as follows;

92 m or 32%	High-grade magnesite. (>80% magnesite)
59 m or 20%	Medium-grade magnesite. (<80% magnesite)
141 m or 48%	Schist.

The implications of these data to an assessment of total reserves is significant, although more work needs to be done, both in the mineralogical assessment of core from DDH's MC1 and MC2, and in a further drilling program. The fact that analyses of core samples from DDH MC27 show excellent magnesite in substantial quantities provides firm evidence that the interpretation of field evidence is largely correct in that a very thick band of magnesite extends from DDH MC1 at least 2 km north along strike, as is shown in Fig. 1. The position of DDH MC28 lies between DDH MC1 and MC28 and the grade of magnesite through most of this borehole has been shown to be much poorer. This may mean that there are two magnesite-rich lenses, one to the south defined by DDH MC1 and DDH MC2, and one to the north defined by DDH MC27. However, DDH MC28 was, through unavoidable circumstances, very short in length and was started east (relative to strike) of both DDH MC27 and DDH MC2. It is considered likely, therefore, that the main magnesite deposit was only encountered at the base of DDH MC28, and that the major part of the sequence found in this hole represents the same dolomite and schist found at the top(?) of the magnesite in DDH MC1 and 2. Further drilling, at or slightly south of DDH MC28, but extending as deep as DDH MC27, would confirm this interpretation.

Some comparisons can be made about the quality of magnesite ore between DDH MC27, DDH MC2 and DDH MC1. The number and thickness of schist bands found in the southerly located boreholes is much lower. As has already been described, major schist bands occur throughout DDH

MC27, but only one important schist band occurs in DDH MC1, and this separates the dolomite from the main magnesite zone. The grade of ore about DDH MC1 and DDH MC2 is more difficult to compare because relatively few samples have been analysed from DDH MC1 and none have been analysed from DDH MC2. In the earlier report (Frost, 1981, Table 6 and Fig. 43), 54 samples were analysed for magnesite, dolomite and non-carbonates, from the magnesite-rich zone beneath the top dolomite and schist. Out of these, about 10% were found to contain over 90% magnesite and about 43% over 80%. This compares with 41% and 76% respectively for DDH MC27. Therefore, with the reservation that the sample is small for data from DDH MC1, the grade of magnesite from DDH MC27 is higher in the more northerly borehole.

This latest drilling program must raise considerably the estimate of the total reserves. If it is assumed that the carbonate intersection is the same as that calculated for the deposit at DDH MC1, i.e., 37,160 m² (see Frost, 1981, p.59), and that the orebody extends now 3 km instead of 500 m as was previously estimated, projected ore reserves are now about 260 million tonnes (assuming 80% magnesite throughout). Substantial schist bands recorded in DDH MC27 must reduce the high grade magnesite intersection compared with that further south at DDH MC1. Even assuming this intersection is, on average, halved, the projected reserves calculate to 133 million tonnes, or about three times the earlier estimate. ??

4. SUMMARY

The mineralogical analysis of 212 samples of carbonate-rich ore from the two boreholes DDH MC27 and DDH MC28 shows that extensive magnesite of high grade occurs at least 2 km north of the earlier exploration which is situated about DDH MC1 and MC2. It is considered likely that most of the main magnesite zone was missed by DDH MC28 and that a very thick deposit of magnesite extends continuously from Bowry Creek, or south of Bowry Creek, 2 or 3 km northwards. Therefore, this latest drilling program substantiates the idea that the whole deposit is very large with estimated reserves of between 130 and 260 million tonnes.

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To confirm that the magnesite extends continuously from DDH MC1 north to DDH MC27, it would be necessary to sink a deep hole close to, or slightly south of DDH MC28. A further hole, sunk about Bowry Creek would also be very enlightening because it would provide valuable evidence as to the southerly extent of the main orebody.

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1. Frost, M.T. The Savage River Magnesite Deposit. CSIRO Mineral Chemistry Report 351 (1981).
2. Barrett, D., Frost, M.T., Harrowfield, I.R., and Thomson, M., 1983. Symposium of the Royal Australian Chemical Institute, Solid State Division, p.20.

066

388067

Table 1. Modal analyses (vol.%) of a sample from DDH MC28.

Sample No.	Magnesite	Dolomite	Quartz	Talc	Hematite
1*	46.4	41.4	11.6	0.4	0
2	47.8	39.6	12.2	0.2	0.2
3	48.6	40.6	10.1	0.5	0.2
4	42.8	45.0	11.5	0.2	0.5
5	47.7	46.1	5.0	0.7	0.5
6	45.2	45.9	8.0	0.5	0.3
7	47.7	44.8	6.8	0.2	0.5
8	44.2	45.4	9.6	0.5	0.3
9	44.6	46.9	8.0	0.3	0.2
Means	46.1	44.0	9.2	0.4	0.3
s.d.	2.0	2.4	2.4	0.2	0.2

* 0.1% apatite.

067

388068

Table 2. The proportion of minerals in samples from DDH 28 (volume).

Depth	Ref.No.	Carbonates	Magnesite	Dolomite	Calcite	Silicates	Quartz	Talc	Hematite	Pyrite	Thin s.
53	476	90.6	49.2	41.4		9.4	9.4				
54	477	81.0	44.0	37.0		9.0	19.0				
55	478	85.0	61.2	23.8		4.9	14.9				
56	479	83.1	38.8	44.3		6.9	16.9				MF315
57	480	90.8	51.5	39.3		9.2	9.2				
58	481	92.3	72.9	19.4		7.7	7.7				
59	482	87.6	18.7	68.9		2.4	12.4				
60		--- schist ---									
61	483	92.7	63.4	29.3		7.3	7.3				
62	484	97.4	77.7	19.7		2.6	2.6				
63	485	82.0	57.5	23.5	1.0	8.0	3.0	15.0			
64	486	71.0	11.5	59.5		8.5	8.5	20.0			MF316
65	487	71.3	0.0	71.3		8.7	28.7				MF398
66	488	72.5	0.0	72.5		7.4	27.4				MF399
67	489	74.8	56.2	18.6		5.2	25.2				
68	490	54.0	32.5	20.0		3.5	43.0	2.5	0.5		MF400
69											
70		--- schist ---									
71	491	88.9	0.0	88.9		1.1	11.1				
72	492	97.9	2.0	87.9		0.0	10.0				
73	493	90.5	54.5	36.0	1.0	8.0	0.0	8.0			
74	494	91.0	59.5	31.5	0.5	7.0	0.0	7.0			
75	495	83.0	59.0	24.0		7.0	0.0	17.0			MF317
76	496	96.6	70.3	26.3		3.4	3.4				
77	497	96.0	0.8	95.2		4.0	4.0				
79	498	97.7	3.4	94.3		2.3	2.3				
80	499	98.4	0.1	98.3		1.6	1.6				
81	500	96.0	3.0	93.0	2.0	1.0	0.5	0.5			
82	501	89.5	13.0	76.0	0.5	0.5	0.0	10.5			
83	502	94.5	56.5	38.0		6.0	0.0	6.0			MF318
84	503	86.5	67.0	19.5	0.5	3.0	1.0	12.0			
85	504	80.0	9.5	70.5	1.5	8.5	2.5	16.0			
86	505	65.0	44.5	20.5	0.5	4.5	3.0	31.5			MF319
87	506	77.5	57.5	22.0		0.5	2.5	18.0			
88	507	86.5	60.0	18.5		1.0	0.5	20.5		0.5	
89											
90											
91		--- schist ---									
92											
93											
94	508	73.0	54.5	18.5		7.0	0.0	27.0			MF320
95	509		34.0	31.6	1.3	3.6	3.4	29.2			MF401
96	510	98.6	60.1	38.5		1.3	1.3				
97											
98											
99											
100		--- schist ---									
101											
102											
103	511	69.9	0.0	69.9		0.1	30.1				
106	512	89.5	0.0	89.5		0.5	10.5				
107	513	81.5	17.7	63.8		9.2	19.2				MF321
108	514	87.8	53.6	34.2		2.2	12.2				
109											

068

388069

Table 2 (continued).

Depth	Ref.No.	Carbonates	Magnesite	Dolomite	Calcite	Silicates	Quartz	Talc	Hematite	Pyrite	Thin s.
110		--- schist ---									
111											
112	515	89.6	0.7	88.9		0.4	10.4				
113	516	89.5	8.0	76.5	5.0	9.5	4.5	5.0			MF322
114		--- schist ---									
115											
116	517	97.8	31.2	66.6		2.1	2.1				
117		--- schist ---									
118	518	94.9	82.6	12.3		4.9	4.9				
119											
120											
121											
122											
123											
124											
125											
126											
127											
128		--- schist ---									
129											
130											
131											
132											
133											
134											
135											
136											
137											
138	519	97.5	79.9	17.6		2.4	2.4				
139											
140		--- schist ---									
141											
142	520	97.7	75.8	21.9		2.3	2.3				
143	587	97.9	13.1	84.8		2.1	2.1				
144	588	95.9	88.8	7.1		4.1	4.1				
145	589	98.4	73.5	24.9		1.2	1.2				
146	590	98.7	70.8	27.9		1.2	1.2				
147											
148											
149		--- schist ---									
150											
151											
152	591	98.0	91.0	7.0		1.5	1.0			0.5	
153	592	98.6	93.9	4.7	0.1	1.3	1.3				
154	593	00.0	91.0	9.0		0.0	0.0				
156	595	97.0	82.0	17.0					1.0		
157	594	87.2	0.0	87.2	2.2	0.5	10.5				
158	596	97.0	85.9	11.1		2.8	2.8				MF325
159	597	96.2	75.9	20.3		3.4	3.4				MF326
160		--- schist ---									
161											
162	598	95.4	72.0	23.4		4.4	4.4				
163	599	88.3	69.2	19.1		1.7	11.7				

069

388070

Table 3. The proportion of minerals in samples from DDH 27(volume %).

Depth	Ref.No.	Carbonates	Magnesite	Dolomite	Calcite	Silicates	Quartz	Talc	Chlorite	Felspar	Hematite	Pyrite	Thin S.
33	685	99.4	95.4	4.0		0.6	0.6						
34	686	99.2	92.1	7.1		0.8	0.8						MF327
35	687	99.3	93.9	5.4		0.6	0.6				0.1		
36	688	99.3	95.3	4.0		0.5	0.5				0.2		
37	689	98.0	87.3	10.7		2.0	1.0			1.0			
38		-----	schist	-----									
39	690	8.5	8.5			90.0	8.5		58.5	23.0		1.5	
40	691	98.2	86.9	11.3		1.8	1.8						
41	692	99.3	85.7	13.6		0.7	0.7						
42	693	99.4	95.7	3.7		0.6	0.6						
43		-----	schist	-----									
44	694	96.8	91.8	5.0		3.2	3.2						
45	695	96.9	91.5	5.4		3.1	3.1						
46	696	99.7	96.4	3.3		0.3	0.3						
47	697	99.1	90.9	8.2		0.9	0.9						
48	698	99.4	96.5	2.9		0.6	0.6						
49	699	98.0	92.6	5.2	0.2	1.9	1.9				0.1		MF328
50	700	98.4	94.0	4.4		1.6	1.6						
51	701	99.4	96.8	2.6		0.6	0.6						
52	702	98.3	91.1	7.2		1.7	1.7						
53	703	99.4	96.9	2.5		0.6	0.6						
54	704	98.7	89.9	8.8		1.3	1.3						
55	705	99.1	95.0	4.1		0.9	0.9						
56	706	99.4	95.7	3.7		0.6	0.6						
57	707	99.5	90.0	9.5		0.5	0.5						
58	708*	99.0	90.2	8.8		0.5	0.5						
59	709	98.4	71.2	27.2		1.6	1.6						MF329
60	710	99.0	93.0	6.0		1.0	1.0						
61	711	97.4	92.5	4.9		2.4	2.4					0.1	
62	712	97.3	93.7	3.6		2.5	2.5					0.2	
63	713	13.0	3.0	10.0		86.0	24.0	1.0	44.0	17.0	1.0		
64		-----	schist	-----									
65	714	97.9	86.5	11.4		1.9	1.9					0.2	
66	715	98.0	79.2	18.8		1.9	1.9					0.1	
67		-----	schist	-----									
68	716*	6.0	1.0	3.0	2.0	93.0	14.0	1.0	56.0	22.0			
69		-----	schist	-----									
70													
71	717	98.1	90.9	7.2		1.7	1.7					0.2	
72	718	96.2	87.8	8.4		3.8	3.8						
73	719	97.5	95.1	2.4		2.5	2.5						
74	720	96.1	74.8	21.3		3.8	3.8					0.1	MF331
75	721	95.5	79.6	15.9		4.3	4.3					0.2	
76	722	98.9	86.1	12.7	0.1	1.1	1.1						
77	723	94.8	39.0	55.8		5.0	5.0					0.2	
78		-----	schist	-----									
79													
80	724	96.9	68.4	28.5		3.1	3.1						
81		-----	schist	-----									
82	725	9.0	0.9	8.1		88.3	24.3		45.1	18.9	2.7		MF332
83													
84													
85		-----	schist	-----									
86													

070

388071

Table 3 (continued).

Depth	Ref.No.	Carbonates	Magnesite	Dolomite	Calcite	Silicates	Quartz	Talc	Chlorite	Felspar	Hematite	Pyrite	Thin S.
87		----- schist -----											
88													
89	726	88.0	53.0	35.0		11.0	1.0		10.0			1.0	MF333
90													
91													
92													
93													
94		----- schist -----											
95													
96													
97													
98													
99													
100	727	96.5	83.6	12.9		3.4	3.4					0.1	
101		----- schist -----											
102	728	97.3	61.3	36.0		2.6	2.6					0.1	
103	729	97.4	85.5	11.9		2.6	2.6						
104													
105													
106													
107		----- schist -----											
108													
109													
110													
111													
112	730	97.1	89.9	7.2		2.8	2.8					0.1	
113	731	97.1	84.7	12.4		2.8	2.8					0.1	
114	732	99.0	74.8	24.2		1.0	1.0						
115	733	98.3	84.5	13.8		1.7	1.7						
116	734	98.6	84.9	13.7		1.4	1.4						
117	735	98.6	87.4	11.2		1.3	1.3					0.1	
118	736	98.6	90.0	8.6		1.4	1.4						
119	737	96.9	42.0	54.9		3.1	3.1						
120		----- schist -----											
121													
122	738	4.5		2.7	1.8	93.7	19.5		44.4	29.8		1.8	MF334
123													
124													
125		----- schist -----											
126													
127													
128													
129	739	98.8	92.9	5.9		1.2	1.2						
130	740	99.9	98.6	1.3		0.1	0.1						
131	741	99.1	94.1	5.0		0.6	0.6					0.3	
132	742	99.4	97.1	2.3		0.6	0.6						MF335
133	743	98.9	94.0	4.9		1.1	1.1						
134	744	99.1	91.6	7.5		0.9	0.9						
135		----- schist -----											
136													
137	745	99.3	90.6	8.7		0.6	0.6					0.1	
138	746	98.2	87.8	10.4		1.7	1.7					0.1	
139	747	98.3	84.9	13.4		1.5	1.5					0.2	
140	748	97.1	90.5	6.6		1.0	1.0					1.9	

071

388072

Table 3 (continued)

Depth	Ref.No.	Carbonates	Magnesite	Dolomite	Calcite	Silicates	Quartz	Talc	Chlorite	Felspar	Hematite	Pyrite	Thin S.
141	749	99.3	81.3	18.0		0.7	0.7						
142	750	98.8	79.2	19.6		1.0	1.0					0.2	
143	751	98.5	17.5	81.0	1.0	0.5			0.5				
144	752	99.0	82.5	16.5		1.0	1.0						
145	753	96.8	29.7	67.0	0.1	3.0	3.0				0.1	0.1	MF336
146	754	98.1	56.0	42.1		1.9	1.9						
147	600	98.3	39.0	60.3		0.7	0.7						
148	601	98.8	26.0	72.8		1.2	1.2						
149	602	98.0	4.0	94.0		2.0	2.0						
150	603	98.4	4.1	94.3		1.6	1.6						
151	604	98.7	8.5	90.2		1.3	1.3						
152	605	97.8	34.1	63.7		2.2	2.2						
153	606	98.7	79.9	18.8		1.3	1.3						
154	607	99.5	95.4	4.1		0.5	0.5						
155	608	98.5	64.0	34.5		1.2	1.2					0.3	
156	609	98.0	7.5	90.5		2.0	2.0						
157	610	98.7	63.0	35.7		1.3	1.3						
158	611	98.3	90.5	7.8		1.6	1.6					0.1	
159	612	96.3	67.6	28.7		3.5	3.5					0.2	
160	613	99.5	95.8	3.7		0.5	0.5						
161	614	94.8	90.8	4.0		5.2	5.2						MF402
162	615	98.6	90.7	7.9		1.4	1.4						
163	616	98.0	70.4	27.6		2.0	2.0						
164	617	97.8	67.1	30.7		2.2	2.2						
165	618	98.3	29.4	68.9		1.7	1.7						
166	619	97.5	7.9	89.6		2.5	2.5						
167	620	99.2	53.9	45.3		0.8	0.8						
168	621	99.0	60.0	39.0		1.0			1.0				
169	622	99.0	39.0	60.0		1.0	1.0						
170	623	99.9	25.3	74.6		1.0	1.0						
171	624	97.9	42.1	55.8		2.1	2.1						
172	625	97.1	74.3	22.8		2.9	2.9						
173	626	98.8	89.7	9.1		1.2	1.2						
174	627	99.4	37.4	62.0		0.6	0.6						
175	628	96.4	80.5	15.9		3.6	3.6						
176	629	99.5	86.6	12.9		0.5	0.5						MF403
177	630	93.9	89.1	4.8		6.1	6.1						
180	631	98.4	82.7	15.7		1.6	1.6						
181	632	98.7	49.9	48.8		1.3	1.3						MF338
182	633	98.2	65.3	32.9		1.8	1.8						
183	634	98.4	57.2	41.2		1.6	1.6						
184	635	97.7	55.0	42.7		2.3	2.3						
185	636	96.4	52.5	43.9		3.6	3.6						MF339
186	637	97.5	62.4	35.1		2.5	2.5						
187	638	96.4	58.5	37.9		3.3	3.3					0.3	
188	639	97.9	78.8	19.1		2.1	2.1						
189	640	98.0	77.0	21.0		2.0	2.0						
190													
191													
192													
193													
194													
195													
196													

- - - - schist - - - -

072

388073

Table 3 (continued).

Depth	Ref.No.	Carbonates	Magnesite	Dolomite	Calcite	Silicates	Quartz	Talc	Chlorite	Felspar	Hematite	Pyrite	Thin S.
197													
198			----- schist -----										
199													
200	641	5.3		1.5	3.8	92.4	15.9		49.2	27.3	2.3		MF340
201													
202													
203													
204													
205													
206													
207													
208													
209													
209													
210													
211													
212													
213													
214													
215													
216													
217													
218													
219			----- schist -----										
220													
221													
222													
223													
224													
225													
226													
227													
228													
229													
230													
231													
232													
233													
234													
235													
236													
237													
238													
239	642	96.4	58.6	37.8		3.6	3.6						
240	643	96.6	36.3	60.3		3.2	3.2					0.2	
241													
242													
243													
244													
245			----- schist -----										
246													
247													
248													
249													

073

388074

Table 3 (continued).

Depth	Ref.No.	Carbonates	Magnesite	Dolomite	Calcite	Silicates	Quartz	Talc	Chlorite	Felspar	Hematite	Pyrite	Thin S.
250													
251													
252													
253													
254													
255													
256													
257													
258													
259													
260													
261													
262													
263													
264													
265													
266													
267													
268													
269													
270													
271													
272													
273													
274	644	96.3	27.3	69.0		3.7	3.7						
275	645	98.3	62.2	36.1		1.7	1.7						
276	646	97.8	80.5	17.3		2.2		0.7	1.5				
277	647	98.8	82.7	16.1		1.2	1.2						
278	648	98.6	92.2	6.4		1.4	1.4						
279	649	99.3	90.6	8.7		0.7	0.7						
280	650	99.4	72.9	26.5		0.6	0.6						
281	651	98.7	74.2	24.5		1.3	1.3						
282	652	98.7	79.4	19.3		1.3	1.3						
283	653	97.5	83.1	14.4		2.5	2.5						
284	654	97.6	65.9	31.7		2.4	2.4						
285	655	98.2	71.8	26.4		1.8	1.8						
286	656	97.0	76.0	21.0		1.0	1.0	2.0					
287	657	98.4	58.5	39.9		1.6	1.6						
288	658	95.0	81.0	14.0		5.0		5.0					
289	659	92.2	77.5	14.7		7.8		7.8					
290	660	98.4	81.7	16.7		1.6	1.6						
291	661	96.0	74.0	22.0		4.0		4.0					
292	662	92.5	73.6	18.9		7.5	0.9	6.6					
293	663	90.0	73.0	17.0		1.0		10.0					
294	664	91.0	75.0	16.0		9.0		9.0					
295	665	92.3	89.4	2.9		7.7		7.7					
296	666	98.5	77.5	21.0		1.5	0.5	1.0					
297	667	95.0	54.0	41.0		5.0	1.0	4.0					
298													
299													
300													
301													
302													
303													

074

388075

Table 3 (continued).

Depth	Ref.No.	Carbonates	Magnesite	Dolomite	Calcite	Silicates	Quartz	Talc	Chlorite	Felspar	Hematite	Pyrite	Thin S.
304													
305													
306			----- schist -----										
307													
308	668	96.7	15.6	81.1		3.3	3.3						MF341
309	669	94.7	61.7	33.0		5.3	5.3						
310	670	97.0	38.7	58.3		3.0	2.6	0.4					MF404
311			----- schist -----										
312													
313	671	98.6	82.7	15.9		1.4	1.4						
314	672	98.5	88.3	10.2		1.5	1.5						
315	673	98.8	91.2	7.6		1.2	1.2						
316	674	99.1	90.9	8.2		0.9	0.9						
317	675	99.2	83.7	15.5		0.8	0.8						
318	676	99.2	72.0	27.2		0.8	0.8						
319	677	98.8	80.0	18.8		1.2	1.2						
320	678	99.1	65.1	34.0		0.9	0.9						
321	679	98.2	79.7	18.5		1.8	1.8						
322	680	99.0	88.8	10.2		1.0	1.0						
323	681	96.7	91.5	5.2		3.3	3.3						
324	682	97.9	78.3	19.6		2.1	2.1						
325	683	96.9	57.1	39.8		3.1	3.1						
326													
327													
328													
329													
330													
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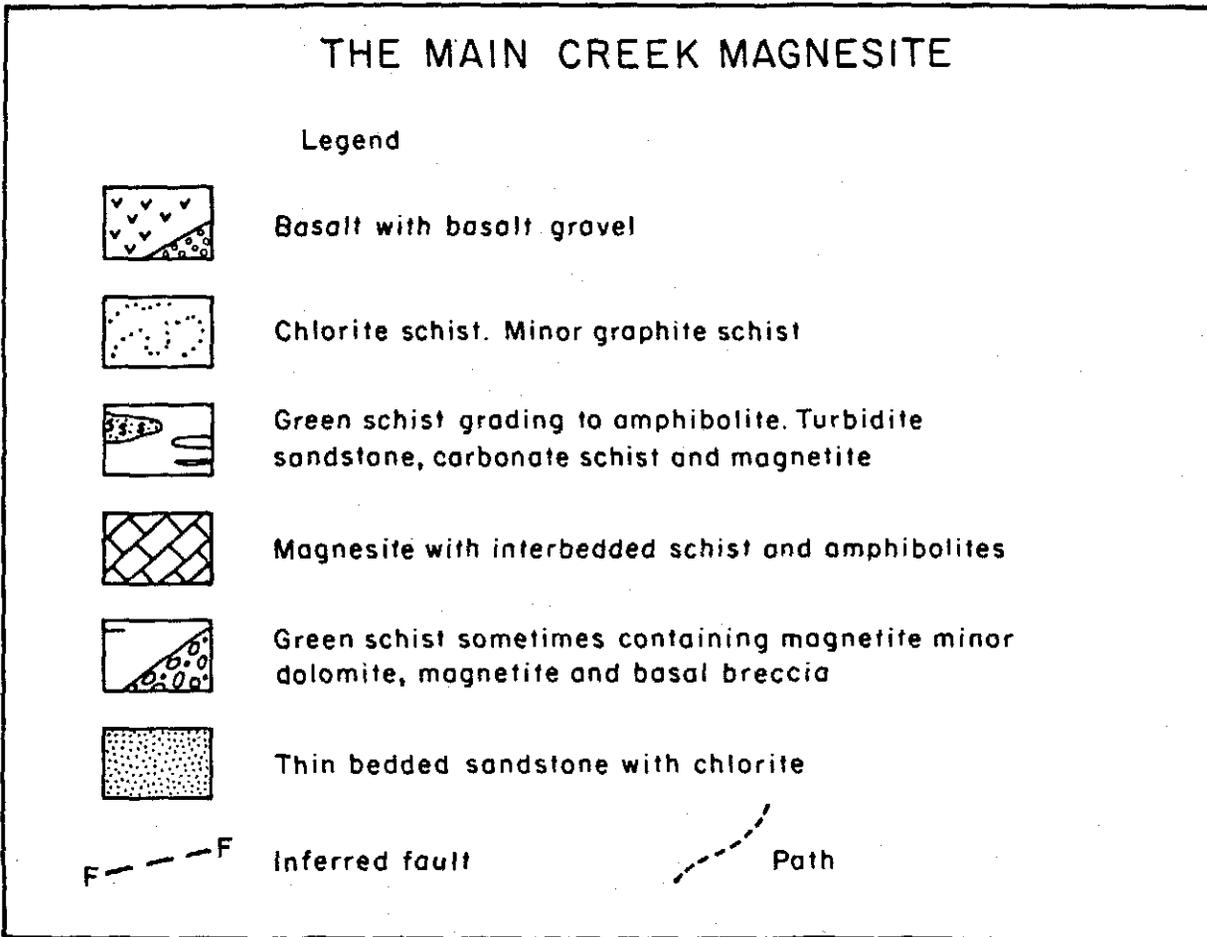
075

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Table 3 (continued).

Depth	Ref.No.	Carbonates	Magnesite	Dolomite	Calcite	Silicates	Quartz	Talc	Chlorite	Felspar	Hematite	Pyrite	Thin S.
359													
360													
361	684	24.8		24.8		67.6	11.4	16.2	4.8	35.2		7.6	NF342

*Contains apatite.



077

388078

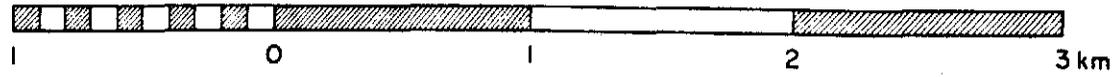
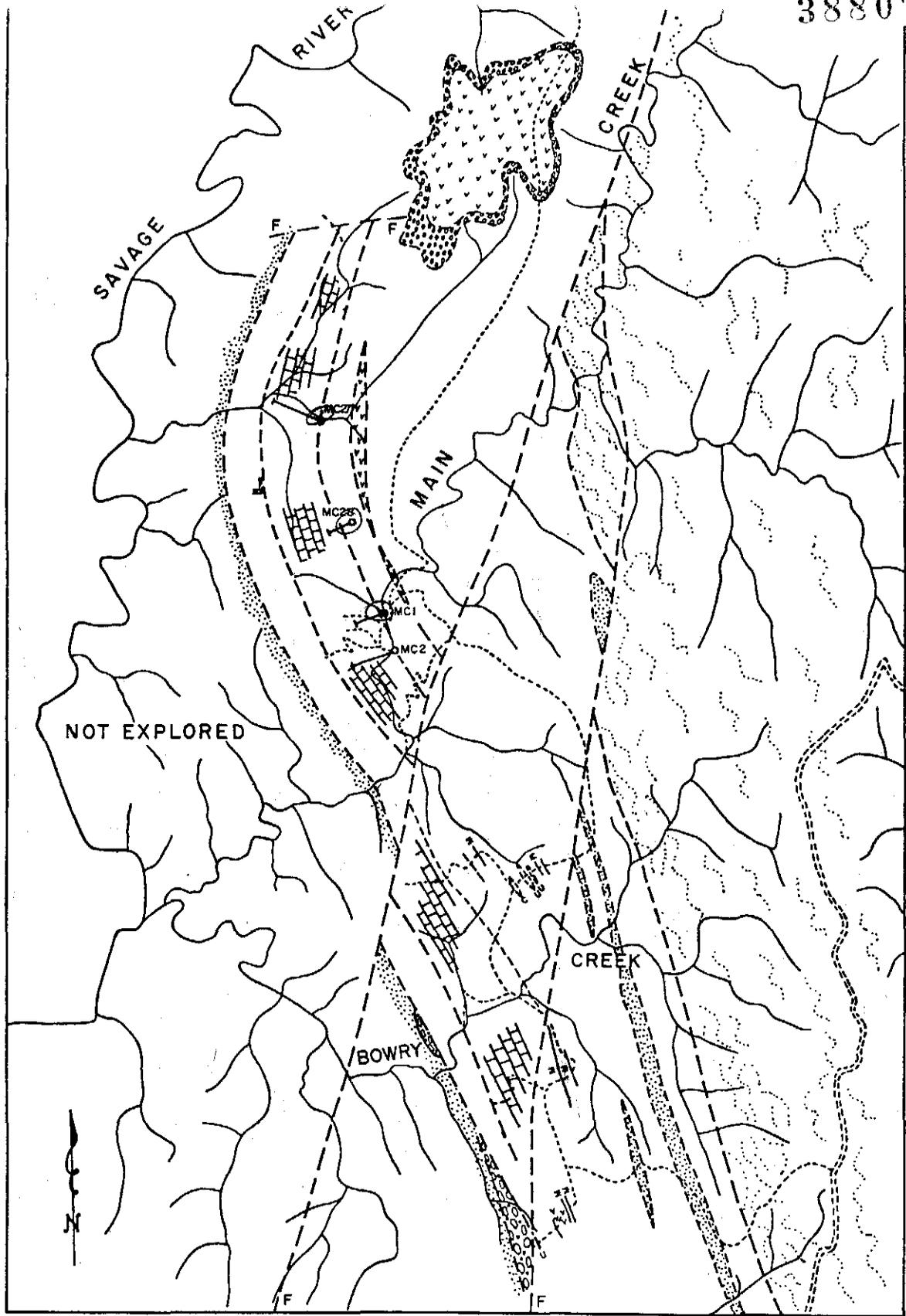
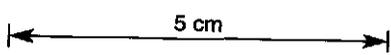


Fig. 1. The geology of the Main Creek area. The two recently sunk holes, DDH MC28 and DDH MC27 are marked, together with DDH MC1 and DDH MC2 to the south.



D.D.H. 28

- 20 -

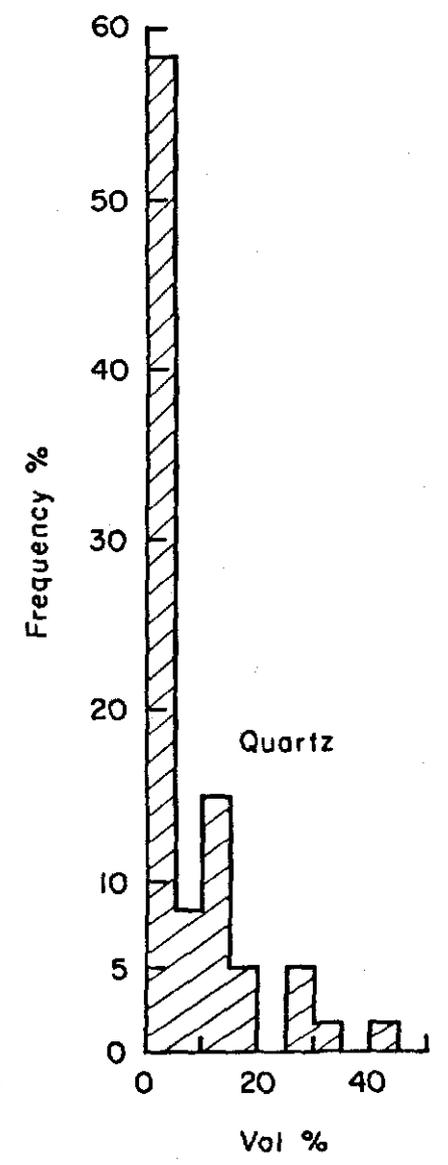
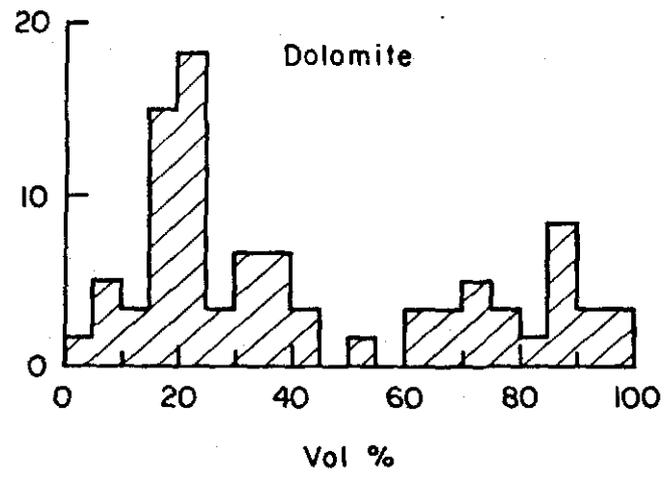
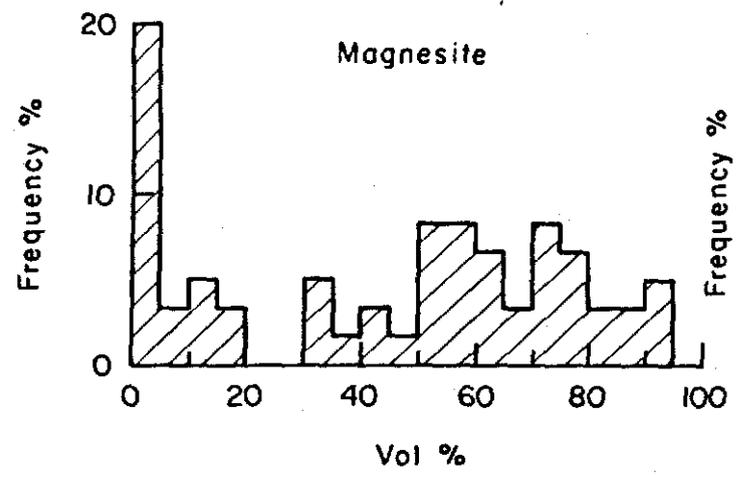


Fig. 2. The distribution of magnesite, dolomite, quartz and talc from 58 samples of ore from DDH MC28.

D.D.H. 27

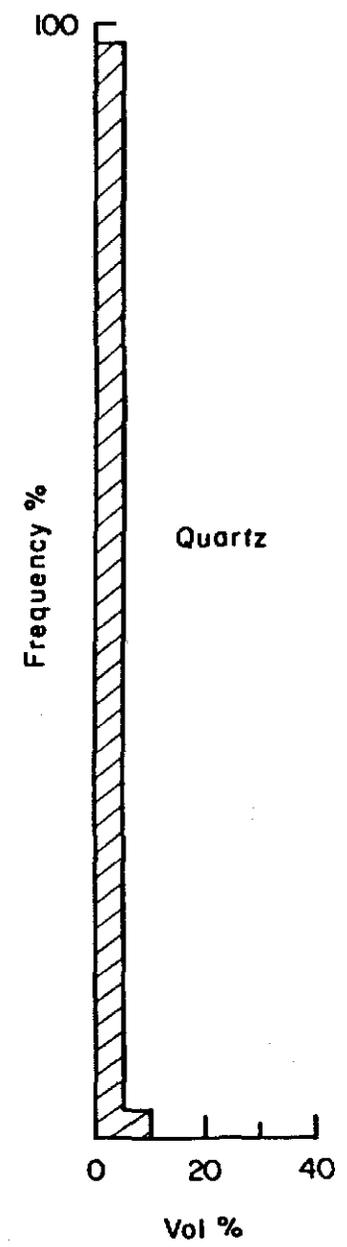
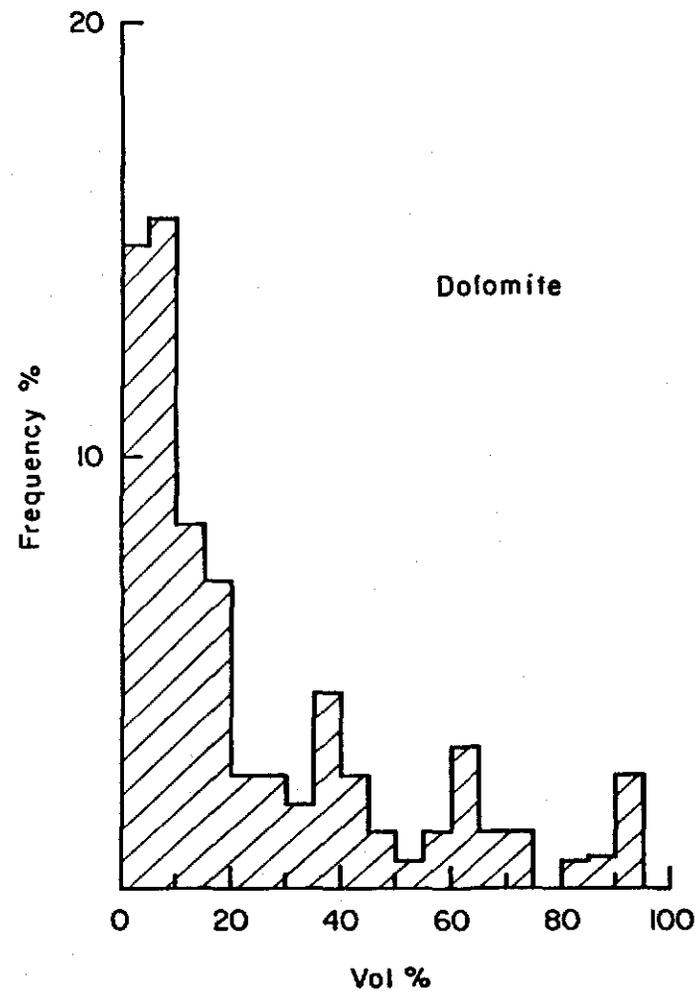
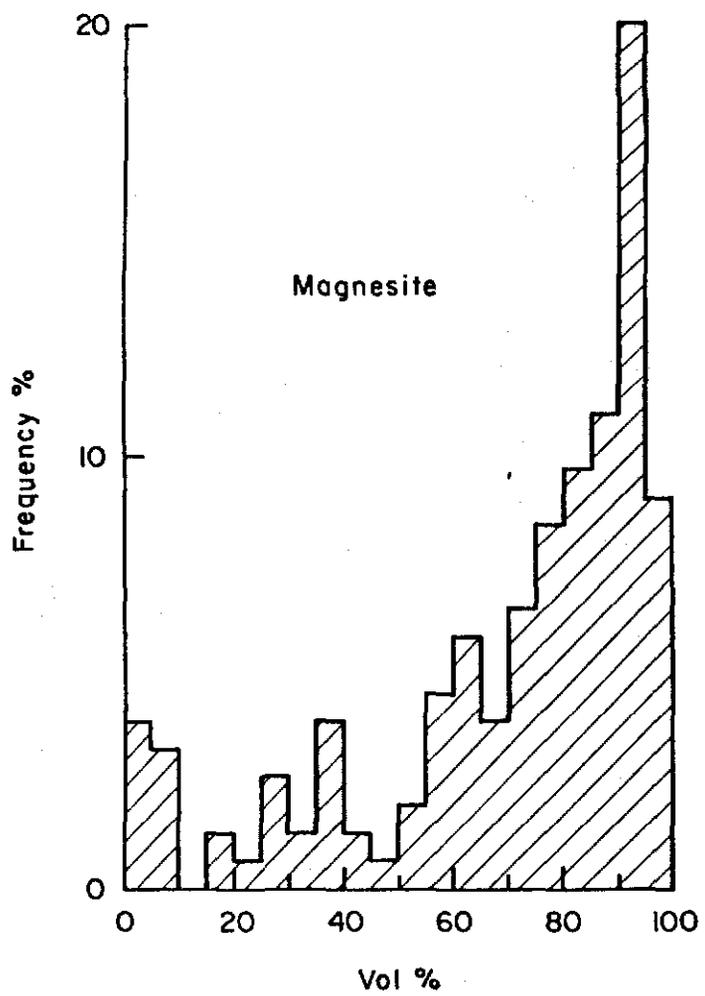


Fig. 3. The distribution of magnesite, dolomite and quartz from 155 samples of ore from DDH MC27.

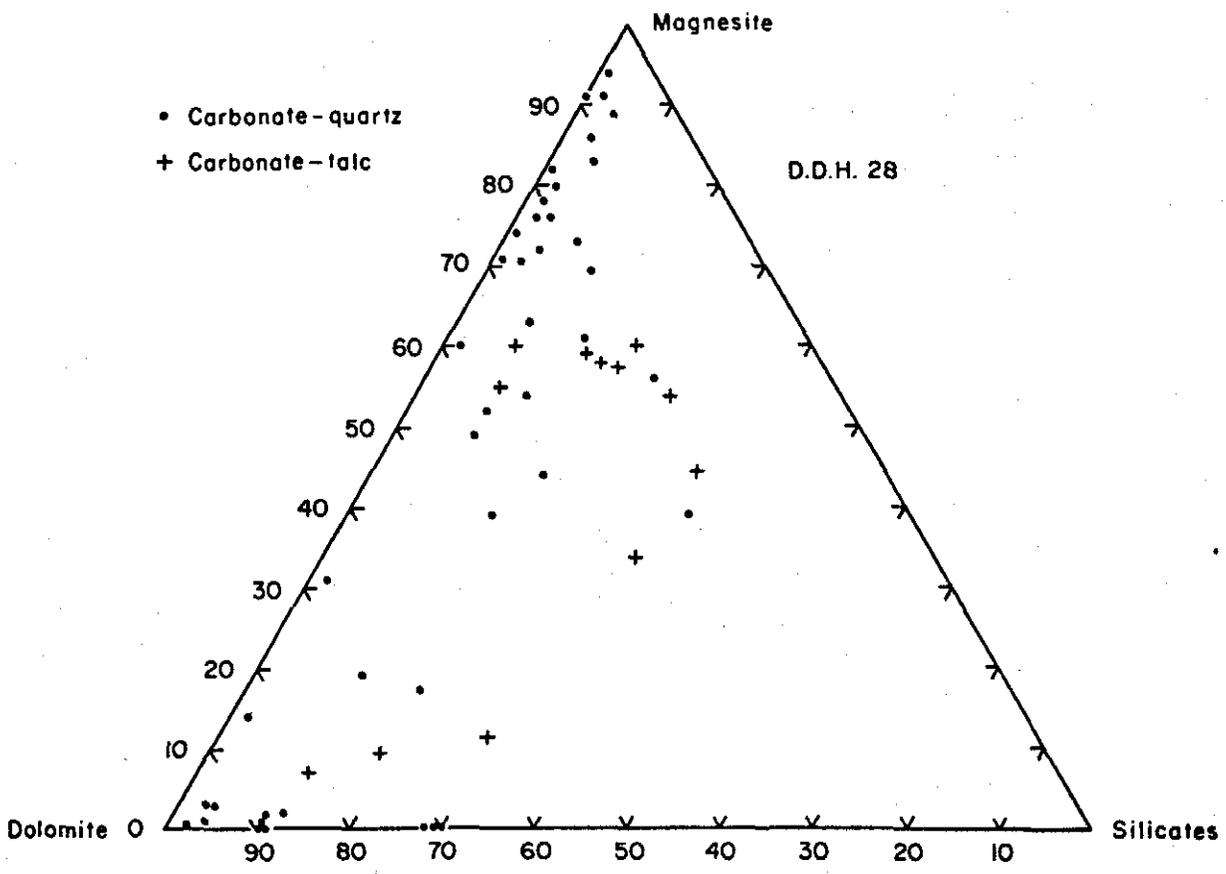


Fig. 4. A ternary plot illustrating the distribution of mineral proportions from samples taken from DDH MC28.

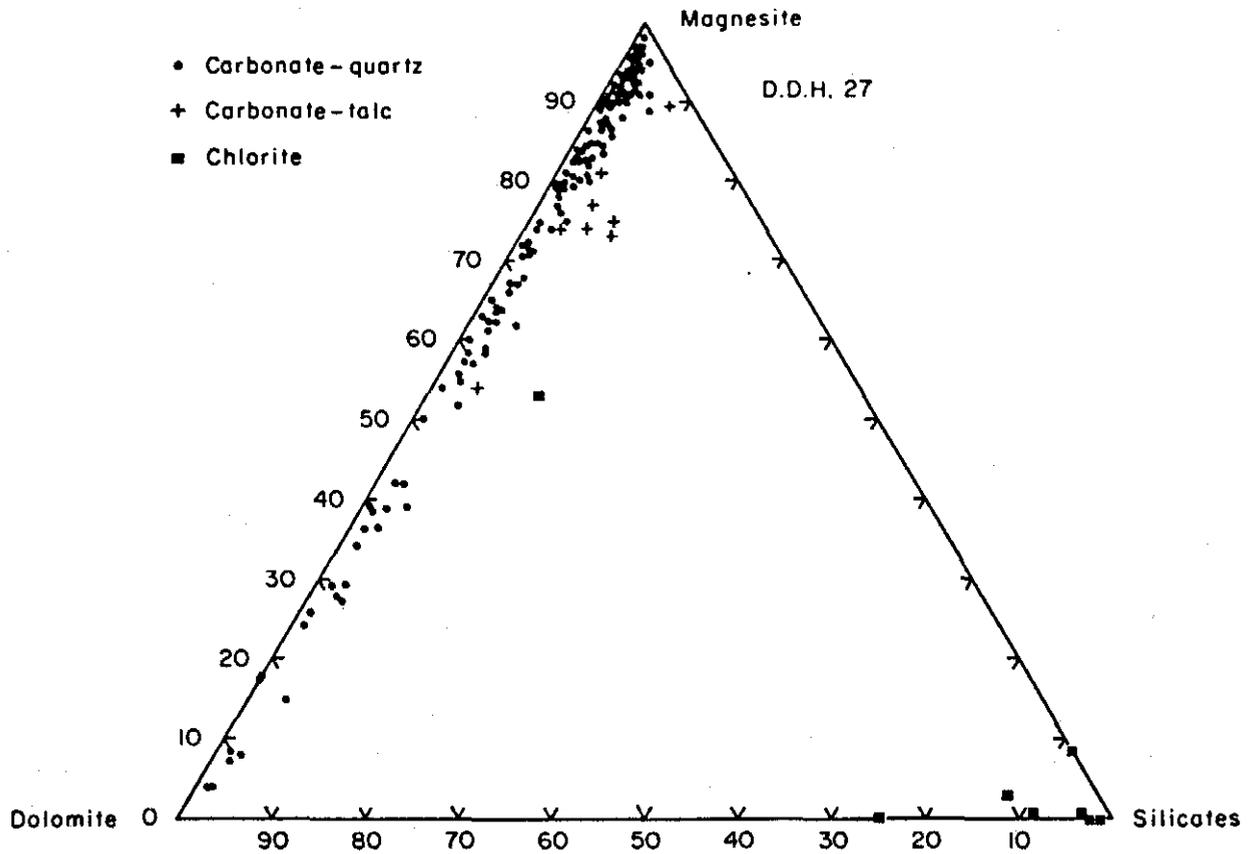
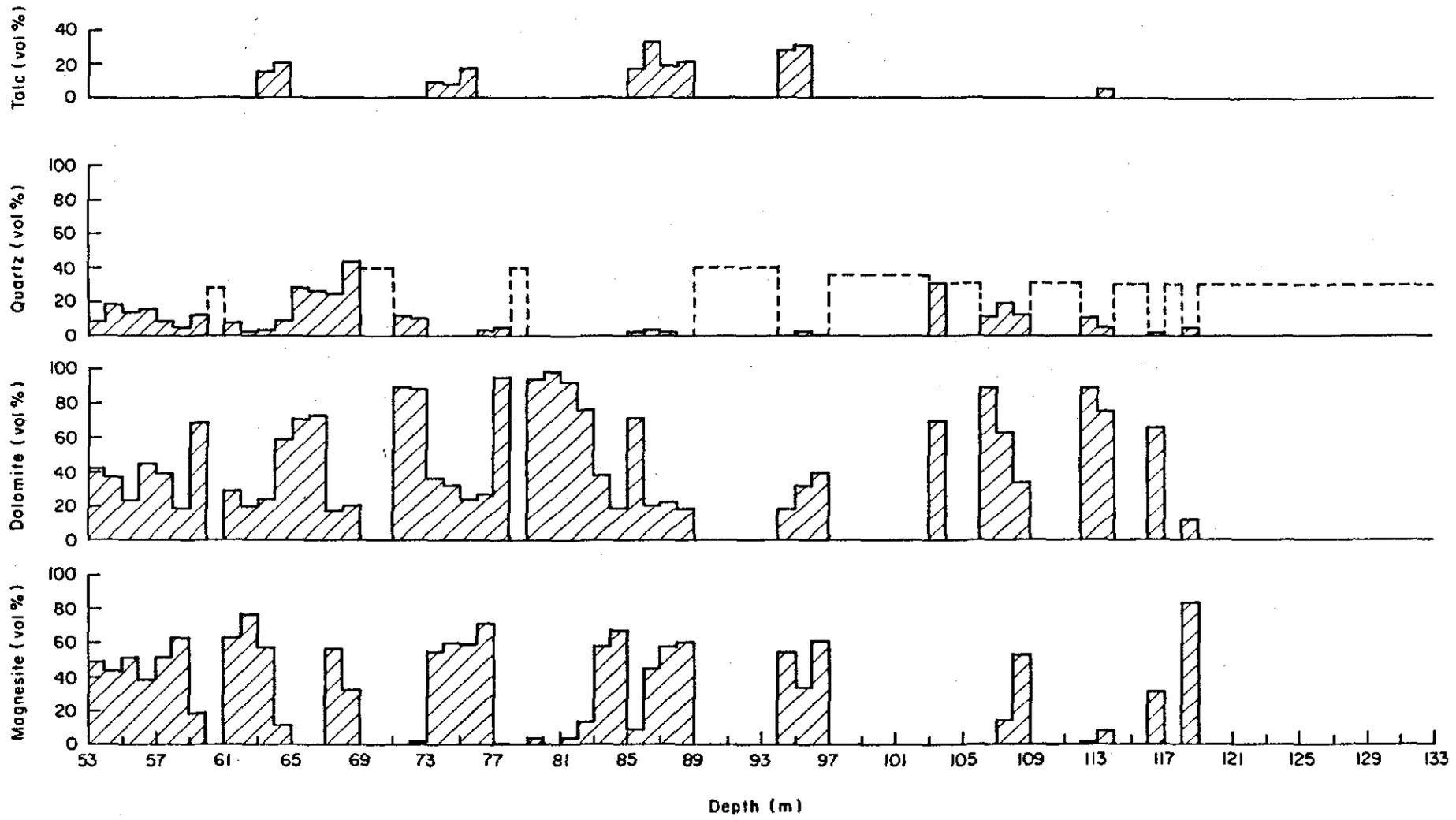


Fig. 5. A ternary plot illustrating the distribution of mineral proportions from samples taken from DDH MC27.

D.D.H. 28 (53-133m)



D.D.H. 28 (135-163)

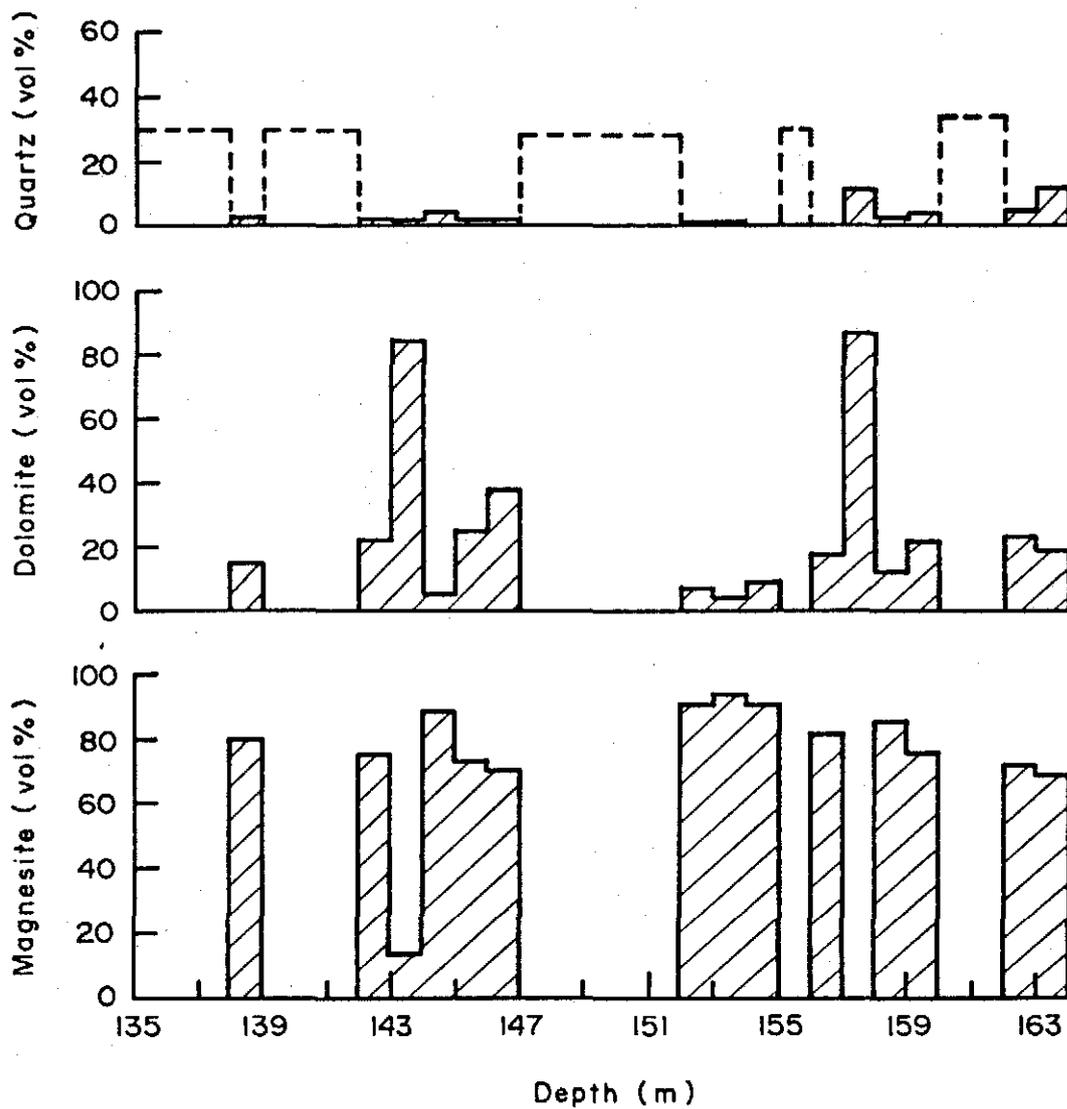


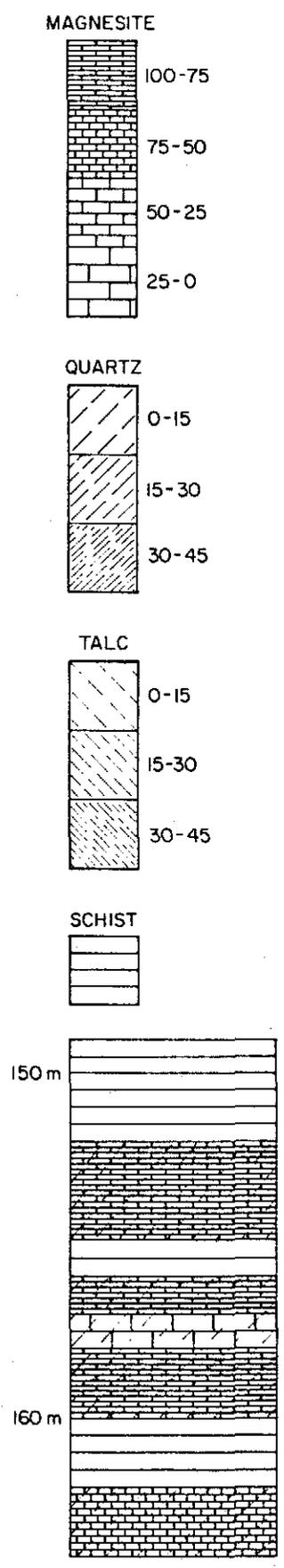
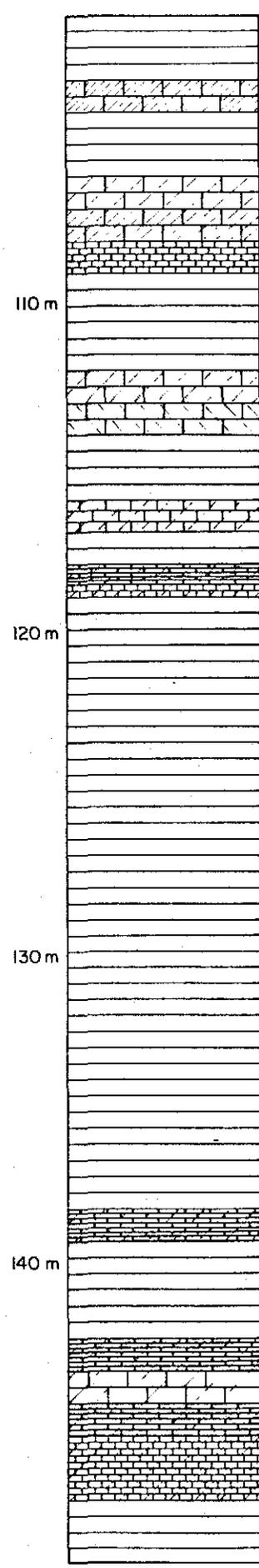
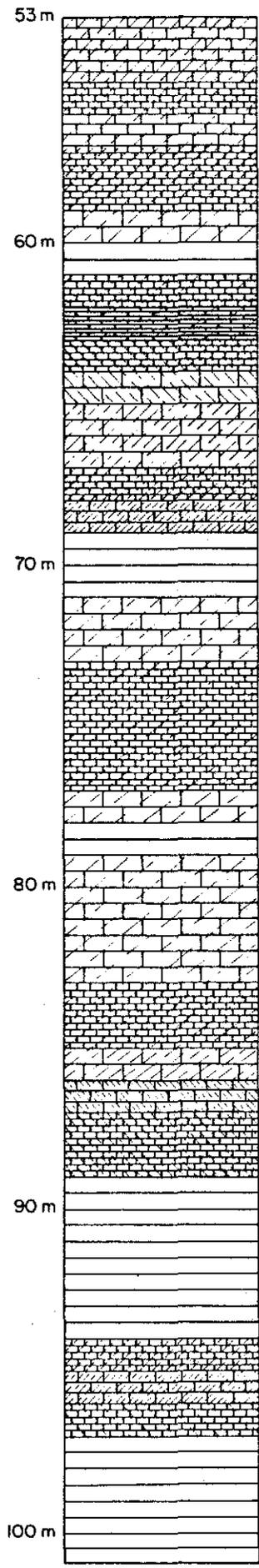
Fig. 6. The variation of magnesite, dolomite, quartz and talc with depth through DDH MC28.

Fig. 7. An illustration of the rock types and grade of magnesite found in DDH MC28. Notice how in some cases proportionally more magnesite is found nearer the centre of a carbonate sequence between two schist bands (e.g., 71-78 m).

087

388088

D.D.H. 28

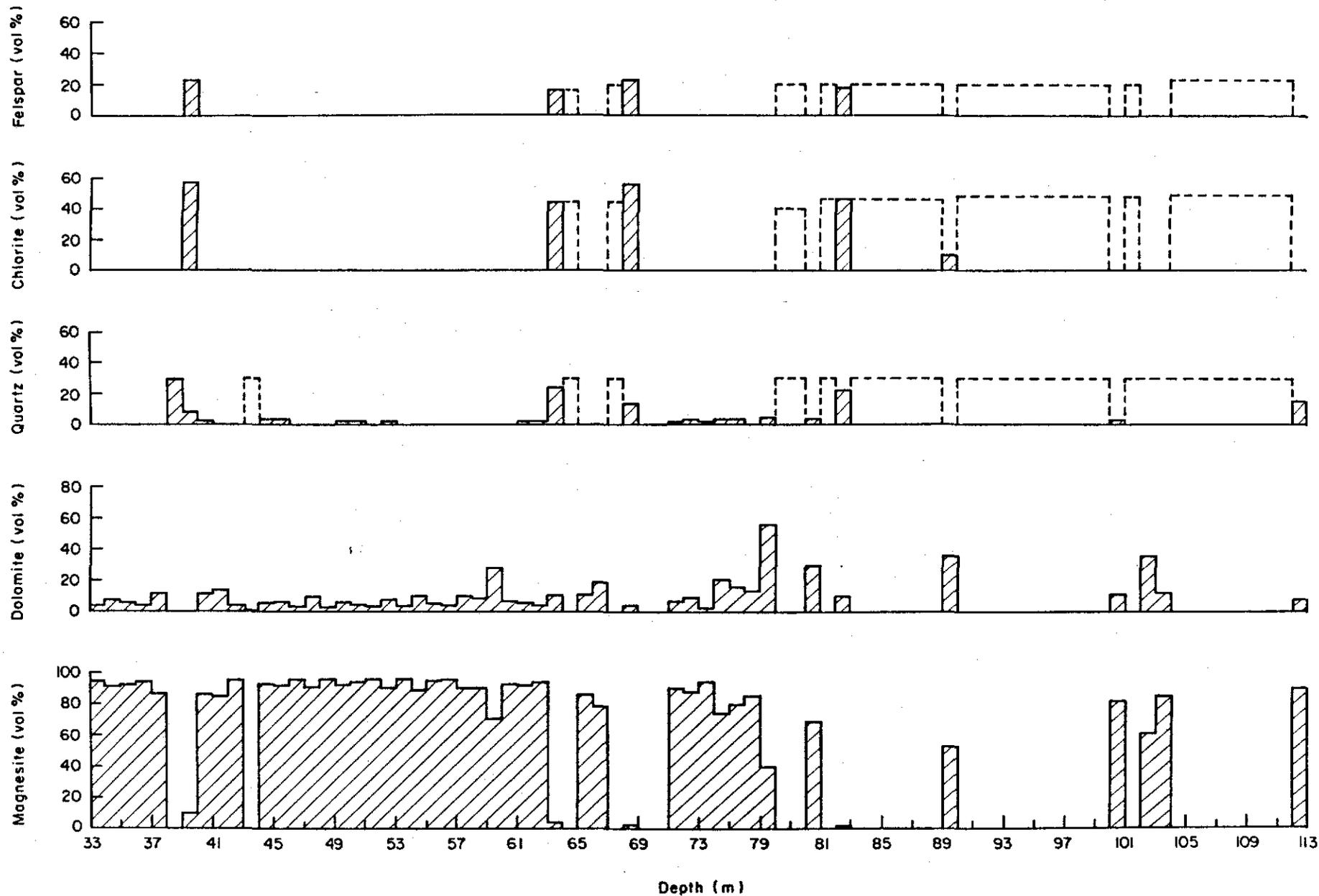


150 m

160 m

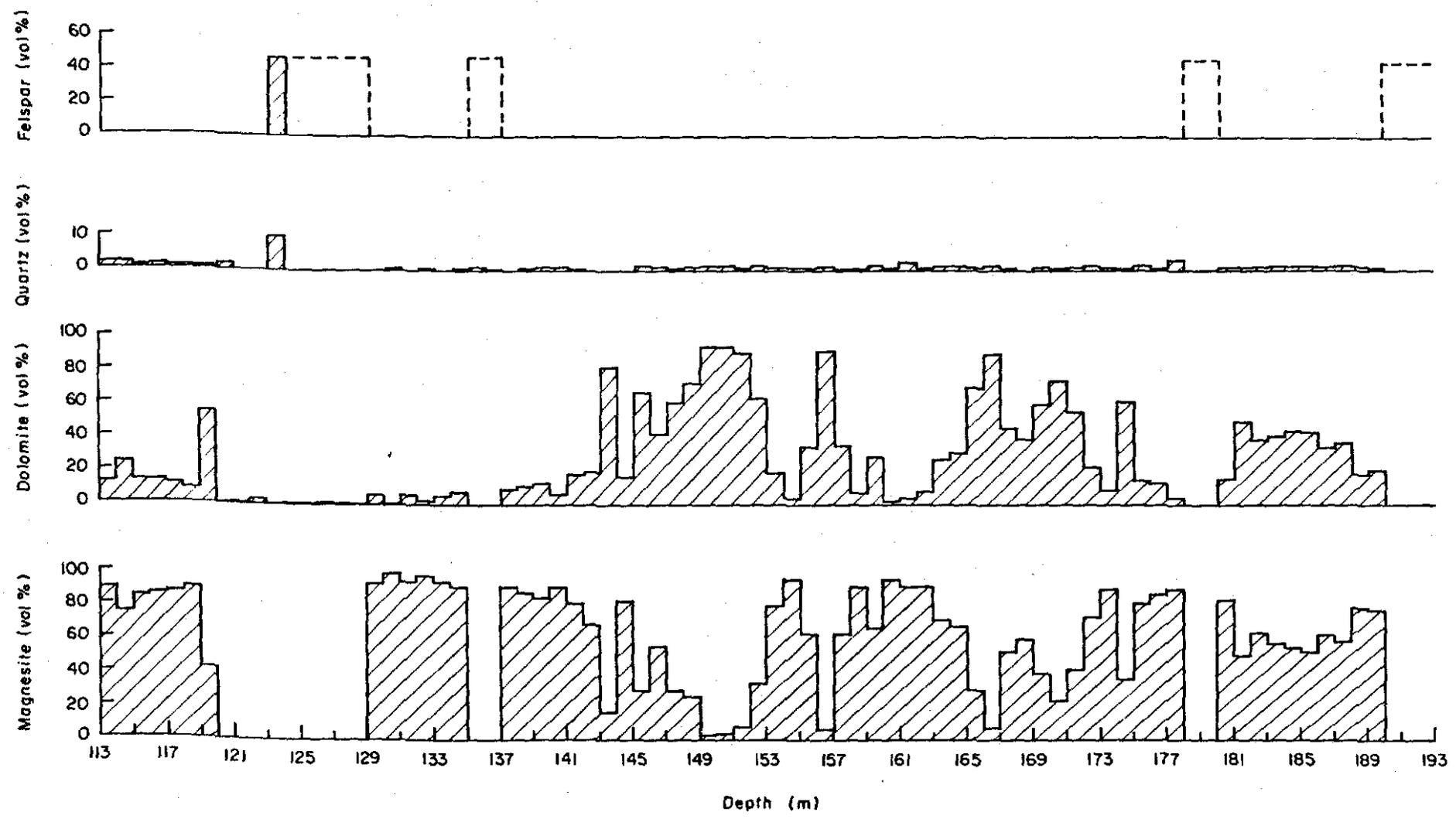
Fig. 8. The variation of magnesite, dolomite, quartz and talc with depth through DDH MC27.

D.D.H. 27 (33-113m)

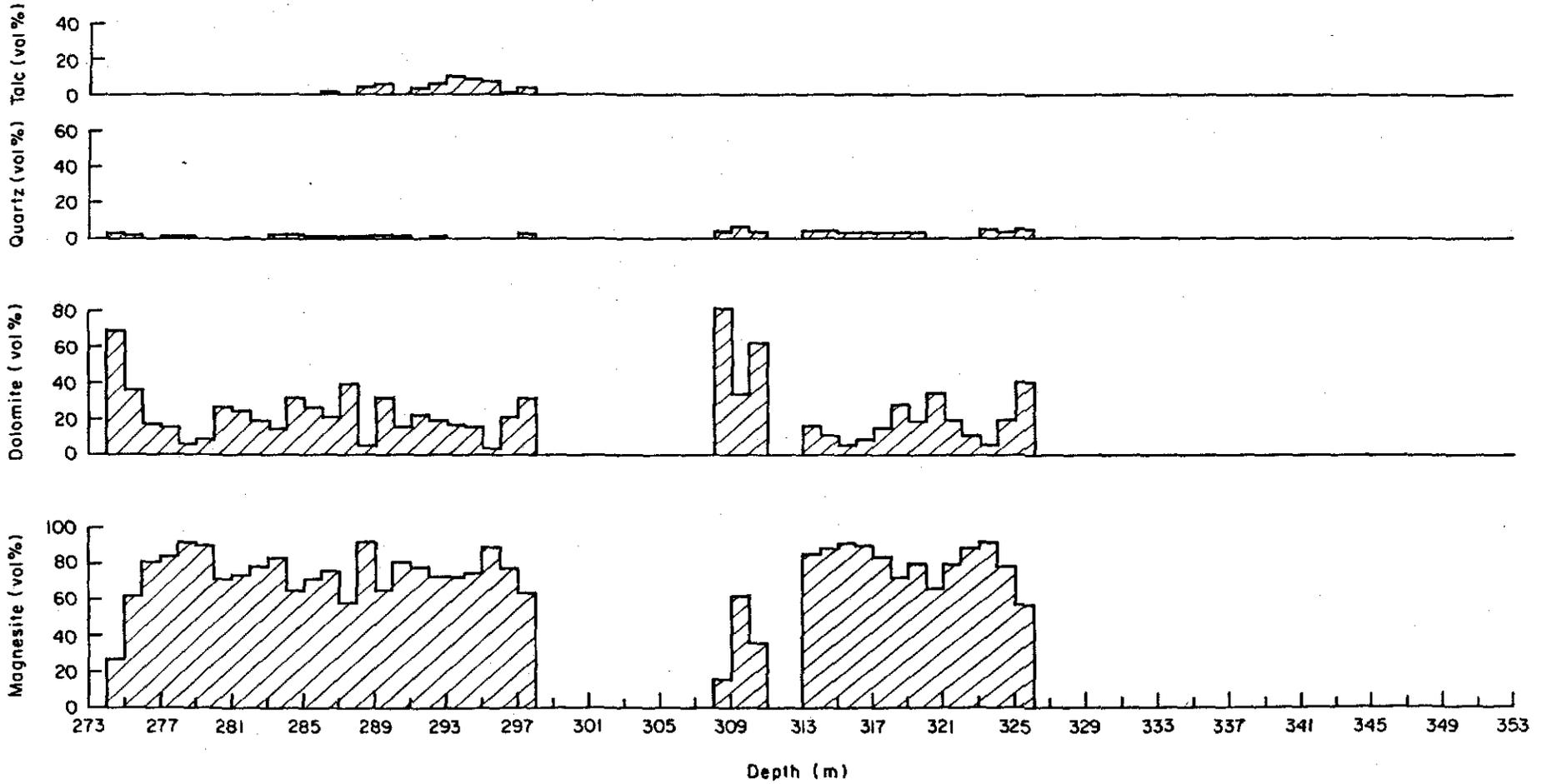


D.D.H. 27 (113-193m)

- 32 -



D.D.H. 27 (273-353m)



- 34 -

D.D.H. 27 (353 - 361m)

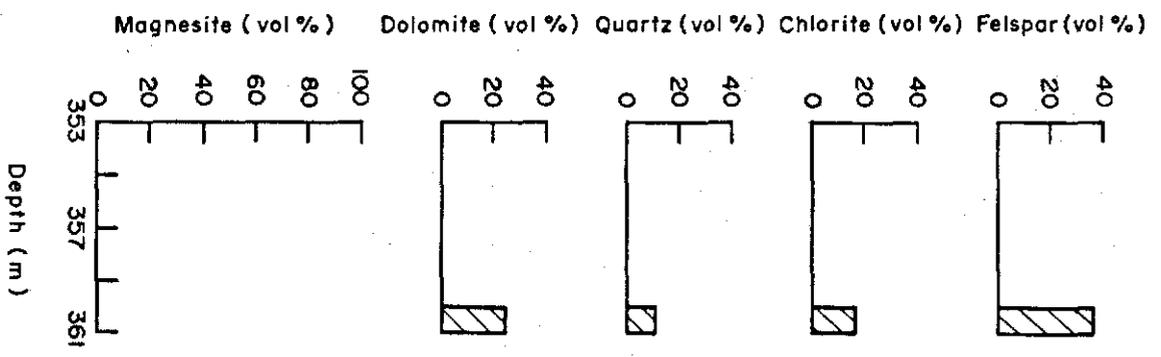
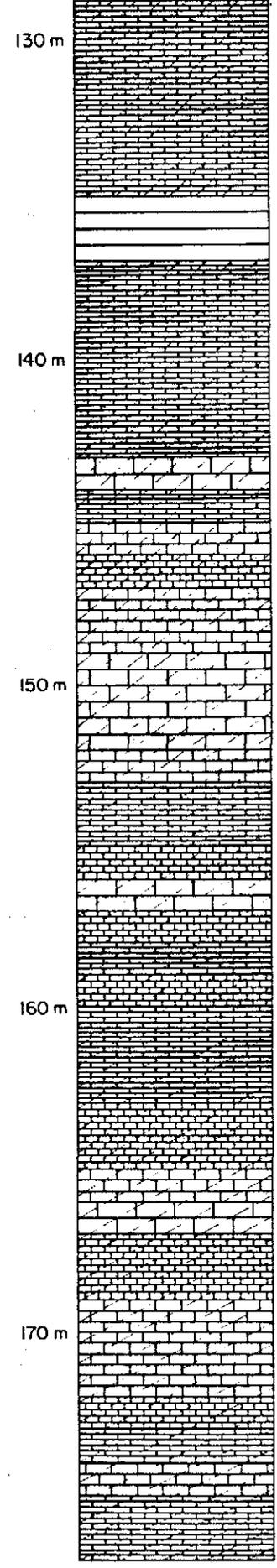
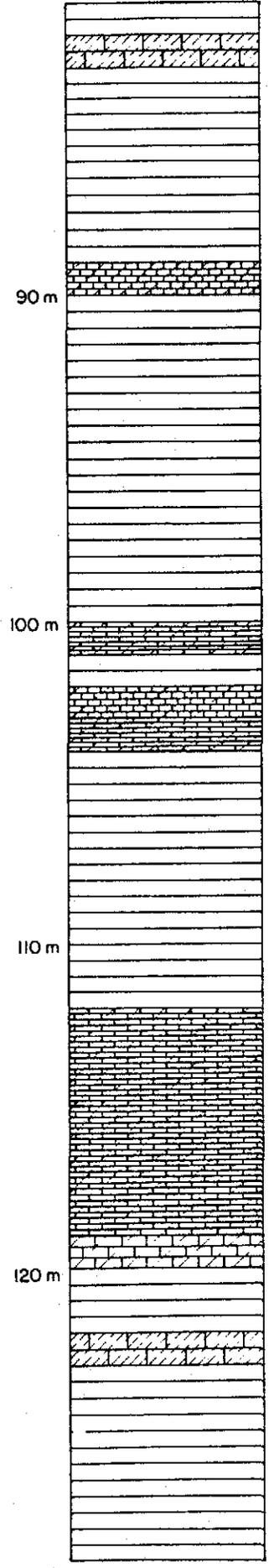
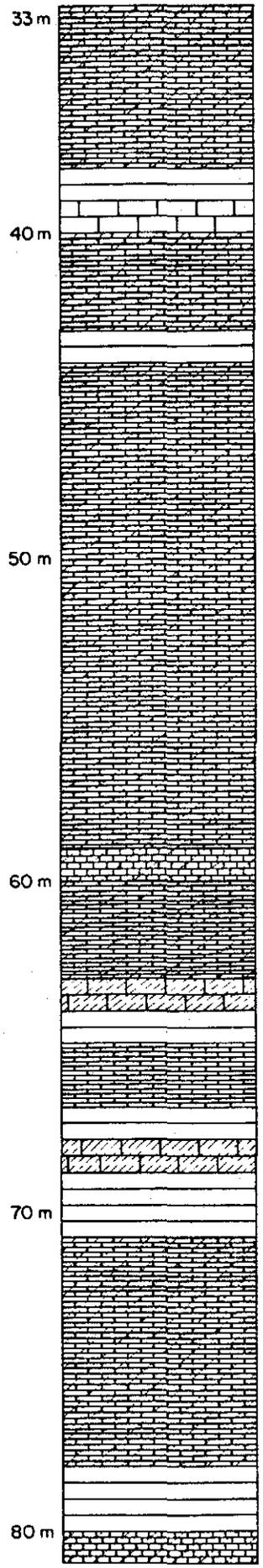
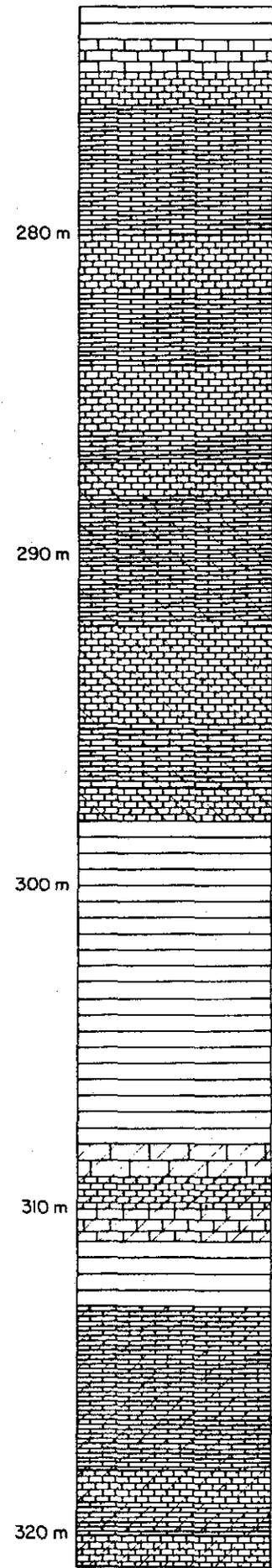
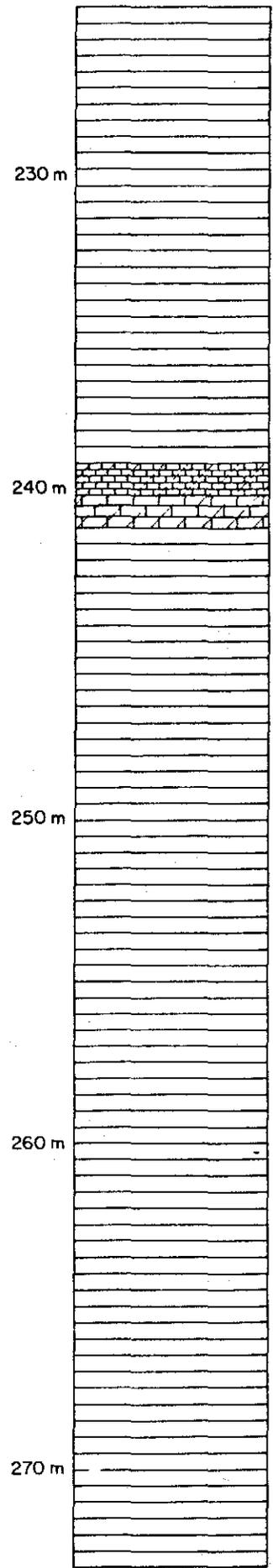
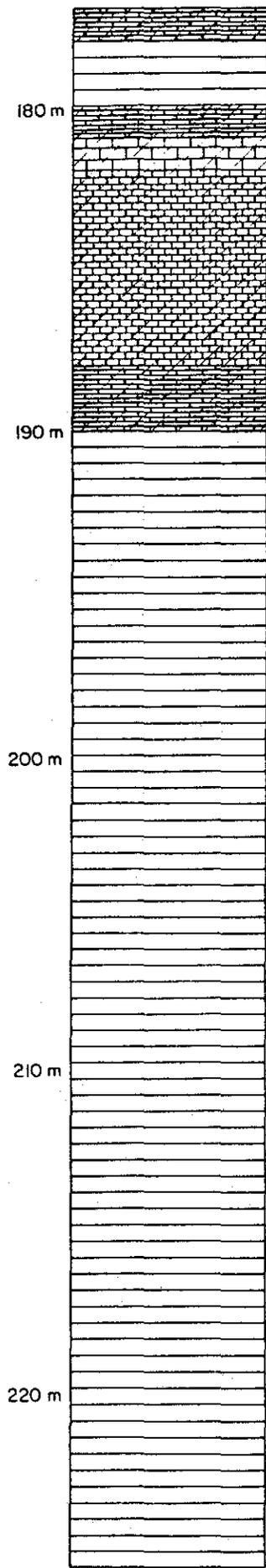
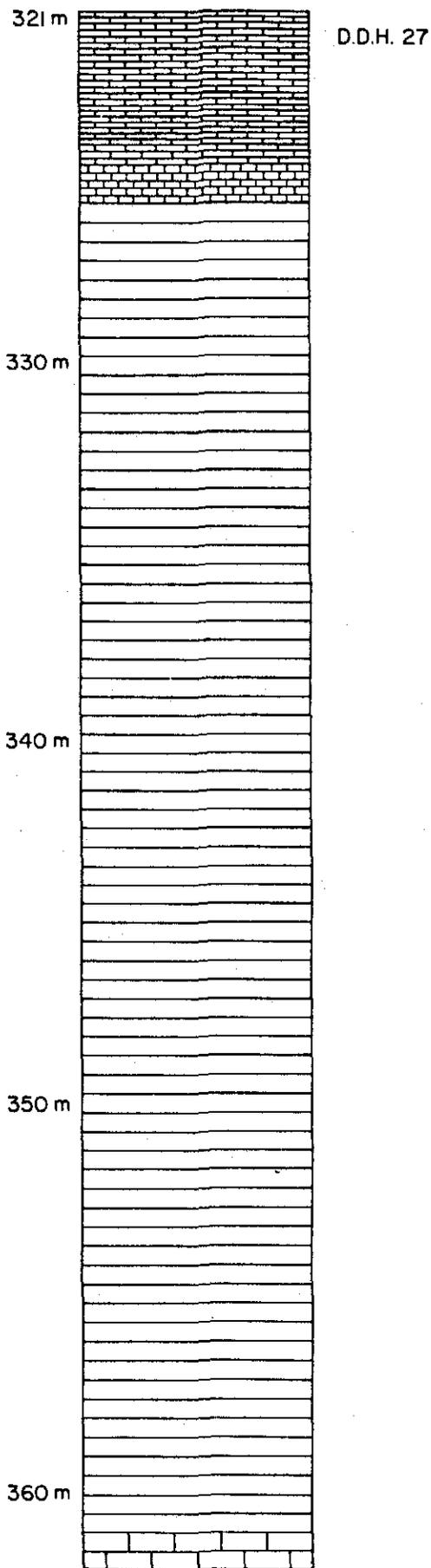


Fig. 9. An illustration of the rock types and grade of magnesite found in DDH MC27. Schist bands are much more prevalent in this part of the orebody than that encountered at DDH MC1 and DDH MC2. See p. 2⁹ for legend.



D.D.H. 27





APPENDIX III

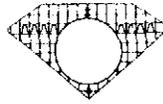
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388099

Diamond Laboratory Services Pty. Ltd.

HEAVY MINERAL DIVISION

Australian Representative for:



3rd Floor
89 York Street
Sydney, N.S.W. 2000
Telephone (02) 290 1022

DIAMOND GRADING LABORATORIES

HEAVY MINERAL CONCENTRATE ANALYSIS

EXAMINATION FOR KIMBERLITIC MINERAL INDICATOR GRAINS

CONSIGNMENT (Lab.Ref.No.): AAL5650
 CLIENT: INDUSTRIAL AND MINING INVESTIGATIONS P/L
 SAMPLE NUMBER (Client's Ref.): LSD 7, LSD 18, LSD 26
 TOTAL NUMBER OF SAMPLES: THREE
 DATE SAMPLES RECEIVED: 4.4.84
 DATE SAMPLES COMPLETED: 12.4.84

The above consignment has been sorted and checked and the results tabulated on the accompanying sheets.

Key to symbols used in the report:

□ Etched
 l.abr. Lightly abraded
 abr. Abraded
 R.O.S. Remnant of original surface
 R.O.K. Remnant of kelyphitic surface
 ♦ Diamond
 N.K. Non-kimberlitic
 Δ Angular



 Laboratory Supervisor Date 19.4.84

099

METHOD OF EXAMINATION

Three samples numbered LSD 7, LSD 18 and LSD 26 were received for inspection.

The processing and visual inspection of all samples was carried out at the Sydney premises of Diamond Laboratory Services Pty. Ltd.

Each of the samples was screened and processed using all steps required to produce a heavy mineral concentrate for observation.

As none of the samples had undergone any preparation, the steps required after the initial weight was recorded involved washing and screening and heavy media separation using bromoform as the flotation medium. The heavy mineral fraction of each sample was sieved into the following size fractions:

- +16 mesh : coarse fraction
- +25 mesh : medium fraction
- +44 mesh : fine fraction
- 44 mesh : extra fine fraction

No further work was performed on the light float which was discarded, nor was the extra fine fraction inspected at this stage.

Visual inspection of the concentrates was carried out by qualified sorters using stereomicroscopes. Each sample was examined grain by grain for traces of kimberlitic indicator minerals.

Grains considered to have morphological characteristics consistent with kimberlitic indicator minerals were isolated and sent for further confirmatory analysis.

Other grains of interest recognised by our sorters are listed in the 'Other Grains' column and may include the following: moissanite, fluorite, pyroxene, olivine, zircon, tourmaline, kyanite, corundum, rutile, haematite, cassiterite, mica, pyrites, gold, bronzite, etc.

Representative samples of all grains listed in the following pages as present in these samples are available for further inspection if needed.

RESULTS AND DISCUSSION

Samples LSD 7, 18, 26

Each of the samples was found to be abundant in black grains whose appearance suggests chromite and therefore warrant further investigation.

A representative number of these grains have been sent for further investigation by electron microprobe analysis to determine their composition.

In addition to these grains the samples contained grains of non-kimberlitic garnets, topaz, tourmaline, zircon, cassiterite, pyroxene and gold.

Silvery grey metallic grains were also noticed in samples LSD 18 and LSD 26 which are thought to be an alloy of the platinum group of metals.

The results are tabled on the following page.

Representative grains of the minerals listed are available for inspection if required.

CONCENTRATION OF RAW SAMPLES

The concentrate from each of these samples was small in relation to the size of the raw samples.

Therefore, a substantial saving of transport and establishment of concentrate costs could be made if the samples are washed and partially concentrated before shipping to Sydney.

However, because of the size of the concentrate, especially in the -1 mm. size fraction, extreme care should be exercised in the initial concentrating steps to avoid loss of these important grains.

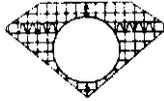
Only partial concentration is therefore recommended with a cut-off point which allows plenty of margin for error.

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Diamond Laboratory Services Pty. Ltd.

HEAVY MINERALS DIVISION



3rd Floor
89 York Street
Sydney, N.S.W. 2000
Telephone (02) 290 1022

CONSIGNMENT *AA. 15450....* SAMPLE No's. *4527: LSD: 18: LSD: 26....* DATE *12.4.84....*

Sample No.	Mesh Size	Garnet	Ilmenite	Chrome Diopside	Spinel	Other Grains	Remarks
<i>LSD 7</i>	+16	<i>1 N.K.</i>	—	—	<i>10</i>	<i>20 TOPAZ. 1 TOURMALINE.</i>	
	+25	<i>5 N.K.</i>	—	—	<i>20</i>	<i>ABUNDANT TOPAZ. 1 ZIRCON: 4 TOURMALINE.</i>	
	+44	<i>10 N.K.</i>	—	—	<i>ABUNDANT</i>	<i>ABUNDANT TOPAZ: 1 CASSITERITE: 1 GOLD: 2 PYROXENE: 10 TOURMALINE.</i>	
	+60	—	—	—	—	—	
<i>LSD 18</i>	+16	<i>3 N.K.</i>	—	—	<i>10</i>	<i>1 TOURMALINE: 10 TOPAZ.</i>	
	+25	<i>12 N.K.</i>	—	—	<i>ABUNDANT</i>	<i>AB. TOPAZ: 5 HAEMATITE: 2 GOLD: 10 TOURMALINE.</i>	
	+44	<i>26 N.K.</i>	—	—	<i>ABUNDANT</i>	<i>AB. TOPAZ: 6 HAEMATITE: 1 METALLIC SILVERY 4 ZIRCON: 5 CASSITERITE: NUGGET. 2 RUTILE: 6 GOLD: 10 TOURMALINE.</i>	
	+60	—	—	—	—	<i>3 PYROXENE:</i>	
<i>LSD 26</i>	+16	<i>3 N.K.</i>	—	—	<i>15</i>	<i>1 HAEMATITE 1 GOLD: 10 TOPAZ.</i>	
	+25	<i>13 N.K.</i>	—	—	<i>ABUNDANT</i>	<i>7 GOLD: 10 HAEMATITE: 1 METALLIC SILVERY 20 PYROXENE: AB. TOPAZ. NUGGET.</i>	
	+44	<i>28 N.K.</i>	—	—	<i>ABUNDANT.</i>	<i>20 HAEMATITE: 25 PYROXENE: 2 METALLIC 10 GOLD: 1 CASSITERITE: AB. TOPAZ. SILVERY NUGGETS.</i>	
	+60	—	—	—	—	—	
	+16						
	+25						
	+44						
	+60						
	+16						
	+25						
	+44						
	+60						

SAMPLES RECEIVED IN LAB *4.4.84* SAMPLES SEPARATED *4.4.84*
 SAMPLES UNPACKED AND CHECKED *4.4.84* SLIDES CHECKED *12.4.84*

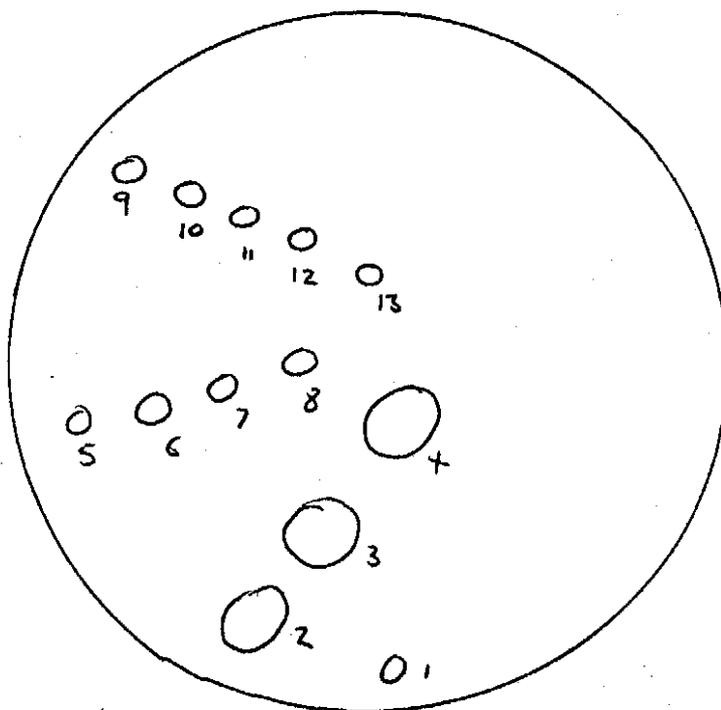
INDUSTRIAL & MINING INVESTIGATION

AA15650 11.5.84

<u>Sample No.</u>	<u>Grain No.</u>	<u>Type of grain.</u>
LSD 26	1	Alloy
LSD 26	2,3,4	3 Chromites
LSD 7	5,6,7,8	4 Chromites
LSD 18	9,10,11,12,13	5 Chromites

Grain Mount

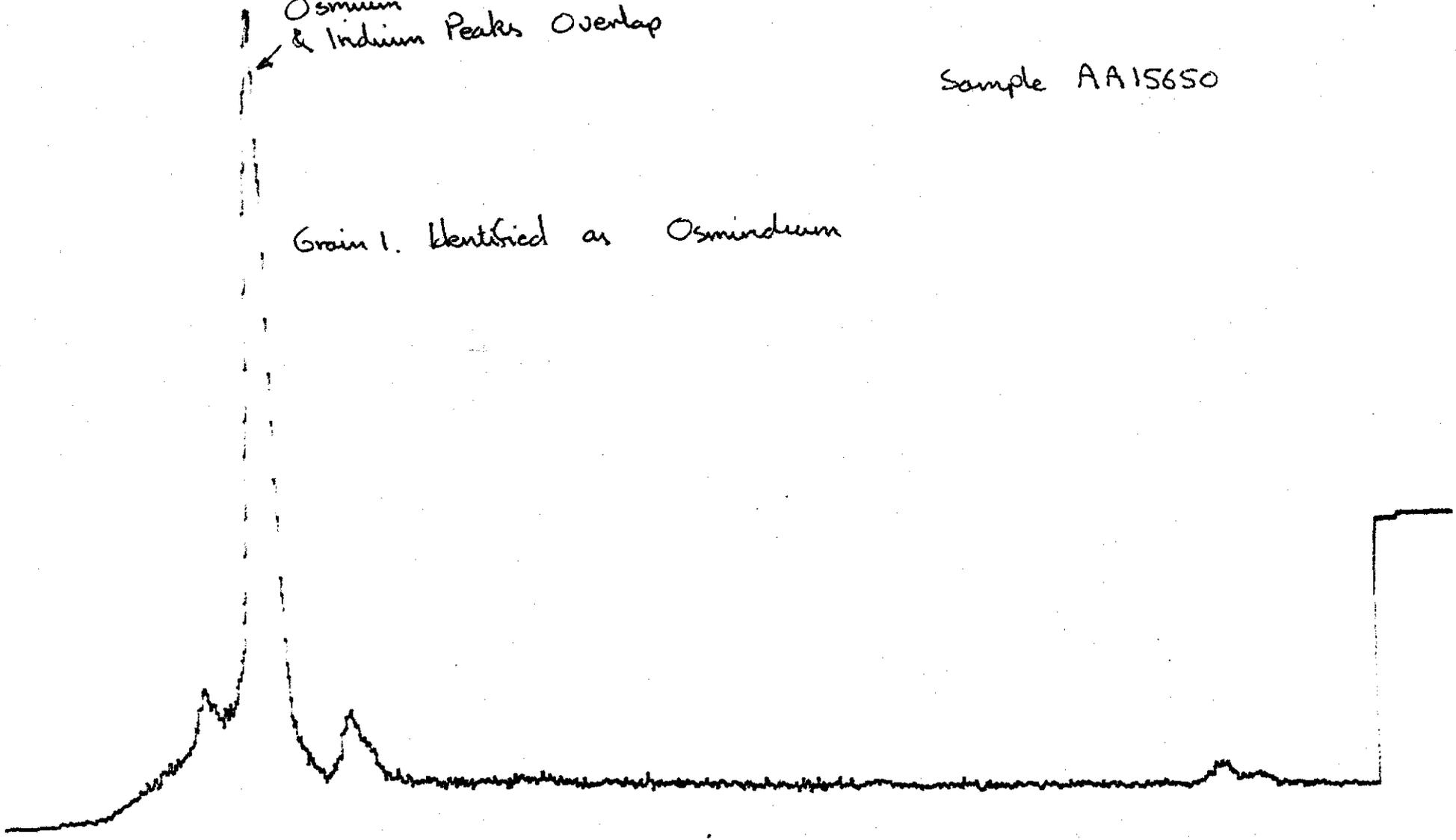
AA15650



Sample AA15650

Osmium
& Indium Peaks Overlap

Grain 1. Identified as Osmidium



GRAIN 2\? 5

OXIDE	WT% UNORM	WT% NORM	6 OXYGEN	4 CATIONS
TIO2	.17	.16	.005	.004
AL2O3	59.14	58.57	2.662	2.359
CR2O3	9.91	9.82	.299	.265
FE0	10.29	10.19	.329	.291
MNO	.16	.16	.005	.005
MGO	21.3	21.1	1.213	1.075
TOTAL	100.97	100	4.513	5.316
MG:FE	.786641 : .213359			
CA:NA:K	0 : 0 : 0			
CA:MG:FE	0 : 78.6641 : 21.3359			
	0 0 .17 59.14 0 9.91 10.29 0			
	.16 21.3 0 0 0 0 100.97			

2129 24902 71617 2763 2229 1985 1708 1592
 1299 1038 6297 1648 5056 640 3029 1950

SELECT E.D.S. ROUTINE? GRAIN 3\? 5

OXIDE	WT% UNORM	WT% NORM	6 OXYGEN	4 CATIONS
AL2O3	60.43	60.02	2.715	2.409
CR2O3	8.82	8.76	.266	.236
FE0	10.31	10.24	.329	.292
MNO	.09	.09	.003	.003
MGO	21.03	20.89	1.195	1.061
TOTAL	100.68	100	4.508	5.323
MG:FE	.784121 : .215879			
CA:NA:K	0 : 0 : 0			
CA:MG:FE	0 : 78.4121 : 21.5879			
	0 0 0 60.43 0 8.82 10.31 0			
	.09 21.03 0 0 0 0 100.68			

2046 24779 73404 2669 2108 2086 1697 1520
 1137 1031 5709 1538 5067 638 3097 1877

SELECT E.D.S. ROUTINE? GRAIN 4\? 5

OXIDE	WT% UNORM	WT% NORM	6 OXYGEN	4 CATIONS
TIO2	.1	.1	.003	.002
AL2O3	56.6	56.3	2.6	2.307
CR2O3	12.17	12.11	.375	.333
FE0	11.93	11.87	.389	.345
MNO	.27	.27	.009	.008
MGO	19.46	19.35	1.131	1.004
TOTAL	100.53	100	4.507	5.322
MG:FE	.744079 : .255921			
CA:NA:K	0 : 0 : 0			
CA:MG:FE	0 : 74.4079 : 25.5921			
	0 0 .1 56.6 0 12.17 11.93 0			
	.27 19.46 0 0 0 0 100.53			

2032 22620 68568 2776 2203 2085 1831 1630
1278 1162 7569 1882 5771 650 3100 1952

SELECT E.D.S. ROUTINE? GRAIN 5? 5

OXIDE	WT% UNORM	WT% NORM	6 OXYGEN	4 CATIONS
SiO2	.1	.1	.004	.004
TiO2	.15	.14	.005	.004
Al2O3	31.12	30.53	1.577	1.387
Cr2O3	38.41	37.68	1.306	1.149
FeO	13.92	13.65	.501	.441
MnO	.13	.13	.004	.004
MgO	.41	.4	.015	.013
	17.71	17.37	1.136	.999
TOTAL	101.95	100	4.548	5.277
Mg:Fe	.693952 : .306048			
Ca:Na:K	0 : 0 : 0			
Ca:Mg:Fe	0 : 69.3952 : 30.6048			
0 .1 .15 31.12 0 38.41 13.92 .13				
.41 17.71 0 0 0 0 101.95				

1844 18763 37527 3339 2647 2401 2051 1953
1478 1391 22420 4005 6779 750 3443 2413

SELECT E.D.S. ROUTINE? GRAIN 6? 5

OXIDE	WT% UNORM	WT% NORM	6 OXYGEN	4 CATIONS
TiO2	.18	.18	.007	.006
Al2O3	5.39	5.34	.32	.284
Cr2O3	66.83	66.15	2.657	2.361
FeO	18.18	17.99	.765	.68
MnO	.94	.93	.04	.036
MgO	9.51	9.41	.713	.634
TOTAL	101.03	100	4.502	5.329
Mg:Fe	.482409 : .517591			
Ca:Na:K	0 : 0 : 0			
Ca:Mg:Fe	0 : 48.2409 : 51.7591			
0 0 .18 5.39 0 66.83 18.18 0				
.94 9.51 0 0 0 0 101.03				

1609 10262 9186 3838 3266 2924 2480 2388
1762 1660 39700 6731 8913 822 4068 2957

SELECT E.D.S. ROUTINE? GRAIN 7? 5

OXIDE	WT% UNORM	WT% NORM	6 OXYGEN	4 CATIONS
TiO2	.19	.18	.007	.006
Al2O3	4.71	4.68	.279	.243
Cr2O3	64.17	63.66	2.545	2.223
FeO	18.59	18.45	.781	.682
MnO	.49	.49	.021	.018
MgO	12.65	12.55	.946	.827
TOTAL	100.8	100.01	4.579	5.239
Mg:Fe	.547771 : .452229			
Ca:Na:K	0 : 0 : 0			
Ca:Mg:Fe	0 : 54.7771 : 45.2229			
0 0 .19 4.71 0 64.17 18.59 0				
.49 12.65 0 0 0 0 100.8				

1636 12836 8369 3874 3107 2971 2464 2403
1754 1527 39005 6256 9042 868 4034 2937

SELECT E.D.S. ROUTINE? GRAIN 8\? 5

OXIDE	WT% UNORM	WT% NORM	6 OXYGEN	4 CATIONS
TIO2	.11	.11	.004	.004
AL2O3	6.28	6.25	.368	.328
CR2O3	67.57	67.22	2.651	2.365
FEO	14.89	14.82	.618	.552
MNO	.65	.64	.027	.024
MGO	11.01	10.96	.815	.727

TOTAL 100.51 100 4.483 5.351
 MG:FE .568737 : .431263
 CA:NA:K 0 : 0 : 0
 CA:MG:FE 0 : 56.8737 : 43.1263
 0 0 .11 6.28 0 67.57 14.89 0
 .65 11.01 0 0 0 0 100.51

1685 11603 10147 3865 3153 2809 2470 2295
1694 1602 39949 6582 7441 813 4038 2883

SELECT E.D.S. ROUTINE? GRAIN 9\? 5

OXIDE	WT% UNORM	WT% NORM	6 OXYGEN	4 CATIONS
TIO2	.17	.16	.006	.005
AL2O3	3.72	3.67	.22	.195
CR2O3	68.87	67.97	2.734	2.423
FEO	16.85	16.63	.708	.627
MNO	1	.99	.042	.038
MGO	10.73	10.59	.803	.712

TOTAL 101.34 100.01 4.513 5.314
 MG:FE .531436 : .468564
 CA:NA:K 0 : 0 : 0
 CA:MG:FE 0 : 53.1436 : 46.8564
 0 0 .17 3.72 0 68.87 16.85 0
 1 10.73 0 0 0 0 101.34

1535 11166 7275 3782 3153 2869 2418 2320
1721 1643 40861 6894 8319 850 4021 2852

SELECT E.D.S. ROUTINE? GRAIN 10\? 5

OXIDE	WT% UNORM	WT% NORM	6 OXYGEN	4 CATIONS
TIO2	.26	.26	.009	.008
AL2O3	15.17	15.05	.858	.756
CR2O3	53.63	53.21	2.036	1.793
FEO	19.47	19.31	.782	.689
MNO	.74	.73	.03	.026
MGO	11.54	11.45	.826	.728

TOTAL 100.81 100.01 4.541 5.282
 MG:FE .513682 : .486318
 CA:NA:K 0 : 0 : 0
 CA:MG:FE 0 : 51.3682 : 48.6318
 0 0 .26 15.17 0 53.63 19.47 0
 .74 11.54 0 0 0 0 100.81

1637 12285 19800 3475 2937 2731 2364 2174
1712 1504 31633 5497 9345 828 3803 2757

SELECT E.D.S. ROUTINE? GRAIN 11? 5

OXIDE	WT% UNDRM	WT% NORM	6 OXYGEN	4 CATIONS		
TIO2	.18	.18	.007	.006		
AL2O3	5.67	5.64	.337	.299		
CR2O3	65.76	65.34	2.621	2.324		
FE0	18.31	18.2	.773	.685		
MNO	.97	.96	.041	.037		
MGO	9.75	9.69	.733	.65		
TOTAL	100.64	100.01	4.512	5.318		
MG:FE	.48672 : .51328					
CA:NA:K	0 : 0 : 0					
CA:MG:FE	0 : 48.672 : 51.328					
0 0	.18	5.67	0	65.76	18.31	0
.97	9.75	0	0	0	100.64	

1649 10476 9495 3707 3013 2981 2446 2364
1764 1622 39042 6661 8970 800 4062 2976

SELECT E.D.S. ROUTINE? GRAIN 12? 5

OXIDE	WT% UNDRM	WT% NORM	6 OXYGEN	4 CATIONS		
TIO2	.13	.13	.004	.004		
AL2O3	26.62	26.37	1.42	1.251		
CR2O3	41.53	41.14	1.486	1.309		
FE0	18.82	18.64	.713	.628		
MNO	.57	.57	.022	.019		
MGO	13.28	13.15	.896	.789		
TOTAL	100.95	100	4.541	5.283		
MG:FE	.556868 : .443132					
CA:NA:K	0 : 0 : 0					
CA:MG:FE	0 : 55.6868 : 44.3132					
0 0	.13	26.62	0	41.53	18.82	0
.57	13.28	0	0	0	100.95	

1779 14324 32605 3363 2668 2515 2166 2074
1519 1419 24395 4391 8944 746 3537 2567

SELECT E.D.S. ROUTINE? GRAIN 13? 5

OXIDE	WT% UNDRM	WT% NORM	6 OXYGEN	4 CATIONS		
TIO2	.11	.11	.004	.004		
AL2O3	4.75	4.75	.283	.251		
CR2O3	67.06	67.1	2.679	2.375		
FE0	16.07	16.08	.68	.603		
MNO	1.05	1.05	.045	.04		
MGO	10.9	10.91	.822	.728		
TOTAL	99.94	100	4.513	5.317		
MG:FE	.54727 : .45273					
CA:NA:K	0 : 0 : 0					
CA:MG:FE	0 : 54.727 : 45.273					
0 0	.11	4.75	0	67.06	16.07	0
1.05	10.9	0	0	0	99.94	

1589 11417 8449 3812 3120 2958 2492 2272
1700 1549 39707 6779 7983 800 3979 3017

SELECT E.D.S. ROUTINE?

VARIATION IN THE COMPOSITION OF CHROMITE FROM A
NUMBER OF GEOLOGICAL ENVIRONMENTS.

Chromite (or chrome spinel) is a common accessory mineral found in all of the various rock types associated with:-

1. The ophiolite suite (ocean-floor rocks), including
 - (a) Alpine - type (Metamorphic) peridotites and
 - (b) Cumulate (igneous) peridotites.
2. Continental layered mafic - ultramafic intrusions.

In some cases the chromite becomes concentrated to form tabular, lens-shaped or irregular masses to form economic concentrations. Chromite deposits associated with ophiolitic rocks are known by the general term podiform chromites. Those associated with the large continental layered intrusions are known as stratiform chromites.

3. Chromite is also a very minor accessory in kimberlites where it occurs in several different ways.

Chromite variation in Podiform and Stratiform types.

The published literature does not differentiate between chromite found as an accessory mineral in the various rock types of the ophiolite suite and the continental layered complexes, and the chromite found as a major constituent in podiform and stratiform deposits. Information which can be found refers entirely to the economic occurrences of the mineral. There is no reason however, why it should not also apply within the main body of the rocks themselves.

The composition of chromite from podiform deposits is very variable because of the complicated crystallization and deformational history of most ophiolitic rocks.

In stratiform deposits on the other hand, the chemical variation is a direct reflection of the degree of fractionation of the mineral from its parent.

The Fe content of podiform chromites remains fairly constant (10-16% FeO) while in stratiform chromites Fe and Cr. show a reciprocal arrangement with Fe increasing with the degree of fractionation while Cr decreases.

Chromites from podiform deposits are typically more magnesian than those from stratiform deposits. In podiform chromites the $Fe^{2+}:Mg$ is usually < 1 and is almost constant for an individual deposit, while in the stratiform chromites, $Fe^{2+}:Mg = 0.5 - 2.5$ and may vary considerably in individual deposits.

The diagram below illustrates this point.

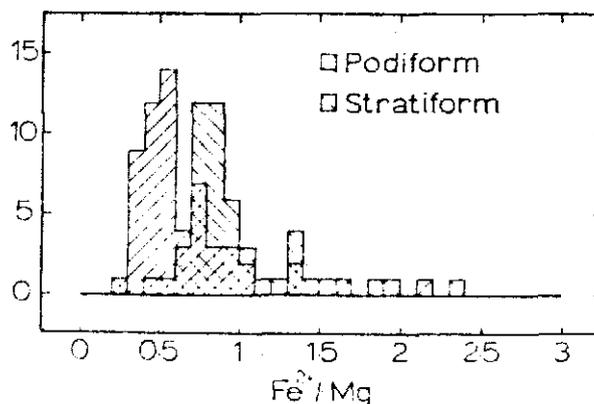


Fig. 3. Atomic ratio of Fe^{2+} vs Mg for chromites from stratiform and podiform deposits. Fe^{2+} calculated from total Fe by assuming spinel stoichiometry. Analyses by electron microprobe.

It is the reciprocal relation of Cr and Al which characterizes podiform chromites. They tend to be bimodal, concentrating into high Al and / or high Cr groups. The reason for this bimodality is not clear but may be pressure related. Nearly all high Cr and high Al chromites come from podiform deposits.

The figure below illustrates the atomic proportions of Cr, Al and Fe for chromites from podiform and stratiform intrusions.

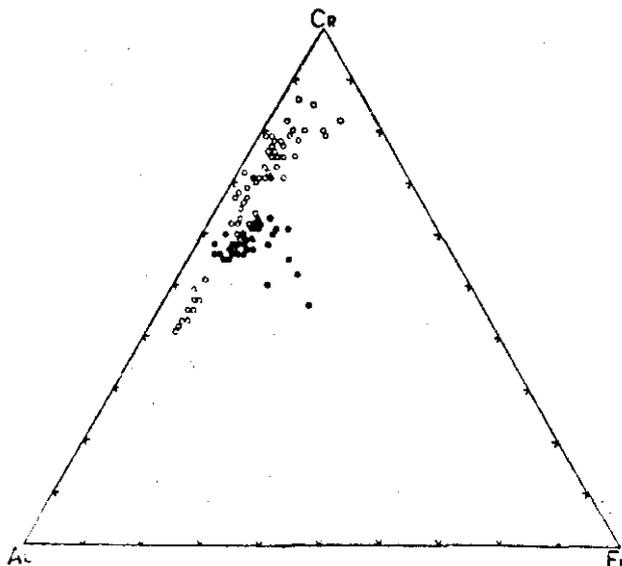


Fig. 5. Atomic proportions of Cr, Al, and Fe for chromites from stratiform intrusions (solid circles) and podiform deposits (open circles). Fe^{3+} calculated from total Fe by assuming spinel stoichiometry and shown as Fe on diagram. Analyses by electron probe. (After Dickey, 1975)

A distinction between chromites from stratiform and podiform deposits can also be made on the basis of TiO_2 concentrations. Podiform chromites usually contain $< 0.3\%$ TiO_2 while in stratiform deposits it may range from 0.5 -> 2%.

In summary:

	PODIFORM	STRATIFORM
Fe ²⁺ :Mg	< 1	0.5 - 2.5
FeO	Fairly constant 10-16%	Variable with differentiation, as high as 28%. Reciprocal with Cr.
Cr / Al	Reciprocal wide variation.	Fairly uniform.
TiO ₂	< 1%	0.5 - 2.5%

Chromite variation in Kimberlites

There are quite large variations in the chemistry of chrome spinels found in kimberlites. This is because the mineral occurs in a variety of ways. It is more properly referred to as "Chrome spinel" rather than true chromite.

Occurrences of chrome spinel are:

1. As xenocrysts (single large crystals in rock)
2. Primary groundmass spinels.
3. Secondary spinels mantling (1) and (2).
4. Secondary spinels in garnet kelyphitic rims.
5. Secondary spinels mantling microilmenite.
6. As exsolved inclusions in microilmenite.

The outstanding and characteristic features of categories (1), (2) and (4) are the presence and degree of extraordinary complex zoning in the chrome spinel.

Xenocrystic chrome spinels and those mantling garnet kelyphites (categories (1) and (4)) compositionally match those chromites occurring in a wide range of peridotite inclusions in kimberlites and cover the range of podiform and stratiform types from which they cannot be distinguished except by the presence of zoning.

They were probably shed into the kimberlite during fragmentation of peridotite xenoliths.

Some primary groundmass chrome spinel, secondary mantling spinels and those exsolved from microilmenite (categories (2), (3), (5) and (6)) tend to be much richer in TiO₂ and Fe, especially Fe³⁺. They may contain up to 5% TiO₂, 10% Fe₃O₄ and 25% FeAlO₄. Their composition is not unique to kimberlites. However, the complex zoning where by up to 5 distinct and contrasting primary chrome spinels may be found together between the innermost core and outermost mantle of an

individual grain is unique.

Some spinels which either mantle or exsolve from picroilmenite may contain up to 16% TiO_2 and 28% Fe_2O_3 and are unique to kimberlites. These could not be considered to be "chrome" spinels in the true sense, however.

References:

- DICKEY, J.S (1975) A hypothesis of origin for podiform chromite deposits. *Geochem. Cosmochim. Acta*, 39 p. 1061 -1074
- HAGGERTY, S.E. (1975) The chemistry and genesis of opaque minerals in kimberlite.
First Internat. Kimberlite Conference. p. 295 - 307.
- THAYER, T.P. (1970). Chromite segregations as petrogenetic indicators. *Geol. Soc. S.Africa Spec. Publ.* 1 p. 380 - 390.

Analyses of grains probed:-

Grain	2	3	4	5	6	7
Fe/Mg	0.5	0.5	0.7	0.9	2	1.5
FeO	10.	10.	12.	14.	18	18.5
Cr:Al	1:6	1:8	1:5	1:09	12:1	16:1
TiO ₂	.16	-	.1	.1	.18	.18
	8	9	10	11	12	13
Fe/Mg	1.2	1.6	1.8	2.	1.5	1.6
FeO	15.	16.	19.	18.	18.5	16.
Cr/Al	11:1	22:1	4:1	13:1	2:1	16:1
TiO ₂	.11	.16	.26	.18	.13	.11

Conclusions:

1. Not stratiform - because of TiO₂ content and wide variation in Cr:Al ratio.
2. Some features of podiform, except that Fe content is too variable.
3. Cannot tell whether kimberlitic or not - no unique features.

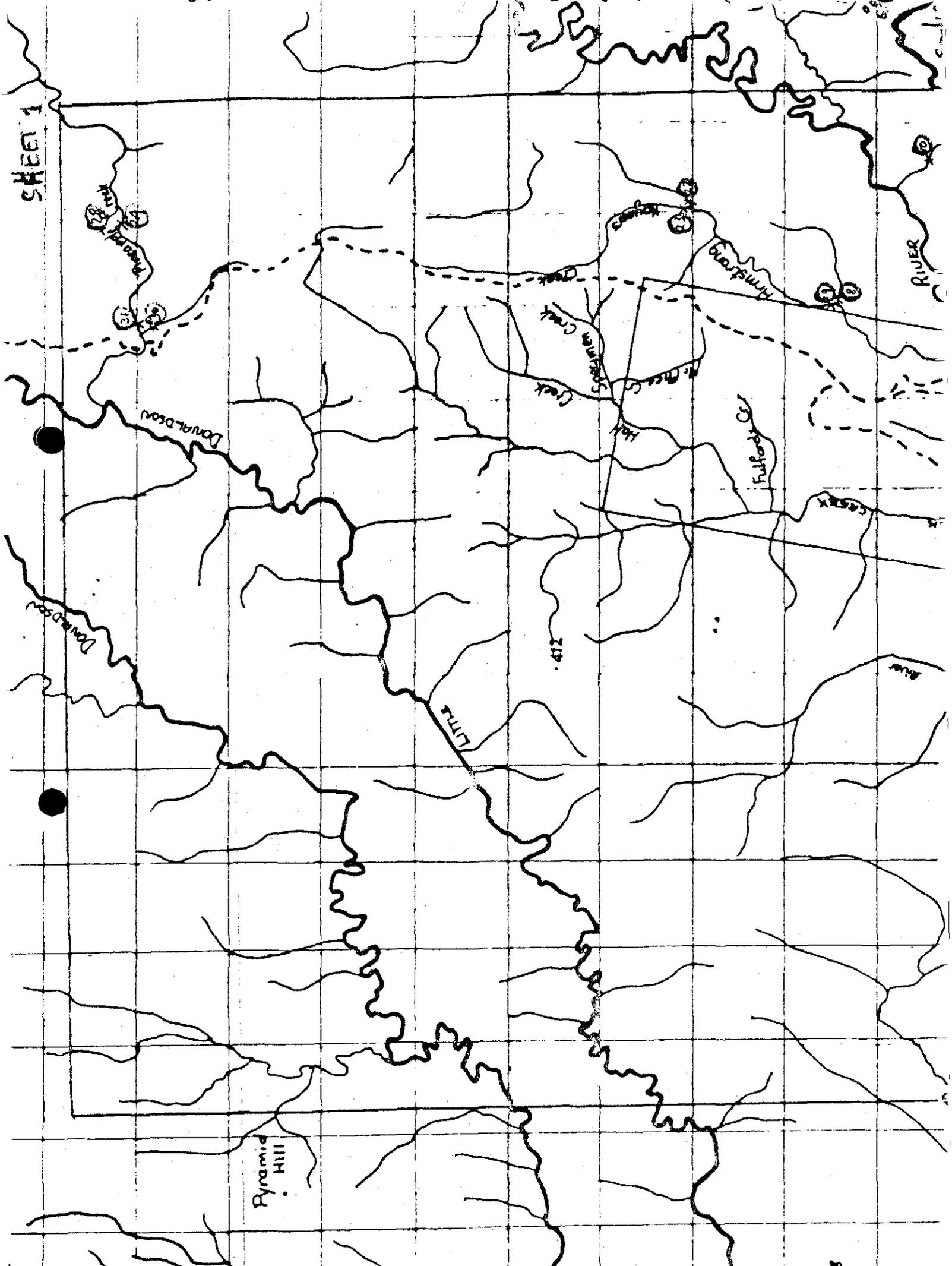
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SAMPLE LOCATIONS

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