

**ANNUAL REPORT
RETENTION LICENCE 8802 BOWRY CREEK
SAVAGE RIVER, TASMANIA**



for the period
31st AUGUST, 1989 to 22 MAY, 1990

**OCHRE DEPOSIT AUGER DRILLING
SUMMER PROGRAM**

BY

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15-6-1990

90-3158 R/F

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File Ref. RL 8802	
- 8 AUG 1990	
Doc. Ref.	
Action Officer	Initials
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SAVAGE RESOURCES LIMITED
Incorporated in Tasmania

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Surface survey

The auger holes in the main drilling area have now been located on the Australian map grid by theodolite survey. These locations supercede those given in the winter program report for "HT" site drilling.

Geology of the ochre deposit

The ochre occurs as both residual and transported material in a superficial deposit up to some tens of metres in thickness. Current observations indicate that ochre exists over a strike distance of 2.5km and up to 400m wide in the Main Creek area, with another deposit 2.0 km long and up to 400m wide at Bonny Creek.

Soils in the region generally comprise a layer of transported and gravelly wash, overlying weathered bedrock in which relict textures are discernable. Pedogenic processes act from the surface to impose a further layering effect including the illuvial transport of fines to produce a pug layer. Over the magnesite area these soil processes are developed on a grand scale and enhanced by karst related pipe structures and sinkhole subsidence which can greatly expand the thickness of the transported layer. The ochre occurs as matrix in the transported layer and as the weathered bedrock.

The weathered bedrock form is termed residual ochre and is recognized by relict textures preserved from the original magnesite rock. Residual ochre also occurs apparently as isolated blocks in a matrix of reworked ochre. These ochres are of good quality and include varieties classifiable as sienna and umber. Some are talc-rich particularly some of the dark browns (umbers). They visually express higher iron oxide content than the reworked ochres which always contain clasts resulting from erosion and redeposition. The reworked ochre with minor clasts grades into breccia, mostly with corresponding loss of purity and pigmenting power. Nevertheless reworked ochres have benefited well in initial testing.

The reworked ochre is not the only component of the transported layer over the magnesite area. It grades through increase of greenschist derived wash material into clay matrix breccias. Certain sinkhole fills contain only peaty gravel and lacustrine clay. There is also an area of sand which overlies a form of tarry peat in sand, over magnesite, often with no residual ochre. It may be that this area once had a thicker cover of ochre and is a source for some of the reworked ochre. The tarry peat may be a large scale illuvial layer of humic acid rather than peat that was once exposed at the surface but too poorly preserved to show plant remains. But in one borehole there is peat with very good preservation of plant remains. Near the surface there is accumulation of a clay-rich B horizon which may have good colour but which lacks pigmenting power, there are also patches

of "white pug" which also appear to be illuvial "soft concretions".

Actual magnesite rock outcrop is confined to minor creek bed exposures and the small magnesite karst outcrop near Main Creek. Some small exposures were mapped to assist in the positioning of the greenschist belts which notionally pass through the drilled area, so that these belts could be excluded from the resource estimates. The notional magnesite area is not quite equal to the ochre deposit area on present evidence because of the non-ochre phases in the superficial cover. The area with superficial sand cover provided several holes which bottomed on magnesite after passing through tarry peat, but the magnesite bottom of the deposit was not found below the typical reworked ochre dominant sections and it is anticipated that a layer of residual ochre exists at depth. With drill penetration restricted to 31m it was not possible to prove this. Residual ochre is mostly found next to a greenschist body which has prevented extreme subsidence occurring.

Laboratory examinations

Composite samples were prepared by first amalgamating samples from individual holes then bulking the remainder for processing tests producing 8 samples in all. The samples were selected from the logs for the winter program looking for 1-2 holes per line with near-surface, minable thicknesses of yellow ochre. It happens that much near-surface clayey material is included, and reworked ochres

dominate; the only residual ochre included occurs as clasts in some of the reworked ochre. The following samples were included.

TABLE 1

HZ1-1,2 4,5	HZ2-1,2,3,4	HA4-1,2 4,5,6	HB2-1,2,3	HD1-1,2,3,4
HE3-3 5	HC1-1,2 4			

Dr. Ralph Shackelford has investigated the fines extract from these samples and conducted the transformation processes to produce yellows, reds, black and brown materials for testing as unfinished pigments. He notes that the powders require further treatment before being considered saleable pigments, despite very good performance on appropriate tests. He has not provided the quantitative data because "--- interpretation of the data is not possible without a thorough understanding of the subject, test procedures, market norms vis-a-vis intended application etc.

R.A. Day has produced scanning electron microscope images of ochres in various levels of refinement as follows.

TABLE 2

G19, G20	bulk sample of table 1 specimens
G21	a commercial synthetic yellow
G30-38	mix of samples HC1/5 and HC1/6. A brown clayey ochre.

The work on the G30-38 group shows very little of the probable residual form of ochre: goethite in practically pure and porous form, essentially resembling a micro scale gossan boxwork including some acicular crystals.

The common form of the goethite which must be from reworked ochre contains chlorite cores on which goethite is precipitated as hemispheres grading to continuous coatings. The iron in this case has been transported in solution and reprecipitated. This character will probably prove typical of the reworked ochres.

A processing laboratory has been set up at Savage River in which the fines are being extracted from the samples (initially from the winter program only) and yields, colour and Fe₂O₃ compositions determined prior to further processing experiments. Few results are yet available but the following table gives the first ones available.

TABLE 3

Table of Munsell colours, iron oxide content and dry weight yields of crude ochre.

Borehole /surface weight Sample No	Munsell colour: dry slip	Extract of fines Sample No	Munsell colour powder	iron content Fe2O3 %	yield as dry sample %
Borehole HB 2.					
HB2/1	10YR 5/8	SR02	9.5YR 5.4/5.6	54.8	54.9
HB2/2	10YR 5/9				
HB2/3	10YR 5/9				
HB2/4	10YR 5/8	SR03	8.6YR 5.3/4.7	34.8	39.9
HB2/5	9YR 5/5				
HB2/6	10YR 5/8	SR05	8.7YR 5.4/4.8	30.1	61.2
HB2/7	8YR 6/6				
HB2/8	10YR 5/8				
HB2/9	10YR 5/5	SR06	9.1YR 5.8/4.7	23.1	33.8
HB2/10	10YR 5/5				
HB2/11					
HB2/12	10YR 5/4	SR04	8.7YR 5.6/4.4	26.8	59.0
Borehole HB 3.					
HB3/1	10YR 6/8	SR07	9.6YR 6.9/5/9	20.1	49.9
HB3/2	10YR 6/8	SR08	9.3YR 5.8/5.2	32.4	47.1
HB3/3	10YR 5/10				
HB3/3	10YR 5/10	CG01	9.6YR 5.8/5.4	50.8	49.0
HB3/4	10YR 5.8	SR09	9.3YR 6.1/6.3	50.8	61.0
HB3/5	10YR 4.5/10	SR10	8.6YR 5.2/5.2	20.7	49.5
HB3/6	10YR 4.5/10				
HB3/7	10YR 4/7	SR11	8.6YR 5.1/4.9	64.1	44.9
HB3/8	10YR 4/5				
HB3/9	10YR 4/6				

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HB3/10	10YR 4/6	SR12	8.5YR 5.1/4.7	64.3	46.5
HB3/11	10YR 4/7				
HB3/12	10YR 4/5	SR13	8.7YR 4.8/4.1	48.4	28.2
Borehole HA 4 (part)					
HA4/14	10YR 5/6	SR14	9.1YR 6.4/6.1	34.2	16.1
Borehole HC 1 (part)					
HC1/5	10YR 5/5	CG02	0.1Y 5.8/4.0	22.2	55.3
HC1/6	10YR 5/5				
Borehole HE 1 (part)					
HE1/1	8YR 5/8	CG03	not received		
HE1/2					
Borehole HE 3 (part)					
HE3/8	10YR 6/8	CG04	9.3YR 6.4/5.0	17.9	42.2
Roadside exposure HT 5/1 (excellent residual ochre)					
HT 5/1		SRO1	9.8YR 5.9/6.5	93.1	37.8

Resource estimates

A resource estimate has been prepared (see Appendix 3 page 175) using the log data provided in appendices 1 and 2 using "Techbase", with some necessarily procrustean assumptions about density and recovery factor that are deliberately conservative.

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APPENDIX 1:

Revised bore logs: Winter program

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Auger Hole HZ 1

Drilled 20/6/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Revised log from consolidated samples by H. Shannon, 2-5-1990. Total depth 20.0m. Location 346630.90mE, 5400371.04mN; RL 179.94m.

Sample	From- to	Description
HZ1/1	0.0- 1.5	7.5YR 5/8 (9YR 6/8 when dry) CLAY/OCHRE, clasts 10% to 7mm, quartz, spongy quartz, limonite; dry slip colour 8YR 5/8.
HZ1/2	1.5- 2.0	8YR 5/8 (10YR 6/8 dry, with minor 10YR 7/6) clayey OCHRE, clasts 10% to 7mm; limonite, quartz, white clay ex greenschist?; dry slip colour 9YR 5/10.
HZ1/3	2.0- 3.0	7YR 5/8 (8YR 7/6 dry, with minor 10YR 6/6, 10YR 8/8) silty CLAY/OCHRE, clasts <2%, <2mm; dry slip colour 8YR 6/6.
HZ1/4	3.0- 4.5	8YR 6/6 (9YR 7/8 dry) clayey OCHRE, clasts 15% to 5mm; white clay ex-greenschist?, weathered greenschist, quartz; dry slip colour 9YR 5.5/8.
HZ1/5	4.5- 6.0	7YR 5/7 (9YR 5.5/8 and 9YR 6.5/8 when dry) clayey OCHRE, clasts 15% <5mm; weathered greenschist, quartz, talc?; dry slip colour 9YR 5/8.
HZ1/6	6.0- 7.5	8YR 5/8 (9YR 6/7 dry) clayey OCHRE with 10% clasts <5mm; limonite, quartz, white clay; dry slip colour 9YR 5/8.
HZ1/7	7.5- 8.5	8YR 5/6 (9YR 6.5/6 dry) clayey OCHRE with clasts to 7mm, 10%; white clay ex greenschist, quartz, limonite; dry slip colour 9YR 6/7.
HZ1/8	8.5- 9.5	8YR 6/7 (9YR 5.5/8 dry) clayey OCHRE with 10% clasts to 5mm; weathered greenschist, quartz, limonite; dry slip colour 9YR 6/8.
HZ1/9	9.5-10.5	9YR 5/7 (9YR 6.5/7 dry) clayey OCHRE with clasts to 1cm, 20%; talc schist, weathered greenschist, limonite, talc; dry slip colour 9YR 6/7.

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- HZ1/10 10.5-12.0 8YR 6/6 (9YR 6/8 and 7YR 7/3 when dry) 50% clayey OCHRE with 10% clasts to 7mm, 50% soft talc schist breccia in talcose pulp matrix. The consolidated dry slip colour is 9YR 6/6.
- HZ1/11 12.0-14.5 9YR 5/6 (10YR 6/7 dry) reworked OCHRE with 25% clasts to 1cm; talc schist, residual ochre, limonite, talc; dry slip colour 10YR 5/6.
- HZ1/12 14.5-15.0 9YR 5/6 (10YR 5.5/7 dry) clayey OCHRE grading to talc schist BRECCIA; clasts 30% to 1cm, all talc schist; dry slip colour 9YR 5.5/6.
- HZ1/13 15.0-18.0 3Y 5/4 with 10YR 5/5 (5Y 6/2 with 9YR 5/6 dry) talc schist BRECCIA with talcose pulp matrix with minor 10YR 5/6 clayey OCHRE; dry slip colour 1Y 6/3.
- 18.0-20.0 GREENSCHIST, no sample taken.

Hole ended at 20m; too hard, no progress.

Auger Hole HZ 2

Drilled 20/6/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Revised log from consolidated samples by H. Shannon, 2-5-1990. Total depth 14.5m. Location 346612.55mE, 5400382.83mN; RL 177.20m.

Sample	From- to	Description
HZ2/1	0.0- 1.5	8YR 4.5/6 (9YR 5/8 dry) CLAY/OCHRE with clasts 25% to 2cm; limonite, talc schist, white clay ex greenschist; dry slip colour 9YR 6/8.
HZ2/2	1.5- 3.0	8YR 5/6 (9YR 5/12 dry) reworked OCHRE with clasts 20% to 7mm, comprising residual ochre (15%), quartz (3%), limonite (2%); dry slip colour 9YR 5/11.
HZ2/3	3.0- 6.0	8YR 5/6 (9YR 5/12 dry) reworked OCHRE with clasts 25% to 1cm; comprising residual ochre (15%) limonite (8%) quartz (2%); dry slip colour 10YR 5/12.
HZ2/4	6.0- 7.5	8YR 5/6 (10YR 5/12 dry) reworked OCHRE with clasts to 7mm, 20%; talc schist, limonite, minor residual ochre; dry slip colour 10 YR 5/11.
HZ2/5	7.5- 8.5	10YR 5/6 (10YR 6/6, 10YR 6/8 and 10YR 7/6 dry) reworked OCHRE grading to CLAY/OCHRE. Clasts to 1cm, 20%; talc schist, spongy quartz, quartz; dry slip colour 9YR 6/7.
HZ2/6	8.5-12.0	2Y 5/4 (2Y 6/6 dry) talc schist BRECCIA in clay matrix; clasts to 1cm, 35%; all talc schist; dry slip colour 2Y 6/5.
	12.0-14.5	GREENSCHIST, no sample taken.

Hole ended at 14.5m; too hard.

Auger Hole HZ 3

Drilled 21/6/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Revised log from consolidated samples by H. Shannon, 15/5/1990. Total depth 14.5m. Location 346586.96mE 5400396.04mN; RL 173.54m.

Sample	From- to	Description
HZ3/1	0.0- 1.5	8YR 5/10 80% brecciated sandy residual OCHRE with reworked OCHRE matrix and 20% 1Y 7/6 softened talc schist; sample disperses to 9YR 6/12; dry slip colour 10YR 5/12.
HZ3/2	1.5- 2.5	8YR 5.5/10 80% brecciated residual OCHRE with reworked OCHRE matrix, with other clasts to 1cm, 10%; quartz, limonite and 20% softened talc schist; sample disperses to 10YR 6/10; dry slip colour 10YR 5/10.
HZ3/3	2.5- 3.5	10YR 6/6 CLAY/OCHRE with clasts to 2cm, 20%; talc schist; disperses to 10YR 6/8; dry slip colour 10YR 6/6.
HZ3/4	3.5- 4.5	8YR 6/6 CLAY/OCHRE with clasts to 1cm, 20%; talc schist, weathered greenschist; disperses to 7.5YR 6/8; dry slip colour 8YR 6/8.
HZ3/5	4.5- 5.5	8YR 5.5/8 clayey OCHRE with clasts to 1cm, 20%; talc schist, quartz; disperses to 9YR 6/10; dry slip colour 9YR 5/8.
HZ3/6	5.5- 6.0	8YR 5/8 reworked OCHRE with clasts to 1cm, 20%; talc schist; disperses to 8YR 6/10; dry slip colour 9YR 5.5/8.
HZ3/7	6.0- 6.0	9YR 6/8 clayey OCHRE with clasts to 7mm, 15%; talc schist, limonite; disperses to 9YR 5.5/10; dry slip colour 9YR 5/8.
HZ3/8	8.0- 8.5	9YR 5.5/8 clayey OCHRE with clasts to 7mm, 25%; talc schist, quartz; disperses to 9YR 5.5/10; dry slip colour 9YR 5.5/8.
HZ3/9	8.5- 9.0	9YR 6/7 clayey OCHRE with clasts <5mm, 25%; talc schist, quartz; disperses to 8YR 6/10; dry slip colour 9YR 5.5/8.

HZ3/10 9.0-10.5 1Y 6/4 talc schist BRECCIA with sandy clay
matrix clasts to 7mm, 30%; disperses to 1Y 5/5;
dry slip colour 2Y 5/5.

Hole ended at 10.5m; too hard.

Auger Hole HZ 4

Drilled 21/6/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Revised log from consolidated samples by H. Shannon, 17-5-1990. Total depth 21.0m. Location 346564.17mE 5400408.66mN; RL 169.77m.

Sample	From- to	Description
HZ4/1	0.0- 1.0	9YR 5/6 BRECCIA with CLAY/OCHRE matrix (sandy, not much fines) with clasts to 2cm, 30% quartz, spongy quartz, limonite; disperses to 10YR 6/7; dry slip colour 9YR 6/7.
HZ4/2	1.0- 1.5	9YR 5.5 80% BRECCIA as above and 20% 10 YR 6/6 softened talc schist. Sample disperses to 10YR 6/6; dry slip colour 9YR 6/7.
HZ4/3	1.5- 2.5	10YR 6/8 clayey OCHRE (silty) clasts <2mm, <2% quartz, limonite (isolated limonite to 1cm); disperses to 10 YR 6/8; dry slip colour 10YR 6.5/10.
HZ4/4	2.5- 3.0	9YR 6.5/8 clayey OCHRE (silty) with clasts to 2mm, 5% quartz, limonite (isolated quartz to 1cm); disperses to 8YR 6/9; dry slip colour 10YR 6/10.
HZ4/5	3.0- 4.5	6YR 5/7 clayey OCHRE clasts to 5mm, 15% weathered greenschist, quartz, limonite; disperses to 5YR 5/8; dry slip colour 7.5YR 5.5/8.
HZ4/6	4.5- 6.0	6YR 5/6 clayey OCHRE clasts to 5mm, 20% spongy quartz, quartz, limonite; disperses to 5YR 5/8; dry slip colour 8YR 5.5/8.
HZ4/7	6.0- 7.0	5YR 5/6 clayey OCHRE clasts to 5mm, 15% limonite, spongy quartz, quartz, weathered greenschist; disperses to 6YR 5/8; dry slip colour 7.5YR 5/6.
HZ4/8	7.0- 7.5	7YR 5/6 clayey OCHRE with clasts <2mm, <2% limonite, quartz (isolated limonite to 7mm); disperses to 6YR 5/8; dry slip colour 7YR 5.5/6.
HZ4/9	7.5- 9.0	7YR 6/6 CLAY/OCHRE (silty), clasts to 5mm, 2% limonite, quartz; disperses to 5YR 5/7; dry slip colour 7YR 5.5/6.

HZ4/10	9.0-10.5	5YR 5/6 clayey OCHRE clasts to 2mm, <2% quartz, limonite; disperses to 5YR 5/7; dry slip colour 7YR 5.5/6.
HZ4/11	10.5-12.0	4YR 5/6 clayey OCHRE clasts to 2mm, <2% quartz, limonite; disperses to 5YR 5/7; dry slip colour 7YR 5/6.
HZ4/12	12.0-13.5	6YR 5/5 clayey OCHRE clasts to 5mm, 20%; weathered greenschist, limonite, quartz; disperses to 7YR 5/6; dry slip colour 8YR 5/6.
HZ4/13	13.5-15.0	5YR 5/6 clayey OCHRE clasts to 1cm, 10% quartz, limonite; disperses 6YR 5/7; dry slip colour 7YR 5/6.
HZ4/14	15.0-16.0	9YR 5.5/7 reworked OCHRE with clasts to 7mm, 20%; quartz, limonite; disperses to 8.5YR 5/9; dry slip colour 9YR 6/7.
HZ4/15	16.0-18.0	9YR 6/7 reworked OCHRE with clasts to 1cm, 15%; quartz, limonite; disperses to 8YR 5.5/8; dry slip colour 9YR 6/6.
HZ4/16	18.0-19.0	9YR 6/6 CLAY/OCHRE with clasts to 7mm, 20%; quartz, limonite, weathered greenschist; disperses to 7.5YR 5/8; dry slip colour 9YR 6/7.
HZ4/17	19.0-19.5	8YR 6/6 CLAY/OCHRE with clasts to 5mm, 20%; quartz, weathered greenschist, talc; disperses to 7.5YR 5/9; dry slip colour 9YR 6/6.
HZ4/18	19.5-20.5	8YR 6/6 CLAY/OCHRE with clasts to 7mm, 15%; weathered greenschist, quartz; disperses to 7.5YR 5/8; dry slip colour 8YR 5.5/6.
HZ4/19	20.5-21.0	7YR 5/6 CLAY/OCHRE with clasts to 1cm, 20%; weathered greenschist, quartz; disperses to 7.5YR 5/8; dry slip colour 8YR 5.5/6.

Hole terminated in ochre at 21m.

Auger Hole HA 1

Drilled 15/6/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Revised log from consolidated samples by H. Shannon, c.4-4-1990. Location 346567.48mE, 5400345.96mN; RL 177.61m.

Sample	From- to	Description
HA1/1	0.0- 1.5	10YR 5/10 and minor 10YR 6/8 reworked OCHRE, with a few clasts <5%, <2mm. Dried slip colour 10YR 6/10.
HA1/2	1.5- 3.0	10YR 5/10 reworked OCHRE, few clasts, <5%, <2mm limonite. Dried slip colour 10YR 6/10.
HA1/3	3.0- 4.0	10YR 5/10 and minor 10YR 6/10 reworked and minor residual OCHRE. Dried slip colour 10YR 6/10.
HA1/4	4.0- 4.5	10YR 6/8 and minor 10R 4/6, 8YR 4/6 clayey reworked OCHRE with clasts <5%, <3mm. Dried slip colour 8YR 8/6.
HA1/5	4.5- 6.0	8YR 6/8 and 10YR 6.5/6 CLAY/OCHRE, with clasts <5%, <3mm. Dried slip colour 10YR 6/6.
HA1/6	6.0- 7.5	9YR 5/6 and 10R 4/6 CLAY/OCHRE, with clasts 5%, to 5mm. Dried slip colour 7YR 5/6.
HA1/7	7.5- 9.0	8YR 5/6 CLAY/OCHRE, with clasts to 1cm, 5%, including limonite and talc. Dried slip colour 7YR 5/6.
HA1/8	9.0-10.5	9YR 4/6 reworked clayey OCHRE, with clasts to 1cm, 20%; limonite, some residual ochre, talc. Dried slip colour 9YR 5/5.
HA1/9	10.5-11.0	8YR 4/2 reworked clayey OCHRE, clasts 20% to 1cm; limonite, minor talc. Dried slip colour 9YR 4.5/4.
HA1/10	11.0-12.0	7YR 5/6 and 9YR 4/4, 9YR 6/6 CLAY/OCHRE, with clasts; limonite, weathered greenschist, quartz. Dried slip colour 9YR 6/6.
HA1/11	12.0-13.5	6YR 4/6 to 7YR 5/6 CLAY/OCHRE, with clasts to 5mm, limonite, weathered greenschist, talc. Dried slip colour 8YR 6/6.
HA1/12	13.5-14.0	7YR 5/6 and minor 10YR 6.5/8 CLAY/OCHRE with clasts 20%, greenschist, quartz, talc, limonite. Dried slip colour 8YR 6/6.

- HA1/13 14.0-15.0 8YR 7/6 and 8YR 5/6 CLAY/OCHRE with clasts limonite, weathered greenschist, quartz, talc 20% to 1.0cm. Dried slip colour 9YR 6/6.
- HA1/14 15.0-16.5 8YR 6/6 to 8YR 7/6 and minor 8YR 5/6 CLAY/OCHRE, with clasts 10% to 0.7cm; quartz, limonite, talc, weathered greenschist. Dried slip colour 9YR 6/6.
- HA1/15 16.5-17.0 8YR 6/6 to 6/8 CLAY/OCHRE, clasts 10%; quartz, weathered greenschist, limonite, talc. Dried slip colour 9YR 6/6.
- HA1/16 17.0-18.0 6YR 5/6 and minor 7YR 6/6 CLAY/OCHRE, clasts to 2.0cm, 10%; quartz, limonite, weathered greenschist. Dried slip colour 9YR 6/6.
- HA1/17 18.0-20.0 10R 5/7 and minor 7YR 6/4 CLAY/OCHRE, clasts 10%, weathered greenschist, limonite. Dried slip colour 5YR 5/6.

Hole terminated in ochre.

Auger Hole HA 2

Drilled 16/6/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Revised log from consolidated samples by H. Shannon, 10-5-90; total depth 7.5m. Location 346579.52mE 5400341.22mN; RL 181.09.

Sample	From- to	Description
HA2/1	0.0- 1.5	10YR 6/6 laminated CLAY with sparse clasts and 10YR 5/6 CLAY/OCHRE with clasts 20%; soft weathered greenschist, white clay, limonite; dry slip colour 10YR 7/7.
HA2/2	1.5- 3.0	8YR4/4, 10YR 5/6 reworked OCHRE and 10YR 7/6 CLAY, clasts to 1cm, 20%; weathered greenschist, white clay, limonite spongy quartz; dry slip colour 10YR 5/10.
HA2/3	3.0- 3.5	9YR 5/6 reworked OCHRE and 9YR 7/6 CLAY/OCHRE with clasts to 5mm, 15%; weathered greenschist, limonite, quartz; dry slip colour 10YR 5/10.
HA2/4	3.5- 4.5	5YR 5/4 and minor 10YR 6/6 weathered greenschist BRECCIA with CLAY/OCHRE matrix; clasts to 1cm, 25%; soft weathered greenschist, minor limonite; dry slip colour 7YR 6/5.
HA2/5	4.5- 5.5	7YR 6/4 and 8YR 6/6 greenschist BRECCIA with CLAY/OCHRE matrix; clasts to 2cm, 50%; weathered greenschist, minor limonite; dry slip colour 9YR 6/6.
HA2/6	5.5- 6.0	10YR 5/6 residual OCHRE, 50%, possibly as large clasts in 8YR 6/6 greenschist BRECCIA, 50% (possibly contamination from next interval above); dry slip colour 10YR 5.5/10.
HA2/7	6.0- 7.5	9YR 4/4 limonite BRECCIA with CLAY/OCHRE (umber) matrix; clasts to 7mm, 50%; limonite, weathered greenschist, white clay; dry slip colour 10YR 5/4.

End hole.

Auger Hole HA 3

Drilled 16/6/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Revised log from consolidated samples by H. Shannon, 10-5-90. Total depth 22.5m. Location 346590.52mE 540037.41mN; RL 183.71m.

Sample	From- to	Description
HA3/1	0.0- 1.5	8YR 6/6 weathered greenschist BRECCIA, clasts <1cm, 40%; soft weathered greenschist, minor limonite; dry slip colour 10YR 6/6.
HA3/2	1.5- 3.0	7YR 5/6 CLAY/OCHRE with clasts <5mm, 5%; weathered greenschist, limonite; dry slip colour 8YR 6/6.
HA3/3	3.0- 4.5	8YR 6/6 silty CLAY/OCHRE, clasts <5mm, 5% weathered greenschist; dry slip colour 9YR 6/6.
HA3/4	4.5- 6.0	9YR 5.5/6 clayey OCHRE with clasts <5mm, 10%; weathered greenschist, white clay, limonite, residual ochre; dry slip colour 10YR 6/7D.
HA3/5	6.0- 7.5	9YR 5.5/6 clayey OCHRE with clasts to 2cm, 20%; limonite, weathered greenschist, white clay; dry slip colour 10YR 5.5/7.
HA3/6	7.5- 8.5	9YR 5/6 clayey OCHRE, clasts to 7mm, 15%; weathered greenschist, limonite, quartz; dry slip colour 9YR 5.5/6.
HA3/7	8.5-10.5	8YR 5/6 CLAY/OCHRE clasts to 7mm, 10%; weathered greenschist, limonite, quartz; dry slip colour 9YR 5.5/7.
HA3/8	10.5-12.0	8YR 5.5/7 clayey OCHRE, clasts <7mm, 10%; limonite, quartz, white clay; dry slip colour 9YR 5.5/8.
HA3/9	12.0-12.5	9YR 5/7 reworked OCHRE, clasts <1cm, 15%; limonite, quartz, residual ochre; dry slip colour 10YR 5/8.
HA3/10	12.5-13.5	10YR 5/6 reworked OCHRE grading to breccia, clasts 30%; limonite, spongy quartz, residual ochre; dry slip colour 10YR 5/7.
HA3/11	13.5-14.5	9YR 5/7 reworked OCHRE with clasts <7mm, 10%; quartz, limonite; dry slip colour 10YR 5/7.

- HA3/12 14.5-15.5 9YR 5/8 reworked OCHRE with clasts <1cm, 15%; comprising residual ochre 7%, limonite 5%, quartz 3%; dry slip colour 10YR 5/8.
- HA3/13 15.5-16.5 9YR 5/6 reworked OCHRE (and 10YR 7/4 soft weathered greenschist); isolated clasts to 1cm, 5%; dry slip colour 9YR 6/7.
- HA3/14 16.5-19.5 9YR 6/7 greenschist BRECCIA with clayey OCHRE matrix; clasts to 1cm, 50%; greenschist, limonite; dry slip colour 10YR 5.5/8.
- HA3/15 19.5-20.5 9YR 5.5/7 clayey OCHRE clasts to 5mm, 15%; greenschist, residual ochre, limonite; dry slip colour 10YR 5.5/7.
- HA3/16 20.5-22.5 8Y 6/2 talc schist BRECCIA in talc pulp matrix; dry slip colour 2Y 6/4.

End of hole.

Auger Hole HA 4

Drilled 19/6/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Revised log from the consolidated samples by H. Shannon, 19-20/4/1990. Total depth 21.0m. Location 346599.28mE, 5400331.55mN; RL 186.08m.

Sample	From- to	Description
	0.0- 1.0	CLAY (discarded)
HA4/1	1.0- 1.5	8YR 5/6 reworked clayey OCHRE with clasts up to 1cm, 15%, soft talc schist, limonite, spongy quartz, quartz. Dried slip colour is Munsell code 8YR 6/8.
HA4/2	1.5- 3.0	8YR 5/6 reworked clayey OCHRE with clasts to 5mm, 15%; limonite quartz. Dried slip 8YR 6/7.
HA4/3	3.0- 4.5	8YR 4/6 reworked clayey OCHRE, with clasts to 7mm, 20%; weathered greenschist, limonite, quartz. Dried slip 8YR 6/7.
HA4/4	4.5- 6.0	10YR 6.5/6 silty CLAY/OCHRE with greenschist clasts. Dried slip 8YR 6/7.
HA4/5	6.0- 8.0	9YR 6/6 reworked clayey OCHRE with clasts to 7mm, 10%; weathered greenschist, quartz. Dried slip 9YR 6/6.
HA4/6	8.0- 9.5	9YR 6/7 reworked clayey OCHRE, with clasts to 5mm, 5%; quartz, talc, weathered greenschist. Dried slip 9YR 6/6.
HA4/7	9.5-10.5	8YR 5.5/6 reworked clayey OCHRE with clasts to 2mm, limonite, talc. Dried slip 9YR 6.5/6.
HA4/8	10.5-12.5	8YR 5/6 reworked clayey OCHRE with clasts to 2mm, 10%; limonite, quartz, talc. Dried slip 9YR 6/7
HA4/9	12.5-14.0	9YR 5/6 reworked clayey OCHRE with clasts to 1cm, 10% weathered greenschist, talc. Dried slip 9YR 5.5/7
HA4/10	14.0-15.0	8YR 5/6 reworked clayey OCHRE with clasts to 7mm, 15%; limonite, quartz, talc, weathered greenschist. Dried slip 9YR 5.5/7.

- HA4/11 15.0-17.0 9YR 5/6 reworked OCHRE with clasts to 5mm, 10%; residual ochre, quartz, weathered greenschist. Dried slip 10YR 5/6.
- HA4/12 17.0-18.0 9YR 5/5 reworked OCHRE with clasts to 1cm, 10%; quartz and residual ochre and 9YR 6/6 TALC SCHIST BRECCIA with CLAY/OCHRE matrix; clasts to 1cm, 50% talc schist. Dried slip 10YR 6/4.
- HA4/13 18.0-19.0 9YR 5/6 reworked OCHRE grading to ochre matrix BRECCIA, clasts to 1cm, 30%; limonite, quartz, residual ochre, talc schist. Dried slip 10YR 6/6.
- HA4/14 19.0-20.0 9YR 6/6 greenschist BRECCIA with CLAY/OCHRE matrix, clasts to 1cm, 40%; talc schist, quartz, residual ochre, sand ex sandstone? Dried slip 10YR 6/5.
- HA4/15 20.0-21.0 8YR 6/6 and 10YR 7/4 greenschist BRECCIA with CLAY/OCHRE matrix, clasts to 1cm, 60%; mostly talc schist, minor limonite, residual ochre, weathered greenschist. Dried slip 10YR 6/5.

End of hole.

Auger Hole HA 5

Drilled 19-20/6/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Revised log taken from the consolidated samples by H. Shannon, 11-5-1990. Total depth 21.0m. Location 346612mE 5400319.52mN; RL 189.30m.

Sample	From- to	Description
HA5/1	0.0- 1.5	10YR 5/10 residual OCHRE 30% and reworked OCHRE with clasts to 1cm, 30%; comprising residual ochre 20%, limonite 7%, weathered greenschist 2%, quartz 1%; disperses to 10YR 6/14; dry slip colour 10YR 5/10.
HA5/2	1.5- 2.0	9YR 5/8 reworked OCHRE with clasts to 7cm, 20% limonite, residual ochre, quartz, disperses to 10YR 6/12; dry slip colour 10YR 5/12.
HA5/3	2.0- 2.5	9YR 5/7 reworked OCHRE with clasts to 1cm, 25%; limonite, quartz residual ochre white clay; disperses to 10YR 6/14; dry slip colour 10YR 5/10.
HA5/4	2.5- 3.5	9YR 5/7 reworked OCHRE (and minor 10YR 5/5 clay/ochre or weathered greenschist) clasts to 1cm, 20%; limonite weathered greenschist quartz residual ochre; disperses to 10YR 6/8; dry slip colour 10YR 5/8.
HA5/5	3.5- 4.5	5YR 5/5 CLAY/OCHRE with clasts to 7mm, 20%; weathered greenschist, limonite, quartz; disperses to 5YR 5/5; dry slip colour 8YR 5/6.
HA5/6	4.5- 6.0	7YR 5/5 CLAY/OCHRE with clasts <5mm, 20%; weathered greenschist, limonite, and soft talc schist; disperses to 7.5YR 6/8; dry slip colour 9YR 5.5/7.
HA5/7	6.0- 8.5	7YR 5/5 CLAY/OCHRE with clasts to 1cm 25%; weathered greenschist, talc schist, spongy quartz, limonite; disperses to 7.5YR 6/6; dry slip colour 9YR 6/6.
HA5/8	8.5- 9.0	7YR 6/5 greenschist BRECCIA with talcose CLAY/OCHRE matrix; clasts 30%; weathered greenschist, limonite, white clay; disperses to 7.5YR 6/6; dry slip colour 9YR 6/7.

HA5/9	9.0-10.5	6YR 6/5 CLAY/OCHRE with clasts to 7mm, 15%; limonite, weathered greenschist, white clay; disperses to 7YR 6/6; dry slip colour 8YR 6/5.
HA5/10	10.5-12.0	6YR 5/6 CLAY/OCHRE with clasts to 2mm, 5% plus rare quartz to 2cm; disperses to 7YR 6/6; dry slip colour 8YR 6/5.
HA5/11	12.0-13.5	8YR 5/7 clayey OCHRE with clasts to 5mm, 15%; limonite, white clay, quartz (isolated 1cm 5R 5/4 weathered greenschist); disperses to 9YR 6/8; dry slip colour 9YR 6/6.
HA5/12	13.5-15.0	8YR 5/7 clayey OCHRE with clasts to 7mm, 5%; limonite, quartz; disperses to 9YR 6/7; dry slip colour 9YR 6/6.
HA5/13	15.0-16.0	8YR 5.5/7 reworked OCHRE with clasts to 2mm, 5%; weathered greenschist, quartz, white clay; disperses to 9YR 6/10; dry slip colour 8YR 6/6.
HA5/14	16.0-17.0	8YR 5/6 and minor 10R 5/4 CLAY/OCHRE with clasts to 7mm, 10%; weathered greenschist, limonite, quartz; disperses to 8YR 6/8; dry slip colour 7YR 6/6.
HA5/15	17.0-18.5	9YR 5/6 reworked OCHRE with clasts to 7mm, 10%; quartz, weathered greenschist, limonite; disperses to 10YR 6/8; dry slip colour 10YR 5/7.
HA5/16	18.5-19.5	10YR 5/6 reworked OCHRE with clasts to 5mm, 5%; quartz, weathered greenschist, limonite; disperses to 10YR 5/8; dry slip colour 10YR 4.5/8.
HA5/17	19.5-21.0	9YR 5/6 reworked OCHRE with clasts to 2cm; residual ochre, limonite, weathered greenschist, white clay (residual ochre 10% of whole); disperses to 10YR 5/10; dry slip colour 10YR 5/8.

Hole bottomed in ochre.

Auger Hole HB 1

Drilled 21-22/6/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Revised log from the consolidated samples by H. Shannon, 12-5-1990. Total depth 21.0m. Location 346551.80mE, 5400302.31mN; RL 176.67m.

Sample	From- to	Description
HB1/1	0.0- 0.7	8YR 4/6 reworked OCHRE grading to limonite BRECCIA with ochre matrix; clasts to 1cm, 30%; limonite, weathered greenschist, residual ochre (also minor 1Y 5/4 CLAY with organic matter). The sample disperses to 9YR 5/8; dry slip colour 10YR 6/8.
HB1/2	0.7- 1.5	4YR 5/6 reworked OCHRE, clasts to 7mm, 25%; limonite, residual ochre. The sample disperses to 6YR 4/8; dry slip colour 4YR 5/8.
HB1/3	1.5- 2.5	6YR 5/6 limonite BRECCIA with OCHRE matrix (and 8YR 7/7 clay matrix BRECCIA); clasts to 1cm, 40%; limonite, weathered greenschist; disperses to 8YR 5/9; dry slip colour 7YR 6/8.
HB1/4	2.5- 4.5	8YR 4/6 limonite BRECCIA with OCHRE matrix; isolated clasts to 2cm, clasts to 7mm, 40%; limonite quartz, weathered greenschist, spongy quartz; disperses to 10YR 4/8; dry slip colour 8YR 5/7.
HB1/5	4.5- 6.0	6YR 5/6 clayey OCHRE grading to limonite BRECCIA clasts to 1cm, 25%; limonite, weathered greenschist; disperses to 7.5YR 5.5/6; dry slip colour 5YR 5/7.
HB1/6	6.0- 7.5	7YR 5/7 clayey OCHRE grading to limonite BRECCIA clasts to 7mm, 25%; limonite, minor spongy quartz; disperses to 7.5YR 5.5/6; dry slip colour 6YR 5/7.
HB1/7	7.5- 9.0	6YR 6/6 clayey OCHRE with clasts to 1cm, 20%; limonite; disperses to 8YR 5.5/6; dry slip colour 5YR 5/8.
HB1/8	9.0-10.5	6YR 5/6 clayey OCHRE (sandy/silty), with clasts to 5mm, 10%; limonite, quartz, white clay; disperses to 8YR 5/6; dry slip colour 5YR 5/6.

- HB1/9 10.5-12.0 7YR 4.5/7 clayey OCHRE with clasts to 1cm, 20%; limonite, "yellow" clay pug, weathered greenschist; disperses to 8YR 5/6; dry slip colour 5YR 5/6.
- HB1/10 12.0-12.5 4YR 5/6 and 5YR 5/6 clayey OCHRE (silty) with clasts <2mm, 5% and isolated clasts to 1cm; limonite, quartz, white clay; disperses to 6YR 4.5/6; dry slip colour 4YR 5/7.
- HB1/11 12.5-15.0 4YR 5/6 clayey OCHRE (silty) with clasts <5mm, 25%; limonite, quartz; disperses to 6YR 4.5/6; dry slip colour 2.5YR 5/7.
- HB1/12 15.0-16.5 2YR 4.5/6 CLAY/OCHRE with clasts to 7mm, 5%; limonite, quartz; disperses to 5YR 5/6; dry slip colour 2YR 4.5/8.
- HB1/13 16.5-18.0 2YR 4.5/6 CLAY/OCHRE with clasts to 1cm, <5%; limonite, talc; disperses to 6YR 5/6; dry slip colour 2.5YR 5/8.
- HB1/14 18.0-19.0 4YR 5/6 clayey OCHRE with clasts to 7mm, 10%; limonite, quartz, spongy quartz; disperses to 7YR 5/6; dry slip colour 4YR 5/7.
- HB1/15 19.0-20.0 5YR 5/6 CLAY/OCHRE (silty) with clasts to 2mm, <2% and isolated limonite clasts to 1cm; disperses to 7.5YR 5/6; dry slip colour 4YR 5/7.
- HB1/16 20.0-20.3 6YR 5/6 CLAY/OCHRE with clasts to 1cm, 10%; limonite, talc schist, quartz; disperses to 7YR 6/8; dry slip colour 5YR 5.5/8.
- HB1/17 20.3-20.5 10YR 6/8 residual OCHRE (with minor 5YR 6/6 weathered greenschist BRECCIA; clay/ochre matrix clasts to 7mm, 50%); disperses to 9YR 5.5/8; dry slip colour 7.5YR 5.5/12.
- HB1/18 20.5-21.0 4YR 5/6 weathered greenschist BRECCIA with CLAY/OCHRE matrix, clasts 40%; disperses to 8YR 5/4; dry slip colour 5YR 5/7.

End hole at 21m.

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Auger Hole HB 2

Drilled 22/6/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Revised log from consolidated samples by H. Shannon, c2-4-1990. Total depth 21.0m. Location 346576.44mE, 5400287.67mN; RL 181.89m.

Sample	From- to	Description
HB2/1	0.0- 1.5	10YR 5/6 reworked OCHRE, 10% clasts; dry slip colour 10YR 5/8.
HB2/2	1.5- 3.0	10YR 5/8 reworked OCHRE, 10% clasts, <5mm; dry slip colour 10YR 5/9.
HB2/3	3.0- 4.5	10YR 5/8 to 10YR 6/8 reworked OCHRE; dry slip colour 10 YR 5/9.
HB2/4	4.5- 5.5	5R 4/4 and 10YR 5/8 and minor 10 R 4/4 reworked OCHRE, with 20% small greenschist and quartz clasts; dry slip colour 10YR 5/8.
HB2/5	5.5- 6.0	5R 4/4 and 10YR 5/8 reworked OCHRE with clasts to 0.5cm, 15%; dry slip colour 9YR 5/5.
HB2/6	6.0- 6.5	10YR 5/6 and 7YR 5/6 with small clasts (<2mm) 20%; dry slip colour 10YR 5/8.
HB2/7	6.5- 8.0	5YR 4/6 to 5YR 5/6, minor 8YR 5/6 reworked clayey OCHRE, clasts to 0.5cm, 20%; dry slip colour 8YR 6/6.
HB2/8	8.0-10.0	7.5YR 5/6 reworked OCHRE grading to greenschist BRECCIA with ochre matrix, clasts to 0.5cm, 25%; dry slip colour 10YR 5/8.
HB2/9	10.0-12.0	9YR 5/5 greenschist BRECCIA with clay rich clay/ochre matrix, clasts to 0.5cm, 25%; dry slip colour 10YR 5/5.
HB2/10	12.0-13.5	8-9YR 5/5 clay matrix greenschist BRECCIA 25% clasts, dry slip colour 10 YR 5/5.
HB2/11	13.5-15.0	9YR 5/4 clay matrix greenschist BRECCIA grading to CLAY/OCHRE; 20% clasts; dry slip colour 10YR 5/4.
HB2/12	15.0-18.0	8YR 5/4 CLAY/OCHRE and 9YR 7/6 CLAY; clasts 15%; dry slip colour 10YR 5/4.

HB2/13 18.0-19.5 8YR 4/5 CLAY/OCHRE, small clasts 10%, isolated
clasts to 0.3cm; dry slip colour 10YR 4.5/5.

19.5-21.0 GREENSCHIST.

Hole terminated in greenschist at 21m.

Auger Hole HB 3

Drilled 22/6/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Revised log from consolidated samples by H. Shannon c3-4-1990. Total depth 21.0m. Location 346590.71mE, 5400276.15mN; RL 183.04m.

Sample	From- to	Description
HB3/1	0.0- 2.0	10YR 6/6 CLAY/OCHRE with quartz and greenschist clasts, small, to 0.3cm, 10%; dry slip colour 10YR 6/8.
HB3/2	2.0- 3.0	10YR 4/4 CLAY/OCHRE with minor sand, disperses to 10YR 5/6 clasts <10%, <0.2cm; dry slip colour 10YR 6/6.
HB3/3	3.0- 5.0	10YR 4/4 clayey OCHRE, clasts 10%, <0.2cm; dry slip colour 10YR 5/10.
HB3/4	5.0- 6.0	10YR 6/8 reworked OCHRE, clasts 5%; dry slip colour 10YR 5/8.
HB3/5	6.0- 7.5	9YR 4/4 reworked OCHRE, disperses to 9YR 5/5, small clasts <5%; dry slip colour 10YR 4.5/10.
HB3/6	7.5- 9.0	8YR 5/6 reworked OCHRE with minor 10YR 7/6 gritty CLAY; dry slip colour 10YR 4.5/10.
HB3/7	9.0-11.0	10YR 4/4 reworked OCHRE, <5% small clasts; dry slip colour 10YR 4/7.
HB3/8	11.0-14.0	as above; dry slip colour 10YR 4/5.
HB3/9	14.0-15.0	as above; dry slip colour 10YR 4/6.
HB3/10	15.0-16.5	10YR 4/6 (10 YR 5/6 when dry) reworked OCHRE, disperses to 10YR 4/6, small greenschist clasts 5%; some to 0.5cm; dry slip colour 10YR 4/6.
HB3/11	16.5-18.0	as above; dry slip colour 10YR 4/7.
HB3/12	18.0-20.5	10YR 3/4 reworked OCHRE with quartz and schist clasts; dry slip colour 10YR 4/5.
	20.5-21.0	white TALC SCHIST at 20.5.

End hole at 21m.

Auger Hole HC 1

Drilled 22/6/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Revised log from consolidated samples by H. Shannon. Total depth 21.0m. Location 346552.38mE, 5400233.91mN; RL 167.87m.

Sample	From- to	Description
HC1/1	0.0- 1.5	8YR 5/8 reworked clayey OCHRE with clasts to 0.5cm, 25%; limonite, talc schist, quartz; dry slip colour 7YR 6/8.
HC1/2	1.5- 2.5	10YR 5/8 reworked OCHRE, clasts to 0.5cm, 25%; talc schist, weathered greenschist, talc, limonite; dry slip colour 8YR 6/8.
HC1/3	2.5- 3.0	10YR 6/6 CLAY/OCHRE, clasts to 0.5cm, weathered greenschist; dry slip colour 9YR 6/7.
HC1/4	3.0- 5.0	10YR 5/6 and 10YR 5/8 with minor 10YR 5/4 and 10YR 2/2 reworked OCHRE with clasts to 2cm, talc schist, quartz, weathered greenschist, residual ochre; dry slip colour 10YR 5/9.
HC1/5	5.0- 6.0	9YR 5/5 reworked clayey OCHRE clasts to 0.7cm, 25%; talc schist, residual ochre; dry slip colour 10YR 5/5.
HC1/6	6.0- 9.0	9YR 4/4 reworked clayey OCHRE clasts to 0.7cm, 10%; talc schist, quartz; dry slip colour 10YR 5/5.
HC1/7	9.0-10.5	9YR 5/4 to 9YR 5/6 CLAY/OCHRE, stratified? clasts 15%; talc schist and quartz; dry slip colour 10YR 5/5.
HC1/8	10.5-13.0	9YR 5/5 CLAY/OCHRE, clasts to 1.5cm, 20%; talc schist, weathered greenschist, residual ochre, quartz; dry slip colour 10YR 6/5.
HC1/9	13.0-14.0	8YR 5/6 CLAY/OCHRE with large clasts of soft weathered talc schist to >10cm, 20%, also clasts to 1cm, 20%; quartz, weathered greenschist, talc schist; dry slip colour 10YR 6/6.
HC1/10	14.0-15.0	9YR 5/6 (talcose) CLAY/OCHRE, clasts to 1cm, 10%; talc schist, quartz, also residual ochre and limonite; dry slip colour 10YR 6/5.

- HC1/11 15.0-18.0 5R 4/6 with minor 10R 4/6 clayey OCHRE, clasts to 1cm, 10%; quartz, limonite, weathered greenschist; dry slip colour 1YR 5/5.
- HC1/12 18.0-20.0 10R 4/4 and 5YR 5/6 with minor 10YR 6/8 clayey OCHRE, clasts to 0.5cm, 5%; quartz, limonite, talc, greenschist; dry slip colour 5YR 5/5.
- HC1/12 20.0-21.0 10YR 6/8 residual OCHRE; 80% of sample, as large clasts? in matrix of 7YR 5/6 reworked OCHRE; 20% of sample, with quartz clasts to 0.5cm. Dried slip colour 10YR 5.5/12.

End hole at 21m.

Auger Hole HC 2

Drilled 26/6/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Revised log from the consolidated samples by H. Shannon, 13-5-1990. Total depth 18.0m. Location 346370.87mE, 5400222.02mN; RL 170.30m.

Sample	From- to	Description
HC2/1	0.0- 1.5	9YR 5/8 CLAY/OCHRE with clasts to 1cm, 20%; quartz, limonite; disperses to 10YR 6/8; dry slip colour 9YR 5/10.
HC2/2	1.5- 3.0	10YR 4/3 clayey OCHRE (umber) with clasts to 7mm, 20%; quartz, limonite, talc schist; disperses to 9YR 4/4; dry slip colour 10YR 4/4.
HC2/3	3.0- 3.5	9YR 4/3 CLAY/OCHRE with clasts to 7mm, 20%; weathered greenschist, limonite; dispersing to 8YR 4/5; dry slip colour 10YR 4/6.
HC2/4	3.5- 5.0	10YR 5/5 talc schist BRECCIA with clayey OCHRE matrix, clasts to 1cm, 40%; talc schist, weathered greenschist, quartz; dispersing to 10YR 5/6; dry slip colour 10YR 6/6.
HC2/5	5.0- 6.0	10YR 5/5 and 4YR 5/6 CLAY/OCHRE with clasts to 5mm, 10%; weathered greenschist, minor talc; dispersing to 7YR 5/6; dry slip colour 8YR 5/6.
HC2/6	6.0- 8.0	6YR 5/5 and 8YR 5/5 CLAY/OCHRE grading to talc schist BRECCIA, clasts to 1cm, 25%; talc schist, weathered greenschist, limonite, quartz; dispersing to 7YR 5/6; dry slip colour 8YR 5/5.
HC2/7	8.0-12.0	9YR 5/5 greenschist BRECCIA with CLAY/OCHRE matrix with clasts to 1cm, 40%; softened "fresh" and weathered greenschist, limonite, quartz; dispersing to 8YR 5/6; dry slip colour 9YR 5/5.
HC2/8	12.0-15.0	1Y 5/4 talc schist BRECCIA with CLAY matrix, clasts 40%; green talc schist (or chlorite schist), minor limonite quartz talc; dispersed colour 10YR 5/4; dry slip colour 10YR 6/4.
HC2/9	15.0-17.0	8YR 4/5 reworked OCHRE (umber) with clasts to 3mm, <10%; talc schist, talc; dispersed colour 7YR 5/7; dry slip colour 8YR 5/8.

HC2/10 17.0-18.0 10Y 7/2 60% talc schist BRECCIA in talc pulp matrix, clasts to 1cm, 30% and 8YR 5/4 40% talc schist BRECCIA in CLAY/OCHRE matrix, clasts to 1cm, 50%; dispersed colour of sample 9YR 5/6; dry slip colour 10YR 6/5.

End hole at 18m in greenschist.

Auger Hole HC 3

Drilled 26/6/89; Drillers T. Lodge, J. Walker; Stacpoolle's, Launceston. Revised log from the consolidated samples by H. Shannon, 12-5-1990. Total depth 9.0m. Location 346590.20mE, 5400211.58mN; RL 174.92m.

Sample	From- to	Description
HC3/1	0.0- 1.5	5YR 4/6 and 10R 4/4 CLAY/OCHRE with clasts to 5mm, 15%; limonite, weathered greenschist, quartz; disperses to 3YR 5/4; dry slip colour 6YR 5/4.
HC3/2	1.5- 2.5	7.5YR 4/10 reworked OCHRE (sienna) with clasts to 5mm, 20%, comprising residual ochre 15%, limonite 5%; disperses to 7.5YR 5/11; dry slip colour 8YR 5/12.
HC3/3	2.5- 3.0	6R 5/6 and 7YR 5/6 CLAY/OCHRE with clasts <5mm, 20%; weathered greenschist; disperses to 4YR 5/7; dry slip colour 7YR 5/8.
HC3/4	3.0- 4.0	6YR 4/3 CLAY/OCHRE (umber) with clasts <7mm, 20%; weathered greenschist, quartz, residual ochre; disperses to 6YR 4/4; dry slip colour 9YR 4/6.
HC3/5	4.0- 6.0	6YR 4/4 CLAY/OCHRE (umber) with clasts to 7mm, 10%; limonite, weathered greenschist, quartz; disperses to 6YR 4/6; dry slip, colour 7YR 5/5.
HC3/6	6.0- 9.0	7YR 4/3 CLAY/OCHRE (umber) with clasts <7mm, 20%; limonite, talc schist, quartz; disperses to 7YR 5/4; dry slip colour 9YR 5/5.

End hole.

Auger Hole HC 4

Drilled 26/6/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Revised log from consolidated samples by H. Shannon, 13-5-1990. Total depth 9.0m. Location 346533.12mE, 5400247.64; RL 163.95m.

Sample	From- to	Description
	0.0- 1.5	light green friable weathered greenschist (basic tuff)
HC4/1	1.5- 3.0	10YR 6/6 CLAY/OCHRE (silty/sandy) with clasts to 7mm, 25%; talc schist, weathered greenschist; dispersing to 10YR 5/8; dry slip colour 1Y 6/6.
HC4/2	3.0- 5.0	7YR 5/6 with minor 2Y 5/6, 10R 4/6 and 10Y 6/2 CLAY/OCHRE grading to greenschist BRECCIA; disperses to 7YR 5/6; dry slip colour 8YR 5/6.
HC4/3	5.0- 5.5	7YR 5/6 clayey OCHRE with clasts to 7mm, 10%; spongy quartz, weathered greenschist; disperses to 5YR 5/8; dry slip colour 7YR 5/7.
HC4/4	5.5- 9.0	10YR 5/8 residual OCHRE; disperses to 10YR 6/10; dry slip colour 10YR 5/14.

Hole abandoned at 9m in excellent ochre because the sample was being washed off the auger flights.

Auger Hole HD 1

Drilled 27/6/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Revised log from consolidated samples by H. Shannon. Total depth 21.0m. Location 346533.38mE, 5400152.42mN; RL 168.66m.

Sample	From- to	Description
HD1/1	0.0- 1.5	8YR 5/6 and minor 5Y 7/4 gravelly CLAY with clasts to 1cm, 30%; quartz, weathered amphibole greenschist, trace charcoal; dry slip colour 9YR 5/9.
HD1/2	1.5- 3.0	10YR 4/8 reworked ochre, clasts to 5mm, 20%; quartz, limonite, residual ochre, decomposed sandstone; dry slip colour 9YR 5/9.
HD1/3	3.0- 6.0	10YR 4/8 reworked OCHRE (and 20% residual OCHRE as clasts). Other clasts greenschist, quartz, limonite 10%; dry slip colour 10YR 5/10.
HD1/4	6.0-11.5	10YR 5/10 reworked OCHRE (and 40% residual OCHRE as clasts to 5mm). Also other clasts quartz to 1cm, 2% and limonite to 1mm, 1%; dry slip colour 10YR 5/10.
HD1/5	11.5-12.0	10YR 6/10 and 4.5Y 6/6 with minor 10YR 3/3 residual OCHRE, all as large clasts? in 20% reworked OCHRE matrix; dry slip colour 10YR 5/11.
HD1/6	12.0-13.0	10YR 5/9 reworked OCHRE with clasts to 5mm, 15%; limonite, residual ochre; dry slip colour 10YR 5/12.
HD1/7	13.0-15.0	6R 4/6 and minor 10YR 6/6 clayey OCHRE, with rare large clasts to 1.5cm, 5%; talc schist, quartz; dry slip colour 1YR 5/6.
HD1/8	15.0-17.0	2YR 5/6 reworked clayey OCHRE with clasts to 5mm, 15%; talc schist, quartz, residual ochre, limonite; dry slip colour 2YR 6/4.
HD1/9	17.0-18.0	5YR 7/4 with minor 2YR 5/6 and 10YR 5/9 talc schist BRECCIA with clasts of talc schist and minor quartz and residual ochre, 60% in talc schist pulp/ clay/ochre matrix; dry slip colour 7YR 7/4.

HD1/10 18.0-20.0 7YR 7/4 leached greenschist BRECCIA with talcose
clay/ochre matrix; minor quartz and residual
ochre clasts; dry slip colour 7YR 7/4.

20-21 GREENSCHIST.

Hole terminated in greenschist at 21m.

Auger Hole HD 2

Drilled 27/6/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Revised log from consolidated samples by H. Shannon, 18-5-1990. Total depth 15.0m. Location 346510.58mE, 5400162.57mN; RL 167.30m.

Sample	From- to	Description
	0.0- 1.5	brown CLAY and yellowish orange CLAY with greenschist chips; (transported cover material) over GRAVEL, with rounded quartz rich clasts in yellowish orange clay matrix.
HD2/1	1.5- 3.0	30% 7.5YR 7/8 sandy CLAY with charcoal, 60% 2.5YR 4/4 and 2.5YR 2/1 laminated peaty CLAY, 10% 10YR 6/7 gravelly CLAY including rounded quartz to 2cm; sample disperses to 1Y 5/4; dry slip colour 1Y 4/4.
HD2/2	3.0- 6.0	90% 2Y 4/4 GRAVEL with clay matrix rounded clasts to 2cm, 30%; quartz, chlorite schist, weathered greenschist. 10% 9YR 6/8 sandy CLAY. Sample disperses to 2Y 5/4; dry slip colour 2Y 5/4.
HD2/3	6.0- 9.0	2Y 4/4 BRECCIA with sandy CLAY matrix and 1% fibrous peaty plant remains; clasts to 2cm, 30% comprise fresh to softened greenschist 15%, rounded quartz 4%, angular quartz 4%, residual ochre 4%, weathered greenschist 4%, charcoal 1%; disperses to 2.5Y 5/4; dry slip colour 2Y 4/4.
HD2/4	9.0-12.0	5B 6/4 to 5Y 7/1 and minor 10YR 5/4 BRECCIA with CLAY matrix (minor sand only), clasts to 3cm, 30%; softened "fresh" chlorite schist with isolated large quartz; disperses to 3Y 5/4; dry slip colour 4Y 5/4.
HD2/5	12.0-15.0	2Y 4/4 BRECCIA with sandy CLAY matrix, clasts to 1cm, 25% comprising angular quartz 10%, chlorite schist 12%, residual ochre 3%; disperses to 2.5Y 5/4; dry slip colour 3Y 5/4.

Hole terminated in greenschist breccia at 15m.

Auger Hole HD 3

Drilled 27/6/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Revised log from consolidated samples by H. Shannon. Total depth 15.0m. Location 346550.43mE, 5400146.68mN; RL 169.88m.

Sample	From- to	Description
	0.0- 1.5	yellowish orange CLAY?, pale light green clay; transported soil and/or alluvium?
	1.5- 3.0	yellowish orange CLAY? and weathered greenschist chips.
HD3/1	3.0- 6.5	10YR 5.5/6 CLAY/OCHRE with clasts to 7mm, 10%; talc schist, quartz; disperses to 10YR 6/8; dry slip colour 1Y 7/6.
HD3/2	6.5- 7.5	10YR 5.5/6 CLAY/OCHRE with clasts to 1cm, 20%; talc schist; disperses to 10YR 6/7; dry slip colour 1Y 7/6.
HD3/3	7.5- 9.0	7YR 6/7 talc schist BRECCIA with CLAY matrix, clasts to 1cm, 30%; talc schist, weathered greenschist; disperses to 9YR 6/8; dry slip colour 10YR 6/6.
HD3/4	9.0-11.5	9YR 5.5/6 talc schist BRECCIA with CLAY matrix, clasts to 1cm, 25%; disperses to 9YR 6/8; dry slip colour 10YR 6/6.
HD3/5	11.5-14.0	10YR 5.5/6 CLAY with clasts to 7mm, 15%; talc schist, quartz; disperses to 10YR 6/7; dry slip colour 1Y 6/6.
	14.0-15.0	no recovery: possibly wet yellow ochre c.f. 6.5-7.5.

Hole terminated at 15m owing to non-recovery of sample.

Auger Hole HE 1

Drilled 27/6/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Revised log from consolidated samples by H. Shannon, 14-5-1990. Total depth 9.0m. Location 346601.74mE, 5400104.91mN; RL 171.08m.

Sample	From- to	Description
	0.0- 1.5	gravelly soil over light greenish grey sandy clay; transported soil and/or alluvium?
	1.5- 2.5	pale greenish grey chloritic weathered greenschist.
HE1/1	2.5- 6.0	8YR 5/8 reworked OCHRE (sandy) with clasts to 5mm, 20%; talc schist, quartz; disperses to 8YR 5/10; dry slip colour 8YR 5/8.
HE1/2	6.0- 7.0	9YR 5/7 reworked OCHRE with clasts <5mm, 25%; talc schist, talc, residual ochre, quartz, limonite; disperses to 9YR 6/8; dry slip colour 10YR 6/7.
HE1/3	7.0- 9.0	9YR 5/8 reworked OCHRE with clasts <5mm, 20%; limonite, residual ochre, talc, (isolated talc clasts to 1cm); disperses to 9YR 6/10; dry slip colour 10YR 5/8.

End hole.

Auger Hole HE 2

Drilled 28/6/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Revised log from consolidated samples by H. Shannon, 14-5-1990. Total depth 14.5m. Location 346577.82mE, 5400107.54mN; RL 170.68m.

Sample	From- to	Description
	0.0- 1.5	weathered greenschist, no sample taken.
HE2/1	1.5- 3.0	10YR 6/8 reworked OCHRE with clasts to 7mm, 15% (and isolated quartz clasts to 2cm); quartz, spongy quartz, limonite, talc schist; disperses to 10YR 6/8; dry slip colour 1Y 6/8.
HE2/2	3.0- 4.5	10YR 5/9 reworked OCHRE with clasts to 5mm, 10% (and isolated quartz clasts to 2cm); spongy quartz, limonite, talc schist; disperses to 10YR 6/12; dry slip colour 1Y 5/12
HE2/3	4.5- 6.0	9YR 5/8 limonite BRECCIA with OCHRE matrix, clasts to 2cm, 40% limonite, talc schist, quartz, spongy quartz; disperses to 10YR 5/10; dry slip colour 1Y 5/10.
HE2/4	6.0- 8.0	1Y 5/6 reworked OCHRE with clasts to 1cm, 20% talc schist, limonite, talc; disperses to 10YR 5.5/8; dry slip colour 2Y 6/8.
HE2/5	8.0- 9.0	1Y 5/4 50% reworked OCHRE with talc schists and limonite clasts to 1cm, 15% and 50% 5Y 7/3, 2YR 6/4 softened talc schist. Sample disperses to 10YR 5.5/9; dry slip colour 2Y 6/8.
HE2/6	9.0-10.5	1YR 5/8 reworked OCHRE with clasts to 1cm, 10% limonite, talc schist; disperses to 3YR 4/5; dry slip colour 3YR 5/7.
HE2/7	10.5-12.0	3YR 5/6 reworked OCHRE with clasts to 7mm, 15% talc schist, limonite; disperses to 4YR 5/7; dry slip colour 5YR 5/6.
HE2/8	12.0-14.5	2YR 5/6 reworked OCHRE with clasts to 1cm, 10% talc schist, quartz; disperses to 5YR 5/7; dry slip colour 5YR 5/6.

End hole.

Auger Hole HE 3

Drilled 28/6/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Revised log from consolidated samples by H. Shannon. Total depth 14.5m. Location 346553.61mE 5400110.12; RL 170.76m.

Sample	From- to	Description
	0.0- 1.5	yellowish orange clay (transported soil), no sample taken.
HE3/1	1.5- 3.0	5YR 5.5/8 and 10YR 7/5 laminated clay; dry slip 9YR 7/5.
HE3/2	3.0- 3.5	7YR 5.5/8 CLAY/OCHRE with clasts <5mm, 2%; limonite, quartz, talc; dry slip 9YR 7/6.
HE3/3	3.5- 5.0	10YR 5/10 reworked OCHRE, clasts 5%; quartz weathered greenschist, limonite; dry slip 10YR 6/12.
HE3/4	5.0- 6.0	9YR 7/8 and 5YR 7/6 CLAY, and 10YR 5/8 with minor 10YR 6/10 reworked OCHRE, clasts 10%; limonite, quartz, weathered greenschist; dry slip 10YR 7/6.
HE3/5	6.0- 9.0	10YR 6/10 reworked OCHRE, clasts to 5mm, 10%; quartz, talc, limonite; dry slip colour 10YR 6/10.
HE3/6	9.0-10.5	10YR 5/8 ochre matrix BRECCIA, clasts 40%, quartz, limonite, talc schist; dry slip 10YR 6/9.
HE3/7	10.5-12.0	8YR 5/8 to 8YR 6/8 with minor 9YR 6/8 clayey OCHRE, clasts 15%; limonite, talc schist, quartz; dry slip 9YR 6/8.
HE3/8	12.0-15.0	8YR 6/6 and 10YR 5/5 CLAY/OCHRE, CLASTS to 2mm, 5%; dry slip 10YR 6/6.
HE3/9	15.0-17.0	10YR 5/7 clayey OCHRE, clasts to 5mm, 15%; quartz, talc, weathered greenschist, limonite; dry slip colour 10YR 6/7.
	17.0-18.0	dark green greenschist.

Hole terminated in greenschist at 18.0m.

APPENDIX 2:

Drilling logs: Summer program

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Auger hole JH 1.

Drilled on 18/1/90 commencing 8.45am by T. Lodge, Stacpoole's Launceston. Logged by H. Shannon. Total depth 21 metres. Location 346636.52mE, 5400630.22mN; RL 201.74m.

Sample	From- to	Description
JH1/1	0.0- 0.5	quartz GRAVEL (includes spongy quartz)
	0.5- 1.0	fine sand; pinkish grey 5YR 8/1.
JH1/2	1.0- 1.7	fine SAND; yellowish grey 3Y 7/2.
	1.7- 2.5	SAND with peaty binder, smells swampy; olive grey 3Y 4/2.
JH1/3	2.5- 3.5	PEAT with greenschist clasts; dark brownish grey 5YR 3/1.
	3.5- 4.0	ground up GREENSCHIST in pulp; greenish grey 5GY 5/1 (not sampled).
JH1/4	4.0- 5.1	GREENSCHIST ground up in pulp; light greenish grey 5Y 8/1.
	5.1- 5.5	greenschist BRECCIA; yellowish grey 5Y 7/4, with minor OCHRE; strong yellowish orange 10YR 6/8.
JH1/5	5.5- 7.0	greenschist/quartz BRECCIA with very clayey clay/ochre matrix; dark orange yellow 2Y 6/4 to moderate brown 10YR 5/4.
	7.0- 7.8	as above (not sampled).
JH1/6	7.8- 8.5	reworked sandy OCHRE with clasts of spongy quartz and greenschist; dark yellowish orange 10YR 5/6 dispersing to strong yellowish orange 10YR 6/7.
JH1/7	8.5- 9.5	greenschist/quartz BRECCIA with clay/ochre matrix, moderate yellowish brown 10YR 5/4 dispersing to 10YR 5/6, darker at base.
	9.5-10.0	CLAY/OCHRE grading to PEAT; olive black 2Y 2/1 dispersing to dark olive brown 5Y 4/2.
JH1/8	10.0-11.5	peaty CLAY/OCHRE with clasts; very dark yellowish brown 10YR 3/2, grading to ochre near base; dusky yellow 3Y 6/4 and moderate brown 8YR 4/4.

- JH1/9 11.5-13.0 sandy reworked CLAY/OCHRE, dark yellowish brown 10YR 4/4 wet, sample loss and contamination; includes trace of OCHRE, dull orange yellow 2Y 6/4.
- JH1/10 13.0-14.5 probably as above (sample lost).
- JH1/11 14.5-16.0 greenschist BRECCIA with clay matrix; olive brown 5Y 5/4.
- JH1/12 16.0-18.0 reworked OCHRE with clasts and some OCHRE with ex magnesite texture; olive brown 3Y 4/6.
- JH1/13 18.0-19.0 reworked ochre; olive yellowish orange 2Y 5/6.
- JH1/14 19.0-20.9 OCHRE; dull orange yellow ochre 3Y 6/6; dries to strong orange yellow 4Y 6/7. (most of sample lost).
- JH1/15 20.9-21.0 white chalky weathered MAGNESITE; hard at bottom.

Hole complete. Note. more yellow than usual but low chroma.

051

Auger hole JH 2.

Drilled 18/1/90 commencing 12.15pm by T. Lodge, Stacpoole's
Launceston. Logged by H. Shannon. Total depth 23.5 metres. Location
346645.27mE, 5400622.35mN; RL 203.80m.

Sample	From- to	Description
JH2/1	0.0- 1.0	gritty SAND; very pale orange 10YR 8/2.
JH2/2	1.0- 2.0 2.0- 2.5	SAND; light brownish grey 5YR 6/1. talc schist BRECCIA; light brownish grey 5YR 6/1.
JH2/3	2.5- 3.2 3.2- 4.0	as above (not sampled). muddy SAND; brownish grey 5YR 5/1, grading to PEAT brownish black 5YR 2/1 at base.
JH2/4	4.0- 5.5	muddy PEAT with greenschist clasts, dark brownish grey 5YR 3/1.
JH2/5	5.5- 6.5 6.5- 7.0	PEAT with some schist clasts including a block of greenschist breccia; dusky brown 5 YR 7/2. greenschist BRECCIA with pulp matrix, clasts mostly grey talc schist; (more green than) olive grey 5Y 6/1.
JH2/6	7.0- 8.5	as above.
JH2/7	8.5- 9.5 9.5-10.0	as above. ground up TALC SCHIST; greenish grey 5Y 6/1 (boulder).
JH2/8	10.0-11.5	greenschist BRECCIA with clay/ochre matrix; drab yellowish orange 10YR 6/5.
JH2/9	11.5-13.0	reworked OCHRE; intense orange 10YR 4/8 dispersing to dark yellowish orange 10YR 6/8.
JH2/10	13.0-14.5	sandy OCHRE, reworked and residual; strong orange 10YR 5/7 dispersing to 10YR 6/8.
JH2/11	14.5-16.0	SAND and greenschist BRECCIA with clay/ochre matrix; moderate yellowish brown 10YR 4/2 to yellowish orange 10YR 6/7.
JH2/12	16.0-17.5	as above.

JH2/13	17.5-19.0	reworked OCHRE with greenschist clasts; strong dark yellowish orange 10YR 5/7 dispersing to 10YR 6/8.
JH2/14	19.0-20.5	as above.
JH2/15	20.5-22.0	as above.
JH2/16	22.0-23.0	as above, part sample lost: hard bottom.

At the end 2 auger flights were broken off and lost down the hole.
End hole.

Auger hole JH 3

Drilled 19/1/90 commenced 8.00am by T. Lodge, Stacpoole's Launceston. Logged by H. Shannon. Total depth 22 metres. Location 346653.74mE, 5400334.01mN; RL 202.76m.

Sample	From- to	Description
JH3/1	0.0- 1.0	SAND, pinkish grey 5YR 7/1 over greenschist BRECCIA (or greenschist); greenish grey 5GY 6/1 pulp matrix, clasts of talc schist.
JH3/2	1.0- 2.5	laminated CLAY with isolated quartz clasts, yellowish grey 5Y 7/2 to very dark yellow brown orange 10YR 4/6.
JH3/3	2.5- 4.0	greenschist BRECCIA with clay matrix, light olive brown 5Y 5/6 to 5Y 5/4.
JH3/4	4.0- 5.5	greenschist BRECCIA with clay matrix, light olive brown 5Y 5/6, clasts greenish grey talcy subfissile schist.
JH3/5	5.5- 7.0	greenschist BRECCIA as above, clasts to 1cm, patches light olive grey 5Y 5/2 mostly 5Y 5/6.
JH3/6	7.0- 8.0	greenschist BRECCIA in clay matrix; olive grey 5Y 4/2, grading to greenschist BRECCIA with peaty clay matrix; olive brown 5Y 3/11.
	8.0- 8.5	PEAT; (contaminated); olive brown 5Y 3/1.
JH3/7	8.5- 9.3	muddy PEAT; olive brown 5Y 3/1 with a few clasts.
	9.3-10.0	peaty CLAY; dark olive brown 5Y 2/1.
JH3/8	10.0-11.5	greenschist BRECCIA with clay matrix; brownish grey 5YR 4/1; abundant clasts of chlorite schist, soft but otherwise fresh. The mud matrix is laminated and has a silvery appearance from contained chlorite.
JH3/9	11.5-13.0	greenschist BRECCIA with clay matrix, soft fresh clasts as above; yellowish brown 10YR 5/2.
JH3/10	13.0-14.5	greenschist BRECCIA with clay matrix, small clasts, brownish grey 2Y 5/2.

- JH3/11 14.5-15.3 reworked sandy OCHRE with a few clasts;
greenschist, quartz and talc; dark yellowish
orange 10YR 6/6 same dispersed colour.
- 15.3-16.0 reworked SAND/OCHRE with a few clasts of quartz,
greenschist and talc; moderate yellow brown 3Y
5/4.
- JH3/12 16.0-17.0 SAND/OCHRE as above with talc, greenschist and
quartz clasts.
- 17.0-17.5 SAND/OCHRE as above with talc and quartz clasts.
- JH3/13 17.5-18.5 greenschist BRECCIA with clay matrix, greenschist
and vein quartz clasts of "allochthonous" aspect
(no spongy quartz), dusky orange yellow 3Y 6/3.
- JH3/14 18.5-19.5 as above.
- JH3/15 19.5-20.5 as above.
- JH3/16 20.5-21.5 as above with isolated peat clasts.
- JH3/17 21.5-22.0 as above, yellow brown 1Y 6/4.

Hole very tight at base, and chain problems: Hole abandoned.

Auger hole JH 4.

Drilled 19/1/90 commencing 2.40m by T. Lodge, Stacpoole's
Launceston. Logged by H. Shannon. Total depth 7 metres. Location
346665.20mE, 5400609.28mN; RL 203.13m.

Sample	From- to	Description.
JH4/1	0.0- 1.0	SAND with quartz clasts, pinkish grey 5YR 7/1.
JH4/2	1.0- 2.5	SAND with quartz clasts, pinkish grey 2YR 7/2.
JH4/3	2.5- 4.0	wet SAND with quartz clasts, orange grey 2Y 7/2 traces of PEAT at base.
JH4/4	4.0- 5.5	PEAT; black to dusky brown 5YR 2/2 (sample lost except for base).
JH4/5	5.5- 7.0	PEAT with sparse clasts including quartz, black M1 dispersing to dusky brown 5YR 2/2.

Hole collapsed and abandoned.

Auger hole JH 5.

Drilled 19/1/90 commencing 3.45pm by T. Lodge, Stacpoole's
Launceston. Logged by H. Shannon. Total depth 23.5 metres. Location
346675.84mE, 5400603.63mN; RL 202.78m.

Sample	From- to	Description.
JH5/1	0.0- 1.0	SAND with quartz clasts, pinkish grey 5YR 7/1.
JH5/2.1	1.0- 2.0	SAND with quartz clasts; pinkish grey 5YR 7/1.
.2	2.0- 2.5	Fine sand; white N9 and yellowish grey 5Y 8/1.
JH5/3	2.5- 4.0	peaty CLAY with greenschist clasts grading to PEAT; dusky brown 5YR 2/3.
JH5/4.1	4.0- 5.0	greenschist BRECCIA, clasts actinolite schist; grey olive green 5GY 3/2.
.2	5.0- 5.5	PEAT with abundant (actinolite) greenschist clasts brownish black 5YR 2/1.
JH5/5.1	5.5- 6.5	peaty CLAY with abundant quartz and greenschist clasts; dark yellowish brown 10YR 3/2.
.2	6.5- 7.0	peaty CLAY as above, and greenschist BRECCIA; greyish olive green 5GY 3/2.
JH5/6	7.0- 8.5	greenschist BRECCIA with clay/pulp matrix; actinolite schist and quartz clasts; greyish olive green 5GY 3/2 to moderate olive brown 5Y 5/4.
	8.5- 9.0	as above (not sampled).
JH5/7	9.0-10.0	greenschist BRECCIA with (sandy) pulp matrix, isolated quartz clasts; greyish olive 10Y 4/2.
JH5/8	10.0-11.5	greenschist BRECCIA with sandy clay matrix; olive grey 7Y 5/2.
JH5/9	11.5-13.0	greenschist BRECCIA with sandy clay matrix, clasts of actinolite schist, talc schist and quartz; greyish olive 10Y 4/2.
JH5/10	13.0-14.5	greenschist BRECCIA with sandy clay matrix; greyish olive 7Y 4/2, and some light olive grey 5Y 5/2 (which indicates the peat-free material).

- JH5/11 14.5-16.0 greenschist BRECCIA with clay matrix; light olive grey 5Y 5/2 to brownish olive grey 2Y 5/2. At base, ochre; brown 5YR 3/6.
- JH5/12 16.0-17.5 greenschist BRECCIA as above; brownish olive grey 2Y 5/2 then greyish olive 10Y 4/2.
- JH5/13 17.5-18.5 greenschist BRECCIA in clayey sand matrix grading to pulp derived from actinolite SCHIST which is the common clast type, also minor quartz and peat (small clasts); bands of peat mud. Overall colour brownish olive 2Y 4/2.
- JH5/14 18.5-19.5 as above.
19.5-20.5 greenschist BRECCIA with pulp matrix and layers of peat mud, clasts to 1cm but mostly small. The matrix colour is greyish olive green 5GY 3/2 and dusky brown 5YR 2/4.
- JH5/15 20.5-23.5 BRECCIA as above over talc schist BRECCIA, fine clasts in pulp matrix; light bluish grey 5B 6/1. Poor recovery, (bedrock a possibility) sample contaminated.

Hole abandoned.

Auger Hole JH 6.

Drilled 20/1/90 commencing 1.15pm by T. Lodge, Stacpoole's, Launceston. Logged by H. Shannon. Total depth 11.9 metres. Location 346686.19mE, 5400597.10mN; RL 203.62m.

Sample	From- to	Description.
JH6/1	0.0- 1.0	SAND with clasts of quartz and talc schist and ochre binder; dark yellowish orange 10YR 4/7.
JH6/2	1.0- 2.5	talc schist BRECCIA in clay/pulp matrix; yellowish grey 5Y 7/2.
JH6/3	2.5- 4.0	SAND with greenschist/quartz clasts, ochre binder; strong dark yellowish orange 10YR 5/7.
JH6/4.1	4.0- 4.7	SAND/TALC/OCHRE with talc clasts; dark yellowish orange 10YR 6/6.
.2	4.7- 5.0	TALC; pale yellowish orange 10YR 8/6 and OCHRE; moderate yellowish brown 10YR 5/4.
.3	5.0- 5.5	reworked OCHRE with clasts talc/greenschist/quartz; dark yellowish orange 10YR 5/7 dispersing to 10YR 6/8.
JH6/5.1	5.5- 6.5	OCHRE as above.
.2	6.5- 7.0	sandy OCHRE; yellowish orange 10YR 6/8.
JH6/6.1	7.0- 7.5	sandy talc BRECCIA with ochre matrix; moderate yellowish orange 10YR 6/7.
.2	7.5- 8.5	greenschist BRECCIA, clay/ochre matrix; yellowish orange 10YR 6/6; and greenschist BRECCIA, clay/pulp matrix; yellow grey 5Y 8/1.
JH6/7.1	8.5- 9.2	as above, talc schist clasts.
.2	9.2-10.0	greenschist BRECCIA as above yellowish orange 10YR 6/6 and yellowish grey 2Y 7/2.
JH6/8	10.0-11.5	TALC SCHIST boulder, (recovered as bluish grey 5B 9/1 pulp and chips) in clay matrix talc schist BRECCIA; yellowish grey 5Y 6/2.
JH6/9	11.5-11.9	as above; at base, TALC SCHIST as chips and pulp; dark bluish grey 5B 8/1; boulder?.

Hole abandoned.

Auger Hole JH 2.

Drilled 20/1/90 commencing 3.15pm by T. Lodge, Stacpoole's, Launceston. Logged by H. Shannon. Total depth 14.5 metres. Location 346698.80mE, 5400591.40mN; RL 205.33m.

Sample	From- to	Description.
JH7/1	0.0- 1.0	sandy OCHRE with limonite, quartz and greenschist clasts; yellowish brown 10YR 5/6.
JH7/2	1.0- 2.5	reworked OCHRE with clasts; dark yellowish orange 10YR 6/7, and more talcose reworked OCHRE; greyish orange 10YR 7/4.
JH7/3	2.5- 4.0	talc schist BRECCIA in clay/pulp matrix; greyish yellow green 5GY 7/2 to yellowish grey 5Y 7/2.
JH7/4	4.0- 5.5	talc schist BRECCIA with patches of limonite staining and clasts of quartz etc.; yellowish grey 5Y 7/2, orange brown, 5YR 5/8, grey etc over SAND; greyish orange 10YR 7/2.
JH7/5	5.5- 5.8	talc schist BRECCIA with clay matrix; light yellowish brown 2Y 6/4.
	5.8- 6.8	TALC with seams of OCHRE; greyish yellow 5Y 8/4 to dark yellowish orange 10YR 6/6 and orange brown 5YR 5/8.
	6.8- 7.0	SAND with quartz clasts and ochre binder; dark yellowish orange 10YR 6/7.
JH7/6.1	7.0- 7.8	SAND with quartz and talc clasts and ochre binder; dark yellowish orange 10YR 6/7.
.2	7.8- 8.5	SAND as above brownish orange 10YR 4/6?
JH7/7	8.5-10.0	SAND with quartz clasts and ochre binder; strong dark yellowish orange 10YR 5/7.
JH7/8	10.0-11.5	talc schist BRECCIA with clay/ochre matrix; dark yellowish orange 10YR 6/7, grading downwards to clay matrix 10YR 6/6.
JH7/9	11.5-12.0	reworked OCHRE with quartz and talc clasts brownish orange 10YR 5/6 dispersing to 10YR 5/7.
	12.0-13.0	talc schist BRECCIA with clay matrix; dark yellowish orange 10YR 6/6 to greyish orange 10YR 7/4.

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JH7/10	13.0-14.5	talc schist BRECCIA with clay matrix, some clasts to 1.5cm most small; greyish yellow 2Y 7/4.
JH7/11	14.5-15.0	as above.
JH7/12	15.0-16.0	talc schist BRECCIA in talcy clay matrix; yellowish grey 5Y 7/2.
JH7/13	16.0-17.2	talc schist BRECCIA as above with probable boulder (possible bedrock) at base 2Y 6/4 orange yellow 2Y 6/4.

End Hole.

Auger Hole JH 8.

Drilled 21/1/90 commencing 8.50am by T. Lodge, Stacpoole's, Launceston. Logged by H. Shannon. Total depth 23.5 metres. Location 346704.84mE, 5400576.98mN; RL 204.32m.

Sample	From- to	Description.
JH8/1	0.0- 1.0	TALC and talcose OCHRE; dark yellowish orange 10YR 6/6, greyish yellow 5Y 8/4 and moderate yellowish brown 10YR 5/4.
JH8/2	1.0- 2.5	TALC; greyish yellow 5Y 8/4 and talcose OCHRE; moderate yellowish brown 10YR 8/4.
JH8/3.1	2.5- 3.7	as above.
.2	3.7- 4.0	OCHRE with some TALC; yellowish orange 10YR 5/7, dispersing to 10YR 6/8.
JH8/4.1	4.0- 4.5	OCHRE as above.
.2	4.5- 5.5	talc BRECCIA with talcose ochre matrix and isolated clasts of quartz and talc schist; dark yellowish orange 10YR 6/6.
JH8/5.1	5.5- 6.3	talc BRECCIA as above.
.2	6.3- 7.0	SAND with ochre binder and clasts of quartz, talc and talc schist; dark yellowish orange 10YR 5/7.
JH8/6.1	7.0- 7.5	talc BRECCIA with ochre matrix and minor clasts of quartz and talc; dark yellowish orange 10YR 6/6.
.2	7.5- 8.5	reworked OCHRE with sparse spongy quartz and talc clasts; strong dark orange yellow 2Y 6/7 dispersing to 2Y 6/8 some ex-magnesite texture.
JH8/7.1	8.5- 9.2	reworked OCHRE grading to talc BRECCIA; dark yellowish orange 10YR 6/7.
.2	9.2- 9.7	TALC and OCHRE; dark yellowish orange 10YR 6/7.
.3	9.7-10.0	OCHRE with relict magnesite texture strong dark yellowish orange 10YR 6/7.

JH8/8	10.0-11.0	talc BRECCIA with talcose ochre matrix; dark yellowish orange 10YR 6/6.
JH8/9	11.0-12.0	greenschist BRECCIA with clay/ochre matrix; light brown 5YR 5/6. The clasts now include normal greenschist (chloritic) weathered to pale reddish brown 10YR 5/4.
JH8/10	12.0-13.0	as above, tends to sandy ochre matrix at base.
JH8/11	13.0-14.0	greenschist/talc/quartz BRECCIA with clay/ochre matrix; dark yellowish orange 10YR 6/7 dispersing to 10YR 6/8.
JH8/12	14.0-15.0	reworked ochre with greenschist/quartz/talc clasts, dark yellowish orange 10YR 5/7 dispersing to 10YR 6/8.
JH8/13	15.0-16.0	as above.
JH8/14	16.0-17.0	reworked sandy OCHRE with few clasts, quartz/greenschist/talc; moderate yellowish brown 10YR 5/5 dispersing to dark yellowish orange 10YR 5/7.
JH8/15	17.0-18.0	as above.
JH8/16	18.0-19.0	reworked sandy OCHRE with clasts as above; dark yellowish orange 10YR 5/6 dispersing to 10YR 5/8.
JH8/17	19.0-20.0	reworked talcose OCHRE with talc and quartz clasts; dull yellowish orange 10YR 6/4 dispersing to dark yellowish orange 10YR 6/6.
JH8/18	20.0-21.0	reworked OCHRE with small talc clasts; dark yellowish orange 10YR 5/6 dispersing to dark yellowish orange 10YR 6/7.
JH8/19	21.0-22.0	as above, with talc schist BRECCIA at base.
JH8/20	22.0-23.5	TALC SCHIST (as chips in pulp); yellowish grey 5Y 8/1, (contaminated sample).

Bolt sheared on rig, hole abandoned at 12.45pm. The last sample is bedrock-like but suspected to be a boulder.

Auger hole JH 2.

Drilled 24/1/90 commencing 12.00am by T. Lodge, Stacpoole's Launceston. Logged by H. Shannon and M. Whitty (7-14.5m). Total depth 14.5 metres. Location 346715.95mE, 5400580.59mE; RL 202.45m.

Sample	From- to	Description.
JH9/1	0.0- 1.0	laminated CLAY simulating weathered greenschist (or weathered greenschist). Variable approximately dark yellowish orange 10YR 6/6.
JH9/2	1.0- 1.5	as above with isolated quartz clasts, moderate yellowish brown 10YR 5/4 to dark yellowish orange 10YR 6/7.
JH9/3	1.5- 2.5	as above, moderate reddish brown 10R 4/6 with bands of moderate red 5R 4/6.
JH9/4	2.5- 4.0	CLAY/OCHRE with sparse clasts, quartz and talc; strong orange 7YR 5/7.
JH9/5	4.0- 5.5	CLAY with sparse quartz and talc clasts; greyish orange 10YR 6/4.
JH9/6	5.5- 7.0	CLAY with sparse clasts, brown 7YR 4/4.
JH9/7	7.0- 8.5	as above.
JH9/8	8.5-10.0	CLAY with sparse clasts, strong brown 7.5YR 5/8.
JH9/9	10.0-10.7	as above.
	10.7-11.5	CLAY, friable lightweight light brown 7.5YR 6/8, thickly studded with talc clasts.
JH9/10	11.5-13.0	SAND with ochre binder, dry friable containing talc/greenschist clasts. Strong brown 7.5YR 5/8.
JH9/11	13.0-14.5	SAND, dry friable 7.5YR 5/8, with clasts of breccia.

No real ochre observed so far, so hole abandoned.

Auger hole JH 10.

Drilled 24/1/90 commencing 4pm by T. Lodge, Stacpoole's Launceston. Logged by M. Whitty, 0-7 metres. Hole continued 15/2/90, commencing 10.45am, logged by H. Shannon, 7-31 metres. Total depth 31 metres. Location 346751.79mE, 5400584.53mN; RL 199.38m.

Sample	From- to	Description.
JH10/1	0.0- 1.0	CLAY with traces of greenschist; 7.5YR 4/6.
JH10/2	1.0- 2.5	CLAY; brown 7.5YR 4/4 with sparse peat clasts.
JH10/3	2.5- 4.0	CLAY/OCHRE; light brown 7.5YR 6/6, with smears of greenschist throughout.
JH10/4	4.0- 5.5	CLAY/OCHRE, slightly brighter 7.5YR 5/6, with greenschist clasts.
JH10/5	5.5- 7.0	CLAY, sticky strong brown 7.5YR 5/6 with clasts breccia. No ochre, hole is tight and difficult drilling.

Hole abandoned.

Auger hole JH 10.

15/2/90 Continuation of previous drilled hole commencing 10.40am by T. Lodge and R. Dean, Stacpoole's Launceston. Logged by H. Shannon. Total depth 31 metres.

Sample	From- to	Description.
JH10/6	7.0- 8.2	reworked clayey OCHRE with small clasts of fresh and weathered greenschist also quartz to 0.5cm, 20%; yellowish brown 10YR 4/6 to 10YR 5/6.
JH10/6	8.2- 8.5	greenschist BRECCIA with clay/ochre matrix; moderate yellowish brown 10YR 5/6.
JH10/7.1	8.5- 9.5	reworked clayey OCHRE with sparse greenschist clasts 5%; yellowish orange 9YR 6/6 dispersing to 9YR 6/8
.2	9.5-10.0	reworked clayey OCHRE, few clasts; yellowish orange 8YR 6/8 dispersing to 8YR 6/8.
JH10/8	10.0-11.5	reworked clayey OCHRE, few clasts; yellowish orange 9YR 6/8 dispersing to 9YR 6/8.

JH10/9	11.5-13.0	CLAY/OCHRE with clasts of greenschist and quartz; yellowish orange 9YR 6/6, same dispersed colour.
JH10/10	13.0-14.0	as above; 8YR 6/6 to 9YR 6/6.
JH10/11	14.0-15.0	as above; 8YR 5/6.
JH10/12	15.0-15.8	as above; 10 YR 5/6 yellowish brown.
JH10/13	15.8-16.0	quartz and greenschist BRECCIA with ochre matrix, clasts 50% to 1cm; strong yellowish brown 10YR 5/8 dispersing to 10YR 5/9.
JH10/13	16.0-16.6	CLAY/OCHRE, with minor sand sized clasts 5%; 9YR 6/7.
JH10/14	16.6-17.5	CLAY/OCHRE as above; 8.5YR 6/7 brownish orange.
JH10/15.1	17.5-18.3	as above.
	.2 18.3-19.0	CLAY/OCHRE with small clasts 5%, isolated spongy qtz to 2cm; 9YR 6/8.
JH10/16	19.0-19.8	CLAY/OCHRE with small clasts of greenschist and quartz, <5%; brownish yellow/orange 9YR 6/6.
JH10/17	19.8-20.5	CLAY/OCHRE as above grading to yellowish brown 9YR 5/4.
JH10/18.1	20.5-21.3	CLAY/OCHRE as above; yellowish brown 9YR 5/6.
	.2 21.3-22.0	as above, more moist.
JH10/19	22.0-23.0	CLAY/OCHRE as above; yellowish orange 10YR 6/7.
JH10/20	23.0-24.2	clayey OCHRE with small clasts 5%; dull yellowish orange 10YR 6/6 to yellowish brown 10YR 5/8 dispersing to 10YR 5/9.
JH10/21	24.2-25.0	as above; 9YR 5/8 dispersing to 9YR 5/9.
JH10/22	25.0-25.8	clayey OCHRE as above dispersing to 9-10YR 6/7.
JH10/23	25.8-26.6	clayey OCHRE as above dispersing to 10YR 6/8.
JH10/24	26.6-27.3	as above 10YR 6/8.

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JH10/25 27.3-28.0 as above 9-10YR 6/7.

JH10/26 28.0-28.7 as above.

JH10/27 28.7-29.5 as above.

JH10/28 29.5-30.3 as above.

JH10/29 30.3-31.0 as above.

Last rod used, end hole.

Auger hole JH 11.

Drilled 16/2/90 commencing 8.45am by T. Lodge and R. Dean, Stacpoole's Launceston. Logged by H. Shannon. Total depth 8.5 metres. Location 346751.79mE, 5400584.53mN; RL 199.38m.

Sample	From- to	Description.
JH11/1	0.0- 1.0	greenschist BRECCIA with clay matrix; 8YR 5/6 strong orange brown.
JH11/2	1.0- 2.5	CLAY/OCHRE with small clasts; 9YR 5/6 yellowish brown.
JH11/3	2.5- 4.0	CLAY/OCHRE grading to CLAY with greenschist clasts 20%; brown 7YR 5/4.
JH11/4	4.0- 5.5	silty CLAY with greenschist clasts; yellowish brown 9YR 5/4, minor clasts or thin beds of OCHRE or CLAY; orange 8YR 7/8.
JH11/5	5.5- 7.0	silty CLAY and CLAY with small chips?/ clasts of weathered, and little fresh, greenschist; brown 8YR 5/4
JH11/6	7.0- 8.5	silty CLAY grading to CLAY/OCHRE, with greenschist clasts mostly sand size up to 0.5 cm; yellowish brown 9YR 4/4.
JH11/7	8.5-10.0	as above; 8YR 5/4, at base 10YR 5/4.

Hole discontinued owing to pressure of time, with none of the expected bedrock appearing.

Auger hole JH 12.

Drilled 19/2/90 commencing 2.40pm by T. Lodge and R. Dean, Stacpoole's Launceston. Logged by H. Shannon. Total depth 7 metres. Location 346610.61mE, 5400641.44mN; RL 191.58m.

Sample	From- to	Description.
JH12/1	0.0- 1.0	quartz and greenschist BRECCIA in sandy clay matrix; light yellowish brown 10YR 6/4.
JH12/2	1.0- 2.5	greenschist BRECCIA in clay matrix; light yellow brown 2Y 6/4.
JH12/3	2.5- 4.0	as above; olive yellow 2Y 6/4.
JH12/4	4.0- 5.5	reworked OCHRE grading to ochre matrix greenschist BRECCIA, clasts to 0.5cm 20%; strong yellow brown 10YR 5/6 dispersing to 10YR 5/8.
JH12/5	5.5- 7.0	TALC SCHIST (as chips in pulp) 2Y 7/2 greyish yellow.

End of Hole.

Auger hole JE 1.

Drilled 16/1/90 commencing 3.30pm. Driller T. Lodge, Stacpoole's Launceston. Logged by H. Shannon. Total depth 16 metres. Location 346677.99mE, 5400549.65mN; RL 200.58m.

Sample	From- to	Description
JF1/1	0.0- 1.0	sandy weathered quartz/greenschist BRECCIA; dark yellowish orange 10YR6/6
JF1/2	1.0- 2.5	sandy quartz/greenschist BRECCIA with clay/ochre matrix grading to OCHRE at base, clasts to 0.5cm; dark yellowish orange 2Y 6/7.
JF1/3	2.5- 4.0	talc schist/greenschist/quartz BRECCIA with clay/ochre matrix, dark orange yellow 2Y 6/6 and greyish orange 10YR 7/4 (some clay matrix BRECCIA near top).
JF1/4	4.0- 5.5	mixed BRECCIA with talc, talcose clay/ochre matrix, large Fe ox. stained greenschist clasts towards base; drab yellowish orange 10YR 5/6.
JF1/5	5.5- 6.0 6.0- 7.0	as above talc rich mixed breccia, (quartz/greenschist/talc) with talcose ochre matrix; yellowish orange 10YR 6/3 to greyish orange 10YR 7/4, talc rich at base.
JF1/6	7.0- 8.0 8.0- 8.5	as above greenschist BRECCIA with clay matrix, small clasts to 0.5cm; dusky yellow 2Y 6/4.
JF1/7	8.5-10.0	greenschist BRECCIA with clay matrix, green actinolite schist clasts and minor talc; dirty yellow 2Y 6/4 to pale greyish green 5GY 6/2
JF1/8	10.0-11.0 11.0-11.5	as above, not sampled. OCHRE and white TALC; pale yellowish brown 10YR 6/2.
JF1/9	11.0-13.0	as above.
JF1/10	13.0-14.5	CLAY/OCHRE with clasts of dense spongy quartz to 3cm; moderate brown 10YR 5/4.
JF1/11	14.5-16.0	as above; moderate brown 5YR 3/4.

Hole collapsing, so abandoned.

Auger hole JE 2.

Drilled 16/1/90 by T. Lodge, Stacpoole's Launceston. Logged by H. Shannon. Total depth 26.5 metres. Location 346685.83mE, 5400542.04mN; RL 203.80m.

Sample	From- to	Description.
JF2/1	0.0- 1.0	powdery GREENSCHIST (boulder?) yellowish grey 5Y 7/2.
JF2/2	1.0- 2.5	ground GREENSCHIST and CLAY, breccia? yellowish grey 5Y 7/2 as above, greyish orange pink 5YR 7/2, dark yellowish orange 10YR 6/6.
JF2/3	2.5- 4.0	ground greenschist BRECCIA clasts mainly talcose grey schist; dusky yellow 5Y 3/4.
JF2/4	4.0- 5.5	probably greenschist BRECCIA, clasts of grey schist to 2 cm; dusky yellow 3Y 6/4.
JF2/5	5.5- 7.0	SAND with ochre binder and larger quartzite and talc clasts; strong yellowish orange 10YR 6/8.
JF2/6	7.0- 8.5	SAND with ochre binder; greenschist and quartz clasts to 1.0 cm and smaller talc clasts; strong orange 7YR 6/8.
	8.5- 9.0	SAND as above, not sampled.
JF2/7	9.0-10.0	reworked TALC/OCHRE with clasts of quartz, talc, and greenschist; dark yellowish orange 10YR 6/6.
JF2/8	10.0-11.5	reworked SAND/BRECCIA with talc/ochre binder; brownish orange 8YR 5/6 to light brown 5YR 5/6. More talc towards base 5YR 6/4.
JF2/9	11.5-12.0	greenschist/quartz/talc BRECCIA with clay/ochre matrix; brownish orange 7YR 5/6.
JF2/10	12.0-13.2	OCHRE with relict magnesite banding dispersing to strong yellowish orange 10YR 5/8.
JF2/11	13.2-14.0	reworked OCHRE with small clasts of greenschist; dark yellowish orange 10YR 5/7.
JF2/12	14.0-14.5	reworked OCHRE grading to greenschist BRECCIA with clay/ochre matrix; moderate yellowish brown 10YR 5/4.

JF2/13 14.5-16.0 reworked OCHRE as above then talc schist BRECCIA with talc/ochre matrix, yellowish grey 3Y 7/2.

JF2/14 16.0-17.5 grey talc schist BRECCIA with TALC SCHIST (boulder?) at base; yellowish grey 5Y 7/1.

JF2/15 17.5-18.5 reworked OCHRE with sparse clasts of greenschist; strong yellowish brown 10YR 4/6 (contaminated with talc schist).

JF2/16 18.5-19.5 reworked ochre as above; strong yellowish brown 10YR 4/6.

JF2/17 19.5-20.4 as above.

JF2/18 20.4-21.4 as above, more clasts near base; at top relict magnesite texture for 10cm.

JF2/19 21.4-22.5 reworked OCHRE with clasts including talc; moderate brown 5YR 3/4.

JF2/20 22.5-23.0 reworked OCHRE grading to ochre matrix BRECCIA, c.f. above with more talc; moderate brown 5YR 3/4.

JF2/21 23.0-23.5 reworked OCHRE as above, greyish brown 5YR 3/2, and some OCHRE with relict magnesite texture; strong brownish orange 10YR 4/6.

JF2/22 23.5-24.5 reworked ochre; greyish brown 5YR 3/2.

JF2/23 24.5-25.5 as above

JF2/24 25.5-26.5 as above.

26.5-31.0 no recovery, drilling character as before; ochre likely.

End hole.

Auger hole JE 3.

Drilled 17/1/90 commencing 9am by T. Lodge, Stacpoole's Launceston.
 Logged by H. Shannon. Total depth 10.6 metres. Location 346693.59mE,
 5400534.01mN; RL 202.76m.

Sample	From- to	Description
JF3/1	0.0- 1.0	light olive grey 3Y 6/1 greenschist BRECCIA with clay matrix.
JF3/2	1.0- 1.5 1.5- 2.5	as above. spongy quartz BRECCIA with ochre matrix, dark yellowish orange 10YR 6/6.
JF3/3	2.5- 4.0	grey TALC SCHIST as clasts in talc schist pulp (boulder); yellowish grey 5Y 8/1.
JF3/4	4.0- 5.5	talc schist BRECCIA; greyish orange 10YR 7/4 to yellowish grey 5Y 7/2.
JF3/5.1	5.5- 6.5	greenschist BRECCIA with clay/ochre matrix; pale yellow brown 10YR 6/3.
.2	6.5- 7.0	sandy reworked OCHRE with small greenschist clasts, strong yellow orange 10YR 6/8.
JF3/6.1	7.0- 7.4	sandy OCHRE with small greenschist clasts; dark brown 5YR 3/3.
.2	7.4- 8.5	OCHRE with relict magnesite texture, mass colour yellowish brown 10YR 4/8 dispersing to 10YR 5/8.
JF3/7	8.5-10.0	reworked and some residual OCHRE dispersing to strong moderate yellowish brown 10YR 4/8.
JF3/8	10.0-10.6	OCHRE as above.

Hard bottom, traces of ground magnesite and disaggregated weathering rind.

Hole complete.

Auger hole JF 4.

Drilled on 17/1/90 commencing 11.45am by T. Lodge, Stacpoole's Launceston. Logged by H. Shannon and M. Whitty (10.0-19.0). Total depth 27 metres. Location 346705.20mE, 5400525.53mN; RL 202.12m.

Sample	From- to	Description
JF4/1	0.0- 1.0	SOIL, clayey; pale yellowish brown 10YR 6/2 to dark yellowish orange 10YR 6/6 over weathered banded GREENSCHIST (or laminated clay) also 10YR 6/6.
	1.0- 1.5	greenschist/quartz BRECCIA in clay matrix; light brown 5YR 5/6 over stone layer (not sampled).
JF4/2	1.5- 2.5	spongy quartz BRECCIA in sandy matrix with ochre binder; orange yellow 2Y 6/6.
JF4/3.1	2.5- 3.2	BRECCIA, spongy quartz clasts in sandy clay/ochre matrix; dark yellowish orange 10YR 6/6.
.2	3.2- 4.0	talc clast BRECCIA in talcy ochre? matrix; pale yellow orange 10YR 8/6. Some clay/ochre matrix BRECCIA near base.
JF4/4.1	4.0- 4.3	talc clast BRECCIA; yellowish grey 5Y 7/2.
.2	4.3- 4.7	quartz/talc etc. BRECCIA with sandy clay/ochre matrix; orange 8YR 6/6.
.3	4.7- 5.1	talc clast BRECCIA in sandy clay/ochre matrix; greyish orange 10YR 7/4 to strong yellowish orange 10YR 6/7.
.4	5.1- 5.5	SAND; white N9; at base 5YR 4/4 moderate brown.
JF4/5.1	5.5- 6.5	sandy OCHRE grading to talc clast BRECCIA with sandy ochre matrix; dark yellowish brown 10YR 3/4.
.2	6.5- 7.0	TALC SCHIST as clasts in pulp (boulder); yellowish grey 5Y 6/2.
JF4/6	7.0- 8.5	greenschist BRECCIA with clay matrix, talc schist clasts common, moderate brown 5YR 4/4 to yellowish brown 10YR 5/4.

JF4/7.1	8.5- 9.5	greenschist BRECCIA with clay/ochre matrix 10YR 5/4, patch of OCHRE near base 10YR 6/8.
.2	9.5-10.0	TALC SCHIST as chips in pulp (boulder); yellowish grey 5Y 7/2.
JF4/8	10.5-11.5	powdered TALCSCHIST; pinkish grey 5YR 8/1.
JF4/9	11.5-13.0	reworked OCHRE with clasts of dense spongy quartz; moderate brown 10 YR 5/4?
JF4/10.1	13.0-13.7	taic rich friable reworked OCHRE 5YR 4/4.
.2	13.7-14.5	reworked OCHRE with small talc clasts; moderate brown 5YR 4/4.
JF4/11	14.5-16.0	as above with small clasts.
JF4/12	16.0-17.5	OCHRE with relict magnesite texture; moderate brown 5YR 4/4 to moderate yellowish brown 10YR 5/4.
JF4/13	17.5-19.0	OCHRE with relict magnesite texture; strong dark orange 6YR 4/8 to yellow orange 10YR 6/8.
JF4/14	19.0-20.5	reworked OCHRE; strong dark orange 6YR 4/8 to 10YR 4/8.
JF4/15	20.5-22.0	as above.
JF4/16	22.0-23.5	as above.
JF4/17	23.5 25.0	as above but more yellow at base 10YR 5/8.
JF4/18	25.0-26.5	OCHRE; strong dark orange 8YR 4/8. At base, disaggregated magnesite over hard bottom.

Hole complete.

Auger hole JE 5.

Drilled 16/2/90 commencing 11.00pm by T. Lodge and R. Dean, Stacpoole's Launceston. Logged by H. Shannon. Total depth 8.0 metres. Location 346671.93mE, 5400570.17mN; RL 200.24m.

Sample	From- to	Description.
JF5/1	0.0- 1.0	CLAY/OCHRE with greenschist clasts; yellowish brown 9YR 5/4 to 9YR 5/6.
JF5/2.1	1.0- 2.0	sandy reworked OCHRE with quartz and greenschist clasts, 25%; yellowish brown 9YR 5/6.
.2	2.0- 2.5	as above; light olive brown 2Y 5/6.
JF5/3.1	2.5- 3.5	as above; olive brown 2Y 5/4.
.2	3.5- 4.0	as above with in the last 0.2m a change to OCHRE with relict magnesite texture; dull yellowish brown, reddish brown and yellowish orange. The dispersed slurry coating the sample is strong dark brown 8YR 4/6.
JF5/4.1	4.0- 5.2	gritty reworked OCHRE with clasts mainly quartz but including some good ochre; dispersed colour 8YR 6/6.
.2	5.2- 5.5	reworked OCHRE; very dark brown 8YR 3/2.
JF5/5	5.5- 7.0	sandy reworked OCHRE with clasts; dark yellowish brown 10YR 4/4 to 10YR 4/6, over OCHRE with residual ochre texture; variable colours include orange 8YR 6/8 with black and strong brown 7YR 4/6.
JF5/6	7.0- 8.0	OCHRE with residual magnesite texture; mainly dark yellowish brown 8-9YR 4/6 but including other colours as above.
JF5/7	8.0	bottom sample; OCHRE and decomposed MAGNESITE.

Hole complete.

Auger hole IE 6.

Drilled 16/2/90 commencing 12.30pm by T. Lodge and R. Dean, Stacpoole's Launceston. Logged by H. Shannon. Total depth 19.2 metres. Location 346673.50mE, 5400560.98mN; RL 199.34m.

Sample	From- to	Description.
	0.0- 1.0	not sampled; talc schist clasts to 1.5 cm in yellowish orange CLAY; 10YR 6/6.
JF6/1	1.0- 2.5	talc schist BRECCIA, traces of bedding in the clay matrix; 10YR 6/6 yellowish orange. Also some white clay and actinolite schist clasts.
	2.5- 2.6	as above - not sampled.
JF6/2	2.6- 3.8	CLAY/OCHRE with clasts to 0.5cm including talc schist, actinolite schist, quartz, white clay 10%; orange 6YR 6/8.
	3.8- 4.0	not sampled - clay/ochre matrix greenschist BRECCIA 10YR 6/6.
JF6/3	4.0- 5.5	greenschist BRECCIA with talcy clay/ochre matrix; yellowish orange 10YR 6/6 some clasts to 1cm talc and/or talc schist (at base).
JF6/4.1	5.5- 6.2	greenschist BRECCIA, clasts 25% various sizes in talcy clay/ochre matrix; pale brownish orange 7YR 6/6.
.2	6.2- 7.0	greenschist BRECCIA as above; yellowish orange 10YR 6/6.
JF6/5	7.0- 8.5	at start greenschist BRECCIA as above, grading to BRECCIA with clayey/ochre matrix; 8YR 5/6 dispersing to 8YR 5/8, over dark yellowish brown reworked OCHRE with sparse quartz clasts to 1cm; 8YR 4/4 dark brown.
JF6/6	8.5- 9.9	reworked OCHRE with clasts; dark brown 8YR 3/4, over reworked OCHRE; dark brown 10YR 3/3, over OCHRE with residual magnesite texture; mottled dark yellowish brown 10YR 3/3 and strong yellowish orange 10YR 6/8.
JF6/7	9.9-10.0 10.0-11.0	OCHRE; strong yellowish orange 10YR 6/8 reworked OCHRE with clasts 15%; dark yellowish brown 10YR 4/4 dispersing to 10YR 4/5.

JF6/8	11.0-12.0	as above dispersing to 10YR 4/6
JF6/9	12.0-13.0	OCHRE, residual; strong brown 8YR 4/6 dispersing to 8YR 4/8?
JF6/10	13.0-14.0	reworked OCHRE with few clasts; dark yellowish brown 9YR 4/4 dispersing to 9YR 4/6.
JF6/11	14.0-15.0	reworked OCHRE with few clasts; dark brown 8-9YR 4/4 dispersing to 8-9YR 4/6 over residual OCHRE with relict magnesite texture; 7.5YR 4/4 to 7.5 YR 5/6 brown dispersing to 8YR 5/8.
JF6/12	15.0-16.0	residual OCHRE showing excellent magnesite cleat and banding; brown 8YR 4/4 to 8YR 5/8 dispersing to 8YR 5/7.
JF6/13	16.0-17.0	residual OCHRE as above; brown 9YR 4/4 dispersing to 9YR 4/6.
JF6/14	17.0-18.0	as above, some clasts? disperses to 8YR 4/4.
JF6/15	18.0-19.0	as above 8YR 4/6 dispersing to 8YR 4/8.
JF6/16	19.0-19.2	rods immediately sank extra 0.2 metres and then hit hard bottom - decomposed magnesite silt recovered from bit tip.

Hole ended.

Auger hole JF 2.

Drilled 19/2/90 commencing 8.40am by T. Lodge and R. Dean, Stacpoole's Launceston. Logged by H. Shannon. Total depth 8 metres. Location 346619.84mE, 5400610.37mN; RL 189.78m. (Near large tilted boulder of greenschist).

Sample	From- to	Description.
JF7/1	0.0- 1.0	silty CLAY with chlorite schist chips; 5GY 7/2 greyish yellow green.
JF7/2	1.0-.2.5	laminated CLAY; greenish to bluish grey 5GY 7/2 to 5B 8/1 with ferric oxide stains.
JF7/3	2.5- 4.0	greenschist BRECCIA and laminated CLAY (fresh as above) and weathered greenschist BRECCIA; yellowish orange 10YR 6/6 clasts of greenschist to 2cm; isolated large ochre clast? dark reddish brown 5YR 3/3.
JF7/4	4.0- 5.2	greenschist BRECCIA with silty clay matrix; light brownish grey, 5YR 6/1.
	5.2- 5.5	TALC SCHIST (as chips in pulp) yellowish grey 5Y 8/1.
JF7/5	5.5- 7.5	CLAY grading to greenschist BRECCIA with silty clay matrix, clasts 20% to 2cm; 3Y 6/3 olive yellow to dull yellow green 5GY 6/2. Some clasts of ochre; brown 8YR 5/4. There is harder drilling at the base; TALC SCHIST (?) but with traces of ochre.
JF7/6	7.5- 8.0	TALC SCHIST (as chips in pulp), very hard to drill.

End of hole.

Auger hole JF 8.

Drilled 19/2/90 commencing 11.15am by T. Lodge and R. Dean, Stacpoole's Launceston. Logged by H. Shannon. Total depth 8.5 metres.

Sample	From- to	Description.
JF8/1	0.0- 1.0	laminated CLAY with greenschist clasts and organics? 10YR 4/3 brown and 7YR 4/2 dark brown.
JF8/2	1.0- 2.5	greenschist BRECCIA and/or actinolite SCHIST; pale brown 5YR 6/2 to greenish grey 5GY 6/1.
JF8/3	2.5- 3.0	greenschist BRECCIA with clay matrix, clasts 50%, (chlorite schist); olive brown 3Y 4/4.
	3.0- 3.9	CLAY with chlorite schist clasts; dull yellowish brown 1Y 4/3.
	3.9- 4.0	as above with PEAT; 10YR 3/2 very dark brownish grey.
JF8/4	4.0- 5.5	greenschist BRECCIA with matrix grading from clay with peat; greyish brown 10 YR 4/2 to greenschist pulp; greyish yellow green 5GY 7/2 clastes to 4cm.
JF8/5	5.5- 7.0	greenschist BRECCIA in clay/pulp matrix with traces of peat; light olive brown 5Y 5/6 to greyish olive 10Y 4/2, clasts mainly chlorite schist to 5cm 30%.
JF8/6	7.0- 8.0	greenschist BRECCIA in peaty clay matrix; dusky yellowish brown 10YR 4/2, clasts 30%.
	8.0- 8.5	actinolite SCHIST; greyish olive 10Y 5/3.

Hard drilling recovers pulp with chips - hole stopped.

Auger hole JF 2.

Drilled 19/2/90 commencing 3.40pm by T. Lodge and R. Dean,
Stacpoole's Launceston. Logged by H. Shannon. Total depth 1.5 metres.
Location 346603.87mE, 5400607.69mN; RL 184.79m.

Sample	From- to	Description.
JF9/1	0.0- 1.0	soil grading to probable SCHIST, (pulp and chips), olive brown 2Y 6/4.
JF9/2	1.0- 1.5	hard TALC SCHIST (pulp and a few chips), light olive grey 5Y 6/1.

End of Hole.

081
Auger hole JF 10.

Drilled 19/2/90 commencing 4.30pm. Driller T. Lodge, Stacpoole's
 Launceston. Logged by H. Shannon. Total depth 8 metres. Location
 346603.87mE, 5400613.49mN; RL 186.51m.

Sample	From- to	Description
JF10/1	0.0- 1.0	soil/silty CLAY with quartz clasts, greyish brown 5YR 4/2.
JF10/2	1.0- 2.5	greenschist BRECCIA with clay matrix, clasts to 2cm, 30%; quartz, actinolite schist; matrix yellowish orange 10YR 6/6 but greenish from soft clasts.
JF10/3	2.5- 4.0	as above 10YR 5/6 orange brown.
JF10/4	4.0- 5.5	greenschist PULP grading to CLAY with greenschist clasts plus quartz as above, clasts 5%; olive brown 5Y 5/6, to olive 8Y 5/4.
JF10/5	5.5- 7.0	greenschist PULP grading to CLAY with greenschist clasts as above 20%; olive brown 5Y 5/6 to greyish olive 10YR 4/2.
JF10/6	7.0- 8.0	CLAY with greenschist clasts 10%; light olive brown 5Y 5/6. Hard at bottom.

End hole.

Auger Hole JE 1

Drilled 15/6/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Logged by M. Whitty and H. Shannon (11.5-19.0). Total depth 19.0m. Location 346706.90mE, 5400457.56mN; RL 202.44m.

Sample	From- to	Description
JE1/1	0.0- 1.0	CLAY/OCHRE, dark yellowish orange, 10YR 6/6.
JE1/2	1.0- 2.5	friable CLAY/OCHRE; moderate yellowish brown 10YR 5/4 with traces laminated moderate red 5R 4/6 greenschist clasts?.
JE1/3	2.5- 4.0	friable/sticky CLAY/OCHRE; mod. red 5R 4/6.
JE1/4	4.0- 5.5	sticky CLAY/OCHRE, as above.
JE1/5	5.5- 7.0	as above.
JE1/6?		
JE1/7	7.0- 8.5	as above.
JE1/8	8.5-11.5	relatively friable CLAY/OCHRE; moderate red 5R 4/6 (as above), with traces of white sandstone-like vein quartz?
JE1/9	11.5-13.0	greenschist BRECCIA with clay/ochre matrix, small greenschist clasts, 40%; moderate red 3R 4/6.
JE1/10	13.0-14.5	TALC BRECCIA with quartzite/spongy vein quartz in talc/ochre matrix; greyish orange 10YR 7/4.
JE1/11	14.5-16.0	as above, but lighter 10YR 8/4.
JE1/12	16.0-17.5	TALC BRECCIA with minor fine granular spongy vein quartz in talcose ochre matrix; dark yellowish orange 10YR 6/6 to moderate yellowish brown 10YR 5/4. It includes dropstones? of clay/ochre matrix greenschist breccia; moderate red 5R 4/6.
JE1/13	17.5-19.0	talc/spongy quartz/ red breccia dropstone BRECCIA with talcose ochre matrix as above; dark yellowish orange 10YR 6/6 grading to greyish yellow 5Y 8/4.

Hole terminated in complex karst breccia fill dominated by talc, spongy quartz and ochre leach residues derived from magnesite rock.

Auger Hole **JE 2**

Drilled 18/12/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Logged by H. Shannon. Total depth 19.0m. Location 346703.40mE, 5400463.07mN; RL 203.33m.

Sample	From- to	Description
	0.0- 1.0	greenschist BRECCIA, small clasts in clay/ochre matrix, brownish to yellowish orange, 1Y 5/6.
	1.0- 2.5	greenschist BRECCIA with clay matrix; greyish yellow 5Y 8/4.
JE2/1	2.5- 4.0	greenschist BRECCIA with clay/ochre matrix, small clasts only; drab red 10R 5/5 grading to light brown 5YR 5/5.
JE2/2	4.0- 5.5	reworked clayey OCHRE with sparse clasts of weathered greenschist; light brown 5YR 6/6; from 4.8m. greenschist clasts larger and more common; moderate red 5R 5/6.
JE2/3	5.5- 7.0	reworked OCHRE with occasional small greenschist clasts; moderate red 5R 5/6; about 6.2m. larger greenschist clasts, towards base colour grades to 3R 4/6? (darker, more purple).
JE2/4	7.0- 8.5	reworked OCHRE grading to greenschist BRECCIA with small clasts; moderate red 5R 4/6. From c.8.0m. larger clasts, duller, more clayey OCHRE.
JE2/5	8.5-10.0	greenschist BRECCIA with clay/ochre matrix; dull moderate red 5R 5/4, more clayey towards base.
JE2/6	10.0-11.5	greenschist BRECCIA with clay/ochre matrix; larger greenschist clasts abundant; dull moderate red 5R 5/4 to 10.5m., then grading to reworked OCHRE with only small clasts; brighter moderate red 5R 4/7.
JE2/7	11.5-13.0	greenschist BRECCIA with ochre matrix; moderate red 5R 4/6 with hard band at c.12.5m.; dull moderate red 5R 4/4.
JE2/8	13.0-14.5	greenschist BRECCIA with ochre matrix; moderate red 5R 4/6 to dark red 5R 3/5.

- JE2/9 14.5-16.0 greenschist BRECCIA with clay/ochre matrix;
larger clasts common; dull moderate red SR 4/4.
- JE2/10 16.0-17.5 as above.
- JE2/11 17.5-19.0 as above (more stones).

Hole terminated in karst breccia fill at 19.0m.

Auger Hole JE 3

Drilled 18/12/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Logged by H. Shannon. Total depth 19.0m. Location 346693.90mE, 5400477.98mN; RL 203.84m.

Sample	From- to	Description
	0.0- 0.9	weathered greenschist BRECCIA, with clay/ochre matrix; yellowish brown, 10YR 4/6 with patches of white clay NB?
	0.9- 1.2	OCHRE; dark yellowish orange 10YR 6/6.
JE3/1	1.2- 2.5	OCHRE, including some banding possibly relict bedding; moderate red 5R 5/4.
JE3/2	2.5- 4.0	as above to 3.0m., then greenschist BRECCIA with ochre matrix and clasts of multicoloured weathered greenschist; moderate yellowish brown 10YR 5/4.
JE3/3	4.0- 5.5	reworked OCHRE with very few small greenschist clasts; damp, "gelatinous"; moderate yellowish brown 10YR 5/4.
JE3/4	5.5- 7.0	reworked OCHRE with sparse clasts; moderate red 5R 5/5, clasts more common towards base.
JE3/5	7.0- 8.5	reworked OCHRE as above; yellowish brown 10YR 5/5.
JE3/6	8.5-10.0	as above.
JE3/7	10.0-11.5	reworked OCHRE as above; darker then more yellow towards base; 10YR 5/5 average colour.
JE3/8	11.5-13.0	reworked OCHRE grading to greenschist BRECCIA with ochre matrix; moderate yellowish brown 10YR 5/4.
JE3/9	13.0-14.5	greenschist BRECCIA with clay/ochre matrix; moderate yellowish brown 10YR 5/4.
JE3/10	14.5-16.0	as above, more yellow and crumbly towards base.
JE3/11	16.0-17.5	talc/greenschist BRECCIA with white talc clasts in talcose clay/ochre matrix grading to talcose reworked OCHRE from 16.8m.; greyish brown 5YR 3/2.

JE3/12 17.5-19.0 greenschist BRECCIA with clay/ochre matrix dark
yellowish brown 10YR 3/2

Hole terminated in karst breccia fill at 19.0m.

Auger Hole JE 4

Drilled 19/12/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Logged by H. Shannon. Total depth 19.0m. Location 346690.64mE, 5400482.97mN; RL 204.07m.

Sample	From- to	Description
JE4/1	0.0- 1.0	clayey OCHRE; bright yellowish orange, 10YR 6/8; at base change to moderate reddish brown 10R 5/6.
JE4/2	1.0- 2.5	reworked OCHRE with isolated greenschist clasts to 5mm.; reddish orange 10R 6/7.
JE4/3	2.5- 4.0	reworked OCHRE with minor greenschist clasts; moderate reddish orange 10R 6/6 to 3.7m. then reddish orange brown 10R 5/7.
JE4/4	4.0- 5.5	reworked OCHRE as above; bright red 5R 5/8 to 3.7m., then reddish brown 10R 5/7.
JE4/5	5.5- 7.0	reworked OCHRE with greenschist clasts; moderate reddish brown 7R 4/7.
JE4/6	7.0- 8.5	reworked OCHRE with sparse small clasts to 5mm.; bright reddish brown 7R 4/8, clasts more common towards base, and colour less vivid.
JE4/7	8.5-10.0	reworked OCHRE as above; bright reddish brown 8R 4/8; a bit duller 9R 4/7 towards base.
JE4/8	10.0-11.5	reworked OCHRE as above. A few small clasts; 9R 4/7.
JE4/9	11.5-13.0	reworked OCHRE as above; reddish brown 10R 4/7. About 12.4 to 12.6m. clasts increase grading to ochre matrix greenschist BRECCIA, moderate reddish brown 10R 4/6; then return to reworked OCHRE; dark reddish brown 10R 3/6.
JE4/10	13.0-13.5	greenschist BRECCIA with clay/ochre matrix; greyish red 5R 4/2 and reworked OCHRE; moderate reddish brown 8R 4/6.
	13.5-14.5	greenschist BRECCIA with clay matrix; yellowish brown 10YR 5/3.
JE4/11	14.5-16.0	greenschist BRECCIA with clay matrix; yellowish brown 10YR 5/3.

JE4/12 16.0-17.5 greenschist/spongy quartz BRECCIA with clay/ochre matrix; reddish brown 2YR 4/4.

JE4/13 17.5-18.0 talc/greenschist BRECCIA with talc schist clasts common in clay/ochre matrix; reddish brown 2YR 4/4.

18.0-19.0 talc schist BRECCIA with reworked talc pulp matrix; pale olive grey 10Y 6/2.

Hole terminated in karst breccia fill at 19.0m.

Auger Hole ID 1

Drilled 19/12/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Logged by H. Shannon and R. Annett (14.5-19.0). Total depth 19.0m. Location 346598.12mE, 5400596.59; RL 180.74m.

Sample	From- to	Description
JD1/1	0.0- 1.0	weathered greenschist BRECCIA with clayey ochre matrix; yellowish orange 10YR 6/8; clasts rather colourful reds; 5R 4/6, 3R 4/4.
JD1/2	1.0- 2.5	reworked OCHPE with greenschist and spongy quartz clasts; yellowish orange 10YR 6/7 to 6/8.
JD1/3	2.5- 3.4	reworked OCHRE, with greenschist clasts to 1cm.; yellowish brown 10YR 4/6; stone layer at base.
	3.4- 4.0	OCHRE, plastic with possible relict magnesite rock textures; dark yellowish orange 10YR 6/6 to orange yellow 3Y 6/6.
JD1/4	4.0- 5.0	reworked? OCHRE sloppy, with grit (spongy quartz, greenschist?) drab yellowish orange 10YR 5/6.
	5.0- 5.5	OCHRE; bright yellowish orange 10YR 6/8.
JD1/5	5.5- 7.0	OCHRE; bright orange yellow 2Y 6/8.
JD1/6	7.0- 8.5	OCHRE with relict magnesite rock bedding discernible in broken surfaces; dispersed colour bright yellowish orange 10YR 6/8.
JD1/7	8.5-10.0	OCHRE as above; minor grit (spongy quartz?) bright yellowish orange 10YR 6/8 to bright orange yellow 2Y 6/8.
JD1/8	10.0-11.5	OCHRE as above; 2Y 6/8.
JD1/9	11.5-13.0	OCHRE as above; 2Y 6/8.
JD1/10	13.0-14.5	OCHRE; more yellow than above 3Y 6/8?
JD1/11	14.5-16.0	OCHRE; as above.
JD1/12	16.0-16.8	OCHRE; as above.
	16.8-17.5	GREENSCHIST.
JD1/13	17.5-18.3	GREENSCHIST.
	18.3-19.0	GREENSCHIST and OCHRE; bright yellow 3Y 6/8.

Hole terminated in ochre at 19.0m.

Auger Hole JD 2

Drilled 20/12/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Logged by H. Shannon. Total depth 19.0m. Location 346602.87mE, 5400593.12mN; RL 179.83m.

Sample	From- to	Description
JD2/1	0.0- 0.5 0.5- 1.0	surface gravel (not sampled). reworked OCHRE with clasts; dark yellowish orange 10YR 6/6.
JD2/2	1.0- 2.5	OCHRE with relict magnesite rock textures; bright orange yellow 2Y 6/8.
JD2/3	2.5- 4.0	reworked? OCHRE; sloppy with spongy quartz? clasts; yellowish brown 10YR 5/7 to yellowish orange 10YR 6/7.
JD2/4	4.0- 5.0	reworked? OCHRE; sloppy, with grit (possibly spongy quartz exclusively, so could be an ochre in situ laced with spongy quartz veins) bright yellowish orange 10YR 6/8.
JD2/5	5.5- 7.0	OCHRE; sloppier with some loss of sample as above but some ex-magnesite textures; bright yellowish orange 10YR 6/8.
JD2/6	7.0- 8.5	OCHRE with relict magnesite rock textures; mass colour yellowish brown 10YR 5/7 to yellowish orange 10YR 6/7; dispersed colour bright yellowish orange 10YR 6/8.
JD2/7	8.5-10.0	OCHRE as above.
JD2/8	10.0-11.5	OCHRE as above.
JD2/9	11.5-13.0	OCHRE generally as above, but includes mass colour variant beds from dusky yellow 5Y 6/4 to moderate yellowish brown 10YR 5/4 although mainly yellowish orange 10YR 6/7; dispersed colour remains 10YR 6/8.
JD2/10	13.0-14.5	OCHRE with ex-magnesite textures (bedding, cleat); dispersed colour 2Y 6/8?
JD2/11	14.5-16.0	OCHRE; light brown 5YR 5/6 to dark yellowish orange 10YR 6/6.

JD2/12 16.0-17.5 OCHRE; bright orange yellow 2Y 6/8 to moderate yellowish brown 10YR 5/4 dispersing to bright yellowish orange 10YR 6/8.

JD2/13 17.5-19.0 as above.

Hole terminated in ochre at 19.0m.

Auger Hole JD 3

Drilled 20/12/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Logged by H. Shannon. Total depth 19.0m. Location 346618.57mE, 5400583.99mN; RL 178.31m.

Sample	From- to	Description
JD3/1	0.0- 1.0	sandy quartz GRAVEL with clay/ochre matrix; dark yellowish brown 10YR 4/2.
JD3/2	1.0- 2.2 2.2- 2.5	approx. as above. quartz GRAVEL with ochre matrix; dark yellowish orange 10YR 6/6-6/7.
JD3/3	2.5- 4.0	spongy quartz/ greenschist BRECCIA grading to reworked OCHRE; with clasts; dark yellowish orange 10YR 6/6.
JD3/4	4.0- 5.0	as above.
JD3/5	5.5- 6.0	as above; BRECCIA with ochre matrix; yellowish orange 10YR 6/7.
JD3/6	6.0- 8.5	greenschist/quartz/spongy quartz BRECCIA with ochre matrix; yellowish brown 10YR 5/7.

Hole terminated in karst breccia at 8.5m., owing to boulder problems.

Auger Hole JD 4

Drilled 20/12/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Logged by H. Shannon. Total depth 11.5m. Location 346624.04mE, 5400580.17mN; RL 179.46m.

Sample	From- to	Description
JD4/1	0.0- 1.0	humus rich SOIL with quartz clasts; dark brownish grey 5YR 3/1.
JD4/2	1.0- 1.8	greenschist BRECCIA with clay matrix; greyish green 5GY 5/2
	1.8- 2.5	soft weathered actinolite GREENSCHIST; greyish blue green 5BG 5/2.
JD4/3	2.5- 3.2	greenschist BRECCIA with clay/ochre? matrix (mainly greenschist pulp?); dusky yellow green 5GY 5/2.
	3.2- 4.0	greenschist BRECCIA; of relatively large clasts with clay/ochre? matrix (with greenschist pulp); light olive brown 5Y 4/6 and greyish olive 10Y 4/2.
JD4/4	4.0- 5.0	greenschist BRECCIA with clay/ochre? matrix (as above); olive brown 5Y 4/6 to dark yellowish brown 10YR 4/2.
JD4/5	5.5- 7.0	(water struck) sloppy greenschist BRECCIA with clay/ochre matrix; moderate olive brown 5Y 4/4 to light olive 10Y 5/4. Pigmenting power is less than proper ochres but still quite good. Greenschist clasts are softened or fresh but not oxidized.
JD4/6	7.0- 7.8	greenschist BRECCIA with clay/ochre? matrix (as above); dusky yellow 5Y 6/4 to 5Y 5/4.
	7.8- 8.5	greenschist/quartz/spongy quartz BRECCIA with clay matrix; pale greyish orange 10YR 7/2.
JD4/7	8.5-10.0	greenschist/quartz BRECCIA with clay matrix; greyish orange pink 5YR 7/1, darker near base.
JD4/8	10.0-11.5	BRECCIA as above with peat stained clay matrix; dark brownish grey 5YR 3/1.

Hole terminated in karst breccia at 11.5m.

Auger Hole JD 5

Drilled 21/12/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Logged by H. Shannon. Total depth 19.0m. Location 346603.25mE, 5400468.12mN; RL 184.35m.

Sample	From- to	Description
JD5/1	0.0- 1.0	reworked OCHRE with clasts; dark yellowish orange 10YR 6/6.
JD5/2	1.0- 2.5	reworked OCHRE with clasts; brownish orange 10YR 5/6.
JD5/3	2.5- 3.7 3.7- 4.0	reworked OCHRE; drab yellowish orange 10YR 5/6 reworked OCHRE; yellowish orange 10YR 6/7.
JD5/4	4.0- 5.0 5.0- 5.5	reworked OCHRE with clasts mostly spongy quartzite (ex siliceous magnesite rock); dark yellowish orange 10YR 6/6. reworked OCHRE as above, yellowish brown 10YR 5/6.
JD5/5	5.5- 7.0	reworked OCHRE as above; dark yellowish orange 10YR 6/6 to yellowish brown 10YR 5/6.
JD5/6	7.0- 8.5	reworked OCHRE with clasts; light brown 5YR 6/4 to dark yellowish orange 10YR 6/6 dispersing to 10YR 6/7.
JD5/7	8.5-10.0	OCHRE with relict textures after magnesite; mass colour moderate brown 10YR 4/4 to moderate yellowish brown 10YR 5/4 dispersing to strong dark yellowish orange 10YR 5/8.
JD5/8	10.0-11.3 11.3-11.5	OCHRE as above; strong dark yellowish orange 10YR 5/8. GREENSCHIST and TALC (boulder?); light bluish grey 5B 7/1, yellowish grey 5Y 8/1 and medium bluish grey 5B 5/1; not sampled.
JD5/9	11.5-13.0	(wet sample) greenschist BRECCIA with clay/ochre matrix; yellowish brown 10YR 5/6.
JD5/10	13.0-14.0 14.0-14.5	as above reworked OCHRE with clasts; yellowish brown 10YR 5/7.
JD5/11	14.5-16.0	reworked? OCHRE, almost free of grit, sloppy; strong dark yellowish orange 10YR 6/8.

JD5/12 16.0-17.5 reworked OCHRE with greenschist clasts; dispersed colour dark yellowish orange 10YR 6/7.

JD5/13 17.5-19.0 reworked OCHRE as above; mass colour moderate yellowish brown 10YR 5/5, dispersed colour dark yellowish orange 10YR 6/7.

Hole terminated in ochre rich karst fill at 19.0m.

Auger Hole JD 4

Drilled 8/1/90; Driller T. Lodge; Stacpoole's, Launceston. Logged by H. Shannon. Total depth 31.0m. Location 346642.41mE, 5400535.07mN; RL 182.54m.

Sample	From- to	Description
JD6/1	0.0- 1.0	quartz/greenschist BRECCIA with minor charcoal, in clay matrix; drab yellowish orange 10YR 6/5-7/5.
JD6/2	1.0- 2.5	quartz/greenschist BRECCIA with clay/ochre matrix; clasts to 1cm; dark yellowish orange 10YR 6/5-6/7, trace charcoal.
JD6/3	2.5- 3.2	reworked OCHRE; dark yellowish orange 10YR 6/7 and BRECCIA, as above; moderate yellowish brown 10YR 5/5.
	3.7- 4.0	BRECCIA, as above; moderate yellowish brown 10YR 5/5.
JD6/4	4.0- 5.0	greenschist BRECCIA with clay/ochre matrix; moderate yellowish brown 10YR 5/5.
	5.0- 5.5	sloppy reworked OCHRE with clasts, brownish orange 10YR 5/7.
JD6/5	5.5- 7.0	BRECCIA with clay/ochre matrix grading to reworked OCHRE dark yellowish orange 10YR 6/6.
JD6/6	7.0- 7.5	BRECCIA with clay/ochre matrix; dark yellowish orange 10YR 6/7.
	7.5- 8.5	CHRE with relict magnesite texture; strong dark yellowish orange 10YR 6/8.
JD6/7	8.5-10.0	CHRE as above; dispersed colour 10YR 6/8; mass colour darker and browner.
JD6/8	10.0-11.5	CHRE as above; dispersed colour 10YR 6/8; mass colour darker and browner
JD6/9	11.5-13.0	CHRE as above dispersed colour 10YR 6/8; mass colour darker and browner with minor greenschist.
JD6/10	13.0-14.3	as above; dark yellowish orange.
JD6/11	14.3-15.2	CHRE as above; dark yellowish orange.
JD6/12	15.2-16.0	greenschist BRECCIA, with clay/ochre matrix, moderate yellowish brown 10YR 5/4

- JD6/13 16.0-17.0 sloppy reworked OCHRE, few greenschist clasts; dark yellowish orange 10YR 6/8
- JD6/14 17.0-18.0 as above.
- JD6/15 18.0-19.0 as above, (talc schist clasts common); mass colour moderate yellowish brown dispersing to dark yellowish orange, 10YR 6/6.
- JD6/16 19.0-20.0 reworked OCHRE with greenschist clasts, dark yellowish orange 10YR 5/7 dispersing to 10YR 5/8.
- JD6/17 20.0-21.0 greenschist BRECCIA with OCHRE matrix; mass colour 10YR 5/6 dispersing to 10YR 5/8.
- JD6/18 21.0-21.2 as above
21.2-22.0 greenschist BRECCIA with matrix; pale yellowish brown 10YR 6/2.
- JD6/19 22.0-23.0 greenschist BRECCIA with ochre matrix; dark yellowish brown 10YR 3/2.
- JD6/20 23.0-24.0 OCHRE; dark yellowish brown 10YR 3/2. (most of the sample lost due to water).
- JD6/21 24.0-25.0 OCHRE; mottled including (chocolate) dark yellowish brown 10YR 3/2; dark yellowish orange 10YR 6/8; orange brown 5YR 6/8 with relict magnesite texture. Poor recovery owing to water.
- JD6/22 25.0-26.0 OCHRE; dark yellowish brown (chocolate) 10YR 3/2 relict magnesite texture; poor recovery.
- JD6/23 26.0-28.0 OCHRE; dark yellowish brown (chocolate) 10YR 3/2 and greenschist BRECCIA with clay matrix at base; clasts to 4cm., poor recovery.
- JD6/24 28.0-31.0 OCHRE; strong brownish orange 7YR 4/8, poor sample owing to water, possibly scrapings from a little higher in the hole are included.

End hole.

Auger hole JD Z

Drilled 9/1/90 commencing 8.45am by T. Lodge, Stacpoole's, Launceston. Logged by H. Shannon. Total depth 13.5 metres. Location 346644.11mE, 5400543.09mN; RL 184.18m.

Sample	From- to	Description
	0.0- 0.5	SOIL, not sampled.
JD7/1	0.5- 1.0	CLAY with clasts; dull yellowish brown 10YR 5/4 and dark yellowish orange 10YR 6/6; clasts include quartz and charcoal.
JD7/2	1.0- 2.5	dull yellow orange 10YR 5/6 CLAY/OCHRE with clasts including quartz; dispersing to 10YR 6/6.
JD7/3	2.5- 3.8	as above.
JD7/4	3.8- 4.0	CLAY/OCHRE with clasts; dark yellowish orange 10YR 6/6.
JD7/5	4.0- 5.5	peat stained CLAY with greenschist clasts, dark brownish grey 5YR 3/1; towards base brownish black 5YR 2/1 with <u>peat</u> and <u>woody plant remains</u> .
JD7/6	5.5- 8.5	peaty CLAY as above; from 8.0 fibrous plant remains common. Mass colour light olive grey 5Y 5/2 dispersing to dusky olive yellow 5Y 5/4.
JD7/7	8.5-11.5	peat stained CLAY with greenschist clasts and minor PEAT with <u>woody/fibrous plant remains</u> , colours as above (water struck).
JD7/8	11.5-13.5	as above but more clasts and less peat.

End Hole.

Auger Hole JD 8

Drilled 9/1/90; Driller T. Lodge; Stacpoole's, Launceston. Logged by M. Whitty. Total depth 8.3m. Location 346640.56mE, 5400531.52mN; RL 185.61m.

Sample	From- to	Description
JD8/1	0.0- 1.0	CLAY, dark yellowish orange 10 YR 6/6 mixed with grey sandy CLAY.
JD8/2	1.0- 2.5	CLAY, yellowish grey 5Y 7/2.
JD8/3	2.5- 3.8	as above.
	3.8- 4.0	CLAY/OCHRE?; dark yellowish orange 10YR 6/6.
JD8/4	4.0- 5.5	CLAY/OCHRE?, dark yellowish orange 10YR 6/6 with peat clasts, more boggy.
JD8/5	5.5- 7.0	CLAY/OCHRE?, dark yellowish orange 10YR 6/6 with sandstone and peat clasts merging to greyish olive 10 YR 4/2.
JD8/6	7.0- 8.5	CLAY/OCHRE?, samples becoming water saturated. Dusky yellow 5Y 6/4.
	8.5-11.3	Cavity struck, drill rods dropping through open space of 2.8 metres to hard bottom, plentiful water and unable to retain sample. (The bottom is probably magnesite rock - ed.).

Hole abandoned.

Auger hole JD 9.

Drilled 9/1/90, commencing 2.10pm.

Drilled by T.Lodge, Stacpoole's, Launceston. Logged by M. Whitty.

Total depth 5.5 metres. Location 346635.87mE, 5400521.33mN; RL 187.11m.

Sample	From- to	Description.
JD9/1	0.0- 1.0	MUD.
JD9/2	1.0- 2.5	CLAY/OCHRE with clasts; dark yellowish orange 10YR 6/6 to dusky brown 5YR 2/2.
JD9/3	2.5- 4.0	OCHRE with clasts, sloppy; dusky brown 5YR 2/2. (ochre falling from auger due to water).
JD9/4	4.0- 5.5	OCHRE, dusky brown as above, loose blocky quartz (probably magnesite, ed.) has damaged auger, unable to gain further penetration.

Hole abandoned.

Auger Hole JD 10.

Drilled on 9/1/90, commencing 3.05pm by T. Lodge; Stacpoole's, Launceston. Logged by M. Whitty and H. Shannon (2.5-5.3). Total depth 5.3m. Location 346629.94mE, 5400511.23mN; RL 189.82m.

Sample	From- to	Description.
JD10/1	0.0- 1.0	friable grey SAND.
JD10/2	1.0- 2.5	OCHRE; brecciated, dark yellowish orange 10YR 6/6 mixed with mud.
JD10/3	2.5- 4.0	sandy OCHRE, with quartz and limonite clasts; moderate yellowish brown 10YR 5/4.
JD10/4	4.0- 5.3	OCHRE; moderate yellowish brown 10YR 5/6. At base hard with disaggregated magnesite silt; orange grey 10YR 7/4. Acid test proved carbonate.

Hard Magnesite on bottom; hole complete.

Auger hole JD 11.

Drilled on 9/1/90 commencing 4.15pm. Driller T. Lodge; Stacpoole's, Launceston. Logged by H. Shannon. Total depth 7.1 metres. Location 346625.88mE, 5400506.19mN; RL 190.44m.

Sample	From- to	Description.
JD11/1	0.0- 1.5	SAND, pinkish grey 5YR 8/1.
JD11/2	1.5- 2.5	sandy CLAY/OCHRE; mottled dark yellowish orange 10YR 6/6, greyish orange 10YR 7/4 and dark yellowish brown 10YR 4/2.
JD11/3	2.5- 3.5	sandy OCHRE with clasts, yellowish brown 10YR 5/4.
JD11/4	3.5- 4.0	OCHRE?, very dark yellowish brown 10YR 3/2 to dusky yellow brown 10 YR 2/2, (could be peaty clay).
JD11/5	4.0- 5.0	OCHRE, moderate yellowish brown 10YR 4/2 and dark yellowish orange 10YR 5/8 with yellowish black, soft "concretions" of peat.
JD11/6	5.0- 5.5	OCHRE?, "chocolate and black" dusky yellowish brown 10YR 2/2 (could be peaty clay).
JD11/7	5.5- 7.0	reworked OCHRE; dark yellowish brown 10YR 4/2, with small clasts and a block of chocolate ochre or peat.
JD11/8	7.0- 7.1	OCHRE, very dark yellowish brown 10YR 3/2 merging to diagggregated and hydrated? MAGNESITE; pale yellowish orange 10YR 8/6 at base. Hard at bottom, (magnesite). Acid test proved carbonate.

End hole.

Auger hole JD 12.

Drilled 10/1/90. Driller T. Lodge, Stacpoole's, Launceston. Logged by H. Shannon. Total depth 14.5 metres. Location 346622.45mE, 5400501.11mN; RL 190.37m.

Sample	From- to	Description.
JD12/1	0.0- 1.0	quartz GRAVEL over weathered GREENSCHIST in clay.
JD12/2	1.0- 2.5	actinolite GREENSCHIST, weathered and soft, dusky yellow green 5GY 5/2 and greyish green 10GY 5/2.
JD12/3	2.5- 4.0	(weathered greenschist or) pulp/clay matrix greenschist BRECCIA, small clasts only with compaction foliation. At top matrix is moderate yellowish brown 10YR 5/4; remainder dusky yellow 5Y 6/4, and yellowish grey 5Y 7/2. The clasts are all greyish green 10GY 5/2.
JD12/4	4.0- 5.5	greenschist BRECCIA with clay matrix, 2Y 5/4 yellowish brown.
JD12/5	5.5- 7.0	greenschist BRECCIA with clay matrix as above grading to greenschist BRECCIA with clay/ochre matrix from 6.5m, 2Y 5/6.
JD12/6	7.0- 8.5	greenschist BRECCIA with clayey ochre matrix 3Y 5/6 dispersing to 2Y 5/8.
JD12/7	8.5-10.0	clay/ochre matrix greenschist BRECCIA, 2Y 6/6.
JD12/8	10.0-11.5	greenschist BRECCIA with peaty clay/sand matrix or possibly ochre (umber). Dusky yellowish brown 10YR 2/2 dispersing to pale yellowish brown 10YR 6/2 to 10YR 6/4.
JD12/9	11.5-13.0	matrix supported BRECCIA grading to cemented SAND; sparse greenschist clasts with peat/clay/sand matrix but no recognizable organic remains; black N 1. Large white soft clast at base (decomposed MAGNESITE).
JD12/10	13.0-14.5	as above dispersing to olive black 5Y 2/1.

Too much water, unable to retain sample, hole abandoned (probably close to bottoming on magnesite).

Auger hole JD 13.

Drilled 10/1/90 start 1.30pm. Drilled by T. Lodge, Stacpoles, Launceston. Logged by M. Whitty. Total depth 8.3 metres.

Sample	From- to	Description
JD13/1	0.0- 1.0	SAND.
JD13/2	1.0- 2.5	blocky TALC rock in sand.
JD13/3	2.5- 4.0	Sandy dry ground GREENSCHIST (boulder?).
JD13/4	4.0- 5.5	BRECCIA (greenschist/talc) with dark yellowish orange OCHRE 10YR 6/6.
JD13/5	5.5- 7.0	BRECCIA and friable GREENSCHIST.
JD13/6	7.0- 8.5	BRECCIA and, friable brown clay with clasts of Fe-ox. No ochre.
JD13/7	8.5-10.0	OCHRE, moderate brown 5YR 4/4 with greenschist clasts.
JD13/8	10.0-11.5	BRECCIA, clay to ochre, moderate yellow brown 10YR 5/4. No greenschist.
JD13/9	11.5-13.0	friable BRECCIA(greenschist/talc); greyish brown 5YR 3/2.
JD13/10	13.0-14.5	matrix supported BRECCIA of greenschist clasts in ochre matrix; dark yellowish orange ochre 10YR 6/6.
JD13/11	14.5-16.0	as above.
JD13/12	16.0-17.5	as above, then back into water logged GREENSCHIST.
JD13/13	17.5-19.0	Too much water, unable to retain sample.

End hole.

Auger hole JD 14.

Drilled 11/1/90 commenced 8.40am. Driller by T. Lodge, Stacpoole's, Launceston. Logged by M. Whitty. Total depth 22 metres. Location 346631.19mE, 5400480.46mN; RL 193.95m.

Sample	From- to	Description.
JD14/1	0.0- 1.0	sandy OCHRE.
JD14/2	1.0- 2.5	sandy OCHRE 10YR 6/3 and 10YR 5/6 all mixed with friable and light greenschist.
JD14/3	2.5- 4.0	as above.
JD14/4	4.0- 5.5	actinolite SCHIST, friable and light, greyish green 5B 5/2.
JD14/5	5.5- 7.0	as above.
JD14/6	7.0- 8.5	greenschist BRECCIA, clay matrix; yellow grey 3Y 6/2 trace ochre.
JD14/7	8.5-10.0	greenschist BRECCIA 2Y 6/4 light and friable.
JD14/8	10.0-11.5	as above merging to moderate brown CLAY/OCHRE 5YR 4/4.
JD14/9	11.5-13.0	brecciated GREENSCHIST recovered as lightweight brown clay 5YR 4/4.
JD14/10	13.0-14.5	as above
JD14/11	14.5-16.0	OCHRE, wet, yellowish orange 10YR 6/6.
JD14/12	16.0-17.5	OCHRE, good dark yellow/orange 10YR 6/6.
JD14/13	17.5-19.0	OCHRE as above becoming more pure and pronounced in colour.
JD14/14	19.0-20.05	as above.
JD14/15	20.05-22.0	actinolite GREENSCHIST, waterlogged.

Hole terminated.

Auger hole JD 15.

Drilled 11/1/90 commencing 1.30pm. Driller T. Lodge, Stacpoole's, Launceston. Logged by M. Whitty, and H. Shannon (13.0-17.0m) Total depth 17 metres. Location 346643.09mE, 5400474.81mN, RL 197.59m.

Sample	From- to	Description.
JD15/1	0.0- 1.0	SAND.
JD15/2	1.0- 2.5	red CLAY grading to light friable (actinolite) GREENSCHIST.
JD15/3	2.5- 4.0	loose dry friable actinolite GREENSCHIST.
JD15/4	4.0- 5.5	as above, (traces of clay/ochre, 10YR 6/6).
JD15/5	5.5- 7.0	BRECCIA with clay/ochre matrix and clasts of greenschist; greyish orange 10YR 7/4.
JD15/6	7.0- 8.5	BRECCIA with clay/ochre matrix; dusky yellow 5Y 6/4 with some bright orange clay.
JD15/7	8.5-10.0	moderate yellow brown OCHRE 10YR 5/4, with clasts and traces of bright orange clay as above.
JD15/8	10.0-11.5	as above but with more greenschist clasts (sample dry, friable).
JD15/9	11.5-13.0	as above but more greenschist.
JD15/10	13.0-14.5	talcy greenschist BRECCIA with clay matrix, dark yellowish brown 10YR 4/2.
JD15/11	14.5-15.7 15.7-16.0	BRECCIA as above, yellowish brown 10YR 5/2 greenschist BRECCIA with clay/ochre matrix 10YR 5/4, moderate yellow brown.
JD15/12	16.0-17.0	ochre matrix greenschist BRECCIA and OCHRE dispersing to dark yellowish orange 10YR 5/7.
	17.0	Hard at base with traces of disintegrated MAGNESITE silt.

Hole complete.

Auger hole JD 16.

Drilled by T. Lodge, Stacpoole's, Launceston. Logged by H. Shannon.
Total depth 14 metres. Location 346654.09mE, 5400467.67mN; RL
201.17m.

Sample	From- to	Description.
JD16/1	0.0- 1.0	SAND; 5YR 8/1 pinkish grey.
JD16/2	1.0- 2.5	SAND, grading to sandy OCHRE and some clasts of weathered greenschist; strong moderate brown 5YR 5/6.
JD16/3	2.5- 4.0	SAND with larger vein quartz clasts; greyish orange 10YR 7/4.
JD16/4	4.0- 5.5	SAND with quartz clasts to 1cm; dark yellowish orange 10YR 6/6 to pale yellow 5Y 7/4.
JD16/5	5.5- 7.0	SAND with larger quartz clasts; mottled yellowish grey 5Y 8/1 and greyish orange 10YR 7/4.
JD16/6	7.0- 8.5	wet mottled SAND with quartz clasts, white N 9 to pale yellowish orange 10YR 8/6.
JD16/7	8.5-10.0	SAND as above, yellowish grey 3Y 7/2.
JD16/8	10.0-14.0	peat stained SAND with quartz clasts, poor recovery due to water, dusky yellowish brown 10YR 3/2 with patches of yellowish grey 3Y 7/2.
	14.0	hard bottom; last material disaggregated MAGNESITE silt (carbonates confirmed with acid).

Hole complete.

Auger hole JD 17.

Drilled by M. Whitty. Logged by H. Shannon. Total depth 9.7 metres.
Drilled on 12/1/90 commencing 8.50am. Location 346661.71mE,
5400458.59mN; RL 202.91m.

Sample	From- to	Description
JD17/1	0.0- 1.0	SAND with quartz clasts to 5mm.; mottled greyish yellow 5Y 5/4, yellowish grey 5Y 7/2, pale yellowish brown 10YR 6/2 and greyish orange pink 5YR 7/2.
JD17/2	1.0- 2.5	fine SAND as above, pale yellow 2Y 8/6.
JD17/3	2.5- 4.0	fine SAND with quartz clasts to 1.5cm.; pale yellow 2Y 8/6, yellowish grey 2Y 8/1.
JD17/4	4.0- 5.5	fine SAND with abundant quartz clasts to 5cm.; pale yellow 5Y 8/4 to yellowish grey 2Y 8/1.
JD17/5	5.5- 7.0	fine SAND with quartz clasts; mostly white N 9 (contaminated).
JD17/6	7.0- 8.5	PEAT; brownish black 5YR 2/1 with quartz clasts at top.
JD17/7	8.5- 9.7	PEAT with quartz and fresh magnesite rock clasts to 5cm. Hard drilling for last metre to hard bottom with decomposed MAGNESITE rind.

Hole complete.

Auger hole JD 18.

Drilled by M. Whitty. Logged by H. Shannon. Total depth 13 metres.
 Drilled on 12/1/90 commencing 11.15am. Location 346669.22mE,
 5400449.92mN; RL 202.62m.

Sample	From- to	Description
JD18/1	0.0- 1.0	SAND; pale yellow 2Y 8/4 with spongy quartz and milky vein quartz clasts.
JD18/2	1.0- 2.5	SAND; pale yellow 2Y 8/2.
JD18/3	2.5- 4.0	SAND; yellow with quartz clasts 2Y 7/5.
JD18/4	4.0- 5.5	SAND; pale yellow as above.
JD18/5	5.5- 6.0	as above.
	6.0- 7.0	SAND; white M 9.
JD18/6	7.0- 8.5	white SAND as above (some contamination of sample!).
JD18/7	8.5- 9.5	SAND grading to sandy ochre; strong dark yellowish orange 10YR 6/7.
	9.5-10.0	sandy OCHRE, dark yellowish brown. PEAT with clasts at base of sample.
JD18/8	10.0-11.5	PEAT above peat impregnated SAND with clasts; olive grey 5Y 4/1.
JD18/9	11.5-13.0	(poor recovery) includes PEAT from bottom; brownish black 5YR 2/1.
	13.0	PEAT, soft and boggy, implied by the drill stem sinking under its own weight while changing rods, unable to continue.

Hole abandoned.

Auger hole JD 19.

Drilled by T. Lodge, Stacpoole, Launceston. Logged by H. Shannon.
Total depth 25 metres. Drilled on 15/1/90 starting 9.15am. Location
346679.97mE, 5400436.42mN; 199.95m.

Sample	From- to	Description
JD19/1	0.0- 1.3	SOIL grading to BRECCIA with clay/ochre matrix; greyish brown 5Y 3/2 then reworked ochre with clasts; moderate brown 5YR 3/4.
JD19/2	1.3- 2.5	reworked OCHRE with clasts; dark yellowish orange 10YR 6/7
JD19/3	2.5- 3.8	reworked OCHRE as above with clasts of quartz and greenschist 10YR 6/7.
JD19/4	3.8- 4.0 4.0- 4.5 4.5- 5.5	talcy GREENSCHIST; light bluish grey 5B 7/1 light olive grey 5Y 5/2 greenschist BRECCIA with greenschist pulp/clay matrix. light olive grey 5Y 5/2 greenschist BRECCIA with clay matrix.
JD19/5	5.5- 7.0	greenschist BRECCIA 5Y 5/2 with some CLAY/OCHRE; yellowish brown 2Y 5/4. At base pale brown 5YR 5/2.
JD19/6	7.0- 8.5	greenschist BRECCIA as above; some large blocks?
JD19/7	8.5-10.0 10.0-11.0	greyish olive green 2Y 5/2 greenschist BRECCIA; clasts to 0.5cm. as above, not sampled
JD19/8	11.0-11.5	greenschist/quartz BRECCIA with clay/ochre matrix; brownish orange 10YR 5/6 (contaminated sample).
JD19/9	11.5-13.0	greenschist BRECCIA with clay/ochre matrix; dark yellowish orange 10YR 6/6. At base reworked OCHRE strong yellowish brown 10YR 5/8.
JD19/10	13.0-14.0	reworked OCHRE; strong yellowish brown 10YR 5/8.
JD19/11	14.0-14.7	reworked OCHRE as above 10YR 5/8.

- JD19/12 14.7-16.0 reworked OCHRE sandy in lower half, wet at base; dark yellowish brown 10YR 3/2 with moderate yellowish brown 10YR 3/4.
- JD19/13 16.0-17.0 sandy clay/ochre matrix greenschist/quartz BRECCIA, dark yellowish brown 10YR 4/2.
- JD19/14 17.0-18.0 reworked OCHRE grading to ochre matrix greenschist BRECCIA; strong yellowish brown 10YR 5/7.
- JD19/15 18.0-19.0 greenschist BRECCIA with clayey clay/ochre matrix, dark yellowish brown 10YR 4/2 to yellowish brown 10YR 6/4.
- JD19/16 19.0-20.0 greenschist BRCCIA with clay matrix, (dark possibly peaty); olive grey 5Y 3/2 dispersing to olive brown 3Y 4/2.
- JD19/17 20.0-21.0 greenschist BRECCIA grading to MUD with clasts; olive grey 5Y 4/2.
- JD19/18 21.0-22.0 peat impregnated OCHRE? or peaty CLAY? with traces of bedding, no larger clasts; olive black 5Y 2/1 dispersing to olive grey 5Y 4/2, some smears of silt, pinkish grey 5YR 8/1 possibly disaggregated magnesite or quartz sand, with talc flakes.
- JD19/19 22.0-23.0 reworked "dark chocolate" OCHRE with greenschist clasts and talc (possibly peat stained); olive black 5Y 2/1 dispersing to olive grey 5Y 4/2, inorganic dark colour seems more likely in this sample.
- JD19/20 23.0-23.8 as above.
- JD19/21 23.8-24.6 as above, more compact.
- JD19/22 24.6-25.0 pebbly reworked OCHRE? some clasts to 2cm, MAGNESITE?

End Hole.

Auger hole JD 20.

Drilled 20/2/90 commencing 8.45am. Driller T. Lodge and R. Dean, Stacpoole's Launceston. Logged by H. Shannon. Total depth 24.0 metres. Location 346612.82mE, 5400586.82mN, RL 178.19m.

Sample	From- to	Description
JD20/1	0.0- 1.0	sandy CLAY with quartz gravel clasts; brownish grey 7YR 4/2.
JD20/2	1.0- 2.5	peaty CLAY and quartz/greenschist BRECCIA with clay matrix; 5YR 4/1 brownish grey.
JD20/3	2.5- 3.2 3.2- 4.0	as above. muddy, reworked OCHRE with clasts greenschist/quartz; light olive brown 3Y 5/4.
JD20/4	4.0- 4.5 4.5- 5.5	as above. muddy reworked OCHRE with 5% clasts 2Y 6/6 yellowish olive.
JD20/5.1	5.5- 6.5	muddy, reworked OCHRE with 5% clasts; light olive brown 3Y 5/4 to yellowish olive 2Y 6/6.
JD20/5.2	6.5- 7.0	muddy, reworked OCHRE grading to sandy OCHRE; olive brown 2Y 4/4 to yellowish olive 2Y 6/6 dispersing to 2Y 6/8.
JD20/6	7.0- 8.5	reworked OCHRE with clasts 5%, some sandy OCHRE; (orange) yellow 1Y 6/6 mass colour dispersing to 1Y 6/8.
JD20/7	8.5-10.0	reworked OCHRE as above over reworked OCHRE with quartz clasts 10% to 1cm; yellowish orange 10YR 6/8 dispersing to 10YR 6/10.
JD20/8	10.0-11.5	as above; 9YR 6/7 dispersing to 9YR 6/9.
JD20/9	11.5-13.0	sandy, reworked OCHRE with quartz clasts 10%; yellowish orange 10YR 6/6 dispersing to 10YR 6/8.
JD20/10	13.0-14.5	sandy reworked OCHRE with clasts 5%; yellowish orange 9YR 6/6 dispersing to 9YR 6/8 (a little darker than 6).
JD20/11	14.5-16.0	reworked OCHRE as above; 9YR 6/7, dispersed colour 9YR 6/9 (a little darker than 6).

- JD20/12 16.0-17.0 sloppy, reworked OCHRE with clasts 20% dispersed colour 10YR 6/8 yellowish orange.
- JD20/13 17.0-18.0 sloppy, reworked OCHRE with quartz clasts to 1cm, 15%; dispersed colour 10YR 6/10 yellowish orange.
- JD20/14 18.0-19.0 sloppy, reworked OCHRE, quartz clasts 20%; dispersed colour 10YR 5/10. At base OCHRE with relict magnesite texture. 8YR 5/10 orange brown dispersing to 8YR 6/10 orange.
- JD20/15 19.0-20.0 reworked OCHRE with clasts, grading to ochre matrix BRECCIA, clasts 30% dispersed colour 10YR 6/10 yellowish orange.
- JD20/16 20.0-21.0 as above dispersed colour yellowish orange 10YR 6/10, (a little brighter than above).
- JD20/17 21.0-22.0 poor recovery included OCHRE with relict texture after magnesite, disperses to 9YR 6/10, contaminated with reworked ochre.
- JD20/18 22.0-24.0 poor recovery as above, hard bottom at 24.0m, possibly MAGNESITE.

End hole.

Auger Hole IC 1

Drilled 11/12/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Logged by H. Shannon. Total depth 19.0m. Location 346620.33mE, 5400452.26mN; RL 186.99m.

Sample	From- to	Description
JC1/1	0.0- 1.5	CLAY/OCHRE, dark yellowish orange, 10YR 6/7 mottled near base.
JC1/2	1.5- 2.7	CLAY/OCHRE; dark yellowish orange 10YR 6/7.
JC1/3	2.7- 3.2	CLAY/OCHRE; dark yellowish orange 10YR 6/6, with soft weathered greenschist clasts.
JC1/4	3.2- 4.0	dark yellowish orange OCHRE, as above.
JC1/5	4.0- 4.5	dull yellowish brown OCHRE, 10YR 5/4, with soft talc schist clasts.
JC1/6	4.5- 6.0	CLAY/OCHRE with weathered greenschist clasts, pale greyish orange 10YR 7/4 (does not pigment well).
JC1/7	6.0- 7.5	dull yellowish brown CLAY/OCHRE, 10YR 6/5 (as above).
JC1/8	7.5- 8.5	dark greyish brown CLAY/OCHRE, 10YR 4/4 (as above); also some brownish orange OCHRE.
JC1/9	8.5- 9.0	yellowish brown to yellowish orange OCHRE, dispersed colour 10YR 6/8 (pigments well).
JC1/10	9.0-10.5	moderate yellowish brown OCHRE, 10YR 4/4 dispersing to 10YR 6/6, with small schist clasts.
JC1/11	10.5-12.0	(water struck) wet yellowish brown OCHRE, 10YR 5/6, with minor schist clasts, at base orange brown, disperses to dark yellowish orange 10YR 6/7.
JC1/12	12.0-13.5	dark yellowish orange 10YR 6/6 to moderate yellowish brown 10YR 5/4 OCHRE, with schist clasts; dispersing to dark yellowish orange 10YR 6/7.
JC1/13	13.5-15.0	as above.

JC1/14 15.0-16.5 as above.

JC1/15 16.5-18.0 as above.

JC1/16 18.0-19.0 as above grading to pale yellowish brown 10YR
6/4, very wet at base, about to lose sample.

Hole terminated in ochre at "19.5"m. (A calibration error adds 0.5 m
to the sample depths i.e. 19.5m=19.0m true depth.

Auger Hole JC 2

Drilled 12/12/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Logged by H. Shannon and M. Whitty (2.5-14.5). Total depth 19.0m. Location 346616.00mE, 5400456.21mN; RL 187.04m.

Sample	From- to	Description
JC2/1	0.0- 1.0	CLAY/OCHRE with soft weathered greenschist clasts, yellowish brown, 10YR 6/4.
JC2/2	1.0- 2.5	CLAY/OCHRE; moderate yellowish brown 10YR 5/4.
JC2/3	2.5- 4.0	no record
JC2/4	4.0- 5.5	no record
JC2/5	5.5- 7.0	red brown loose dry clay running to red OCHRE.
JC2/6	7.0- 8.5	red OCHRE, 10R 3/4?
JC2/7	8.5-10.0	red OCHRE, 10R 3/4 dark reddish brown.
JC2/8	10.0-11.5	OCHRE, friable, moderate yellowish brown 10YR 5/4.
JC2/9	11.5-13.0	OCHRE, friable, dark yellowish brown 10YR 4/4.
JC2/10	13.0-14.5	OCHRE, wet dark yellowish orange, 10YR 6/4.
JC2/11	14.5-16.0	OCHRE, some sandy, moderate yellowish brown, 10YR 5/4.
JC2/12	16.0-17.0 17.0-17.5	OCHRE, sandy "muddy" yellowish orange 10YR 6/4. OCHRE, with detectable greenschist clasts, greyish orange 10YR 7/4.
JC2/13	17.5-18.9	OCHRE, dispersing to dark yellowish orange 10YR 6/6 (mass colour moderate yellowish brown 10YR 5/4).
JC2/14	18.9-19.0	greenschist BRECCIA? Chips of soft green and weathered pink and brown greenschist.

Hole terminated in breccia? 19.0m.

note: Relative to the previous hole colours were drab with ambiguous clay rich transported ochres common grading towards greenschist breccia.

Auger Hole JC 3

Drilled 12/12/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Logged by H. Shannon. Total depth 19.0m. Location 346611.24mE, 5400460.25mN; RL 186.65m.

Sample	From- to	Description
JC3/1	0.0- 1.0	weathered GREENSCHIST (boulder?) orange to brown.
JC3/2	1.0- 2.5	CLAY/OCHRE; dark yellowish orange 10YR 6/7 mottled with illuvial clay, very pale orange 10YR 8/2. The sample disperses to a brighter yellowish orange 10YR 6/8.
JC3/3	2.5- 3.5 3.5- 4.0	CLAY/OCHRE; dark yellowish orange 10YR 6/6. BRECCIA, weathered greenschist clasts in clay/ochre matrix; mass colours yellowish brown 10YR 5/2 with minor yellowish orange 10YR 6/6. Disperses to moderate yellowish brown 10YR 5/4.
JC3/4	4.0- 5.5	sandy OCHRE, dark yellowish brown 10YR 4/4 and OCHRE, yellowish brown 10YR 5/4 dispersing to a (drab) dark yellowish orange 10YR 6/6.
JC3/5	5.5- 7.0	OCHRE, with grit; moderate reddish brown 10R 4/6 grading to moderate brown 5YR 5/4.
JC3/6	7.0- 8.5	OCHRE, with weathered greenschist clasts, crumbly sample; dark reddish brown 10R 3/4.
JC3/7	8.5-10.0	OCHRE, greyish brown 5YR 4/2.
JC3/8	10.0-11.5	OCHRE, crumbly sample; very dark red 5R 2/4.
JC3/9	11.5-13.0	OCHRE, very dark greyish red 5R 3/2 dispersing to greyish red 5R 4/2; towards base wet sample mottled with pale reddish brown 10R 5/4.
JC3/10	13.0-15.5	OCHRE, greyish brown, 5YR 3/2 (chocolate); at base boulder? of weathered greenschist, greyish red 5R 4/2.
JC3/11	15.5-16.5	OCHRE, some hard drilling, (limonite seam? clasts recovered); greyish red 5R 4/2.
JC3/12	16.5-17.0	OCHRE with some schist clasts; dusky red 5R 4/4 grading to moderate red 5R 4/6 at base.

JC3/13 17.0-18.0 OCHRE, (hard drilling) moderate reddish brown 10R 4/4).

JC3/14 18.0-18.8 OCHRE (hard drilling) greyish brown 5YR 3/2.

Hole terminated in limonite cemented ochre at 18.8m.

Auger Hole JC 4

Drilled 13/12/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Logged by H. Shannon. Total depth 19.0m. Location 346607.11mE, 5400463.55mN; RL 184.35m.

Sample	From- to	Description
JC4/1	0.0- 1.0	CLAY/OCHRE (drab) dark yellowish orange 10YR 6/6.
JC4/2	1.0- 2.5	CLAY/OCHRE, light orange brown 8YR 5/6? (brighter than 10YR 5/6 and redder).
JC4/3	2.5- 4.0	BRECCIA, weathered greenschist clasts in clay/ochre matrix? crumbly sample; light brown 5YR 6/4.
JC4/4	4.0- 5.2 5.2- 5.5	OCHRE, light orange brown 8YR 6/6 OCHRE, brownish orange 10YR 5/6.
JC4/5	5.5- 6.2 6.2- 6.8	CLAY (weathered greenschist breccia?), pale yellowish brown 10YR 6/2 CLAY, (weathered greenschist breccia?), greyish red 10R 4/2.
JC4/6	6.8- 8.5	CLAY/OCHRE, moderate reddish brown 10R 4/6.
JC4/7	8.5-10.0	CLAY/OCHRE, light brown 7YR 5/6.
JC4/8	10.0-11.5	CLAY/OCHRE, moderate brown 5YR 4/3?
JC4/9	11.5-13.0	clayey OCHRE, moderate brown 5YR 4/4.
JC4/10	13.0-14.5	(clayey) OCHRE, moderate brown, 5YR 4/4.
JC4/11	14.5-16.0	(clayey) OCHRE with rock chips; moderate brown 5YR 4/4.
JC4/12	16.0-17.5	CLAY/OCHRE with weathered greenschist clasts; moderate reddish brown 10R 4/6.
JC4/13	17.5-19.0	as above?

Hole terminated in ochre reworked and contaminated with greenschist detritus.

Auger Hole JC 5

Drilled 13/12/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Logged by H. Shannon. Total depth 19.0m. Location 346603.25mE, 5400468.12mN; RL 184.35m.

Sample	From- to	Description
JC5/1	0.0- 1.0	CLAY (drab) dark yellowish orange 10YR 6/5.
JC5/2	1.0- 2.5	CLAY/OCHRE, dark yellowish orange 10YR 6/6 grading to pale reddish brown 10R 5/4.
JC5/3	2.5- 4.0	CLAY/OCHRE; reddish brown 10R 5/7.
JC5/4	4.0- 5.5	CLAY/OCHRE, reddish brown 10R 4/6.
JC5/5	5.5- 7.0	CLAY/OCHRE; dark yellowish brown 10YR 4/2 and moderate reddish brown 10R 4/6.
JC5/6	7.0- 8.5	CLAY/OCHRE, moderate red 5R 4/6 (mass colour) dispersing to pale reddish brown 10R 5/4; water struck at base.
JC5/7	8.5-10.0	sloppy CLAY/OCHRE, reddish brown 10R 4/6.
JC5/7A	8.5-10.0	ochre matrix BRECCIA, weathered greenschist clasts to 3cm in clayey ochre; moderate red 5R 4/6.
JC5/7B	8.5-10.0	ochre matrix BRECCIA as above; light brown 5YR 5/6.

Hole terminated in a karst breccia of ochre much contaminated with greenschist detritus.

Auger Hole JC 6

Drilled 13/12/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Logged by H. Shannon. Total depth 19.0m. Location 346631.22mE, 5400439.42mN; RL 187.86m.

Sample	From- to	Description
	0.0- 1.0	dirty SAND and clay binder, no sample.
JC6/1	1.0- 2.5	clean white SAND, fine with some grit; some contamination.
JC6/2	2.5- 4.0	fine SAND; dark brown to brownish black (peat stained).
JC6/3	4.0- 5.2	weathered GREENSCHIST boulders? (chips and pulp) dusky yellow 5Y 6/4 to light grey N 7.
	5.2- 5.5	greenschist BRECCIA; soft schist clasts in peat stained mud/sand matrix, brownish dark grey 5YR 3/1.
JC6/4	5.5- 6.5	greenschist BRECCIA, fine grained, pale yellowish brown 10YR 6/2 clayey matrix.
	6.5- 7.0	greenschist BRECCIA; schist clasts in clay matrix, light bluish grey 5B 8/1.
JC6/5	7.0- 8.5	greenschist BRECCIA, small clasts; greenish grey 5GY 6/1, greyish orange 10YR 7/4 at base.
JC6/6	8.5-10.0	greenschist BRECCIA and boulders; recovered clasts up to 4cm; moderate yellowish brown 10YR 5/4 grading to (drab) dark yellowish orange 10YR 6/5 at base.
JC6/7	10.0-11.5	OCHRE and clayey ochre matrix greenschist BRECCIA; orange yellow 2Y 6/7, only moderate pigmenting power.
JC6/8	11.5-13.0	gritty OCHRE, grading to ochre matrix BRECCIA bright orange yellow 2Y 6/8, only moderate pigmenting power. At base change to SAND with peat staining light brownish grey 5YR 6/1 to brownish grey 5YR 3/1.
JC6/9	13.0-14.5	gritty reworked OCHRE, with occasional greenschist clasts and some limonite vein material (dark, soft) bright orange yellow 2Y 6/8.

- JC6/10 14.5-16.0 pebbly OCHRE grading to ochre matrix greenschist BRECCIA with clasts of soft greenschist and hard indeterminate material (quartz, limonite? peat cemented sand? Mass colours dark yellowish orange 10YR 6/7 grading to moderate yellowish brown 5YR 5/4 but dispersing to orange yellow 2Y 6/8.
- JC6/11 16.0-17.5 greenschist BRECCIA with peat stained muddy sand matrix.
- JC6/12 17.5-19.0 greenschist BRECCIA as above.

Hole terminated in non-ochre bearing organic sinkhole fill sediments after penetrating blocks of ochre and reworked ochre/greenschist breccia.

Auger Hole IC Z

Drilled 14/12/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Logged by H. Shannon. Total depth 19.0m. Location 346628.83mE, 5400444.35mN; RL 187.36m.

Sample	From- to	Description
	0.0- 1.0	muddy SAND and CLAY? (discarded by drillers).
ICZ/1	1.0- 2.2	wet OCHRE, drab orange yellow, 2Y 5/5?
	2.2- 2.5	OGHRE as above, dark yellowish orange 10YR 6/6.
ICZ/2	2.5- 3.8	mottled OCHRE, mostly dark yellowish orange 10YR 6/6.
	3.8- 4.0	weathered GREENSCHIST (block?), yellowish orange 10YR 7/6.
ICZ/3	4.0- 5.3	greenschist BRECCIA with CLAY/OCHRE matrix; matrix dark yellowish orange 10YR 6/6 to bright yellowish orange 8YR 6/8
	5.3- 5.5	greenschist BRECCIA with CLAY/OCHRE matrix; matrix dark yellowish orange 10YR 6/6.
ICZ/4	5.5- 6.0	greenschist BRECCIA with CLAY/OCHRE matrix; matrix dark yellowish orange 10YR 6/6.
ICZ/5	6.0- 7.0	OGHRE, drab yellowish orange 10YR 5/7.
ICZ/6	7.0- 8.5	OGHRE, yellowish orange 10YR 6/7.
ICZ/7	8.5-10.0	OGHRE, grading to ochre matrix BRECCIA? (sparse solid lumps) yellowish orange to yellowish brown 10YR 5/6-6/6-6/7.
ICZ/8	10.0-11.5	OGHRE and BRECCIA as above, some very gritty. At the base the sample is wet and shows a brighter dispersed colour; bright yellowish orange 10YR 6/8.
ICZ/9	11.5-13.0	reworked OGHRE with minor schist clasts (sample lost at first then retrieved with the next one down), dispersed colour a darker yellowish orange 10YR 5/7.
ICZ/10	13.0-15.5	OGHRE with minor schist and OGHRE showing cleated fracture, i.e. derived from a piece of magnesite rock directly; dispersed colour 10YR 5/7 but a little darker than above.

J07/11 15.5-17.0 OCHRE as above; 10YR 5/7 or a little lighter.

J07/12 17.0-19.0 as above.

Hole terminated in sinkhole fill of ochre reworked and contaminated with greenschist detritus, but including blocks originally magnesite boulders.

Auger Hole JC 8

Drilled 14/12/89; Drillers T. Lodge, J. Walker; Stacpoole's, Launceston. Logged by M. Shannon. Total depth 19.0m. Location 346625.42mE, 5400448.44mN; RL 187.05m.

Sample	From- to	Description
	0.0- 1.0	muddy SAND and CLAY? (discarded by drillers).
JC8/1	1.0- 2.5	greenschist BRECCIA and SOIL drab yellowish orange 10YR 5/6.
JC8/2	2.5- 4.0	sandy OCHRE, yellowish orange 10YR 6/7.
JC8/3	4.0- 5.5	OCHRE and greenschist BRECCIA with clay/ochre matrix; matrix moderate yellowish brown 10YR 5/4.
JC8/4	5.5- 6.5	greenschist BRECCIA with clay/ochre matrix, small clasts only; matrix yellowish orange 10YR 7/6.
JC8/5	6.5- 7.0	reworked OCHRE, pinkish orange brown 2YR 6/6.
JC8/6	7.0- 8.5	greenschist BRECCIA with clay dominant clay/ochre matrix; reddish brown 3YR 6/6.
JC8/7	8.5-10.0	clay/ochre matrix BRECCIA grading to OCHRE, small greenschist clasts; moderate yellowish brown 10YR 5/4. At base minor white clay and OCHRE, brighter yellowish brown 10YR 5/7.
JC8/8	10.0-11.5	ochre matrix BRECCIA grading to reworked OCHRE, minor clasts only including some limonite; brighter yellowish brown 10YR 5/7.
JC8/9	11.5-13.0	(water struck) OCHRE with relict bedding after magnesite rock, and "cleat" (a distinctive torn surface feature); bright yellowish orange 10YR 6/8.
JC8/10	13.0-14.5	greenschist BRECCIA with ochre matrix; yellowish orange 10YR 6/7.
JC8/11	14.5-16.0	greenschist BRECCIA with clay/ochre matrix (clay dominant); dark yellowish orange 10YR 6/6 (drab).

JCB/12 16.0-17.5 greenschist BRECCIA with clay/sand matrix;
increasing peat stain towards base; light brown
5YR 6/4 to brownish grey 5YR 3/1.

Hole terminated in organic phase of a complex sinkhole fill which
also contains ochre reworked and contaminated with greenschist
detritus, and a large included block of ochre originally a magnesite
boulder.

Auger hole JG 2.

Drilled 14/2/90 commencing 7.45am by T. Lodge, R. Dean, Stacpoole's Launceston. Logged by H. Shannon. Total depth 27 metres. Location 346651.83mE, 5400429.26mN; RL 191.61m.

Sample	From- to	Description.
JC9/1	0.0- 1.0	fine SAND with angular quartz gravel, clasts 5%; pale yellowish brown 10YR 6/2.
JC9/2	1.0- 2.5	SAND with quartz gravel (spongy quartz mainly) 25%; pale orange 10YR 8/4.
JC9/3	2.5- 4.0	SAND with quartz gravel 50%; dark yellowish brown 10YR 4/2.
JC9/4	4.0- 5.5	as above; pale yellowish brown 10YR 6/2.
JC9/5	5.5- 7.0	fine SAND with quartz gravel; pale orange 10YR 7/2 to 10YR 8/2.
JC9/6	7.0- 8.5	fine SAND; pale yellowish grey 5Y 8/2 to white N 9. At base peaty SAND; dark yellowish brown 10YR 4/2.
JC9/7	8.5-10.0	peaty SAND; brownish black 10YR 2/2.
JC9/8	10.0-11.5	peaty SAND; dusky yellowish brown 10YR 2/2.
JC9/9	11.5-13.0	peaty SAND, sloppy; brownish black 10YR 2/1.
JC9/10	13.0-14.0	as above, poor recovery owing to water
JC9/11	14.0-15.0	as above
JC9/12	15.0-16.0	as above
JC9/13	16.0-17.0	greenschist BRECCIA in clay matrix, clasts to 0.5cm, 30%; matrix olive grey 5Y 5/1, clasts are chlorite schist, greenish grey 5GY 6/1.
JC9/14	17.0-18.0	greenschist BRECCIA in clay matrix (clasts soft, becoming clay); olive grey 5Y 5/1.
JC9/15	18.0-19.0	as above with isolated hard clasts; olive grey 5Y 5/1.
JC9/16	19.0-20.0	chlorite schist BRECCIA with matrix of clay grading to schist pulp; dark greenish blue grey; 10G 4/1?

JC9/17	20.0-21.0	as above, over more polymictic greenschist BRECCIA which includes some weathered greenschist and "ochre" clasts in clay matrix; olive black 5Y 2/1.
JC9/18	21.0-22.0	greenschist BRECCIA in clay matrix; greyish brown 10YR 5/2.
JC9/19	22.0-23.5	greenschist BRECCIA in clay matrix, clasts to 1cm, 50%, some blocks of clay, olive brown 5Y 4/3
JC9/20	23.5-25.0	greenschist BRECCIA including a block of grey greenschist breccia and clay with clasts which grades towards clay/ochre, light olive brown 5Y 5/4 and traces dusky yellow 5Y 6/4
JC9/21	25.0-26.9	no recovery, peat? soft ochre?
JC9/22	26.9-27.0	"decomposed MAGNESITE silt and MAGNESITE chips with peaty clay/ochre; olive grey 5Y 4/1 olive black 5Y 2/1 and yellowish grey 5Y 7/2.

End hole.

Auger hole JC 10.

Drilled 14/2/90 commencing 3.00pm by T. Lodge and R. Dean,
Stacpoole's Launceston. Logged by N. Shannon. Total depth 22 metres.
Location 346639.97mE, 5400432.02mN; RL 190.59m.

Sample	From- to	Description.
JC10/1	0.0- 1.0	SAND; pinkish grey 10YR 8/1.
JC10/2	1.0- 2.5	SAND; yellowish grey 5Y 8/1 to white N 9, sparse quartz granules.
JC10/3.1	2.5- 3.8	SAND; yellowish grey 5Y 7/2.
.2	3.8- 4.0	SAND, variable colours; greyish orange 10YR 7/4, very pale orange 10YR 8/2, yellowish grey 5Y 7/2.
JC10/4	4.0- 5.5	SAND with gravel, clasts 20% and clay binder, pale yellowish brown 10YR 7/2 over SAND yellowish grey 5Y 7/2 and orange 10YR 7/5.
JC10/5.1	5.5- 6.5	SAND; pale yellow 3Y 7/4.
.2	6.5- 7.0	peaty SAND; black N 1 and pale yellowish brown 10YR 6/2 over CLAY; light brown 5YR 6/4.
JC10/6.1	7.0- 8.0	peaty SAND with quartz gravel clasts, angular spongy quartz to 1cm 20%, grading to PEAT.
.2	8.0- 8.5	peaty SAND with clasts 10% as above; brown 7YR 4/2 to black N 1.
JC10/7.1	8.5- 9.0 9.0- 9.5	as above. peaty SAND with greenschist clasts 30%; chlorite schist mainly, some quartz; 10YR 2/2 to 10YR 4/2.
.2	9.5-10.0	peaty SAND with clasts as above over greenschist BRECCIA with clay/pulp matrix; greyish yellow green 5GY 6/2.
JC10/8.1	10.0-11.0	greenschist/quartz BRECCIA with clay matrix; dark greyish brown 10YR 4/2 clasts 40% to 1cm., fresh chlorite schist clasts.
.2	11.0-11.5	as above with minor soft greenschist BRECCIA, small clasts, (all green), clay/pulp matrix; greenish grey 10GY 6/1 and pale brown 10YR 6/3, possibly including blocks.

JC10/9	11.5-13.0	greenschist BRECCIA with clay/pulp matrix; yellowish grey 5Y 7/2 to pale olive 10Y 6/2 over greenschist BRECCIA with peat, swampy smell; grey brown 10YR 5/2 to 10YR 5/3 with smears of peat; very dark brown 10YR 2/2.
JC10/10	13.0-14.0	peaty clay matrix greenschist BRECCIA as above with sloppy peaty CLAY; dark brown 10YR 3/3.
JC10/11	14.0-15.0	greenschist BRECCIA with peaty clay matrix grading to CLAY with greenschist clasts; dark brown 10YR 3/3.
JC10/12	15.0-16.0	muddy coarse SAND, greenschist/quartz with peaty clay binder. (Inferred - sample lost then picked up on following run).
JC10/13	16.0-17.0	peaty clay matrix greenschist BRECCIA, fresh greenschist and quartz clasts; dark brown 10YR 3/2.
JC10/14	17.0-18.0	as above.
JC10/15	18.0-19.0	sample lost - then salvaged on next run - sloppy CLAY/PEAT with clasts 30%; 10YR 3/2.
JC10/16	19.0-20.0	clayey PEAT with few clasts; dark brown grey 5YR 3/1.
JC10/17	20.0 21.0	PEAT with greenschist clasts and magnesite; black N 1 to brownish black 5YR 2/1, clasts 30%.
JC10/18	21.0-22.0	PEAT with magnesite and minor greenschist clasts 15%; brownish black 5YR 2/1, end material bituminous PEAT with sticky grease like texture, "tarry".

Rods broke - hole abandoned. A likely cause is that boulder of magnesite "hooked" the auger and caused the breakage.

Auger hole JC 11.

Drilled 12/2/90 commencing 2.30pm. Driller T. Lodge and R. Dean, Stacpoole's Launceston. Logged by H. Shannon. Total depth 11.5 metres. Location 346674.90mE, 5400416.66mN; RL 193.33m.

Sample	From- to	Description
JC11/1	0.0- 1.0	CLAY with isolated clasts mostly quartz; light brownish grey 5YR 6/1.
JC11/2	1.0- 2.5	laminated CLAY with quartz and greenschist clasts and CLAY with traces of peat stain; greyish orange 10YR 7/4, pale brown 7YR 5/2.
JC11/3	2.5- 4.0	peaty CLAY with clasts of chlorite schist to 0.5cm, 30%; brownish grey 5YR 4/1.
JC11/4	4.0- 5.5	peaty CLAY, somewhat sandy with few larger clasts; greyish brown 10YR 5/2, over peaty SAND, wet, dusky brown 7YR 2/2.
JC11/5	5.5- 7.0	sandy CLAY grading to sandy peaty CLAY; light brown 8YR 6/4 to brown 8YR 4/2; over CLAY/PULP with greenschist clasts, greyish yellow green 8GY 5/2.
JC11/6	7.0- 8.5	peaty CLAY with greenschist clasts; greyish brown 10YR 5/2 over GREENSCHIST (chips of chlorite schist in pulp); greyish green 10GY 6/2; possibly greenschist breccia.
JC11/7	8.5-10.0	as above but with more variable clasts, mostly actinolite schist but some quartz and white clay - soft drilling - more likely to be a greenschist breccia with pulp matrix, but could be just softened actinolite schist ground up; greyish green 5G 6/2 to 10GY 5/2.
JC11/8	10.0-11.5	greenschist BRECCIA in pulp matrix; dusky yellow green 5GY 5/2.

End hole.

Auger hole JC 12.

Drilled 22/2/90 commencing 11.00am. Driller T. Lodge and R. Dean, Stacpoole's Launceston. Logged by H. Shannon. Total depth 14.5 metres. Location 346669.97mE, 5400423.83mN; RL 193.77m.

Sample	From- to	Description
JC12/1	0.0- 1.0	CLAY with "mica" and "micaceous" (altered chlorite?) clasts; pale brown 5YR 6/2.
JC12/2	1.0- 2.5	CLAY as above over white SAND; N 9, with quartz clasts to 0.5cm.
JC12/3	2.5- 4.0	CLAY with quartz clasts; pale yellowish brown 10YR 6/2 and minor dark yellowish brown 10YR 4/2.
JC12/4	4.0- 5.5	peaty (bituminous?) CLAY with clasts; dusky yellowish brown 10YR 4/2, and minor CLAY with clasts, pale yellowish brown 10YR 6/2.
JC12/5	5.5- 7.0	peaty/bituminous, silty CLAY with quartz clasts; dark brown 7YR 3/2.
JC12/6	7.0- 8.5	quartz/greenschist BRECCIA; clasts 30%, in peaty bituminous clay matrix; dark brown 7YR 3/2 to pale yellowish brown 10YR 6/2.
JC12/7	8.5-10.0	CLAY with isolated quartz clasts to 0.5cm, 15%; greyish brown to 7YR 4/2. Trace of bituminous odour only.
JC12/8	10.0-11.5	bituminous PEAT with sand? 20%, and quartz clasts 5%; brownish black 5YR 2/1.
JC12/9	11.5-13.0	sandy bituminous PEAT, strong bitumen smell; black N 1.
JC12/10	13.0-14.5	as above.

Hole very tight giving problems drilling - hole abandoned.

Auger hole IA 1.

Drilled 25/1/90 commencing 8.50am by T. Lodge, Stacpoole's Launceston. Logged by M. Whitty and H. Shannon (7.0-19.0). Total depth 23.5 metres. Location 346595.30mE, 5400423.17mN; RL 172.82m.

Sample	From- to	Description.
JA1/1	0.0- 1.0	CLAY/OCHRE, with sparse clasts of quartz; yellowish brown 1Y 5/4.
JA1/2	1.0- 2.5	clay matrix BRECCIA, friable, clasts to 1cm, 20% clasts; olive brown 2Y 5/4.
JA1/3	2.5- 4.0	clay matrix BRECCIA as above, less friable, clasts more frequent and smaller; olive brown 2Y 5/4.
JA1/4	4.0- 5.5	CLAY/OCHRE with angular clasts of mudstone-like weathered greenschist evenly distributed; reddish brown 5YR 5/4.
JA1/5	5.5- 7.0	CLAY/OCHRE as above with clasts 10%; yellowish brown 10YR 5/6.
JA1/6	7.0- 8.5	reworked OCHRE with small clasts (to 2mm) approx 5%; strong brown 8YR 5/4.
JA1/7	8.5-10.0	reworked OCHRE as above; strong brown 8YR 5/6.
JA1/8	10.0-11.5	reworked ochre as above; orange 4YR 5/6.
JA1/9	11.5-13.0	greenschist BRECCIA with ochre matrix, clasts (to 0.5cm), 30%; moderate reddish brown 10YR 4/6 dispersing to orange 5YR 5/8. At base change to yellowish brown 10YR 5/6.
JA1/10	13.0-14.5	reworked OCHRE with greenschist clasts (to 0.5cm), 10%; strong orange 8YR 5/8, same dispersed colour.
JA1/11	14.5-16.0	reworked OCHRE with greenschist clasts (to 0.5cm), 15%; light brown 5YR 5/6 dispersing to 7YR 5/8.
JA1/12	16.0-17.5	reworked OCHRE as above, clasts 5%; orange brown 8YR 5/6 dispersing to 8YR 5/8 then 9YR 6/8 (strong yellowish orange).

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JA1/13	17.5-19.0	reworked OCHRE with greenschist clasts (to .5cm), 10%; dark yellowish orange 10YR 6/7 dispersing to 10YR 6/8.
JA1/14	19.0-20.5	reworked OCHRE free of clasts, greenschist appearance. Light olive brown 5Y 5/6.
JA1/15	20.5-22.0	GREENSCHIST, moderate olive brown 5Y 4/4.
JA1/16	22.0-23.5	GREENSCHIST as above.

End Hole.

Auger hole JA 2.

Drilled 25/1/90 commencing 3pm by T. Lodge, Stacpoole's Launceston.
 Logged by H. Shannon/M. Whitty. Total depth 22 metres. Location
 346578.96mE, 5400436.80mN; RL 171.60m.

Sample	From- to	Description.
JA2/1	0.0- 1.0	reworked OCHRE grading to greenschist breccia; moderate reddish brown 2YR 5/6. The clasts are of angular quartz with weathered greenschist 30%.
JA2/2	1.0- 2.5	reworked OCHRE with small weathered greenschist clasts 10%, moist; moderate reddish brown 2YR 4/4.
JA2/3	2.5- 4.0	as above 2YR 4/4.
JA2/4	4.0- 5.5	reworked OCHRE, 5% clasts, more moist, now brighter red 10R 3/6 (dark red).
JA2/5	5.5- 7.0	as above, 10% clasts; 2YR 5/6 (brownish red).
JA2/6	7.0- 8.5	below water table, sloppy OCHRE with 10% clasts to 0.5cm, strong light brown 5YR 5/7.
JA2/7	8.5-10.0	as above.
JA2/8	10.0-11.5	reworked OCHRE, clasts 5% of the usual rock types; moderate reddish brown? 10R 4/6.
JA2/9	11.5-13.0	reworked OCHRE, becoming drier and showing bands of yellow and red; overall reddish brown 2YR 4/4 dispersing to 5YR 4/6.
JA2/10	13.0-14.5	reworked OCHRE grading to clay/ochre matrix greenschist BRECCIA; clasts to 0.5cm, 20%; mostly weathered greenschist with minor fresh greenschist. There are 2 colour phases in bands; dominantly yellowish orange 8YR 6/6 and also reddish brown 3YR 5/6. The phases follow bedding but are a mottling.
JA2/11	14.5-16.0	reworked OCHRE as above, yellow and red phases. At base reworked ochre, clasts 5%; dull orange 8YR 6/6, traces of bedding.
JA2/12	16.0-17.5	reworked OCHRE with clasts 5%; light brown 5YR 5/6.

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JA2/13	17.5-19.0	CLAY/OCHRE, bedding visible; light brown 5YR 5/6.
JA2/14	19.0-20.5	reworked OCHRE; moderate reddish orange 4YR 5/6.
JA2/15	20.5-21.9 21.9-22.0	CLAY/OCHRE; light brown 5YR 6/6. CLAY with blurred stratification and small clast breccia beds; (clasts 0.1-0.5cm of weathered schist); pale brown 5YR 6/3.

End Hole.

Auger hole JA 3.

Drilled 26/1/90 commencing 9.50am by T. Lodge, Stacpoole's Launceston. Logged by H. Shannon. Total depth 28 metres. Location 346578.96mE, 5400436.80mN; RL 171.60m.

Sample	From- to	Description.
JA3/1	0.0- 1.0	greenschist BRECCIA with clay matrix, schist clasts to 1cm, 40%, matrix; dull yellowish orange 8YR 6/6.
JA3/2	1.0- 2.5	greenschist BRECCIA with clay/ochre matrix grading to reworked OCHRE with clasts as above, 20%; brownish red 4YR 5/6.
JA3/3.1	2.5- 3.3	reworked OCHRE, clasts 10% (up to 1cm); light brown 5YR 5/6.
.2	3.3- 4.0	reworked OCHRE with clasts of greenschist and quartz to 2cm, 10%; orange brown 8YR 5/6.
JA3/4	4.0- 5.5	reworked OCHRE with few clasts; light brown 6YR 5/6. At base, change to yellowish brown 9YR 5/7.
JA3/5.1	5.5- 6.2	reworked OCHRE as above, clasts 5%; light brown 8YR 5/6.
.2	6.2- 7.0	as above; yellowish brown 9YR 5/6 dispersing to 10YR 6/6, dark yellowish orange.
JA3/6	7.0- 8.5	reworked OCHRE with small greenschist clasts 5% and some larger greenschist clasts (discoidal shape; poorly rounded); light brown 7YR 5/5.
JA3/7.1	8.5- 9.2	reworked OCHRE with small clasts 10%, disperses to brownish orange 8 YR 6/7
.2	9.2-10.0	reworked OCHRE with clasts, disperses to strong light brown 5YR 5/8.
JA3/8.1	10.0-10.3	greenschist BRRECCIA with clay/ochre matrix, alternating bands and blotches red 2YR 4/6 and yellowish orange 10YR 7/6; clasts 40%.
	10.3-11.0	reworked OCHRE with quartz and greenschist clasts, orange 7YR 6/6.
.2	11.0-11.5	reworked OCHRE, clasts 10%; mottled brown 7YR 5/6 and orange 8YR 7/7, disperses to 8YR 5/7.

JA3/9	11.5-12.5	at top, greenschist BRECCIA, c.f. 10.0-10.3 interval, then reworked OCHRE with clasts 10%, fairly large (up to 2cm); dark reddish brown 5YR 4/6 dispersing to 5YR 5/7.
JA3/10	12.5-13.5	reworked OCHRE with sparse larger clasts (to 2cm) 5%; reddish brown 5YR 4/5.
JA3/11	13.5-14.5	reworked OCHRE and clasts as above, mass colour reddish brown 5YR 4/4 dispersing to brownish orange 5YR 5/7.
JA3/12	14.5-15.5	reworked OCHRE with small clasts, strong brown 5YR 4/6.
JA3/13	15.5-16.5	as above, strong brown 5YR 4/6 dispersing to 5YR 5/7.
JA3/14	16.5-17.5	as above 6YR 5/6 dispersing to 7YR 5/8.
JA3/15	17.5-18.5	as above (some sample loss) small talc clasts apparent.
JA3/16	18.5-19.5	as above.
JA3/17	19.5-20.0 20.0-20.5	as above. banded CLAY/OCHRE, mostly red 5R 3/7 and yellowish orange 10YR 6/7 with moderate yellowish brown 10YR 5/4 and greyish orange 10YR 7/4, all soft but some clasts apparent (but possibly a relict bedrock texture) disperses to moderate reddish brown 10R 4/6.
JA3/18	20.5-21.5	reworked OCHRE with 25% small clasts including quartz greenschist and talc; light brown 7YR 5/6 dispersing to 7YR 6/7.
JA3/19	21.5-22.5	as above.
JA3/20	22.5-23.5	reworked OCHRE with clasts to 0.7cm, 10%; moderate red 5R 4/6 to moderate reddish brown 10R 4/6 dispersing to 3YR 4/6 brownish red.
JA3/21	23.5-24.5	poor sample, some contamination.
JA3/22	24.5-25.5	as above.
JA3/23	25.5-26.5	reworked OCHRE with greenschist clasts to 1cm, 10%; colour as above.

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JA3/24	26.5-27.5	reworked OCHRE as above.
	27.5-27.8	reworked OCHRE; moderate red BR 5/4.
	27.8-28.0	CLAY/OCHRE; moderate yellowish brown 10YR 5/4 grading to greenschist BRECCIA with clay matrix; pale yellow brown 8YR 7/2.

Note: all the reworked ochres are a bit clayey.

End Hole.

Auger hole JA 4.

Drilled 31/1/90 commencing 9.10am. Drillers T. Lodge and R. Dean, Stacpoole's Launceston. Logged by H. Shannon. Total depth 16 metres. Location 346563.10mE, 5400492.25mN; RL 169.54m.

Sample	From- to	Description
JA4/1	0.0- 1.0	CLAY/OCHRE with clasts to 0.5cm, 15%; yellowish brown 10YR 5/6.
JA4/2	1.0- 2.5	reworked OCHRE, clasts 5% small only; strong orange yellow 10YR 6/10.
JA4/3	2.5- 4.0	reworked OCHRE, clasts to 1cm, 20%; strong orange yellow 10YR 6/10.
JA4/4	4.0- 5.5	as above.
JA4/5	5.5- 7.0	as above.
JA4/6	7.0- 8.5	reworked OCHRE, clasts 5%; strong (orange) yellow 1Y 6/10.
JA4/7	8.5-10.0	OCHRE, with relict ex-magnesite texture; strong (orange) yellow 1Y 6/10.
JA4/8	10.0-11.5	OCHRE as above.
JA4/9	11.5-13.0	OCHRE, relict ex-magnesite texture, mass colour light orange brown 10YR 6/4 dispersing to 10YR 6/6, dark yellow orange.
JA4/10	13.0-14.5	reworked OCHRE, clasts 10% to 1cm; strong orange brown 10YR 5/10.
JA4/11	14.5-16.0	OCHRE, with relict texture from magnesite, striped mass colours orange yellow 10YR 6/8, dull dark yellow brown 10YR 4/4 dispersing to strong orange brown 10YR 5/10, and decomposed MAGNESITE as silt; pale orange 10YR 7/4.

Hole very tight - abandoned for fear of breakage to the rig.

Auger hole JA 5.

Drilled 31/1/90 commencing 1.15pm. Drillers T. Lodge and R. Dean, Stacpoole's Launceston. Logged by H. Shannon and M. Whitty (23.5-31.0m). Total depth 31.0 metres. Location 346559.55mE, 5400481.21mN; RL 168.96m.

Sample	From- to	Description
JA5/1	0.0- 1.0	CLAY/OCHRE with greenschist clasts to 0.5cm, 20%; dark yellowish orange 10YR 6/6.
JA5/2	1.0- 2.5	CLAY/OCHRE with greenschist clasts to 0.7cm, 20%; 7.5YR 5/6 orange brown.
JA5/3	2.5- 4.0	as above; light brown 5YR 5/6.
JA5/4	4.0- 5.5	well bedded CLAY/OCHRE, dispersed colour light brown 5YR 5/6, mass colour variable, beds show prominent colour change, dark red, orange brown, orange yellow, light brown; clasts 5%.
JA5/5	5.5- 7.0	as above.
JA5/6	7.0- 8.5	as above.
JA5/7	8.5-10.0	well bedded CLAY/OCHRE, clasts 5%; colours variable mainly 10R 5/6 red, disperses to red 2.5YR 5/6.
JA5/8.1	10.0-10.8	reworked OCHRE, with few clasts (2%); light orange 7.5YR 6/6.
.2	10.8-11.5	reworked OCHRE as above; dark yellowish brown 10YR 4/3.
JA5/9	11.5-13.0	OCHRE, with relict ex-magnesite texture; dark yellowish brown 10YR 4/3 with patches of orange yellow, 10YR 6/8, minor black N 1 stripes common, disperses to strong dark yellow brown 10YR 4/6.
JA5/10	13.0-14.5	as above.
JA5/11	14.5-16.0	OCHRE, with relict ex-magnesite texture, orange yellow 10YR 6/10 and dark yellowish brown 10YR 4/3 dispersing to yellowish brown 10YR 5/6.

JA5/12	16.0-17.5	OCHRE as above; (orange) yellow 10YR 6/8 with dark yellowish brown 10YR 4/3, dispersing to yellowish brown 10YR 5/6.
JA5/13	17.5-19.0	OCHRE as above, (more of the dark phase), dispersing to 10YR 4/6.
JA5/14	19.0-20.5	OCHRE as above; yellowish brown 10YR 5/4 and dark brown 10YR 3/3, dispersing to 10YR 4/6.
JA5/15	20.5-22.0	OCHRE as above, some contamination.
JA5/16	22.0-23.5	OCHRE; yellowish brown 10YR 5/4, yellowish orange 10YR 6/8 and some black, dispersing to 9YR 5/6.
JA5/17	23.5-25.0	OCHRE with relict ex-magnesite texture dispersing to strong brown 7.5YR 4/6.
JA5/18.1	25.0-25.8	as above.
	.2 25.8-26.5	OCHRE, relict ex-magnesite texture; mass colours moderate brown 7.5YR 5/4 and 10YR 6/7, dispersing to 7.5YR 4/6 strong brown.
JA5/19	26.5-28.0	reworked OCHRE, uniform, doubtful clasts trace only; strong brown 7.5YR 4/8.
JA5/20	28.0-29.5	as above.
JA5/21	29.5-31.0	talc schist BRECCIA in clay/pulp matrix, very pale orange 10YR 8/2.

Down to final auger, no more ochre?, hole ended.

Auger hole JA 6.

Drilled 5/2/90 commencing 9.00am. Drillers T. Lodge and R. Dean, Stacpoole's Launceston. Logged by H. Shannon. Total depth 17.5 metres. Location 346560.42mE, 5400449.35mN; RL 168.75m.

Sample	From- to	Description
JA6/1	0.0- 1.0	CLAY/OCHRE grading to clay/ochre matrix BRECCIA at base; strong yellow orange 10YR 6/8.
JA6/2	1.0- 2.5	reworked OCHRE with small clasts to 0.7cm, 10%; reddish brown 2.5YR 4/4.
JA6/3	2.5- 4.0	reworked OCHRE with clasts as above plus one 4cm discoidal clast of haematite; moderate reddish brown 2.5YR 4/4 dispersing to 2.5YR 4/6, moderate reddish brown clasts greenschist and quartz.
JA6/4	4.0- 5.5	reworked OCHRE, clasts to 1.5cm, 5%; reddish brown 2.5YR 5/4, over reworked OCHRE with bedding and decomposed greenschist clasts to 1cm; moderate reddish brown 10R 5/6 dispersing to 2.5YR 5/6.
JA6/5	5.5- 7.0	reworked OCHRE with small clasts 5%; reddish brown 3YR 5/6. At base, yellowish orange 7.5YR 6/6.
JA6/6	7.0- 8.5	reworked OCHRE, small clasts <5%, some bedding; yellowish brown 10YR 5/4 to yellowish orange 10YR 6/6.
JA6/7	8.5-10.0	reworked OCHRE, small greenschist clasts <5%, rough bedding colour changes; reddish brown 2.5YR 5/4 to 5YR 4/6.
JA6/8	10.0-11.5	reworked OCHRE, small greenschist clasts <5% uniform, moderate reddish brown 10R 4/6.
JA6/9	11.5-13.0	reworked OCHRE, greenschist clasts to 1cm, 5%; pale reddish brown 2.5YR 5/4.
JA6/10	13.0-14.5	CLAY/OCHRE with small greenschist clasts 10% and isolated larger clasts including a fragment of a well rounded quartz cobble 2cm across; light brown 5YR 5/4.

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JA6/11 14.5-16.0 CLAY/OCHRE as above, some bedding colour change; brown 6YR 5/4, 5YR 5/4 and minor dark yellowish orange 10YR 6/6.

JA6/12 16.0-17.5 CLAY/OCHRE with clasts grading to greenschist BRECCIA, clasts to 1cm up to 20%; light brown 5YR 5/4, near base pyrolusite?, bands (black) along bedding, colour change, dark brown 5YR 4/3.

Hole ended.

Auger hole JA 2.

Drilled 5/2/90 commencing 2.30pm. Drillers T. Lodge and R. Dean, Stacpoole's Launceston. Logged by H. Shannon and M. Whitty (5.5-16.0). Total depth 16.0 metres. Location 346564.80mE, 5400449.35mN; RL 172.37m.

Sample	From- to	Description
JA7/1	0.0- 1.0	reworked OCHRE, mottled, clasts 20%; yellow orange 10YR 6/6 over reddish brown 2YR 4/4.
JA7/2	1.0- 2.5	reworked OCHRE, clasts 15%; brownish red 2.5YR 5/6.
JA7/3.1	2.5- 3.2	reworked OCHRE as above; brownish red 2.5YR 5/6.
.2	3.2- 4.0	greenschist BRECCIA with clay/ochre matrix; yellowish brown 7.5YR4/4.
JA7/4.1	4.0- 4.8	reworked OCHRE ochre, with small clasts 10%, greenschist, minor quartz; reddish brown 2.5YR 4/4.
.2	4.8- 5.5	greenschist BRECCIA with clay matrix; yellowish brown 7.5YR 4/4.
JA7/5	5.5- 7.0	greenschist BRECCIA with clay matrix 40% clasts; 5YR 4/6 moderate brown.
JA7/6	7.0- 8.5	greenschist BRECCIA clay/ochre matrix, waterlogged; moderate brown 5YR 4/6, bottoming to harder drier greenschist.
JA7/7	8.5-10.0	OCHRE; light brown 7.5YR 6/8, very little sample retained due to water.
JA7/8	10.0-11.5	reworked OCHRE, clasts 5%; dark brown 7.5YR 4/6.
JA7/9	11.5-13.0	as above bottoming to a tight dry GREENSCHIST.
JA7/10	13.0-14.5	good clean clast free OCHRE; moderate red 5R 4/6.
JA7/11	14.5-16.0	greenschist BRECCIA.

Hole abandoned.

Auger hole HA 6.

Drilled 6/2/90 commencing 9.20am. Driller T. Lodge and R. Dean, Stacpoole's Launceston. Logged by M. Whitty. Total depth 8.5 metres. Location 346537.65mE, 5400354.35mN; RL 170.98m.

Sample	From- to	Description
HA6/1	0.0- 1.0	CLAY; dark yellow brown 10YR 5/8.
HA6/2	1.0- 2.5	reworked CLAY/OCHRE, clasts 15%; brown yellow 10YR 6/8.
HA6/3	2.5- 4.0	OCHRE; dark red 2.5YR 3/6 grading to a plain red 2.5YR 4/8 interbedded with yellow CLAY/OCHRE; 10YR 7/8.
HA6/4	4.0- 5.5	reworked CLAY OCHRE; weak red 10R 4/6, clasts <10%, wet.
HA6/5	5.5- 7.0	more friable CLAY/OCHRE; reddish yellow 7.5YR 6/8, clasts <20%.
HA6/6	7.0- 8.5	CLAY/OCHRE, no clasts; reddish yellow 5YR 6/8 very sticky and great difficulty extracting augers from hole. Hole is collapsing and having to redrill back through. No good quality ochre to this point.

Hole abandoned.

Auger hole HA Z.

Drilled 6/2/90 and 7/2/90 commencing 11.30am and 8.25am. Drillers T. Lodge and R. Dean, Stacpoole's Launceston. Logged by H. Shannon and M. Whitty (0-2.5m, 25-28m). Total depth 31.0 metres. Location 346544.24mE, 5400353.45mN; RL 172.26m.

Sample	From- to	Description
HA7/1	0.0- 1.0	CLAY/OCHRE, laminated with greenschist breccia; yellow 10YR 7/8.
HA7/2	1.0- 2.5	as above.
HA7/3	2.5- 4.0	CLAY/OCHRE with weathered greenschist clasts; mottled brownish orange 2.5YR 5/6 to 5YR 6/6.
	4.0- 4.2	as above, not sampled.
HA7/4	4.2- 5.5	reworked clayey OCHRE with a few small clasts 2%; yellowish orange 10YR 6/6 to 10YR 6/8.
HA7/5.1	5.5- 6.0	reworked clayey ochre as above; moderate yellowish brown 7YR 5/4.
.2	6.0- 7.0	reworked clayey OCHRE with clasts 15%; moderate red 7R 4/6.
HA7/6	7.0- 8.5	reworked OCHRE with small clasts, clayey (does not pigment well) clasts 5%; light brown 2.5YR 5/4 at base grades to greenschist BRECCIA with clasts to 2cm.
HA7/7.1	8.5- 9.8	reworked sandy CLAY/OCHRE; clasts 10% 10R 4/4 - 3YR 4/4 reddish brown.
.2	9.8-10.0	multicoloured weathered GREENSCHIST smeared with ochre; 8YR 6/6 yellowish orange.
HA7/8	10.0-11.5	multicoloured weathered GREENSCHIST as above with a few traces of OCHRE; pale purplish grey 5P 6/1, pale red purple 5RP 6/1, greyish red purple 5RP 4/2, moderate red 5R 4/6. The ochre phases are dark yellowish orange 10YR 6/6, dark brown 8YR 3/4.

- HA7/9.1 11.5-12.0 multicoloured GREENSCHIST as above over reworked CLAY/OCHRE with clasts; mainly small ones with isolated large weathered greenschist clasts; brown 7.5YR 5/4.
- .2 12.0-13.0 sandy CLAY/OCHRE with abundant small talc schist/quartz clasts; yellowish orange 8YR 6/6.
- HA7/10.1 13.0-14.0 compact CLAY/OCHRE with small clasts; talc schist, quartz 10% and some weathered greenschist clasts; yellowish orange 10YR 6/6, 10YR 7/6, sedimentary bedding.
- .2 14.0-14.5 CLAY/OCHRE as above over CLAY/OCHRE; brownish orange 5YR 6/6 more uniform, 20% small clasts.
- HA7/11 14.5-16.0 crumbly well bedded CLAY/OCHRE with sparse small clasts; red 3YR 5/6 but including a large boulder of weathered greenschist and some greenschist breccia (sample in 2 bags).
- HA7/12 16.0-17.5 reworked OCHRE and sandy OCHRE with small clasts 25%; light brownish red 10R 5/6, grades to moderate orange pink 10R 7/4.
- HA7/13.1 17.5-18.0 greenschist BRECCIA with clay matrix, large boulder clasts of weathered greenschist, matrix clay includes 30% clasts; quartz, greenschist, talc and minor yellow ochre.
- .2 18.0-19.0 reworked OCHRE, abundant small clasts 30%, talc schist, talc, quartz; yellowish orange 8YR 6/8 to 10YR 6/8.
- HA7/14.1 19.0-20.0 reworked OCHRE with few clasts, strong yellowish orange 9YR 5/10.
- .2 20.0-21.0 reworked OCHRE as above, rare clasts to 10cm of (clay matrix) greenschist breccia.
- HA7/15 21.0-22.0 at top, reworked OCHRE; yellowish brown 9YR 5/8, 0.2cm over greenschist BRECCIA with clay/ochre matrix grading to clay matrix; orange brown 8YR 6/6 to yellowish brown 10YR 6/4.
- HA7/16 22.0-23.0 CLAY grading to greenschist BRECCIA, small clasts 30%; yellowish brown 10YR 5/4 contamination includes yellow and purple ochres.

- HA7/9.1 11.5-12.0 multicoloured GREENSCHIST as above over reworked CLAY/OCHRE with clasts; mainly small ones with isolated large weathered greenschist clasts; brown 7.5YR 5/4.
- .2 12.0-13.0 sandy CLAY/OCHRE with abundant small talc schist/quartz clasts; yellowish orange 8YR 6/6.
- HA7/10.1 13.0-14.0 compact CLAY/OCHRE with small clasts; talc schist, quartz 10% and some weathered greenschist clasts; yellowish orange 10YR 6/6, 10YR 7/6, sedimentary bedding.
- .2 14.0-14.5 CLAY/OCHRE as above over CLAY/OCHRE; brownish orange 5YR 6/6 more uniform, 20% small clasts.
- HA7/11 14.5-16.0 crumbly well bedded CLAY/OCHRE with sparse small clasts; red 3YR 5/6 but including a large boulder of weathered greenschist and some greenschist breccia (sample in 2 bags).
- HA7/12 16.0-17.5 reworked OCHRE and sandy OCHRE with small clasts 25%; light brownish red 10R 5/6, grades to moderate orange pink 10R 7/4.
- HA7/13.1 17.5-18.0 greenschist BRECCIA with clay matrix, large boulder clasts of weathered greenschist, matrix clay includes 30% clasts; quartz, greenschist, talc and minor yellow ochre.
- .2 18.0-19.0 reworked OCHRE, abundant small clasts 30%, talc schist, talc, quartz; yellowish orange 8YR 6/8 to 10YR 6/8.
- HA7/14.1 19.0-20.0 reworked OCHRE with few clasts, strong yellowish orange 9YR 5/10.
- .2 20.0-21.0 reworked OCHRE as above, rare clasts to 10cm of (clay matrix) greenschist breccia.
- HA7/15 21.0-22.0 at top, reworked OCHRE; yellowish brown 9YR 5/8, 0.2cm over greenschist BRECCIA with clay/ochre matrix grading to clay matrix; orange brown 8YR 6/6 to yellowish brown 10YR 6/4.
- HA7/16 22.0-23.0 CLAY grading to greenschist BRECCIA, small clasts 30%; yellowish brown 10YR 5/4 contamination includes yellow and purple ochres.

HA7/17	23.0-24.0	reworked OCHRE, few clasts, <5% all <2cm; dull red 10R 4/5.
HA7/18	24.0-25.0	as above 10R 4/6 dull red disperses to 2YR 4/6 reddish brown.
HA7/19	25.0-26.0	reworked OCHRE, <20% clasts; red 10R 4/6 with minor traces of reddish yellow 7.5YR 6/8, very wet.
HA7/20	26.0-27.0	reworked OCHRE as above.
HA7/21	27.0-28.0	reworked OCHRE as above becoming more solid and grading to yellowish red 5YR 5/6.
HA7/22	28.0-29.0	reworked OCHRE, few clasts; yellowish orange 7YR 6/6.
HA7/23	29.0-30.0	reworked OCHRE as above; yellowish orange 7YR 6/6 dispersing to 7YR 6/8.
HA7/24	30.0-31.0	as above.

These ochres appear to be clay rich and dull relative to the best material.

Hole ended.

Auger hole HA 8.

Drilled 7/2/90 commencing 11.00am. Drillers T. Lodge and R. Dean, Stacpoole's Launceston. Logged by H. Shannon and M. Whitty (20.5-28m). Total depth 28.0 metres. Location 346553.13mE, 5400351.65mN; RL 173.99m.

Sample	From- to	Description
	0.0- 0.4	gravelly SOIL, not sampled.
HAB/1	0.4- 1.0	reworked clayey OCHRE, few clasts; yellowish orange 10YR 6/6 dispersing to 2Y 6/6.
HAB/2.1	1.0- 2.0	CLAY with (pseudo?) weathered greenschist texture; yellowish orange 10YR 6/6.
.2	2.0- 2.5	CLAY grading to CLAY/OCHRE; yellow 10YR 6/6 and dark red 6R 4/8.
HAB/3.1	2.5- 3.2	CLAY/OCHRE with decomposed greenschist clasts; red-purple 2R 4/8.
.2	3.2- 4.0	CLAY/OCHRE as above; red-purple 4R 4/6.
HAB/4	4.0- 5.5	CLAY/OCHRE, as above; moderate red 5R 4/6.
HAB/5.1	5.5- 6.1	CLAY/OCHRE as above; reddish brown 8R 4/6.
.2	6.1- 6.6	sloppy reworked OCHRE; 9YR 6/8, yellowish orange dispersing to 10YR 6/10; dries to 10YR 7/8.
.3	6.6- 7.0	large clasts of (pseudo?) weathered GREENSCHIST or laminated clay with subordinate OCHRE as above; pale yellowish orange 10YR 8/6.
	7.0- 7.1	purple, not sampled, 4R 4/6.
HAB/6.1	7.1- 8.0	reworked clayey OCHRE, small clasts 20%, isolated larger clasts; yellowish orange 10YR 6/6.
.2	8.0- 8.5	reworked OCHRE, clasts 20%; yellowish orange 9YR 6/8. At the base is a large (0.1m) clast of softened weathered greenschist.

HAB/7.1	8.5- 9.3	reworked sloppy OCHRE, clasts 20%, including spongy quartz; disperses to 8YR 5/8, brownish orange yellow.
.2	9.3-10.0	CLAY/OCHRE with large blocks of bedded clay/ochre with gritty clay ochre matrix; yellowish orange 9YR 6/8.
	10.0-10.2	as above, not sampled.
HAB/8	10.2-11.5	reworked OCHRE with small clasts, 5% (quartz mainly), also isolated blocks of softened greenschist, bedded clay/ochre and ochre with relict magnesite texture; disperses to 10YR 6/8, some sample loss.
HAB/9	11.5-13.0	as above, 9YR 6/8.
HAB/10	13.0-14.5	as above.
HAB/11	14.5-15.0	clayey reworked OCHRE, clasts 10%; disperses 9YR 6/8, yellowish orange.
HAB/12	15.0-16.0	reworked OCHRE, clasts 5%; disperses 9YR 6/10, yellowish orange.
HAB/13.1	16.0-16.8	bedded CLAY grading to CLAY/OCHRE, contaminated with ochre 10YR 6/6 to 7YR 6/6.
.2	16.8-17.5	as above; red to light brown 8R 4/6 to 5YR 5/6, minor clasts.
HAB/14	17.5-18.5	reworked OCHRE; brown 8YR 5/6 with minor clasts.
HAB/15	18.5-19.5	reworked CLAY/OCHRE; light brown 5YR 5/6 rudimentary bedding, small clasts <5%.
HAB/16	19.5-20.5	bedded CLAY/OCHRE as above grading to small clast greenschist BRECCIA which also includes large soft greenschist clasts; red 3R 4/6.
HAB/17	20.5-21.5	reworked OCHRE, smooth and creamlike; red 10R 5/6, <10% clasts but contaminated with yellowish orange 9YR 6/8 from side of hole, wet and sticky.
HAB/18	21.5-22.5	as above.
HAB/19	22.5-23.5	as above.

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HAS/20	23.5-24.5	as above but now with noticeable air vesicles throughout, clasts <5%.
HAS/21	24.5-25.5	as above, auger has picked up a clast of solid limonite rock diameter 1.5cm.
HAS/22	25.5-26.5	as above but grading to a deeper red 10R 4/6.
HAS/23	26.5-28.0	good consistent clean OCHRE, deep red 10R 4/6. Extracting augers becoming extremely difficult. No sign of hitting bottom as in last hole.

Hole ended.

Auger hole HC 5.

Drilled 13/2/90 commencing 7.45am by T. Lodge and R. Dean, Stacpoole's Launceston. Logged by H. Shannon. Total depth 22.0 metres. Location 346531.51mE, 5400240.57mN; 163.74m.

Sample	From- to	Description.
HC5/1	0.0- 1.0	sandy CLAY derived from actinolite schist? with schist clasts? some bedding visible; dusky yellow green 5GY 5/2 with minor yellowish orange 10YR 6/6.
HC5/2	1.0- 2.5	greenschist BRECCIA with clay matrix, clasts 50%, mainly softened actinolite schist; greyish green 10GY 4/2, some larger clasts of soft weathered greenschist; pinkish grey 5YR 8/1, matrix olive brown 2Y 5/4.
HC5/3	2.5- 4.0	greenschist BRECCIA with clay matrix as above and laminated CLAY; olive yellow 2Y 6/4 to 2Y 6/6.
HC5/4	4.0- 5.5	greenschist BRECCIA with clay/ochre matrix, clasts 40%; olive yellow 2Y 6/7.
HC5/5	5.5- 7.0	greenschist BRECCIA as above over greenschist BRECCIA with clay/ochre matrix, hard greenschist clasts to 2cm 40%; light brown 7YR 5/6.
HC5/6	7.0- 8.0	reworked OCHRE with clasts 10%, wet, sample loss; light brown 8YR 5/6.
HC5/7	8.0- 9.0	reworked OCHRE with clasts 10%; light brown 8YR 5/6, and minor greenschist BRECCIA with clay/ochre matrix, clasts 60%
HC5/8	9.0-10.0	greenschist BRECCIA with clay/ochre matrix, clasts to 2cm, 40%; light brown 7YR 5/6.
HC5/9	10.0-11.0	reworked OCHRE, clasts to 1cm, 15%; light brown 8YR 5/6.
HC5/10	11.0-12.0	CLAY with small clasts of greenschist 15%; dull yellow 2Y 7/6.
HC5/11	12.0-13.0	CLAY as above grading to greenschist BRECCIA, clasts to 2cm, 25%; dull orange yellow 1Y 7/6.

HC5/12	13.0-14.0	reworked OCHRE with few clasts; brownish orange 9YR 6/6
HC5/13	14.0-15.0	as above; 9YR 6/6 dispersing to yellowish orange 9YR 6/8.
HC5/14	15.0-16.0	reworked OCHRE with clasts of greenschist and quartz to 0.5cm, 15%; strong brownish orange 9YR 6/7 dispersing to 9YR 6/9.
HC5/15	16.0-17.0	reworked OCHRE with some stratified reworked OCHRE, clasts as above; yellowish orange 9YR 6/8 dispersing to 9YR 6/10.
HC5/16	17.0-18.0	reworked OCHRE as above; yellowish orange 9-10YR 6/8 dispersing to 10YR 6/10.
HC5/17	18.0-19.0	reworked OCHRE as above grading to greenschist BRECCIA with clasts of soft weathered and hard fresh greenschist and quartz to 2.0cm, also some ochre clasts with relict texture; yellowish orange 10YR 6/8 dispersing to 10YR 6/10.
HC5/18	19.0-20.0	reworked OCHRE with small clasts 5%, yellowish orange 10YR 6/8 dispersing to 10YR 6/10.
HC5/19	20.0-21.0	as above, <5% clasts.
HC5/20	21.0-22.0	reworked OCHRE, small clasts to 0.5 cm, 20%; yellowish brown 10YR 5/6 dispersing to yellowish orange 10YR 6/6.

Hole terminated owing to problems with the rig.

Auger hole HQ 1.

Drilled 8/2/90 commencing 8.30am. Driller T. Lodge and R. Dean, Stacpoole's Launceston. Logged by H. Shannon and M. Whitty (14.5-20.5m). Total depth 20.5 metres. Location 346534.86mE, 5400197.33mN; RL 164.23m.

Sample	From- to	Description
HQ1/1	0.0- 1.0	SOIL (not sampled) over CLAY, yellowish brown 10YR 5/6.
HQ1/2	1.0- 2.5	CLAY and clay matrix greenschist BRECCIA, yellowish brown 2Y 6/4, light olive 10Y 5/4 over muddy SAND, purplish grey 10PB 6/1.
HQ1/3	2.5- 4.0	CLAY and clay matrix greenschist BRECCIA, clasts to 2cms, 30%, soft, unoxidized; dark greenish grey 5GY 4/1 and bluish grey 5B 5/1.
HQ1/4	4.0- 5.5	clay matrix greenschist BRECCIA, clasts to 3cm, soft greenschist but some muddy "sand clasts" (decomposed sandstone) and one clast of ochre and one <u>rounded</u> quartz pebble; greyish olive 10Y 4/2.
HQ1/5	5.5- 7.0	(water struck), almost all sample lost, traces of ochre and quartz clasts in MUD as above.
HQ1/6	7.0- 8.0	sloppy MUD 5Y 5/4.
HQ1/7	8.0- 9.5	soft MUD, olive grey 5Y 4/1 with sand clasts (decomposed sandstone) dusky yellow 5Y 7/4.
HQ1/8	9.5-10.5	stiff CLAY grading to clay matrix BRECCIA; quartz and sand clasts, also soft greenschist, isolated Oonah type grey sandstone; medium grey N 5.
HQ1/9	10.5-11.5	greenschist/quartz/sand clast BRECCIA as above; dark grey N 3.
HQ1/10	11.5-12.5	CLAY/OCHRE with small clasts 5%; brown 7.5YR 5/4 to 7.5YR 5/6.
HQ1/11	12.5-13.5	as above; brownish orange 8YR 6/6.
HQ1/12	13.5-14.5	as above; 7YR 5/4 over bedded CLAY/OCHRE with smeared out weathered greenschist clasts to 3cm; brownish orange 5YR 5/6.

HQ1/13	14.5-15.5	CLAY/OCHRE; yellowish red 5YR 5/6 mixed with greenschist BRECCIA, small clasts about 30%; wet, smooth and creamlike.
HQ1/14	15.5-16.5	as above.
HQ1/15	16.5-17.5	as above.
HQ1/16	17.5-18.5	as above.
HQ1/17	18.5-19.5	CLAY/OCHRE slightly drier and more compact, clasts <30%; reddish brown 2.5YR 4/4.
HQ1/18	19.5-20.5	CLAY/OCHRE now drier and tight; reddish brown 2.5YR 4/4, very difficult drilling and slow penetration. Difficulty in extracting augers.

Hole abandoned.

Auger hole HQ 2.

Drilled 8/2/90 commencing 2.45pm. Driller T. Lodge and R. Dean, Stacpoole's Launceston. Logged by M. Whitty. Total depth 13.0 metres. Location 346566.94mE, 5400166.16mN, RL 166.96m.

Sample	From- to	Description
HQ2/1	0.0- 1.0	CLAY with greenschist BRECCIA.
HQ2/2	1.0- 2.5	OCHRE; good bright brown yellow 10YR ?; colour too good to match any on colour chart, supported by greenschist BRECCIA.
HQ2/3	2.5- 3.5	as above.
HQ2/4	3.5- 4.0	clast supported greenschist BRECCIA, clasts <.5cm; 5Y 4/3.
HQ2/4	4.0- 5.5	clay matrix greenschist BRECCIA with minor traces of dark brown ochre 7.5YR 4/4.
HQ2/5	5.5- 7.0	greenschist BRECCIA, clasts to .75cm with minor dark brown ochre as before 7.5YR 4/4.
HQ2/6	7.0- 8.5	greenschist BRECCIA, large clasts to .5cm, with white clay matrix; very pale orange 10YR 8/2.
HQ2/7	8.5-10.0	more pronounced white clay supported BRECCIA 10YR 8/2, easy drilling.
HQ2/8	10.0-11.5	as above, more sloppy.
HQ2/9	11.5-13.0	as above but into water, little sample retained on auger.

Hole ended.

Auger hole HQ 3.

Drilled 8/2/90 and 9/2/90 commencing 4.15pm and 8.05am. Drillers T. Lodge and R. Dean, Stacpoole's Launceston. Logged by H. Shannon and M. Whitty (0.0-2.5m and 13.0-17.0m). Total depth 17.0 metres. Location 346553.16mE, 5400177.04mN; RL 165.96m.

Sample	From- to	Description
HQ3/1	0.0- 1.0	CLAY, few clasts; yellowish orange 10YR 7/8.
HQ3/2	1.0- 2.5	OCHRE, sloppy with quartz clasts; strong yellow orange not on colour chart 8YR 6/10.
HQ3/3	2.5- 4.0	reworked OCHRE, sloppy, quartz clasts; strong yellow orange 8YR 6/10, some sample loss.
HQ3/4	4.0- 5.5	OCHRE, sloppy as above; strong brownish orange 7YR 5/8.
HQ3/5	5.5- 6.0	CLAY with greenschist clasts, yellowish brown 10YR 5/4.
HQ3/6	6.0- 7.0	as above.
HQ3/7	7.0- 8.0	reworked OCHRE; strong yellowish orange but a bit dull, 10YR 5/8.
HQ3/8	8.0- 9.0	CLAY/OCHRE with clasts of greenschist and quartz 5%; light yellowish brown, 10YR 6/4.
HQ3/9	9.0-10.0	CLAY/OCHRE as above; yellowish orange 10YR 6/6, same dispersed colour.
HQ3/10	10.0-11.0	reworked OCHRE, small clasts 5%; mass colour strong brownish yellow 10YR 5/8 dispersing to strong yellowish orange 10YR 6/8.
HQ3/11	11.0-12.0	reworked OCHRE as above; mass colour 10YR 6/6, dispersing to strong yellowish orange 10YR 6/8.
HQ3/12	12.0-13.0	reworked OCHRE as above grading to CLAY/OCHRE; mass colour dull yellowish orange 10YR 6/6, dispersing to yellowish orange. At base, greenschist BRECCIA with clay matrix; light yellowish brown 10YR 6/4 but with smeared clasts of ochre; dark brown 7YR 3/4, probably ex-magnesite.

HQ3/13	13.0-14.0	reworked OCHRE, wet sloppy; dark reddish brown 5YR 3/4 with large loose clasts to 1.5cm.
HQ3/14	14.0-15.0	as above with yellow clay/ochre 10YR 7/8 and large angular clasts to 1.5cm dia.
HQ3/15	15.0-16.0	now becoming dry and tight, greenschist BRECCIA with clay matrix, drill penetration slowing.
HQ3/16	16.0-17.0	hard and tight greenschist BRECCIA, clay supported matrix clasts <.5cm.

End hole.

Auger hole HQ 4.

Drilled 9/2/90 commencing 9.30am. Drillers T. Lodge and R. Dean, Stacpoole's Launceston. Logged by M. Whitty. Total depth 26.5 metres. Location 346535.93mE, 5400169.72mN; RL 165.49m.

Sample	From- to	Description
HQ4/1	0.0- 1.0	CLAY with greenschist BRECCIA.
HQ4/2	1.0- 2.5	OCHRE, yellow 2.5YR 7/8 tinged and mixed with greenschist BRECCIA, wet.
HQ4/3	2.5- 4.0	OCHRE as above.
HQ4/4	4.0- 5.5	good yellow OCHRE 2.5Y 7/8, abundant small clasts to 2mm.
HQ4/5	5.5- 7.0	as above but striking large rounded cobble of solid sandstone, diameter 15cm. (Note by H.S., this is more likely a caving from a gravel at c. 2m, seen in costeans, as are other rounded cobbles seen lower down).
HQ4/6	7.0- 8.5	as above with fewer clasts, creamlike good yellow 2.5Y 7/10.
HQ4/7	8.5-10.0	good clean yellow OCHRE 2.5Y 7/10, occasional large pebble/cobble well rounded to 5cm dia.
HQ4/8	10.0-11.5	as above, consistent bright yellow OCHRE 2.5Y 7/10, with occasional rounded cobbles 10cm and angular quartz 6cm.
HQ4/9	11.5-13.0	water, unable to retain sample, will attempt to penetrate further, still very good yellow OCHRE.
HQ4/10	13.0-14.5	very hard drilling bringing up large chunks of deep red solid limonite rock broken up and mixed with same good OCHRE as above.
HQ4/11	14.5-16.0	as above.
HQ4/12	16.0-17.5	little sample retained, chunks of clear quartz and limonite with good OCHRE.
HQ4/13	17.5-19.0	as above, OCHRE quality too good to abandon at this stage.

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H04/14 19.0-20.5 now grading to a greenschist BRECCIA.

H04/15 20.5-22.0 becoming drier and tighter, hole collapsing from above.

H04/16 22.0-23.5 tight white CLAY and GREENSCHIST with clasts of small angular quartz.

H04/17 23.5-25.0 as above.

H04/18 25.0-26.5 hit bottom, definitely no more good yellow ochre.

Hole ended.

Auger hole HQ 5.

Drilled 12/2/90 commencing 9.30am by T. Lodge, R. Dean; Stacpoole's Launceston. Logged by H. Shannon. Total depth 31 metres. Location 346545.66mE, 5400188.50mN; RL 164.78m.

Sample	From- to	Description.
HQ5/1	0.0- 1.0	CLAY with some banding; pale yellowish grey 10YR 6/3 to yellowish orange 10YR 6/6.
HQ5/2	1.0- 2.5	CLAY as above over pyritic CLAY; dark grey N 3 to light grey N 7, mainly N 6 with clasts to 1 cm of greenschist or decomposed sandstone.
HQ5/3	2.5- 4.0	CLAY; dark grey N 3 to medium grey N 5; mainly N 4.
HQ5/4.1	4.0- 5.0	pyritic CLAY; dark grey N 3 and olive grey 5Y 4/1 with minor clasts weathered greenschist to 1 cm.
.2	5.0- 5.5	CLAY/OCHRE with clasts including quartz; yellowish orange 10YR 6/7.
HQ5/5	5.5- 7.0	OCHRE with relict ex-magnesite texture; mass colour orange brown 8YR 5/6 to 9YR 6/8, disperses to yellowish orange 10YR 7/8.
HQ5/6	7.0- 8.5	reworked OCHRE with clasts including quartz, 20%; disperses to (orange) yellow 1Y 6/8.
HQ5/7	8.5-10.0	as above; 10YR 6/8 (sample loss, contamination).
HQ5/8	10.0-11.0	sample lost initially but recovered (contaminated) the next run as a slurry; 10YR 5/6.
HQ5/9	11.0-12.0	slurry recovered as above; 9YR 6/8.
HQ5/10	12.0-13.0	poor recovery, sloppy OCHRE; strong yellowish orange 10YR 6/9.
HQ5/11	13.0-14.0	still extensive sample loss, but a true sample; sloppy OCHRE probably residual ochre after magnesite, almost no grit; disperses to strong yellowish orange 8YR 6/10.
HQ5/12	14.0-15.0	OCHRE with relict ex-magnesite texture; strong yellowish orange 9YR 6/10.

H05/13	15.0-16.0	as above.
H05/14	16.0-17.0	sloppy OCHRE, some residual texture; 1Y 6/8.
H05/15	17.0-18.0	OCHRE as above; strong yellowish orange 1Y 6/9.
H05/16	18.0-19.0	as above; 1Y 6/9 to base, where traces of duller reworked OCHRE with clasts; 10YR 6/6.
H05/17	19.0-20.0	reworked OCHRE with greenschist? and quartz clasts up to 0.5cm, 20%; strong yellowish orange 9YR 6/9.
H05/18	20.0-21.0	reworked OCHRE as above over OCHRE with relict texture after magnesite rock; strong yellowish orange 9YR 6/9.
H05/19	21.0-22.0	OCHRE with residual texture; mass colours brown 8YR 5/4 to yellowish orange 10YR 6/8 dispersing to strong yellowish orange 9YR 6/9.
H05/20	22.0-23.0	sloppy OCHRE as above; strong brownish orange 9YR 5/9.
H05/21	23.0-24.0	OCHRE with relict ex-magnesite texture; mass colour dark brown 8YR 3/4 to strong brown 8YR 5/6, mainly strong brown 8YR 4/6 dispersing to strong brown 8YR 4/8.
H05/22	24.0-25.0	OCHRE as above; 8YR 4/8 with minor reworked OCHRE; yellowish orange 10YR 6/8.
H05/23	25.0-26.0	as above.
H05/24	26.0-27.0	reworked OCHRE with clasts grading to greenschist BRECCIA with clay/ochre matrix; clasts to 1cm, 30%; yellowish brown 10YR 5/4.
H05/25	27.0-28.0	greenschist BRECCIA with clay matrix; pale orange 10YR 8/4 and greenschist BRECCIA with clay/ochre; yellowish brown 10YR 5/4. The clasts include some bedded breccia, clay and isolated ochre fragments.
H05/26	28.0-29.0	OCHRE, residual and some reworked OCHRE with small clasts common and isolated larger clasts; disperses to strong brown 8YR 4/6.

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HQ5/27 29.0-30.0 OCHRE, residual with good relict ex-magnesite texture; mass colours 7YR 4/4 to 10YR 6/8 dispersing to strong brown 8YR 5/8.

HQ5/28 30.0-31.0 OCHRE, residual and reworked grading to greenschist BRECCIA with clay/ochre matrix, which includes clasts of brown ochre; yellowish brown 9YR 5/6.

End hole, last rod used.

Auger hole HD 4.

Drilled 22/2/90 commencing 1.00pm. Driller T. Lodge and R. Dean, Stacpoole's Launceston. Logged by H. Shannon. Total depth 31.0 metres. Location 346577.02mE, 5400133.51mN; RL 172.42m.

Sample	From- to	Description
HD4/1	0.0- 1.0	quartz BRECCIA in clay; 9YR 7/4 to 9YR 6/6.
HD4/2	1.0- 2.5	CLAY/OCHRE with clasts; 10YR 6/6.
HD4/3	2.5- 4.0	sloppy reworked OCHRE with clasts; dispersed colour 9YR 6/10.
HD4/4	4.0- 5.5	as above.
HD4/5	5.5- 7.0	as above.
HD4/6	7.0- 8.3	as above, hard bands (limonite) near base.
HD4/7	8.3- 8.5	muddy quartz BRECCIA with clay matrix; 10YR 4/2 dark greyish brown, with clasts of residual texture ochre; 10YR 6/8.
	8.5- 9.8	reworked OCHRE with quartz clasts and residual OCHRE (possibly) as large clasts) 1Y 6/10 yellowish orange.
	9.8-10.0	large residual OCHRE clasts, laminated yellowish orange 10YR 6/8 and yellowish brown 10YR 4/4 in muddy quartz BRECCIA with clay matrix; dark yellowish brown 10YR 3/3.
HD4/8	10.0-11.0	sloppy OCHRE, clasts 5%; disperses 10YR 6/10.
HD4/9	11.0-12.0	residual OCHRE; mainly yellowish orange 10YR 6/8, with minor bands of dark yellowish brown 10YR 3/3; disperses to 10YR 6/10 also some grit indicating reworked ochre.
HD4/10	12.0-13.0	residual and reworked OCHRE; yellowish orange 10YR 6/7 and light olive brown 2Y 5/4 dispersing to 2Y 6/8.
HD4/11	13.0-14.0	sloppy OCHRE, including reworked and probable residual ochre dispersing to 1Y 6/9.
HD4/12	14.0-15.0	sloppy OCHRE with quartz clasts as above dispersing to 1Y 5-6/9.

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HD4/13	15.0-16.0	reworked and residual OCHRE with quartz clasts 15%, 10YR 6/4, 10YR 5/4, 10YR 3/3 yellowish orange to dark yellowish brown, dispersing to yellowish brown 10YR 4-5/4.
HD4/14	16.0-17.0	as above, dispersing to 10YR 5/6.
HD4/15	17.0-18.0	mainly residual OCHRE, large clasts, limonite vein? yellowish brown 10YR 4/6 to yellowish orange 10YR 6/8 disperses to 10YR 5/6.
HD4/16	18.0-19.0	as above dispersing 10YR 5/6.
HD4/17	19.0-20.0	as above dispersing to 10YR 4/6.
HD4/18	20.0-21.0	residual OCHRE with limonite; strong brown 8YR 5/16 when dispersed.
HD4/19	21.0-22.0	residual OCHRE probably as large clasts in greenschist/quartz BRECCIA with clay matrix; clasts 40%. The ochre makes up 80% of the sample; colours dull yellow 10YR 5/6 and strong orange brown 7YR 5/8. The breccia matrix is yellowish brown 10YR 4/3.
HD4/20	22.0-23.0	sloppy OCHRE, disperses to 10YR 5/6 yellowish brown.
HD4/21	23.0-24.0	sloppy OCHRE, mainly residual; strong orange brown 6YR 5/8.
HD4/22	24.0-25.0	residual OCHRE, good ex-magnesite texture; strong orange brown 7YR 5/10.
HD4/23	25.0-28.0	as above - poor recovery.
No samples for HD4/24 and HD 4/25.		
HD4/26	28.0-29.0	OCHRE with residual texture and greenschist BRECCIA with weathered greenschist clasts in clayey/ochre matrix. (Compound of ochre and greenschist breccia); 7YR 5/6.
HD4/27	29.0-30.7	OCHRE, residual with some lighter, weathered GREENSCHIST bands 8YR 5/6, strong brown.
HD4/28	30.7-31.0	TALC SCHIST (recovered as chips in pulp) or talc schist breccia in pulp matrix; yellowish grey 10YR 7/3.

End hole.

HD4/13	15.0-16.0	reworked and residual OCHRE with quartz clasts 15%, 10YR 6/4, 10YR 5/4, 10YR 3/3 yellowish orange to dark yellowish brown, dispersing to yellowish brown 10YR 4-5/4.
HD4/14	16.0-17.0	as above, dispersing to 10YR 5/6.
HD4/15	17.0-18.0	mainly residual OCHRE, large clasts, limonite vein?; yellowish brown 10YR 4/6 to yellowish orange 10YR 6/8 disperses to 10YR 5/6.
HD4/16	18.0-19.0	as above dispersing 10YR 5/6.
HD4/17	19.0-20.0	as above dispersing to 10YR 4/6.
HD4/18	20.0-21.0	residual OCHRE with limonite; strong brown 8YR 5/16 when dispersed.
HD4/19	21.0-22.0	residual OCHRE probably as large clasts in greenschist/quartz BRECCIA with clay matrix; clasts 40%. The ochre makes up 80% of the sample; colours dull yellow 10YR 5/6 and strong orange brown 7YR 5/8. The breccia matrix is yellowish brown 10YR 4/3.
HD4/20	22.0-23.0	sloppy OCHRE, disperses to 10YR 5/6 yellowish brown.
HD4/21	23.0-24.0	sloppy OCHRE, mainly residual; strong orange brown 6YR 5/8.
HD4/22	24.0-25.0	residual OCHRE, good ex-magnesite texture; strong orange brown 7YR 5/10.
HD4/23	25.0-28.0	as above - poor recovery.
No samples for HD4/24 and HD 4/25.		
HD4/26	28.0-29.0	OCHRE with residual texture and greenschist BRECCIA with weathered greenschist clasts in clayey/ochre matrix. (Compound of ochre and greenschist breccia); 7YR 5/6.
HD4/27	29.0-30.7	OCHRE, residual with some lighter, weathered GREENSCHIST bands 8YR 5/6, strong brown.
HD4/28	30.7-31.0	TALC SCHIST (recovered as chips in pulp) or talc schist breccia in pulp matrix; yellowish grey 10YR 7/3.

End hole.

Auger hole **HD 5.**

Drilled 22/2/90 commencing 1.30pm. Driller T. Lodge and R. Dean, Stacpoole's Launceston. Logged by H. Shannon. Total depth 22.0 metres. Location 346565.07mE, 5400141.51mN; RL 170.95.

Sample	From- to	Description
HD5/1	0.0- 1.0	reworked OCHRE with quartz clasts 20%; orange brown 8YR 5/10.
HD5/2	1.0- 2.5	CLAY/OCHRE with quartz clasts 15%; dark brown 7YR 4/2.
HD5/3.1	2.5- 3.5	reworked OCHRE with clasts 15%; dark yellowish brown 9YR 4/3.
.2	3.5- 4.0	greenschist BRECCIA with clay matrix; yellowish brown 10YR 4/3 to 10YR 5/4, chips indicate large clasts of weathered schist 50%.
HD5/4.1	4.0- 4.8	greenschist BRECCIA with clay/ochre matrix, clasts <0.5cm, 25%; 10YR 5/4 yellowish brown.
.2	4.8- 5.5	CLAY/OCHRE with some clay after greenschist (large clasts), clasts 20%; yellowish orange 10YR 6/5.
HD5/5	5.5- 7.0	CLAY/OCHRE with small clasts up to 10% and larger weathered greenschist clasts, matrix 10YR 5/8 yellowish brown, clasts mainly yellowish orange 10YR 6/7 with white and trace black bands.
HD5/6	7.0- 8.5	laminated CLAY with large clasts of weathered greenschist. 10YR 7/4, 2R 6/4, 7YR 7/4.
HD5/7	8.5-10.0	CLAY with isolated clasts to 0.5cm, <5%, (and occasional large clasts of weathered greenschist); mostly massive but some laminated clay; greyish orange 10YR 7/4 to light brown 8YR 6/4.
HD5/8	10.0-11.5	CLAY with a few very small clasts to 0.2cm, <2%; 2Y 6/4 greyish yellow to 8YR 5/4 light brown, rare ochre clasts strong brown.
HD5/9	11.0-13.0	CLAY with chlorite schist clasts to 0.5cm, 5%, becoming common near base 40%; 1Y 5/6 greyish yellow.

HD5/10 13.0-14.5 CLAY with greenschist clasts, (some weathered) and minor ochre, all small <0.5cm about 30%; 10YR 7/4 to 2Y 7/4 pale greyish orange to pale greyish yellow.

HD5/11 14.5-16.0 CLAY with small greenschist clasts to 0.2cm, <5%; 10YR 6/4 to 2YR 7/4.

HD5/12 16.0-17.5 CLAY with clasts as above.

HD5/13 17.5-19.0 CLAY with clasts including minor softened actinolite schist; 1Y 6/4 to 10YR 5/4.

HD5/14 19.0-20.5 sloppy CLAY with few clasts disperses to 10YR 5/4 yellowish brown, possibly a clay/ochre.

HD5/15 20.5-22.0 CLAY grading to CLAY/OCHRE with 5% greenschist clasts; dark brown 8YR 4/4.

End hole.

Auger hole HD 6.

Drilled 23/2/90 commencing 8.30am. Driller T. Lodge and R. Dean, Stacpoole's Launceston. Logged by H. Shannon. Total depth 13 metres. Location 346590.26mE, 5400135.24mN; RL 172.89m.

Sample	From- to	Description
HD6/1	0.0- 1.0	clayey OCHRE with small greenschist clasts 10% to 0.5cm; 10YR 6/8 yellowish orange.
HD6/2.1	1.0- 1.8	CLAY/OCHRE with greenschist clasts, 10% to 1cm, some lamination; 'brownish' yellow orange 9YR 5-6/7 grading to reddish brown 10R 4/6.
.2	1.8- 2.5	CLAY/OCHRE; mainly moderate red 1YR 4/6 with thin bands yellowish orange 9YR 5-6/7.
HD6/3	2.5- 4.0	CLAY/OCHRE with small clasts to 0.2cm, 5%; colours as above grading to 10R 4/6 reddish brown.
HD6/4	4.0- 5.5	CLAY/OCHRE with clasts, including some actinolite schist (greenish grey) to 0.5cm, 5%; strong red 7R 4/7.
HD6/5	5.5- 7.0	CLAY/OCHRE, clasts <2%; reddish brown 10R 4/6.
HD6/6	7.0- 8.0	as above.
	8.0- 8.5	CLAY/OCHRE; moderate red 9R 4/6.
HD6/7.1	8.5- 9.5	CLAY/OCHRE with small clasts and laminated "ghost" clasts ex greenschist? to 2cm clasts 10%; red 9R 4/6 reddish brown 10R 4/6 yellowish orange 10YR 5-6/7.
.2	9.5-10.0	CLAY/OCHRE with clasts 20% mainly pale yellowish orange, 10YR 7/6, with reddish brown 10R 4/6.
HD6/8	10.0-11.0	CLAY/OCHRE with clasts 20% as above, over CLAY/OCHRE; 2YR 5/4 to 2YR 5/6.
HD6/9	11.0-12.0	CLAY/OCHRE with small clasts 5%; 3YR 5/6 reddish brown.
HD6/10	12.0-12.8	as above.
	12.8-13.0	CLAY; greenschist clasts 20%; light brown 5YR 6/4.

Hole abandoned - thought to be leaving clay/ochre and entering clay.

Auger hole DA 1.

Drilled 23/2/90 commencing 11.00am. Driller T. Lodge and R. Dean, Stacpoole's Launceston. Logged by H. Shannon. Total depth 9.8 metres. Location 346849.06mE, 5400205.62mN; RL 191.37m.

Sample	From- to	Description
DA1/1	0.0- 1.0	CLAY/OCHRE with lamination and minor clasts; yellowish orange 10YR 6/8.
DA1/2	1.0- 2.5	CLAY/OCHRE as above (pale yellowish orange 10YR 7/8) over talc schist chips and pulp 10YR 7/6.
DA1/3	2.5- 4.0	TALC SCHIST (as chips and pulp); greyish orange 10YR 7/4.
DA1/4	4.0- 5.5	talc schist grading to talc schist BRECCIA (clasts/chips in clay/pulp matrix); 10YR 7/4.
DA1/5	5.5- 7.0	talc schist/quartz BRECCIA in talcose clay matrix 10YR 6/4.
DA1/6	7.0- 8.5	as above.
DA1/7.1	8.5- 9.5	talc schist/quartz BRECCIA with talcose clay/pulp matrix; yellowish brown 10YR 5/4.
.2	9.5- 9.8	OCHRE, yellowish brown 10YR 5/6 with residual textures after magnesite; white powder in end of bit - tested with acid and found to be QUARTZ so ochre zone probably continues

Solid base struck - hole ended.

Auger hole DA 2.

Drilled 23/2/90 commencing 1.00pm. Driller T. Lodge and R. Dean, Stacpoole's Launceston. Logged by H. Shannon. Total depth 14.5 metres. Location 346864.05mE, 5400204.45mN; RL 192.85m.

Sample	From- to	Description
DA2/1	0.0- 1.0	CLAY/OCHRE with isolated quartz clasts; yellowish brown 10YR 5/6, over CLAY/OCHRE strong reddish brown 3YR 4/8.
DA2/2.1	1.0- 2.0	CLAY/OCHRE with few clasts 9YR 6/8 yellowish orange.
.2	2.0- 2.5	weathered greenschist or greenschist BRECCIA; 4YR 5/4 reddish brown with minor dull yellowish orange 10YR 6/6 clay matrix.
DA2/3	2.5- 4.0	CLAY with a few small clasts <2cm, <2%; 6YR 5/6 light brown over 3YR 4/4 reddish brown.
DA2/4	4.0- 5.5	CLAY/OCHRE; 5YR 5/6 light brown with quartz clasts to 1cm, 5%.
DA2/5	5.5- 7.0	CLAY/OCHRE; 6YR 5/6 light brown, few small quartz and greenschist clasts over talcose CLAY/OCHRE; 6YR 5/4 light brown.
DA2/6.1	7.0- 7.5	as above.
.2	7.5- 8.3	reworked clayey OCHRE; 9YR 4/6.
	8.3- 8.5	talcose greenschist BRECCIA in clay/ochre matrix.
DA2/7	8.5- 9.5	CLAY/OCHRE with few clasts; light brown 7YR 5/7.
	9.5-10.0	talcose CLAY/OCHRE grading to greenschist BRECCIA clasts to 0.5cm, 20%; moderate brown 5YR 5/4.
DA2/8.1	10.0-10.6	CLAY/OCHRE with few clasts; light brown 6YR 5/4.
.2	10.6-11.5	clayey OCHRE; brown 7YR 5/6 to 7YR 4/6 clasts as above.
DA2/9.1	11.5-12.4	CLAY/OCHRE, as above, reddish brown 4YR 5/4.
.2	12.4-13.0	as above; light brown 5-6YR 5/6.

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DA2/10.1 13.0-14.0 as above 5YR 5/6.

.2 14.0-14.5 as above 5YR 5/6.

Hole ended.

APPENDIX 3:

Press release:

Drilling outlines major iron oxide resource in Tasmania



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5 June 1990

DRILLING OUTLINES MAJOR IRON OXIDE RESOURCE IN TASMANIA

Results from a 4,000 metre 101 hole auger drilling programme which was completed in early February have now been evaluated.

The drilling was conducted on a portion of the Main Creek iron oxide deposits which are located 5 kilometres southwest of the Savage River Township in northwest Tasmania. The deposits are held under a 10 square kilometre Retention Licence number 8802.

There are three mineralised zones of fine grained iron oxides known as: Sids Creek Extended Deposit, the Main Creek Deposit and the Bowry Creek Deposit, all of which total some 1.07 square kilometres (See Plan 1). The most recent round of drilling evaluated an area of 12 hectares known as the HT Ochre Site. The HT Ochre Site constitutes approximately 19% of the Main Creek Deposit and approximately 11% of the total deposits. (See Plan 2).

Resources of recoverable pigment for the HT Ochre Site broken down by pigment colours are as follows:

<u>Tonnes</u>	<u>Yellow</u>	<u>Brown</u>	<u>Red</u>	<u>Total</u>
Measured	12,100	13,800	4,300	30,200
Indicated	23,000	29,000	7,000	59,000
Inferred	95,000	132,000	33,000	260,000
Total	130,100	174,800	44,300	349,200

The original programme was designed to establish a resource base sufficient to sustain a ten year operation which would produce 10,000 tonnes per annum of pigment. As a result, the measured, indicated and inferred resource of 349,200 tonnes of recoverable pigment is more than adequate for this purpose.

Resource estimations have been modelled using the Techbase mine engineering database management system, using a Polygon Ore Reserve method which manipulates calculated fields. The calculated field applied to individual colour intervals is provided by the following formula:

Specific Gravity x Recovery Factor x Interval Length

The calculated field is then converted to a recovered tonnage using a 12 sided polygon with radii of 5, 10, 20, 30 and 40 metres.

A specific gravity of 1.24 g/cc was used in all calculations. The calculated recovery factor was obtained by subtracting contaminant and non-ochre material from the sample and multiplying the resulting tonnage by 50%. As a result, the mineralised tonnages reported above represent an estimate of recoverable tonnages from the resource after commercial processing. The tonnage estimates do not, however, take into account mining dilution and practical mining depths and other mining related factors.

Where two adjacent drillhole centred 5m radius polygon areas touch, the resource assessment associated with this area is classified as "Measured". Touching polygon areas with radii between 5 and 10 metres represent a resource assessment that is considered as "Indicated", while polygons with radii between 10 and 40 metres represent a resource assessment that is considered as "Inferred". All three resources estimates have been "clipped" to exclude known non-ochre bearing geological features such as greenschist bands and sink holes. (See Plan 3).

Iron oxides have had wide application from the earliest times as fine coloured powders which are used as pigments. Iron oxides are used as colouring agents in paint, brick and tiles, wood stains, plastics, rubber, pet food, face powder and pharmaceutical capsules. More recently, applications have been found for iron oxides in the production of ferrite ceramic magnets and high-fidelity recording tapes and machines.

Iron oxides may be either natural/mineral pigments or synthetically produced pigments which are made from basic chemicals.

Iron oxide pigments are characterised by low chroma and excellent light fastness. They are non-toxic, non-bleeding and relatively inert. Aided by their relatively low cost, they are the most widely used inorganic pigments in the world.

Iron oxides come in a variety of colours, the range being extended through calcination and blending. Hematite contributes a red colour; limonite yellow; and magnetite brown to black. Commercially, there is a gradation of shades from reds and yellows (ochre) iron-rich and manganese poor, through oranges (sienna) to dark browns (umber), iron rich and manganiferous material. The orange hue of sienna turns to firey red on calcination producing "burnt sienna".

World natural iron oxide production is difficult to estimate, but is of the order of 250,000 to 300,000 tonnes per annum principally from India, Spain and the United States. Of this approximately 60% is red, 30% brown and 10% yellow.

The principal synthetic iron oxide producers are Germany (Bayer), the United States (Pfizer), Canada (Northern Pigments) and Japan. Numerous other countries produce on a smaller basis. The Australian market for iron oxide pigments is approximately 15,000 tonnes per annum of which imports account for approximately 14,000 tonnes. Australia has the highest per capita consumption of iron oxide pigments in the world. The major consumer of pigments in Australia is the construction industry which consumes approximately 80%. Potential exists for markedly increased iron oxide consumption should "through pigmenting" of cement products such as roofing tiles commence.

Generally, worldwide demand for iron oxides is strong, mainly as a result of the underpinning of the construction industry with demand resulting in lengthening delivery times. Construction demand mainly has resulted from the increasing popularity of concrete block pavers, a trend which is readily evident in Australia.

Synthetics generally have enjoyed higher prices than natural iron oxides due principally to their superior performance characteristics which are particularly required in the paint and coatings industries. However, while paints and coatings represent a large market sector, the sector has achieved only moderate growth. In less high performance areas, such as the construction industry, high quality naturals with good tinctorial strength can compete equally with synthetics with the attraction of a lower price, and hence construction demand relies heavily on natural iron oxides. Savage will concentrate its marketing efforts in this area.

The average price for natural and synthetic iron oxide pigments imported into Australia in 1986/1987 was approximately \$1,500 per tonne. Savage will be looking to produce a high value added product to a tight specification to attract premium prices.

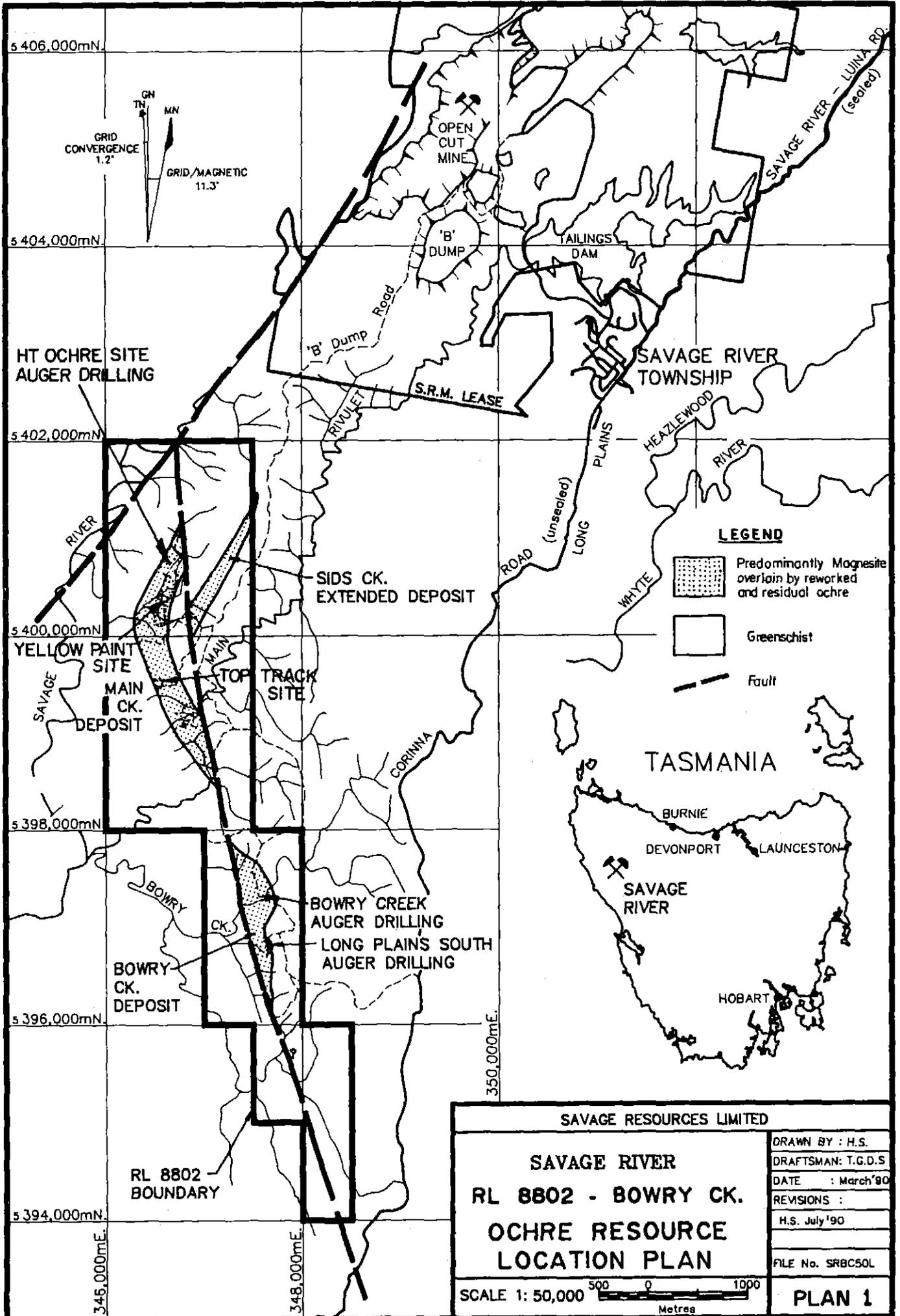
Processing evaluations are continuing and preliminary investigations for the siting of a processing plant at, or near the Savage River Township, have commenced.

For further information contact:

David Archer
Managing Director

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(02) 327 6626 (AH)

Note: The mineral resource estimates quoted in this report conform to the "Australasian Code for Reporting of Identified Mineral Resources and Ore Reserve, Report of the Joint committee of the Australasian Institute of Mining and Metallurgy and Australian Mining Industry Council" of June 1988 and have been prepared under the direction of, and signed by, a "Competent Person".



LEGEND



Predominantly Magnesian overlain by reworked and residual ochre



Greenschist



Fault

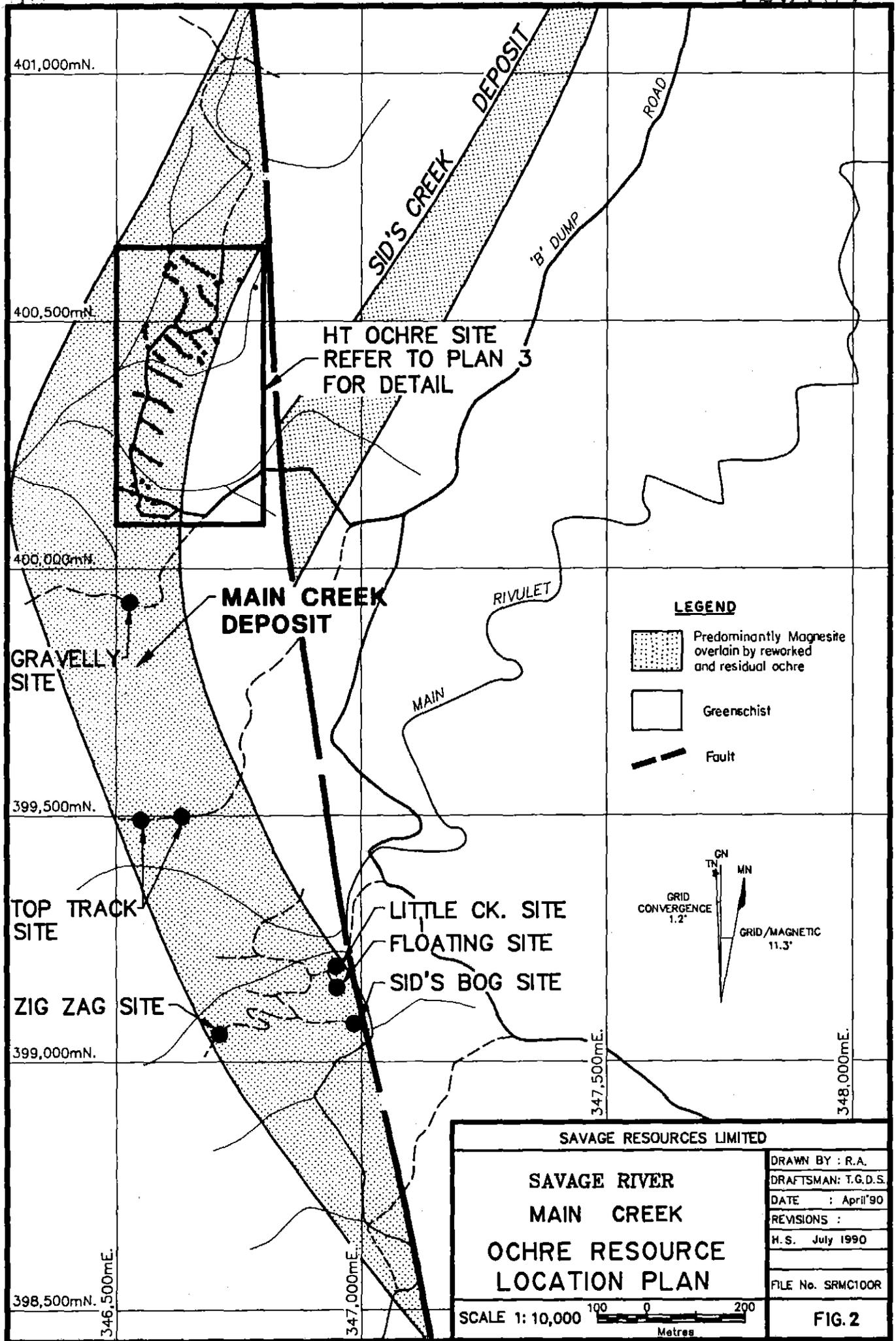
SAVAGE RESOURCES LIMITED

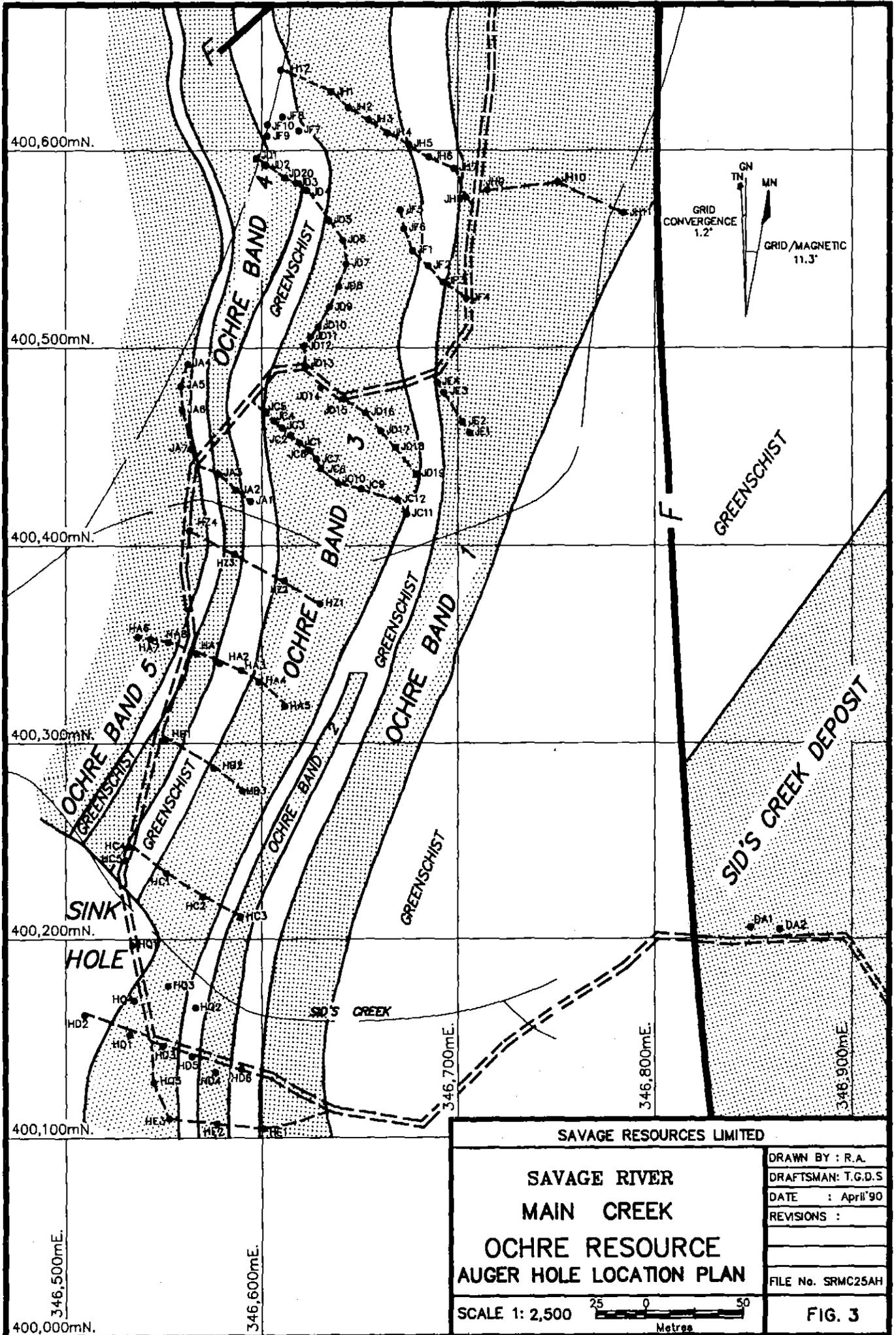
SAVAGE RIVER
RL 8802 - BOWRY CK.
OCHRE RESOURCE
LOCATION PLAN

DRAWN BY : H.S.
 DRAFTSMAN: T.G.D.S.
 DATE : March '90
 REVISIONS :
 H.S. July '90
 FILE No. SRBC50L

SCALE 1: 50,000 Metres

PLAN 1





SAVAGE RESOURCES LIMITED	
SAVAGE RIVER MAIN CREEK OCHRE RESOURCE AUGER HOLE LOCATION PLAN	
DRAWN BY : R.A.	REVISIONS :
DRAFTSMAN: T.G.D.S	FILE No. SRMC25AH
DATE : April '90	FIG. 3
SCALE 1: 2,500	25 0 50 Metres

CONFIDENTIAL

TO

SAVAGE RESOURCES LIMITED

MICROFILMED

THE PRODUCTION OF IRON OXIDE PIGMENTS FROM

SAVAGE RESOURCES LIMITED

SAVAGE RIVER GOETHITES

90-3158A

Report Commissioned by:

Mr David Archer
Managing Director

Report by:

R.E. SHACKLEFORD

1. INTRODUCTION

This report is to be studied in conjunction with the iron oxide pigment marketing report* which was issued to Savage Resources Ltd in December 1989. The reason for this is that the marketing iron oxide pigment background information is not repeated in this document, i.e. in conjunction with the iron oxide pigment marketing report, this document is complete.

Virtually all synthetic iron oxide pigments produced today are manufactured from synthetic goethite ($\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$ yellow iron oxide).

As high purity goethite occurs in the Savage Resources prospects, it seemed reasonable to assume that it might be possible to produce acceptable grades of iron oxide pigments from these deposits.

From the pigment point of view, the process of producing goethite concentrate is simply the first stage of liberating and refining the goethite. This report details the refining and production stages necessary to produce acceptable grades of pigments from Savage Resources Ltd goethite.

It also presents the processes for producing premium quality iron oxide pigments as haematite (reds) and magnetites (browns and blacks) from the Savage Resources goethites.

The report also recommends the further work necessary to commercialise the technologies.

In the iron oxide pigment industry it is rare to find a completely integrated company, in the sense that a single company begins with its own feedstock (natural ore or chemical raw materials) and eventually produces a manufactured good such as paint or a ferrite body. More typically, companies producing natural oxide will confine themselves to mining and selling crude ore, to mining ore and processing it into finished pigments, or to

* This refers to information contained within the report "The Utilization of Savage Resources Limited Goethite as a Pigment" by R. F. Shackelford (90-31583)

buying and processing ore plus making paint to be sold. Similarly, a typical company producing synthetic oxide mainly manufactures pigment.

Such a manufacturer frequently blends finished pigments of various kinds with other materials to produce multi-component pigments meeting certain specifications. A pigment producer may also make and sell dispersions, which are pigmented liquid vehicles whose form may be convenient for paint manufacturing. Some firms in the pigment industry simply buy finished pigments and do blending or dispersing, or perhaps both.

This report is concerned with the methods and materials used in producing crude and finished iron oxide pigments. Blending is considered only within the context of pigment manufacture. Dispersion and other operations and manufacturing carried out using finished pigments are not discussed in any detail.

2. TERMINOLOGY

Terminology for iron oxide pigments can be kept simple, on the basis of colour, except that a few of the natural colours have names that mostly reflect the places where they were initially obtained. Thus, for synthetic oxides, it suffices to speak of black, brown, red, and yellow pigments. Several types of the synthetic pigments can be distinguished according to method of manufacture. We differentiate synthetic reds into copperas red, red manufactured by other chemical processes, and other manufactured red iron oxides. Copperas red is oxide produced by calcination of the iron sulphate chemical known as copperas, "red manufactured by other chemical processes" refers to oxide prepared by calcination of precipitated oxide (usually yellow), and "other manufactured red iron oxides" signifies red obtained by direct precipitation.

For natural oxides, a variety of names have been assigned to materials coming from particulate sources. A still-prominent example is Spanish red, which as the name implies is a natural red of particular characteristics coming from Spain. Many of the other natural oxides having special names are no longer produced or are of only occasional significance. Therefore, the following terms are adequate to describe modern natural oxide products; black (magnetite), brown (includes the variety known as metallic brown), Vandyke brown, red, ochre, sienna, and umber. Metallic brown is an oxide obtained by the calcination of siderite, iron carbonate. Vandyke brown is a carbonaceous material containing only a minor amount of iron; it is included here because of tradition and not because it can be clearly identified as an iron oxide pigment.

Ochre, sienna, and umber can be thought of as a group of yellow to brown pigments which more or less grade into each other on the basis of both chemical composition and colour. The terms "ochre" and "sienna" appear to have been used to describe similar material of both domestic and foreign origin. Use of the term "umber" is more specific of the manganese content and greenish-brown natural shade of this pigment.

For synthetic pigments the terminology usually relates to the producer, and the catalogue number, i.e. Bayer 318 which is black, or Northern Pigment 114 which is a cocoa brown blend.

The task before a pigment manufacturer is either to appropriately reduce the particle size of starting materials that are too coarse or to manufacture oxides having particle sizes that are fine enough to begin with. As a rule, size reduction is necessary only for natural oxides, because the processes used to manufacture synthetic oxides yield sufficiently fine particles. The need to achieve small sizes leads to the differentiation of pigment material into "crude" and "finished". Crude pigment is natural ore which has been dug from the ground like other kinds of ore, but needs to be further treated prior to final use, as in a paint. Washing alone does not produce a finished pigment, but grinding will. Along with size reduction, drying and/or calcining may be required. Finished pigments of iron oxide are part of a larger pigment class termed "dry colours".

3. EXECUTIVE SUMMARY

This segment is presented for the non-chemist with very little if any knowledge of iron oxide pigments, and we apologise to the Savage Resources consultants or technical staff.

There are basically only two forms of iron oxide pigments of any significance, the synthetic iron oxide pigments, and the naturally occurring iron oxide pigments.

The naturally occurring iron oxide pigments have always been used for decoration, and in Australia, the aboriginal cave paintings and prints are excellent examples of this.

Because modern technology and end uses demands consistency of feed, the markets for the synthetically produced iron oxide pigments has grown at the expense of the naturally occurring materials despite their lower costs. Coupled with this, the back to nature trend of the late sixties to mid seventies, which has endured and in fact spread, has generated rapid market demand for synthetic iron oxide pigments for roofing tiles, pavers, concrete, paints etc..

The exceptions are the naturally occurring micaceous iron oxides.

A. The process for producing naturally occurring iron oxide pigments is generally as follows:-

- i. Mine the oxide
- ii. Rough concentrate by hammer milling and ^{wet ?} screening
- iii. Mill by autogenous grinding when possible, or other form of milling
- iv. Wet mill or kek mill to less than 1.5 micron
- v. At some plants gravity and/or magnetic separation is carried out to refine the product.

Because of the materials handling and milling costs, the process is not low in cost, and yet results in an inferior, highly variable product.

By contrast, our process consists of goethite concentration, fine milling and chemical refining. *What is it?*

A. Costs of Goethite Production

Mining
Milling
Chemical refining
Transfer of pulp to pigment plant

goethite concentration

B. Costs to Iron Oxide Pigment Production

- i. Filtration and washing
- ii. Gravity separation and/or magnetic separation
- iii. Drying
- iv. Gaseous reduction
- v. Gaseous oxidation
- vi. Blending and bagging

fine milling

chemical refining

From this report it can be appreciated that we should be able to produce a pigment at a cost of no more than \$350/tonne, and from our marketing report it can be shown that the product should have a market value in excess of \$1600/tonne.

4A. BACKGROUND - Technical - General

Beginning the first part of the 20th century, chemical methods were developed for synthetic production of commercial iron oxides. Synthetic production offered improved uniformity as well as characteristics not obtainable with natural oxides, and consequently synthetics displaced natural materials for many applications. Today the iron oxide pigment industry produces a mix of synthetic oxides still desired of specifications plus a number of specific natural oxides still desired because of lower cost or uniqueness of colour.

The iron oxide industry is mature, with products matched to end uses according to chemical and physical characteristics, outstanding among which are stability and nontoxicity. Because of low cost and availability, iron oxides constitute one of the most important groups of coloured inorganic pigments. Synthetic pigments, frequently produced from wastes or as a byproduct of other industries, are now the more important portion of the iron oxide industry.

Development of colour in iron oxides stems from the electronic structure of the iron atom, which has the ability to exist in more than one valence state. Valence states encountered in pigments are the divalent (ferrous iron) and the trivalent (ferric ion). The trivalent state is more common and is found in Fe_2O_3 , haematite, which is red, and in hydrated ferric oxide, $\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$, limonite or goethite, which is yellow. The divalent state occurs along with the trivalent state in the magnetic oxide, magnetite, Fe_3O_4 , also written as $\text{FeO} \cdot \text{Fe}_2\text{O}_3$, which is black. Thus, iron oxides provide colours ranging from yellow to red to black, as well as intermediate shades and browns depending on method of preparation and impurities. Iron oxides do not give blue or green colours, but pigments with these colours can be produced using other iron-containing chemicals, as in iron blue, ferric ammonium ferrocyanide.

Oxides and hydrous oxides of iron occur or can be made in a variety of forms and physical conditions, and this has resulted in the existence of a number of names for the various compounds, some with only poorly defined chemical nature. However, for pigment purposes it is necessary to consider only five of these compounds; two forms of ferric oxide, two forms of ferric oxide hydrate, and magnetite. The stable form of ferric oxide, haematite, designated $\alpha\text{-Fe}_2\text{O}_3$, alpha iron oxide, has a rhombohedral structure, is non-magnetic, and is the basic compound of red iron oxides. A metastable form of ferric oxide, denoted $\gamma\text{-Fe}_2\text{O}_3$, gamma iron oxide, is a defect spinel which has the magnetic property known as ferrimagnetism. Gamma iron oxide is important mainly for application of its magnetic imaging characteristics in magnetic recording. Heating gamma iron oxide to about 600°C causes permanent transformation to stable alpha iron oxide. Goethite, commonly also called limonite, has the formula $\alpha\text{-FeOOH}$ and is the basic compound of both natural (ochres, siennas, and umbers) and synthetic yellow oxides. Ferric oxide monohydrate also occurs in nature, or can be formed chemically, as $\gamma\text{-FeOOH}$, which is known as lepidocrocite. Its greatest significance is that it can be formed as an intermediate in the preparation of magnetic gamma iron oxide. Magnetite, Fe_3O_4 , has inverse spinel structure and, like gamma iron oxide, is ferrimagnetic.

However, to date it has not been as important in magnetic recording applications and is a relatively minor pigment. Both of the ferric oxide hydrates and magnetite can be changed into haematite by heating; calcination of yellow $\alpha\text{-FeOOH}$ is one of the main ways of producing synthetic red iron oxide.

The technical literature contains descriptions of the various oxides, oxyhydroxides, and hydroxides of iron, the relationships between them and the way these relationships can be used in the production of synthetic pigments. A schematic of these relationships for the compounds of main interest to iron oxide pigments is given in Figure 1. The compounds in this diagram can be classified in terms of two series, the alpha series for $\alpha\text{-FeOOH}$ and $\alpha\text{-Fe}_2\text{O}_3$ and the gamma series for $\gamma\text{-FeOOH}$ and $\gamma\text{-Fe}_2\text{O}_3$.

The stability of the compounds relative to one another, and the variety of ways in which $\alpha\text{-Fe}_2\text{O}_3$, haematite, can be produced are indicated in the diagram. Also shown is the possibility of forming pigments beginning with either a ferrous or a ferric salt. This type of diagram is mainly of interest in visualising the natural processes involved during formation of pigment ores.

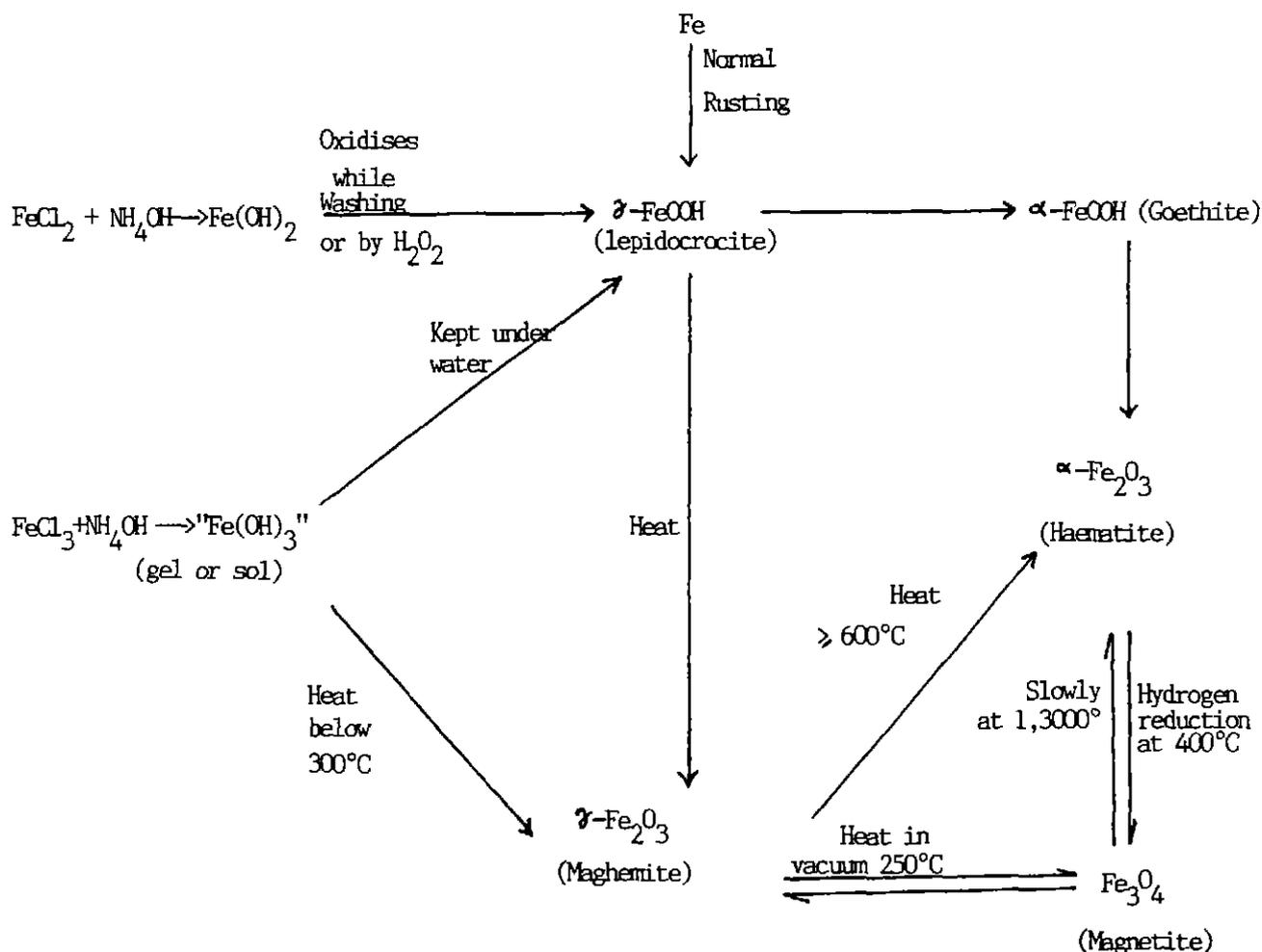


FIGURE 1. Relationships between oxides, oxyhydroxides, and hydroxides of iron.

4B. BACKGROUND - Natural Pigments

Because of the relatively low product prices for natural oxides these products cannot carry a large cost component for transportation of raw materials. Therefore, milling operations are located close to mines for natural pigment, and additional crude sources are sought in the immediate vicinity. On the other hand, crude materials from iron ore mines is shipped considerable distances to existing mills, rather than being ground at plants sited nearby. As freight rates rise, processing and use of foreign natural oxides can be expected to encounter increasing competition from synthetic iron oxides. The Savage Resources goethite is however unique, and of a much higher quality once concentrated, than natural ochres.

Blending is a secondary operation carried out both by crude processors and by other firms handling only finished pigments. In blending, pigments, and perhaps additives, are combined to achieve a particular shade or physical property. Blends may be mixtures of wholly natural or synthetic pigments or mixtures of two kinds of pigments. For example, a small amount of synthetic oxide may be blended with predominantly natural oxide to obtain an acceptable product or brighter shade. Blending is used to manufacture synthetic brown pigments from mixtures of synthetic reds, yellow, and blacks. Some blends are rather complex with as many as a dozen constituents, none of which is dominant in the mixture.

Two classes of mines can be distinguished as sources of crude ore for pigment production, "iron ore mines" and "pigment mines". Iron ore mines are mines operated primarily to produce ore for smelting in the blast furnace. A small amount of the production of these mines may be given additional beneficiation to produce pigment raw material. Although the amount additionally beneficiated is small in comparison to total mine output, this amount constitutes the majority of U.S. crude ore production for pigments. Most of the crude obtained as a co-product of iron ore mining is red oxide, haematite. Pigment mines are mines operated solely to produce crude for pigment production; the

the character of this ore makes it suitable, or at best uneconomic, for iron smelting. Production from pigment mines has tended to be a relatively stable but lesser part of overall crude pigment production.

The most notable features of crude pigment mining are that mining is very selective, even to the use of pick-and-shovel methods in pigment mines.

Goethite, ochre or ocher is still beneficiated by methods much like those described in detail years ago. Ore dumped at the top of an incline is disintegrated into a slurry by water spray. The slurry flows down into a log washer for removal of coarse sand and rock particles. Further removal of clay and sand particles occurs as the slurry passes successively through a separator tank and a Dorr bowl rake. The ochre leaving the rake as an overflow goes to a settling tank, from which it is withdrawn at a controlled solids content. The slurry is dried by being spattered by an agitator onto a slowly rotating steam-heated drum; the speed of the drum is regulated so that drying is complete in less than one drum revolution. Product is removed by a knife edge located on the side of the drum opposite that where fresh slurry is being added.

The size reduction of natural iron oxide pigments involves pulverising and classifying to eliminate agglomerates rather than shattering and crushing to small average particle sizes. Lump ore may be crushed in a hammer mill. As desired or necessary, the resulting powder can be dried or calcined, generally in a rotary kiln. Steam heat can be used to dry ochre, sienna, and umber without producing dehydration and colour change; higher temperature calcining yields burnt umber but is not applied to ochre.

The several kinds of grinding units in use can be distinguished on the basis of operating principle. One of the older units is the Raymond ring-roller mill in which pigment agglomerates are broken down through the crushing action of a roller rotating against a ring. Classification of the product may take place

Process

through the action of a "whizzer" mounted in closed circuit on top of the mill. More recently developed grinding units are high-speed hammer and rotor mills and fluid-energy mills. A hammer mill reduces size by impact of pigment particles with very rapidly moving hammers within a confined circular space, followed by integral air classification. Fluid-energy mills use steam or compressed air to generate an autogenous grinding action by impact of pigment particles with each other as they travel at high speed about a circular path, with classification occurring as a consequence of machine design. Introduction of fluid energy mills has led to the use of the terms "micronising" or "jet milling", one of the main advantages of which is reduction in the number of larger particle agglomerates.

Grinding alone or in combination with calcination may be enough to produce finished pigment containing only one component. In this case, ground material can go directly to a bagging unit, generally automatic. However, intermediate storage and handling steps are required if blending is to be done. Ribbon blenders are commonly used to make mixtures; these mixtures may be passed through a small centrifugal mill to break up any lumps formed during blending, and then the mix can be bagged. In the natural state, the iron colouring agent in these pigments is hydrated ferric oxide, limonite, which tends to give a yellow to brown colour. Heating a limonitic material sufficiently will produce a colour change as water of hydration is driven off and limonite is converted to haematite (red). Therefore, drying these natural ores must be controlled, usually to temperatures below 115°C, if colour change is to be prevented. On the other hand, ores can be calcined deliberately to produce darker shades. Ochre is prized for its natural yellow colour and is not heated other than for drying. However, the option of calcining results in there being two main types of sienna and umber. The term "raw" is used to designate material that has not been heated other than for drying, and the term "burnt" signifies material that has been calcined to produce a colour change.

As stated, the dividing line between ochre and sienna is not sharp. General practice is to associate "ochre" with the light shades of ores, which are also lower in iron; siennas are usually darker and higher in iron. Siennas may also contain some manganese, because of their tendency to be associated with umber deposits. To illustrate, the iron oxide content (Fe_2O_3) in a selection of pigments sold was 20% to 57% for ochre, 35% to 73% for raw sienna, and 23% to 58% for raw umber; the manganese oxide (MnO_2) in raw umber ranged from 6% to 25%.

Micaceous iron oxide is another natural form of iron oxide used as a pigment. As suggested by the name, this material is a flaky haematite whose platelike nature is physically similar to that of mica. Chemical similarity does not exist, and micaceous iron oxide does not contain mica. The particle form in micaceous iron oxide appear to give exceptional resistance to weathering. The oxide therefore finds use in coatings for surface protection, and it has been so employed for many years, as in painting the Sydney Harbour Bridge. However, the predominant use of deposits of micaceous iron oxide has been as ore for iron and steel production, and little, if any, has been used in pigments.

4C. BACKGROUND - Synthetic Iron Oxide Pigments

The description synthetic is a misnomer, which was coined before organic polymers became commonplace. These iron oxides are in fact chemically produced iron oxides.

As evident from the foregoing, the methods used to produce natural iron oxide pigments can all be considered "dry" methods. Processing steps for natural pigments serve to produce the desired physical characteristics in dry solids, and chemical solutions are not involved. The sense in which "dry" is being used here includes calcination, a step which is used also to produce synthetic oxides from dry chemicals. However, the majority of synthetic oxides are produced basically by manipulating chemical solutions, suspensions, or slurries; and the term "wet process" can be used to refer to synthetic oxides made in this way. In considering synthetic oxides, it is well to recall that their colour depends on the oxide formed, by whatever process or sequence of steps; haematite, ferric oxide, $\alpha\text{-Fe}_2\text{O}_3$, is red; goethite, hydrated ferric oxide, $\alpha\text{-Fe}_2\text{O}_3\cdot\text{H}_2\text{O}$, is yellow; and magnetite, Fe_3O_4 , is black.

Thermal Decomposition (Dry Process)

Iron oxide can be produced from a number of iron salts by heating them sufficiently in air. This procedure converts iron carbonate in siderite ore into haematite; this is one of the older methods of producing iron oxide (so called metallic brown) from natural materials. Oxide thus produced from siderite and other natural materials, such as pyrite, is classed as natural oxide because of the origin of the starting material. On the other hand, oxide produced by calcination of iron salts is regarded as synthetic.

Iron oxide has been produced this way for many years from iron sulphate. The iron sulphate commonly used is the heptahydrate of ferrous sulphate, $\text{FeSO}_4\cdot 7\text{H}_2\text{O}$, copperas, and the oxide so produced is referred to as copperas red. A two-step process

has been developed for calcination, in which the heptahydrate is first dehydrated to the monohydrate and then decomposed at temperatures in excess of 600°C to the oxide. This process can be conducted so that the sulphurous offgases can be used to generate sulphuric acid; the sulphuric acid is reacted with scrap iron to produce, with subsequent processing, more copperas. Oxide particles produced by calcining copperas have a spheroidal shape.

Venetian red is a pigment obtained by methods similar to those used for copperas red, a major difference being inclusion of a lime compound in the furnace charge. This effectively introduces calcium oxide into the system and causes the product to contain calcium sulphate (gypsum) as well as iron oxide. The calcium sulphate forms by reaction between calcium oxide and sulphur-containing gases generated by decomposition of the copperas. While Venetian red has been produced for many years, today its production is quite small in comparison with that of other synthetic red oxides.

Ferrite tans constitute another type of iron oxide pigment that is obtained by forming a compound between iron oxide and another oxide. The second oxide may be either magnesium or zinc oxide and is typically reacted at an elevated temperature with ferric oxide hydrate. This procedure can be considered as a dry method and is similar to methods often followed in making ferrites for magnetic applications. In the case of ferrite tans, reaction between the two component oxides is expedited by including a small amount of magnesium or zinc chloride, respectively, in the starting mixture as a reaction catalyst. The advantage of the ferrite tans, which are nonmagnetic, is that they provide a pigment with yellow shading that is heat stable.

Thermal decomposition methods are used also to prepare small quantities of high-purity iron oxide, generally as Fe_2O_3 . Such oxide is made mainly for chemical rather than for pigment purposes; one of its uses is in preparation of specialty ferrites. Oxide is obtained by first preparing a highly pure form of an only moderately stable compound, which is then heated to yield iron oxide. For example, chemical-grade iron carbonate

is readily decomposed into iron oxide and gaseous carbon dioxide.

However, what we are basically describing in this section is the so-called solution method or wet process or chemically precipitated.

The solution methods most generally used in the domestic production of synthetic iron oxides trace their origin to procedures disclosed by R. Penniman and N. Zoph beginning in 1920. The use of their approach and subsequent modifications thereof is commonly referred to as the Penniman-Zoph process. Alternations and variations of the original technology have made possible controlled production of oxides differing in colour and physical specifications.

the 1960 patent by Martin reviews the ten existing state of the art. Also, at about the same date the diverse oxides and hydroxides of iron and methods by which they can be produced synthetically were described in a German article. General features of the various synthetic processes can be obtained from the patent and technical literature. However, a thorough presentation of process chemistry and engineering does not appear to be available; this sort of information is looked upon as proprietary by producers.

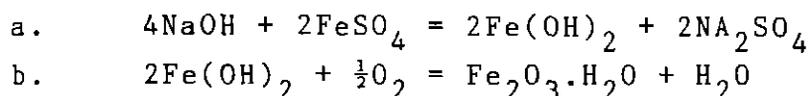
The Penniman-Zoph process can be thought of as pigment production through the controlled rusting of iron. Iron in the form of scrap is reacted with a solution from which iron is simultaneously precipitated as iron oxide. Also, by methods developed later, it is feasible to produce pigment by similar chemistry but without the need for scrap iron. In commercial practice, both kinds of processing, with and without the use of scrap iron, are employed. As generally carried out, the Penniman-Zoph process is a two-step operation. In the first step, a seed solution is prepared by precipitating fine nuclei of ferrous hydroxide. Common practice for preparing this precipitate is to add an alkali such as sodium hydroxide to a ferrous sulphate solution. The ferrous sulphate solution can be obtained by making an aqueous solution of the same chemical, copperas, which can be calcined to iron oxide by dry methodology. Air injected into the seed solution oxidises the nuclei to ferric

oxide hydroxide, γ -FeOOH or α -Fe₂O₃.H₂O, synthetic goethite. The process then passes to a continuous growth phase, in which the seed solution or a portion of it is added to a reactor containing a ferrous sulphate solution in contact with scrap iron. Circulation of the solution over the scrap iron along with air injection causes iron to pass into solution at the same time that iron oxide is depositing out of solution onto the growing nuclei. Product is obtained by filtering the solution and washing the recovered precipitate.

The process described produces a yellow iron oxide whose particles are acicular or needlelike. At the same time of the initial particle formation, the solution has a bluish-green colour. As growth continues, this changes into yellow-brown which gradually deepens with the development of reddish shades. How long the operation is carried out depends on what shade is desired. Some shades may be produced in a few days; in other instances the run may last for several weeks. Even so, the average particle size of the product remains quite small, generally less than 1 micrometer. The reaction is usually carried out in large cylindrical tanks. Construction and design of the tanks vary, as does the method of placing the scrap iron. The scrap iron used is clean low-carbon steel with high surface area, such as punchings and trimmings.

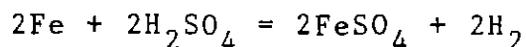
The chemical reactions taking place can be written as follows:

Nucleus or seed formation:

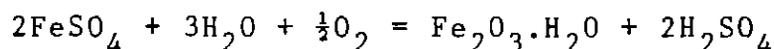


Growth:

a. Solution of iron:



b. Precipitation onto seed:



The course of the reactions and nature of product depend on a number of variables, including rate of circulation of the solution, manner and quantity of oxygen injection, type of precipitant, temperature, iron quality and quantity, acidity, amount and character of seed particles, and presence of other ions in solution, either accidentally or from deliberate addition. Zinc and aluminium salts are prominent among additives that have been recommended for controlling the character of the product.

An important variation of the process is elimination of use of metallic iron, which can be accomplished by careful control of precipitation conditions, including through use of gaseous ammonia. Also it is possible to use iron solutions other than those of the sulphate. An example is the use of ferrous chloride solution, as described in a recent patent.

In this instance, conditions are maintained such that during both seed formation and grown stages the iron compound formed is synthetic lepidocrocite, γ -FeOOH.

As with its natural counterpart, synthetic yellow iron oxide can be heated and its water of hydration driven off, thus yielding red oxide, α -Fe₂O₃. This is an important way of producing synthetic red iron oxide. This introduces another consideration into control of preparation of synthetic yellow, because procedures depend on whether the process is being used to prepare yellow oxide as final product or yellow that is to be calcined to red. Red oxide produced by dehydrating yellow retains the needlelike shape of the yellow, and this gives properties differing from those of spheroidal copperas red.

Precipitation methods can be used to prepare red, black, and brown pigments directly, by careful control of factors such as temperature and extent of reaction. Black oxides can also be produced from red and vice versa. Hydrogen reduction of red haematite can be used to make black magnetite; conversely, calcination of magnetite will yield red iron oxide. Although brown oxide can be made directly, the more usual procedure is to blend a mixture of red, yellow and black.

An important brown iron oxide produced for its magnetic rather than its colouring properties is gamma iron oxide, $\gamma\text{-Fe}_2\text{O}_3$. Gamma iron oxide has a spinel type of crystal structure and is widely used in magnetic recording applications. This oxide can be considered a derivative of the synthetic yellow iron oxide industry and is usually produced by the following sequence of steps:

- (1) Production of synthetic yellow, $\alpha\text{-Fe}_2\text{O}_3\cdot\text{H}_2\text{O}$;
- (2) Dehydration of yellow to red, $\alpha\text{-Fe}_2\text{O}_3$;
- (3) Reduction to magnetite Fe_3O_4 ;
- (4) Oxidation to gamma iron oxide.

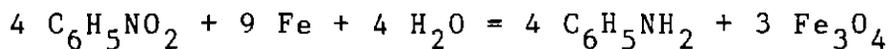
This sequence produces magnetic particles whose shape and physical properties are both desirable. The synthetic yellow oxide produced as starting material in step 1 has an acicular shape with a high ratio of length to width, and this particle geometry is retained throughout the balance of processing. In step 2 water is removed to give temperature-stable ferric oxide. In alpha form, however, the oxide is nonmagnetic (antiferromagnetic). Reduction with hydrogen, step 3, produces magnetite, which has a spinel lattice and itself finds use in magnetic applications although it is deficient in chemical stability. In step 4, oxidation is conducted so as to preserve the spinel structure of magnetite; the end result is an oxide with desirable magnetic characteristics and good stability. Gamma iron oxide is unstable with respect to alpha iron oxide, and heating to about 600°C can cause a permanent reversion to the alpha form.

Precipitation techniques can be controlled so as to produce "transparent" iron oxides. These oxides derive their insignificant hiding power from very fine particle size, measured in hundredths of a micrometer, or an order of magnitude finer in size than ordinary synthetic oxides. Transparent oxides can be produced in yellow, red, and intermediate shades. They constitute a relatively small portion of total synthetic production; the chief applications are automotive finishes and plastics used in vinyl upholstery.

4D. BACKGROUND - The so-called Bayer process - Aniline Procedure

Because Bayer synthetic iron oxide pigments are often referred to as the quality standard for iron oxide pigments, and the fact that the Bayer synthetic iron oxide pigments dominate the market in Australia, we include a description of this process as background..

Until the startup of the Bayer plant in U.S.A. in November of 1970, the Aniline process was unique to Bayer in Germany, where it has been employed for many years as the main method used by Bayer, a major maker of synthetic pigments. The process entails reduction of an aromatic nitro compound to an amine in the presence of iron and acid. The reaction, known as Béchamp reduction, when applied to production of aniline from nitro benzene is nominally



While this reaction was originally utilised to manufacture aniline, the process can be conducted so that byproduct oxide sludge yields valuable pigments.

The technology for making pigments by the aniline process was developed by I.G. Farbenindustrie AG not many years after the Penniman-Zoph process was introduced in the United States. The aniline process is practiced at Uerdingen in North Rhine-Westphalia, West Germany, by Bayer AG, a successor of I.G. Farbenindustrie, and accounts for most of Bayer's large output of synthetic pigments. Iron chips of controlled size are used; they may be of cast iron. To produce yellow pigments, the reaction is carried out in the presence of aluminium chloride; ferrous chloride is added when black pigments are desired. Red pigments may be obtained by calcining either yellow or black products.

The technology is that used by Bayer, West Germany, for the preparation of their yellow grade (goethite). Such yellow oxides are produced by iron reduction of nitrobenzene to aniline using aluminium chloride (AlCl_3) and an excess of nitrobenzene. AlCl_3 was produced by circulating hydrochloric acid over clay containing 17% to 20% aluminium to give an AlCl_3 with a specific

gravity of 1.26, an aluminium content of 7%, and 0.5% free and 28.5% combined hydrochloric acid. Nitrobenzene is water-containing nitrobenzene from the aniline-producing plant or aniline-containing nitrobenzene from washing. Aniline water, the other liquid raw material, was water remaining from steam distillation of aniline and contained 3% to 4% aniline.

Iron used in manufacture of yellow 415 was medium-ground cast iron powder with an iron content of 96% and a specific gravity of about 7.0. This powder is prepared by screening and grinding cast iron chips so as to produce a size fraction of material failing in the 0.6- to 1.75-mm size range, which corresponds to about minus 12 plus 30 mesh (US Series).

The equipment and procedure used in goethite manufacture is as follows:

Twelve autoclaves of 20 cubic meters capacity are available for the reduction process. They are lined with acid-proof brick, have a 3-arm agitator (of 12 percent Si steel), and the following inlets at the top: manhole, distillate outlet, nitrobenzene inlet, return flow pipe, metallic iron screw feed, sampling tube, oil discharge pipe, and steam inlet. Automatic weighing and measuring devices are provided for all raw materials. The iron is fed by a worn screw with interchanging gears so that the rate of feed may be controlled. As aniline is formed, it distils and is condensed on a cooler with a surface of 60 to 100 square meters. The proper safety devices such as bleeding pipes, overflow pipes etc., are connected to the vessel.

The sequence of additions of chemicals to produce Bayer yellows is as follows: First, 1,980 litres of water and 1,763 litres of $AlCl_3$ solution are heated in a separate vessel and pumped into the autoclave simultaneously with the introduction of 5,000kg nitrobenzene. Then add 5,300kg of medium ground cast iron over a period of 10-12 hours. The aniline starts distilling after 2-3 hours, and the agitator, at 35 RPM, shows an increase in power consumption

to 85-90 amperes after 6-8 hours. This power consumption is maintained for the full period of 10-12 hours by admitting 3,500-4,000 litres of aniline water. The resulting aniline is pumped to the neutralising tank of 15 cubic meter capacity where the aniline oil separates from the aniline water. Here, after 24 hours the water is drained off and the oil distilled for 9 hours in the usual commercial manner. The residue of iron oxide and liquid is steamed for 6-8 hours, and the autoclave filled with water. It is then forced by 3-atmosphere air to the iron oxide refining plant...

In the refining plant, aniline process oxides are purified, dried, and pulverised. Purifying consisted of removing any remaining metallic iron and washing free of salts. Removal of metallic iron took place in a "spitzkessel", a narrow brick-lined cylindrical iron tank provided with a conical bottom having a volume of 65 cubic meters and equipped with an arm agitator to which hanging chains are attached. At a gravity of 40° to 50° Baumé (Bé), iron oxide paste from aniline production is run into the tank, diluted with water to 15° to 20° Bé, and agitated. After stirring has stopped, iron is allowed to settle and is drawn off at the bottom, a process that is repeated several times.

Because of the slow settling properties of yellow oxides they are washed by means of a system of Dorr thickeners. The pigment slurry in the "spitzkessel" is diluted to about 10° Bé and pumped through a rake classifier for removal of oversize and foreign matter. From there the slurry is passed to a hydroseparator where water is added to give a 5° Be paste. The hydroseparator overflows to the first of three Dorr thickeners, which produces a 15° to 20° Bé slurry which is pumped to a second thickener. This process is continued through a third thickener, additional water being added in agitated tanks at each stage in amounts regulated so as to produce a maximum chloride content of 0.01% to 0.02% in the final product.

Collection and drying of the aniline yellows includes a brightening process involving heating to 160° to 180° without which the product would be coloured a dirty greenish yellow. Slurry from the thickeners is pumped to a rotating filter to give a filter cake containing 40% to 50% water, which is conveyed by screw feed to an inclined revolving heating drum. The drum is fitted with a gas burner at the charging end and operated so as to produce an outlet temperature of 160° to 180°C. Filter cake, flowing concurrently with hot combustion gases is crushed in the centre of the drum by steel balls held in place by a grid across the diameter. Dried yellow product is finally screened, disintegrated, blended where necessary, and packed, or calcined to produce other colours.

4E. BACKGROUND - General Comments

It can be readily appreciated that in developing our technologies for the processing of the Savage Resources goethite, we have drawn our knowledge of the industry at large and the current production practices.

The reason for our confidence vis a vis our ability to compete on a cost basis is abundantly clear.

It must also be obvious that blending is the key to quality control, and that one will use both in-house and purchased pigments to achieve consistency and a wide range of colours and qualities.

Man's use of mineral earths containing iron for colouring purposes predates written records. Mining of haematites for use as a pigment was carried out in Swaziland in South Africa over 40,000 years ago. Caves at Les Eyzies in south-central France contain 20,000 year old paintings by prehistoric man who used earth materials to make red, yellow, and black colours. In the United States, Indians of the Southwest used ochres and similar pigments in ancient times. Until the late 19th century iron oxide pigments were obtained wholly from natural materials, generally with little alteration other than physical purification. In some cases roasting or calcination was also carried out. However, it took the modern trendy to establish the market for high quality, high cost iron oxide pigments.

And now for the clincher.

Iron oxides are usually produced in batch or intermittent fashion although the processing and milling of natural oxide could be carried out continuously. Milling can be readily started and stopped, and therefore can be done conveniently on a single-shift basis. However, calcining and carrying out wet-process methods require a prolonged period of continuous operation. Also, energy inputs for heating are needed for both of these operations. Therefore, it is desirable to conduct calcining and synthetic oxide manufacture for extended periods, or else

to shut the plant down, rather to run on a stop-and-start basis.

As with many other industries, iron oxide producers have had to take steps in recent years to limit air and water pollution. Problems with pollution have been least for dry operations such as grinding of natural oxide. For the natural oxides, relatively simple equipment suffices to keep airborne emissions within acceptable amounts. However, care and some expense are also involved in avoiding pollution of adjoining waterways by runoff from mill property. More extensive facilities are required to cope with potential water pollution from wet-process production of synthetic oxides. This technology requires handling of acid solutions containing solid fine particles. Meeting environmental standards has meant extra expense for installation of water treatment facilities mainly designed to control suspended solids and iron levels in effluent.

When we want feed, we simply mine it. Our mining can be carried out on a contract basis. Our effluent may be disposed of into an existing facility. We receive our mined feed at low cost, and dispose of our effluent at low cost.

5. THE MANUFACTURE OF IRON OXIDE PIGMENTS FROM SAVAGE RESOURCES GOETHITES

In order to fully appreciate this segment of the report, the reader must have studied Section 4.

Our technology for producing high grade pigments from Savage Resources goethite relies on a number of observed factors:

1. The goethite exists mainly in the form of finely divided clusters.
2. The goethite clusters are reasonably discrete and readily separated from the sands etc., and are fine <5 microns.
3. There is a marked particle size difference between the goethite and the sands (gangue). *once to suggest, as large crystals of yellow colour.*
4. The goethite can be easily reduced to magnetite and separated from the sands, talc etc., by magnetic separation.

NOTE: Account has been taken of the technical and general processing suggestions put forward by Messrs Bob Annett, Colin Graham and Henry in this section. While we include their contributions, we do not specifically identify them in the text, the only credit given, being this general acknowledgement. Their contributions have been significant to date, and we have no doubt that they will be in the future.

THE PROCESS

The main objectives of the process are clear, to separate the goethite from the other constituents, and to produce the various shades of iron oxide pigments from this goethite. There are a number of ways of achieving this. We shall however, handle the subject in the following manner.



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Firstly we shall report what has been achieved to date. Then we shall discuss the potential process alternatives.

In the initial work the procedure was as follows:

1. Wash, screen, size, wash grind. *dy ELABORATE!
yellow.*
2. Reduce the goethite to magnetite.
3. Magnetically separate the magnetite from the non-magnetic fractions.
4. Re-oxidise to produce the other colours. *red brown.*

NOTE: We have produced acceptable cement grades without magnetic separation, and good reds directly from the goethite.

The magnetic separation stage should therefore be seen as an upgrading option.

THE FUNDAMENTALS

As much gangue as possible must be washed from the goethite before milling.

This results in a much cleaner final pigment with good tinctorial strength (pigment properties).

As no pilot plant work of any description has been carried out, this plant must be seen as a pilot facility, and designed to allow for processing options.

The best method of analysing the process is possibly to describe the different functions and the reasons for them, and then to describe the finer points.

PLANT 1

Goethite. Concentrator and yellow iron oxide pigment plant. 5,000 TPA pigment at 50% recovery. New and secondhand equipment costing plus 50% for location allowance.

Front-end loader \$100,000.

The feed from the ore dump is run through a roller crusher which has a spring loaded ilder ^{idler?} roll. (\$20,000). The fragmented material is fed through a rotary washer, and the plus (25) mesh material is discarded. The -25 mesh product is agitated with a blade impeller in a 150,000L steady head and cycloned, with the coarse material going to waste. \$25,000 plus \$5,000.

The fines are fed to a ball mill 3,000 TPA, open circuit and milled for a residence time of about 15 minutes. The mill is open circuit, multi-cycloned, with the coarse fraction from the 3rd cycloning going to waste. *what size?*

The fines are acid washed in 1% HCl for about 15 minutes, and centrifuged and rinsed with water; i.e. 6 rinses. \$350,000.

The rinsed material is dried at below 105°C. \$10,000, dry milled and screened \$80,000, and stored in hoppers for blending \$35,000.

(note that 25 mesh is achieved by washing with sample)

600 mesh

to what size?

211

The material is now blended and bagged. \$40,000.

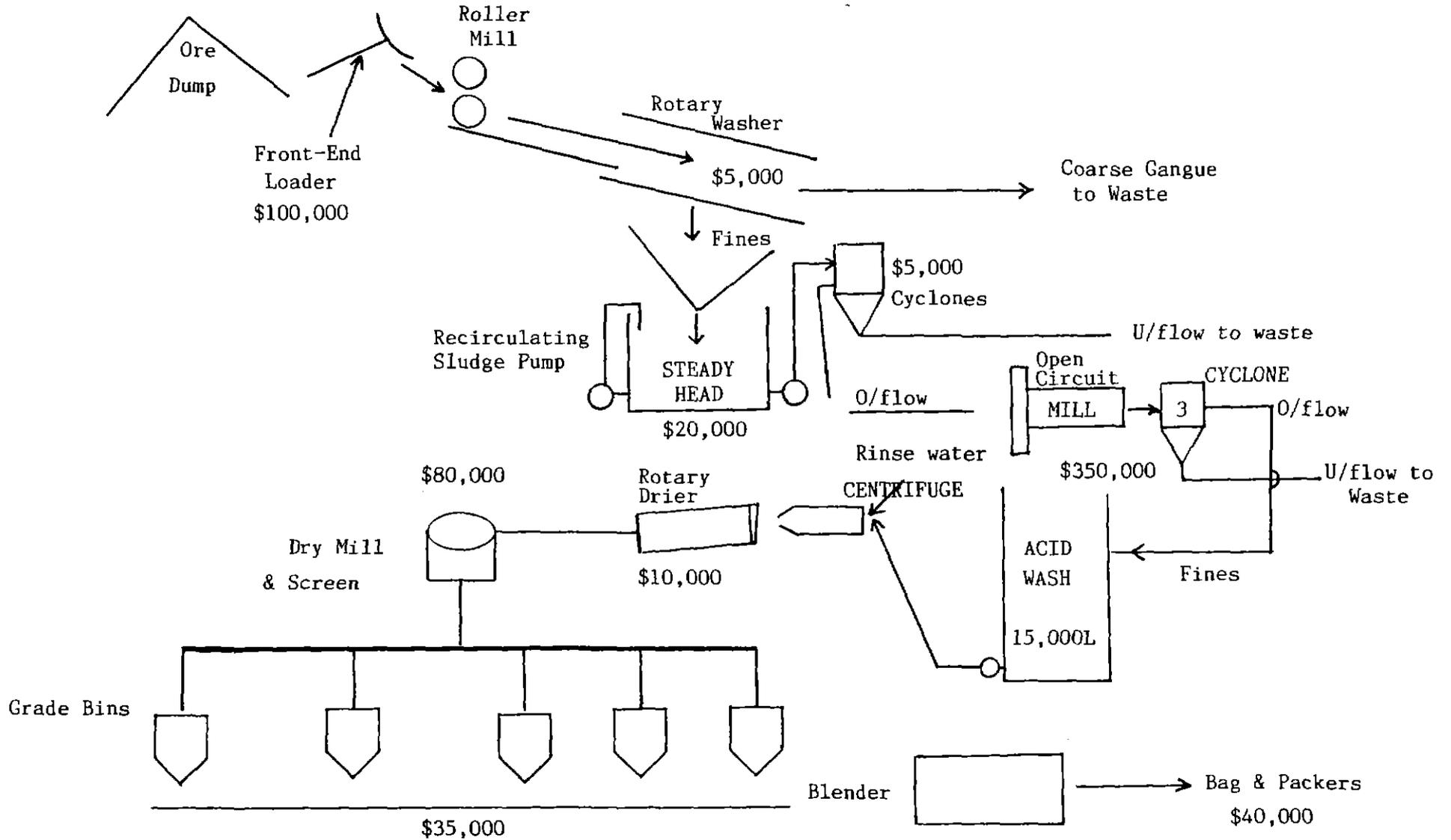
The total capital cost should not exceed \$765,000 which includes an allowance of \$100,000 for sheds and fencing.

It is anticipated that a house will be leased to serve as an office etc..

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PLANT 1

GOETHITE CONCENTRATOR & YELLOW IRON OXIDE PIGMENT PLANT - 5,000 TPA



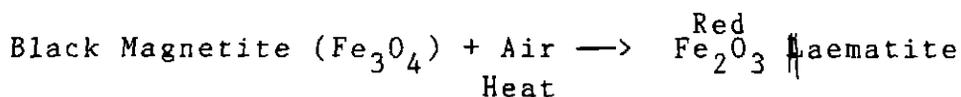
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PLANT 2. REDS, BROWNS & BLACKS, i.e. Oxidation & Direct Reduction

The reject yellow pigment (i.e.^(a) that material that is outside the blending range,^(b) is too coarse, or^(c) contains excessive gangue) is sent to the red and black plant.

We have two options in this plant, i.e. if gangue is excessive, first reduce to magnetite, then magnetically separate, and then produce blacks by drying grinding blending etc., or reds by thermal oxidation to haematite



As the gangue case is the most costly option, and the more complex, we shall proceed on this basis.

The yellow pigment is directly reduced in a rotary kiln to magnetite. (See direct reduction section). \$250,000. This material is then water quenched and magnetically separated from the gangue. \$50,000. The magnetite is centrifuged, dried, ground, screened, blended and bagged. \$150,000 + \$250,000.

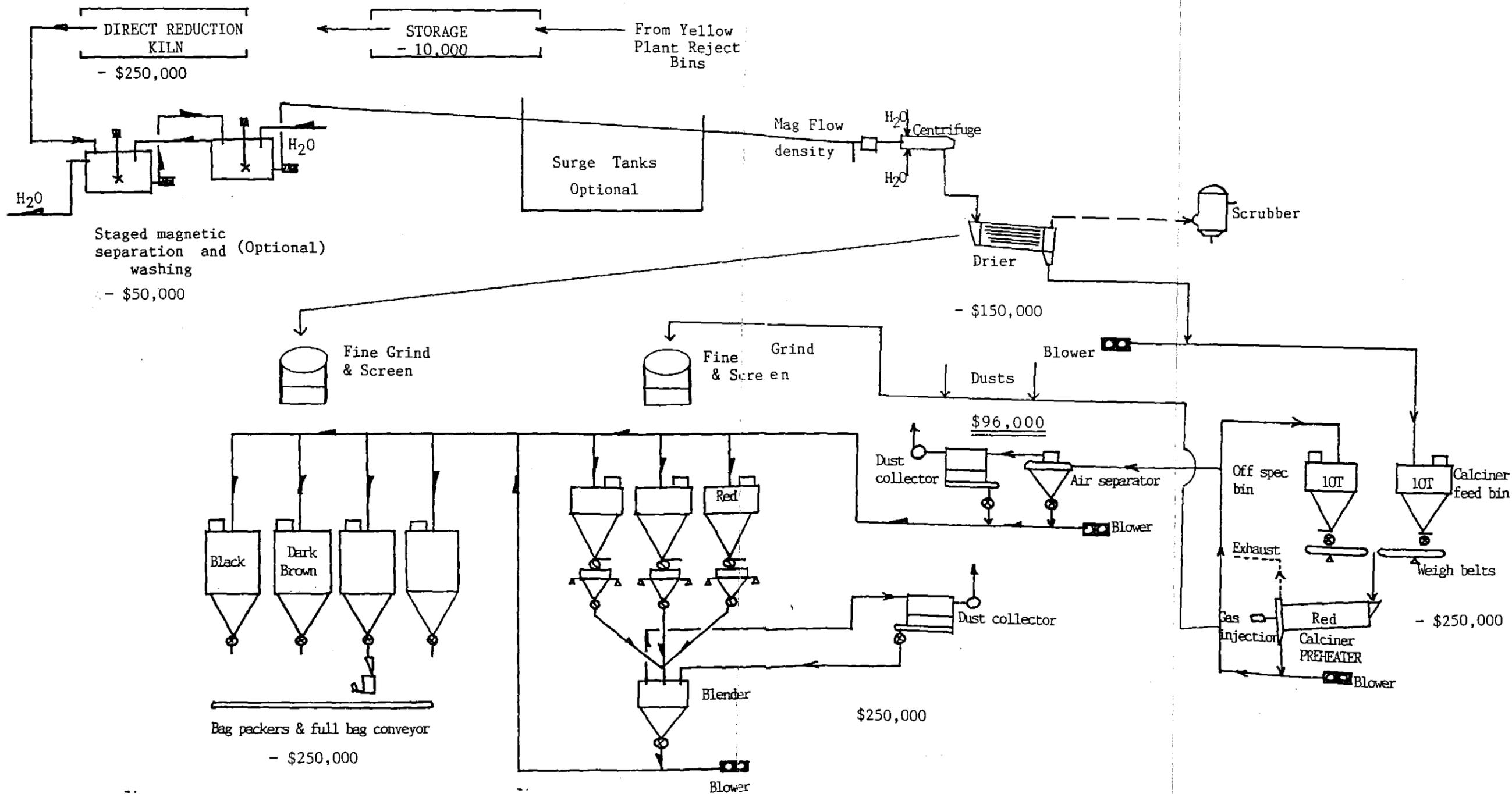
The magnetite may be calcined to produce reds. \$250,000 and ground etc. \$250,000.

If the reject yellow material does not contain gangue, then the yellow may be calcined directly to red or black.

In practice we would use one kiln for both red and black pigment production, at a capital cost saving of \$250,000.

The worst case capital would be \$1,406,000 including \$100,000 for sheds and fences.

PLANT 2



The reduction of goethite ($\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$) to magnetite (Fe_3O_4) using natural gas (methane (CH_4)). We assume that in order to separate the goethite from the remainder of the material in the feed, we would need to reduce the goethite to magnetite, i.e. $\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$ to Fe_3O_4 . Further, because of the fine nature of the goethite fraction and the relatively coarse sizing of the other fractions, we decided to use a rotary kiln rather than a fluidised bed. (The feed to the kiln was somewhat sized by elutriation washing, which concentrated the goethite by gravity separation - see elutriation. The feed was also washed free of alkali and dried prior to direct reduction - filtration and washing).

In the direct reduction process we take advantage of the water contained in the goethite to promote the reduction reaction, and cracking of the gas. At elevated temperatures finely divided iron oxide is an excellent cracking catalyst, so there is no need to reform the gas, or add a cracking catalyst. We also make use of the carbon reversion reaction to: (i) maximise the benefits of using natural gas; (ii) carbon coat the iron particles for certain pigment grades. (The black blacks - see marketing report).

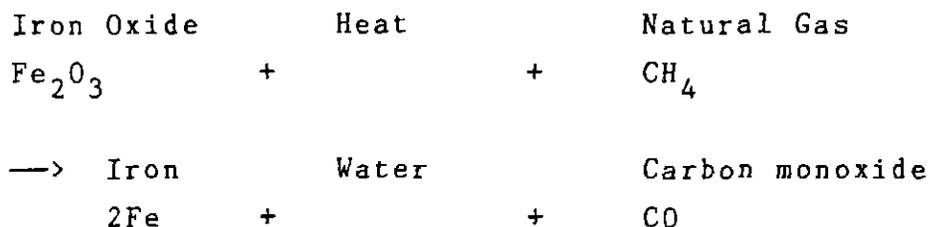
In summary, we are primarily interested in, and will be dealing with three oxides of iron:

Fe_2O_3	- Red	<i>hematite</i>
Fe_3O_4	- Black	<i>magnetite</i>
$\text{FeO}(\text{OH})$	$\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$	- Yellow <i>goethite</i>

and the blends and modifications of these oxides.

A simple explanation

Iron oxide (Fe_2O_3) when heated to elevated temperatures in the presence of natural gas, acts as a catalyst to crack the gas, and is at the same time reduced to a lower oxide or metal.



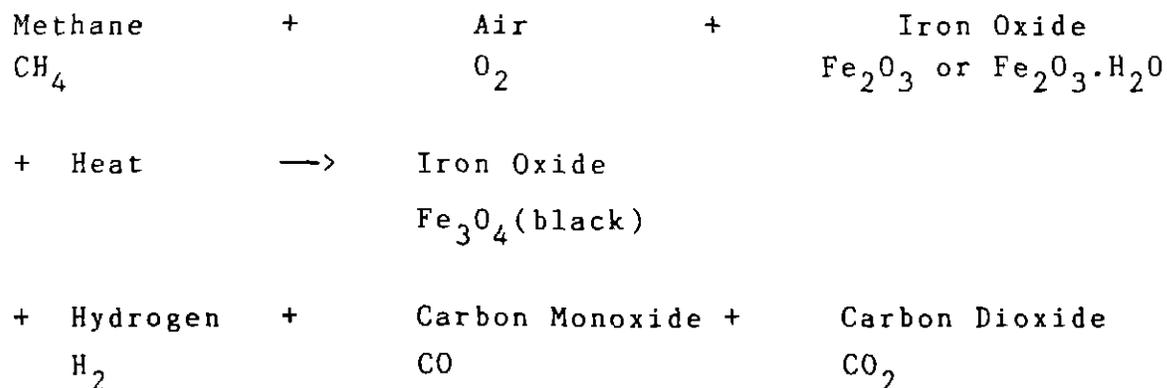
As we only wish to produce the lower oxides, i.e. Fe_3O_4 - magnetite black, we will work at lower temperatures than those used for the production of metal iron Fe. However, the principles and equipment used are one and the same.

The procedure of reducing the oxides of iron with natural gas are known by the common misnomer of direct reduction.

General Description

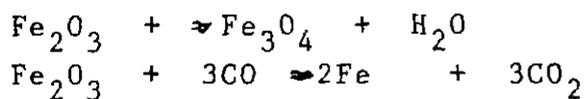
In order to avoid confusion to the non-chemist, some over simplification of the reactions is necessary.

The methane CH_4 at red heat, i.e. $\approx 600^\circ\text{C}$ to 650°C is oxidised by air in the furnace and the iron oxide.

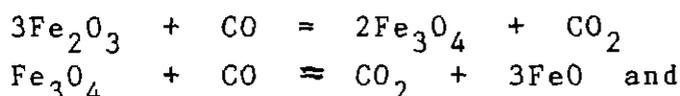


As we are all now expert on the topic, let us list a few more simple iron oxide reduction reactions.

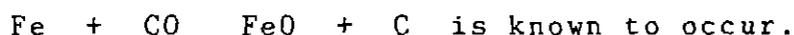
The action commences between 200°C and 500°C



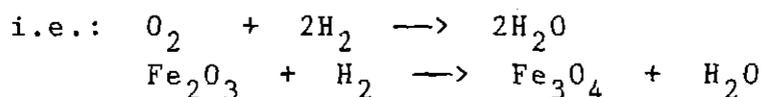
and reduction continues with increasing velocity as the charge presses into the hotter part of the furnace. There appears to be a complex series of side and intermediate reactions:-



below dull redness, the back reaction (carbon reversion reaction)



NOTE: As hydrogen is extremely reactive at elevated temperatures it is immediately consumed (oxidised) on release from the methane.



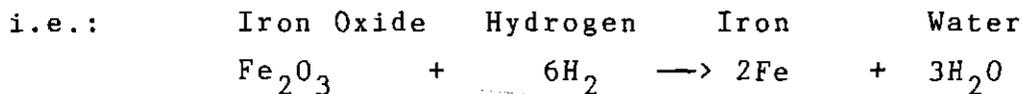
Process Description

In order to appreciate the rationale behind the selection of design of a particular process, it is important that the information is presented.

Regardless of the process, the basics are the same. Natural gas is cracked on the iron oxide, with air and water vapour to form CO, H₂, CO₂ and H₂O.

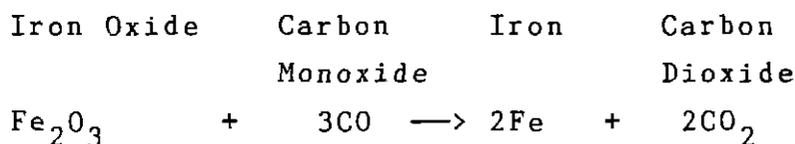
Carbon (C) is oxidised and reduces the iron oxides. Once again air and water vapour assist this reaction.

Natural gas (CH_4) will crack in the presence of hot iron oxide and water vapour to produce reducing gases, i.e. $\text{CH}_4 + \text{H}_2\text{O} = \text{CO} + 3\text{H}_2$, these gases then react with the oxides of iron to form iron metal:

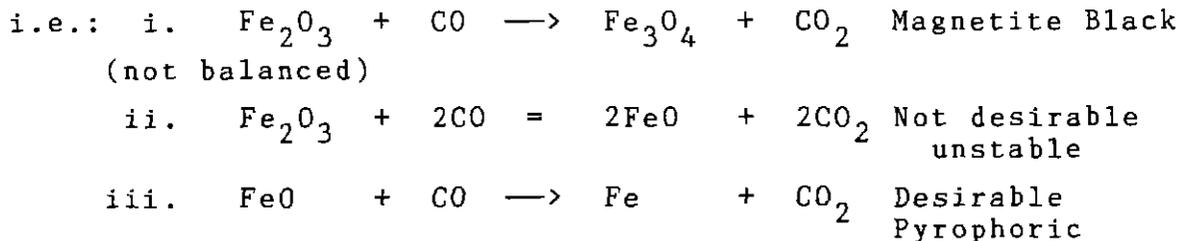


(The only visible pollutant is steam).

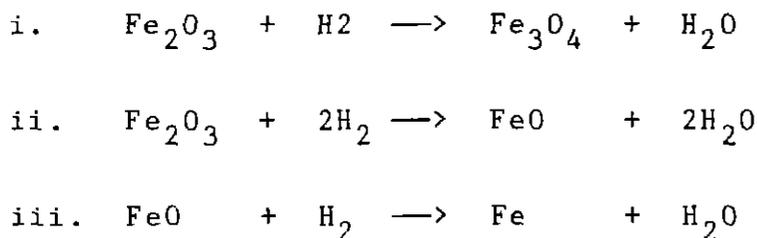
Taking the reaction to Fe, i.e. complete reduction



In reality the reaction proceeds in stages:



and the hydrogen and carbon reactions are occurring at the same time.

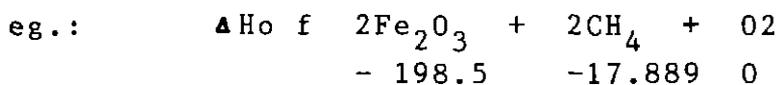


Just to confuse you further, it is important for the record, to advise that the iron oxide reduction reaction occurs in a non-stoichiometric manner, and is in fact much more complex than depicted. The good news is that this is of no consequence as far as we are concerned, and is of academic interest only.

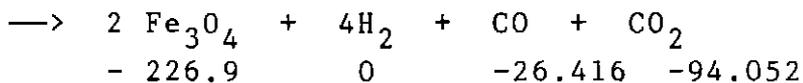
What is important is the fact the the overall reaction is endo-thermic (consumes energy) and that the energy must be paid for.

Because we are running counter current, waste heat is utilised to heat the incoming charge. This saves cash, but complicates the calculation.

Because the calculations are complex, I will not work through them.



$\frac{\text{K cal}}{\text{g mol}}$



per Mol of Fe_3O_4 produced.

$$\begin{aligned} \Delta H_o R &= \frac{1}{2} [2(-226.9) + 440 + (-94.052) + (-26.416)] \\ &= \frac{1}{2} [3(-198.5) + 2(-17.889) + 1 \times 0] \\ &= 28.505 \text{ K cal/Mol } \text{Fe}_3\text{O}_4 \end{aligned}$$

$$= 119.26 \text{ KJ/Mol } \text{Fe}_3\text{O}_4$$

$$\text{No molar mass} = 232 \text{ g/Mol}$$

Therefore 1 tonne Fe_3O_4 has 4.31 K Mols

$$\text{Therefore } \Delta H_o R = 514072.4 \text{ KJ/tonne } \text{Fe}_3\text{O}_4 + 514072.4/\text{tonne } \text{Fe}_3\text{O}_4$$

So much for reducing haematite Fe_2O_3 to magnetite Fe_3O_4 .

The oxidising processes are in practice, as straight forward as the reduction mechanisms.

Magnetite Haematite
Black Iron Oxide + Air Red Iron Oxide



Energy

Because kilns can be heated by either gas or electricity we present both cases.

Before entering the calciner the haematite is heated by gas to 700°C.

$$\begin{aligned} \text{Now } \Delta H &= \int_{298}^{973} cp \, dT \\ &= \int_{298}^{973} \left(24.72 + 0.01604T - \frac{423400}{T^2} \right) dT \\ &= 22580.0 \text{ cal/Mol} \\ &= 94478.5 \text{ J/Mol} \\ &= 95.0 \text{ KJ/Mol} \end{aligned}$$

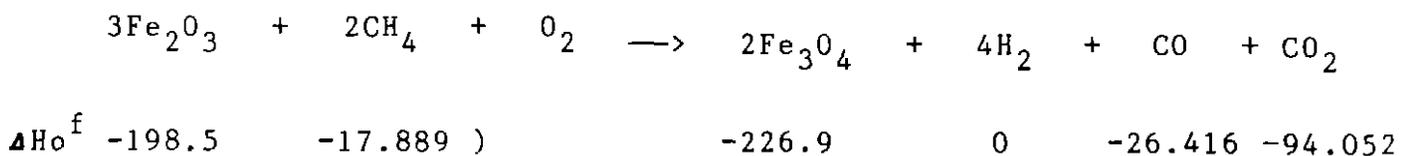
$$\begin{aligned} \text{Hence require } &6.25 \times 1.034 \times 95.0 \times 10^3 \frac{\text{MJ}}{\text{tonne Fe}_3\text{O}_4} \\ &= 613.9 \text{ MJ} \end{aligned}$$

So assuming 50% efficiency in converting from electrical to heat energy

Require

$$\begin{aligned} &1.23 \text{ GJ electricity/tonne Fe}_3\text{O}_4 \\ &1.25 \text{ GJ electricity/tonne Fe}_3\text{O}_4 \end{aligned}$$

Now reduction is endothermic, i.e. takes in heat



kcal
gmol

per mol Fe₃O₄ produced

$$\begin{aligned} H^\circ_R &= \frac{1}{2} [2(-226.9) + 440(-94.052) + (-26.416)] \\ &= \frac{1}{2} [3(-198.5) + 2(-17.889) + 1 \times 0] \end{aligned}$$

$$= 28.505 \text{ Kcal/mol Fe}_3\text{O}_4$$

$$= 119.26 \text{ kJ/Mol Fe}_3\text{O}_4$$

Now molar mass = 232 g/Mol

Therefore in 1 tonne Fe_3O_4 have 4.31 kmols

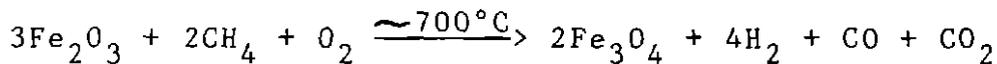
Therefore $\Delta H^\circ_R = 514072.4 \text{ kJ/tonne Fe}_3\text{O}_4$

$$= 514072.4 \text{ kJ/tonne Fe}_3\text{O}_4$$

Once again assume 50% efficient, i.e. require 1.03 GJ/tonne

Calculations:-

1. Magnetite = Fe_3O_4
Molecular weight = 232
Iron content - 72.4%
Hence require 0.724 tonnes of iron to produce 1 tonne of magnetite.
2. Haematite = Fe_2O_3
Molecular weight = 160
Iron content - 70.0%
Hence require $\frac{0.724}{0.700} \times 1$ tonne haematite
= 1.034 tonnes haematite.
3. Balancing the equation:



$$\text{Have to produce 1 tonne Fe}_3\text{O}_4 = \frac{1000}{232} \text{ kmols Fe}_3\text{O}_4$$

$$= 4.310 \text{ kmols Fe}_3\text{O}_4$$

Hence require:

$$\frac{1}{2} \times 4.310 \times 32 \text{ kg/hr of O}_2$$

$$= 68.96 \text{ kg/hr of O}_2$$

$$\text{and } 4.310 \text{ kmols CH}_4$$

Now CH_4 has a calorific value of $802.32 \frac{\text{MJ}}{\text{kmol}}$

$$\text{Therefore require } 802.32 \times 10^{-3} \frac{\text{MJ}}{\text{kmol}} \times 4.310 \text{ kmol}$$

$$= 3.46 \text{ GJ of gas}$$

In practice the energy costs are much higher because of losses due to moisture, waste gases, conduction etc.. In fact, I always apply a factor of 2.5 in any costing.

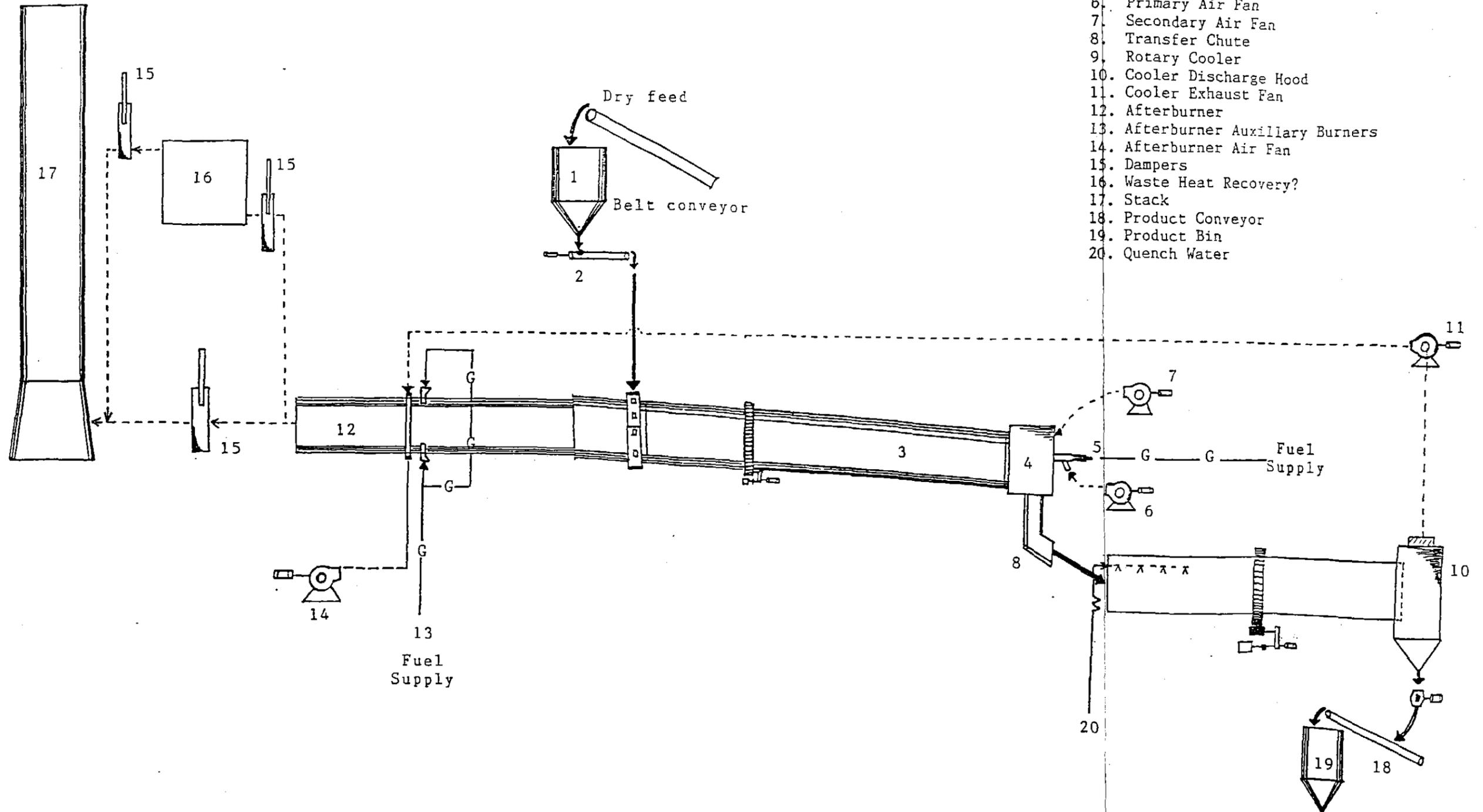
The magnetite produced from Savage Resources goethite ($\text{Fe}_2\text{O}_3 \cdot \text{OH}$) appears to be much more stable than that produced from synthetic goethite, and higher reaction temperatures than predicted from theoretical data must be used, i.e. $\pm 70^\circ\text{C}$ higher. We do not as yet appreciate the reasons for this.

Kilns - Calciners

There are many types of calciners that can be used, and the following represent but a few. The designs can be simple because of the high retention of product in the kiln.

0225

1. Simplified Schematic of Iron Oxide Calcinating Plant



- 1. Kiln Feed Bin
- 2. Weigh Feeder
- 3. Rotary Kiln/wscoop feeders
- 4. Kiln Firing Hood
- 5. Firing system
- 6. Primary Air Fan
- 7. Secondary Air Fan
- 8. Transfer Chute
- 9. Rotary Cooler
- 10. Cooler Discharge Hood
- 11. Cooler Exhaust Fan
- 12. Afterburner
- 13. Afterburner Auxillary Burners
- 14. Afterburner Air Fan
- 15. Dampers
- 16. Waste Heat Recovery?
- 17. Stack
- 18. Product Conveyor
- 19. Product Bin
- 20. Quench Water

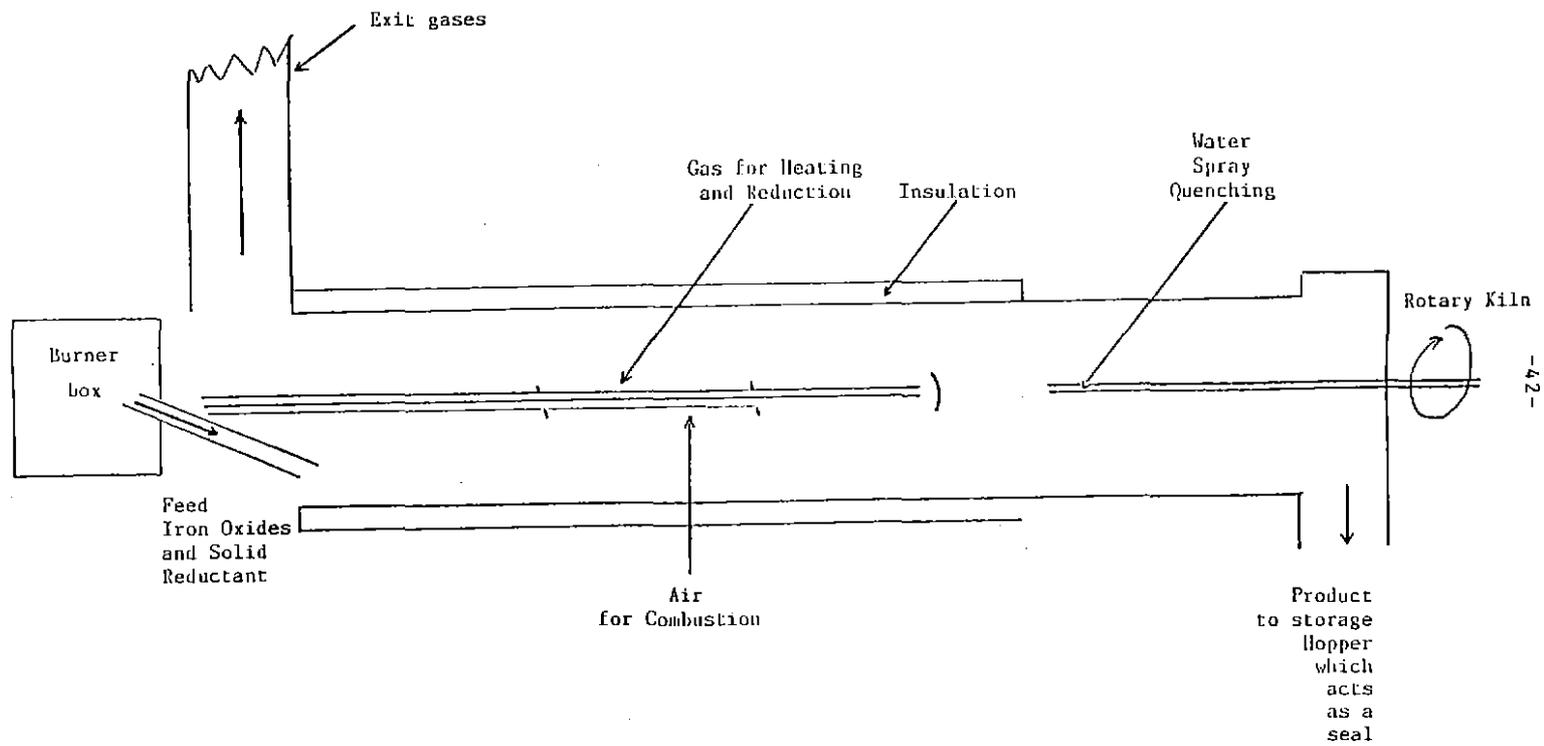


FIGURE: 2

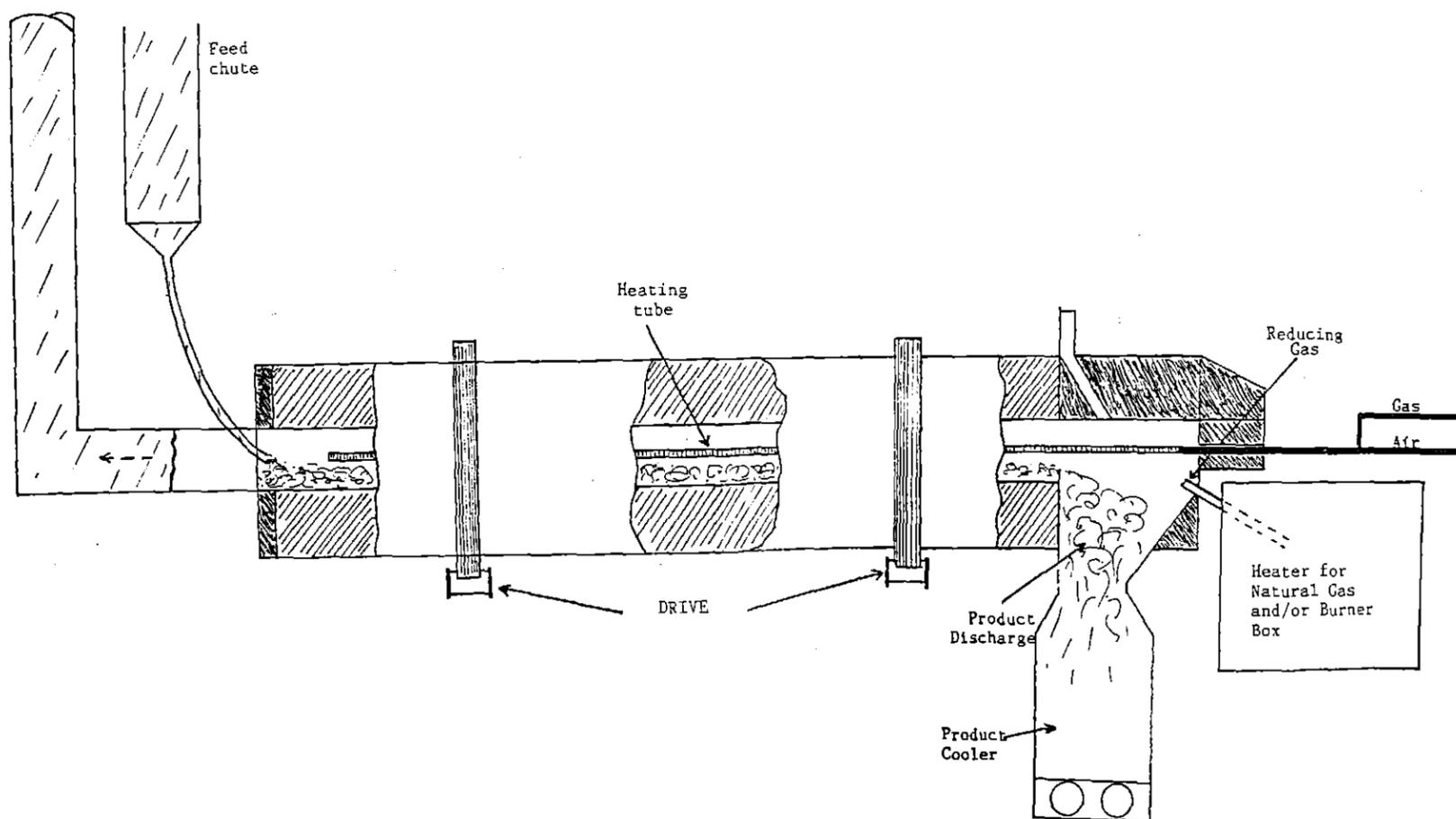
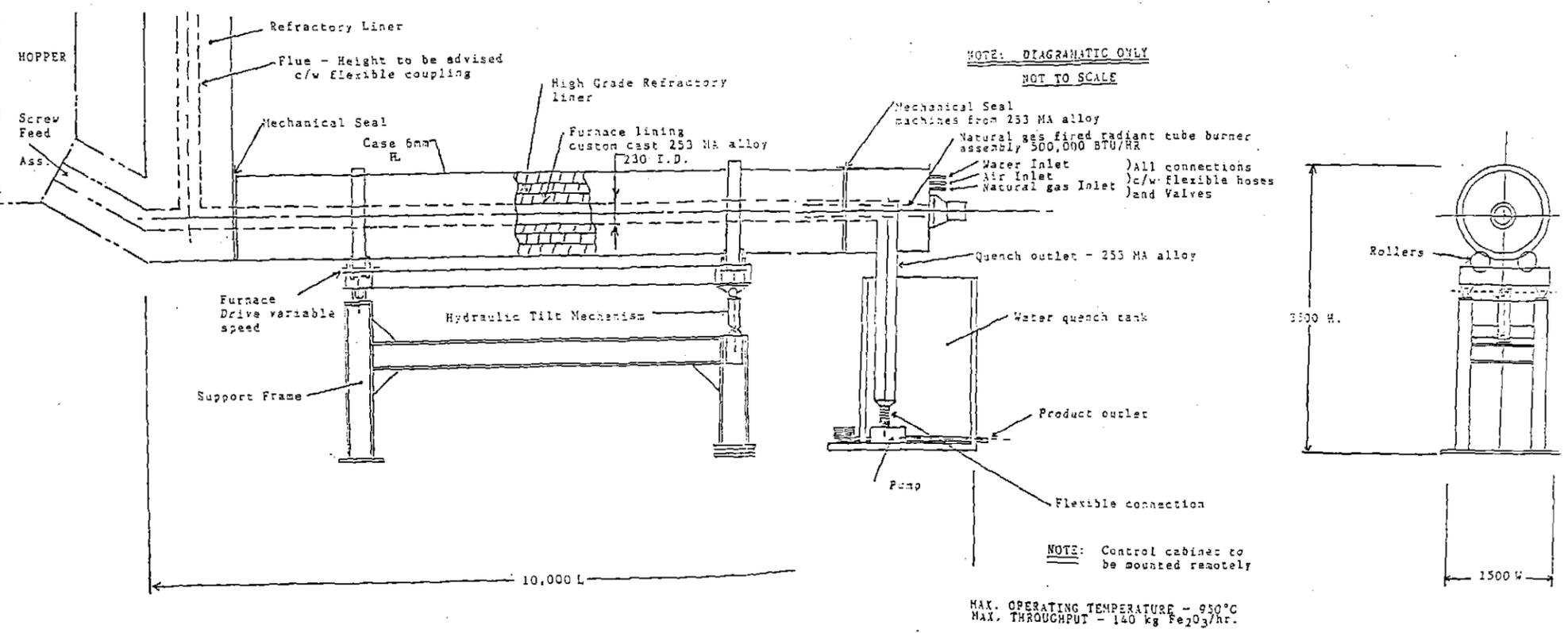


FIGURE: 3 Schematic representation of the rotary kiln & auxiliary equipment

FIGURE 4: Where low cost power is available because of co-generation etc., an electrically heated kiln augmented with gas heating may be used, and in fact we have recently designed one for another application.



And of course we have all seen a kiln.

A rotary kiln type of operation for the calcining of iron ore by gaseous reagents has some inherent disadvantages. For example operation with the reducing gases under pressure is highly impractical. Furthermore, because only a small portion of the total volume in a rotary kiln is occupied by reactant solids, the productive capacity per unit of reactor volume is relatively low. However, these disadvantages may be partly or wholly offset by the ability of a rotary kiln to : (1) handle fine materials; (2) operate at high reducing temperatures without sticking of powder; and (3) operate in a true continuous counter current manner.

While we are aware of, and have used fluidised bed systems we do not favour them for our application. Recall our visit to the SiO_2 plant at Burnie.

Despite all of the points which mitigate against a kiln based process, we are recommending a rotary kiln.

Our reasons for doing so are:-

- i. Low capital cost
- ii. Low maintenance cost
- iii. Mechanically simple
- iv. Versatile - a range of iron oxides and/or reductants may be used. A wide range of products can be produced.
- v. Ideally suited to a market of 20,000 TPA to 60,000 TPA
- vi. Large scale pilot facilities are available on a rental basis.

The Process

Whether or not we feed $\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$ or any other iron oxide the operation is the same. In our process the first step is to produce Fe_3O_4 from $\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$.

1. The combusting gases generate static electrical charges which in turn charge the iron oxides and the kiln components and assist in retaining the fine iron oxides.

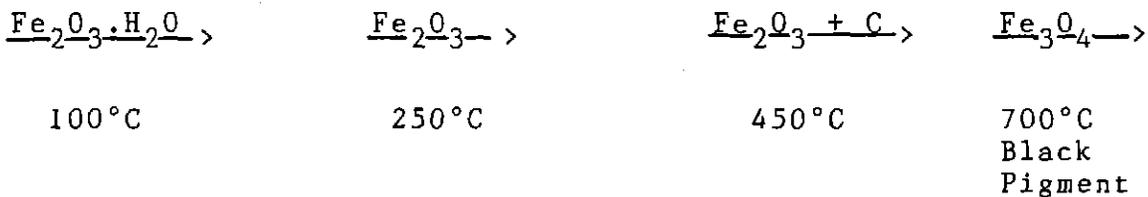
We feed the oxides counter current in order to preheat the incoming air with the hot exhaust gases, and to expel any water vapour which could increase energy costs if they were allowed to enter the high temperature zones of the kiln.

The following diagram best describes this of the process.

Reduction

Production of black pigment $C)_2 + CO + H_2O + CH_4 + Air$

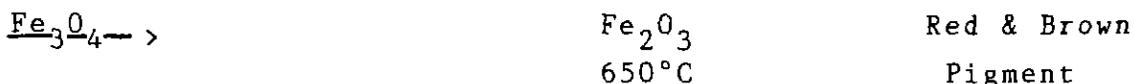
< Gases and Products of Combustion



Oxidation

Production of red and brown pigments

< Combustion gases plus air



Colour

Colour is dependant on a number of factors:

- i. Feed - physical & chemical properties
- ii. Temperature
- iii. Time at temperature
- iv. Cooling rate & atmosphere

v. The kiln.

In practice, every effort is made to produce as consistent a colour as possible. However, the final result can only be achieved by blending.

The operating colour practices must be set by trialing a given kiln.

Black pigment production - from experience we know that we need to finish Savage Resources material at about 780°C for at least 8 minutes to achieve colour, and ^{cool} ~~cool~~ in the reducing zone to about 400°C before exposing to the air. Even at this temperature there will be a slight colour change of the material at the surface, but this will blend out.

The kiln is now in motion and the heating up commenced. From experience we know what the temperature drop will be once the feed is introduced.

Because iron oxide has the same specific heat and thermal conductivity as steel, heating and cooling is efficient, and the exiting gas an efficient means of heating the incoming one.

Let us assume that we are going to feed an 0.5m ID insulated kiln at say 5 TPH of $Fe_2O_3.OH$. Because of water losses (see energy calculations) we would need to have the kiln set at about 1020°C to achieve 780°C at 5 TPH. This allows also for heat loss due to water of crystallisation removal, some conversion of the steam to water gas etc.. Also as we intend to introduce excess CH_4 into the reduction zone, this must also be accounted for.

The kiln is now set at 1020°C, feeding has commenced, the CH_4 is turned on, and yellow $Fe_2O_3.OH$ is being fed in one end, while black Fe_3O_4 exits from the other. A gas analysis shows residual

CO and some CH_4 at the stack entry, but this combusts in the stack. We carry out a draw down check, increase temperature and gas if the material is too brown, increase gas only if the material is too grey, check the draw down again, set the kiln and run the batch.

Red and/or brown oxide:

For red and brown we proceed as above, except that no excess gas is introduced, and we run the kiln at about 820°C for bright red, 760°C for dull red and 640°C for browns.

The most attractive features of this process are that adjustments can be made on the run immediately following checks, and off specification material can be blended out, or re-run through the kiln.

The secret to the process is accurate record keeping, i.e. all recorder charts and draw downs must be filed.

6. FILTERING AND WASHING (CYCLONING)

(It is not necessary for Colin to read this segment).

We have found in ^{as what?} our work that it is necessary to remove as much alkaline material as possible before reducing the goethite to magnetite or some sintering occurred. While this agglomerated material was easily broken down by milling, this does mean another step in the process. For this reason we adopted the philosophy of adequate washing.

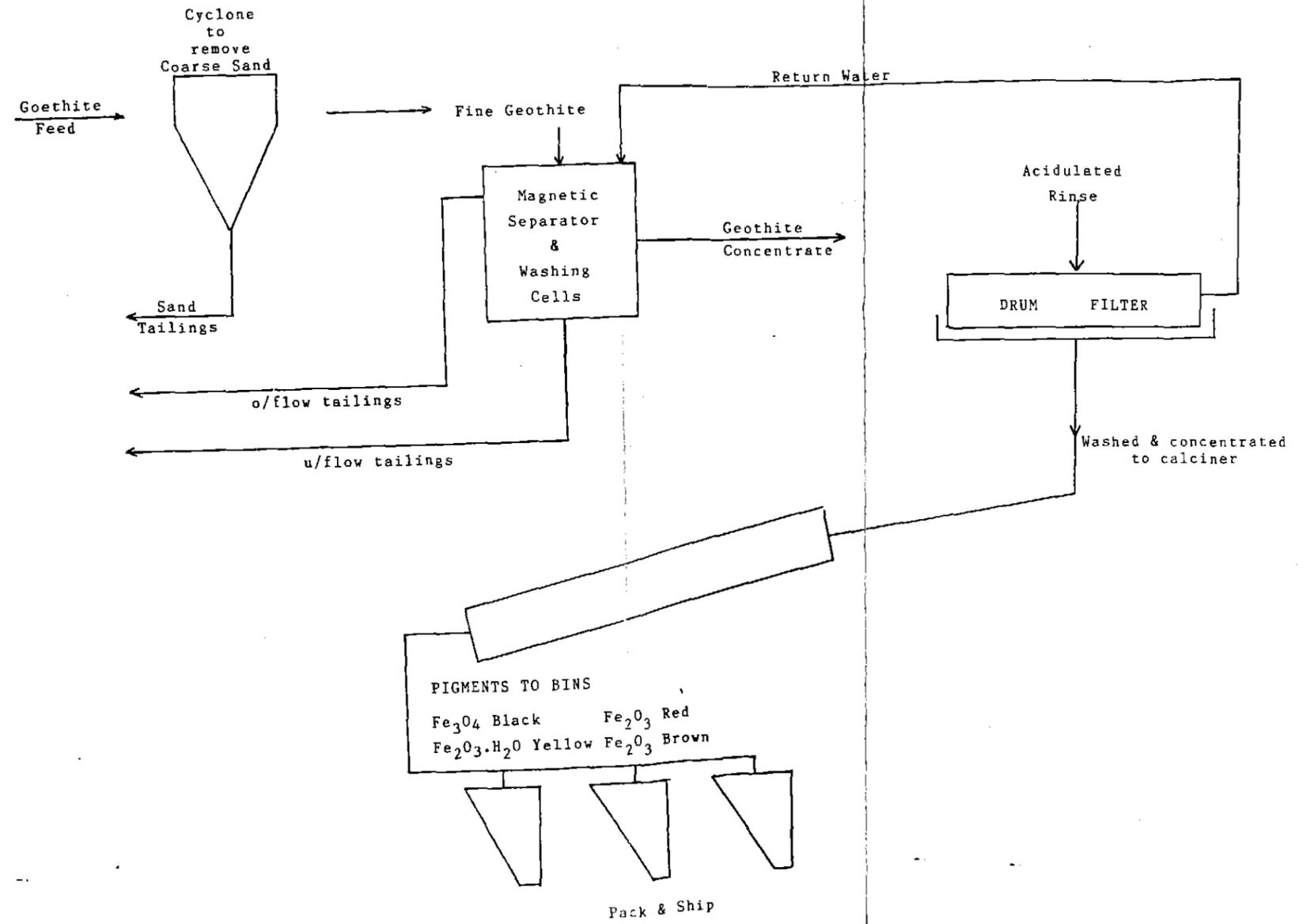
The washing was simply carried out by water in a filter, and five consecutive washes appeared to be adequate.

(Ideally, the washing would best be carried out at the time of magnetic separation, if it was found possible to achieve magnetic separation of goethite; i.e. the procedure suggested by Savage Resources has attractions and must be explored.)

We do not describe the filtering, washing and cycloning technologies either in this section or the Appendix as Savage Resources have demonstrated expertise in this area. (Colin Graham).

Besides, the apex vortex relationships etc., may need to be altered as the ore feed varies; i.e. this is an ongoing operational adjustment.

The following sketch summarises the process.



7. OBSERVATIONS - Processing

A. There are two basic approaches:

(i) Reduce the goethite to magnetite and then magnetically separate from the gangue in order to produce a high quality pigment plant feed.

(ii) Produce a goethite concentrate in order to produce a high quality feed.

If the latter can be achieved it has many cost, process and pigment product advantages. As the potential is easy and low in cost to explore, this should be done.

B. The separation of the coarse fractions by cycloning in order to produce a rough goethite concentrate makes imminent sense, and should be the procedure adopted to produce the feed for either process.

C. As much of the expertise in achieving final pigment quality depends on experience and judgement, this is not readily transferred in a report. It is therefore recommended that as much hands-on experimentation as possible be carried out by Savage Resource staff in liaison with myself.

0234

8. ECONOMIC JUSTIFICATION

Because insufficient data is available regarding potential ore reserves at this juncture, we shall be conservative and assume a production rate of 10,000 TPA of (^{white} pigment) for 10 years. (i.e. the plant as presented could present 5,000 TPA on a pilot plant basis - day shift only). *of finished pigment.*

While there are many sophisticated programs for estimating the R.O.I., we follow the KISS program.

A. Yellow Pigment

- i. As the worst case would be the sale of all risings to Alcoa in bulk on a long term take or pay basis, we shall use this model.
- ii. From the report, the capital cost without blending and bagging plant would be in the order of \$725,000 - say \$800,000.
- iii. A reasonable interest charge on this capital under current economic circumstances would be 25%.

Capital cost per tonne at 10,000 TPA would therefore be \$20/tonne. *interest only, no capital payback*

The operation could be run by 11 personnel, including the Management of the contract miner; i.e. Plant Manager, Secretary, Laboratory Operator, 2 x 2 Shift operators, 2 Maintenance men, 1 stand-by operator (front-end loader driver).

At Savage River, the cost of employing the staff, including house hire etc., would be in the order of \$50,000 per person per annum, i.e. \$55/tonne per annum.

The goethite feed cost, including royalty etc., should not exceed \$24/tonne. While the recovery rate on the samples supplied exceeded 78%, we should not anticipate a general rate in excess of 50% until proven; i.e. \$48/tonne for feed.

230

Power, water, dumping charges and incidentals, i.e. R&M would not exceed \$20/tonne.

We should also apply a H.O. overhead and marketing charge of \$20 per tonne.

R&D tax rebates, depreciation etc., are ignored and we apply a contingency of 50% to cover freight etc..

<u>Outgoings</u>	\$/tonne
Capital	20
Wages	55
Feed	48
Power etc.	20
Overheads	20
Contingency 50%	82
	\$215.00
	=====

Income

Assume Alcoa or another pigment producer require a 100% margin, after packing, transport and other charges, and we can only receive 50% of the market value, i.e. \$800/tonne.

<u>Income</u>	\$/tonne
	800
Less costs	215
MARGIN	\$585
	=====

*Require 20,000 tonnes of feed
for output*

At 10,000 TPA this would give an annual revenue before tax of \$5,850,000, or a one month pay back.

0236

While the selling price could double if we marketed directly, it could take 2 years to reach capacity sales, and there would be incremental travel and marketing costs.

The margins for red, black and brown pigments would be in the same order of magnitude.

There seems little point in detailing complex financial models at this juncture, as doubling all costs would still result in an acceptable margin.

We will accept any model and/or contingencies that Savage Resources Ltd wish to apply to the economic assessments.

BUSINESS SENSITIVE

CONFIDENTIAL TO

SAVAGE RESOURCES LTD

THE UTILISATION OF SAVAGE RESOURCES LTD. GOETHITE AS PIGMENT

Report Commissioned by:-

MR DAVID ARCHER
Managing Director

Report Prepared by:-

R.E. SHACKLEFORD
High Technology Transfer Pty Ltd

90-3158.B

TEST DATA. SAVAGE RESOURCES LTD GOETHITE

Savage Resources Goethite tests were run to achieve the following objectives:

1. Attempt to produce saleable grades of pigment from the samples provided.
2. Determine the reducibility of the material in a rotary kiln. *method to test, time & hours*
3. To produce chemically treated (upgraded) product.
4. Observe the reactions in the kiln and the nature of the product produced.
5. To carry out oxidation and partial reduction runs in an attempt to produce red and brown iron oxide colours.
6. Carry out limited reduction, oxidation and magnetic separation test work on a laboratory basis.
7. The tests were run to produce pigment grade colour.

Not only were all of the objectives achieved, but iron oxide colour of much higher quality than anticipated was produced.

- i.e. 1. The tinctorial strength was good, and this was unexpected.
2. Four excellent basic colours which would have excellent market demand were produced. (i.e. four basic colours not samples. A much larger number of samples were produced and tested in each category).

NOTE: If these four colours can be reproduced with consistency, then we have the basis of a viable manufacturing facility.

*	Drill Hole	Sample	Interval	ANG Collar
	HZ2	1	0 - 1.5	346612 mE 5400382 mN
		2	1.5 - 3	
		3	3 - 6	
		4	6 - 7.5	
	HZ1	1	0 - 1.5	346630 mE 5400371 mN
		2	1.5 - 2	
		4	3 - 4.5	
		5	4.5 - 6	
	HA4	1	0 - 1.5	346599 mE 5400381 mN
		2	1.5 - 3	
		4	4.5 - 6	
		5	6 - 8	
		6	8 - 9.5	
	HB2	1	0 - 1.5	346576 mE 5400287 mN
		2	1.5 - 3	
		3	3 - 4.5	
	HD1	2	1.5 - 3	346533 mE 5400152 mN
		3	3 - 6	
		4	6 - 11	
	HE3	3	3.5 - 5	346553 mE 5400110 mN
		5	6 - 9	
	HC1	1	0 - 1.5	346552 mE 5400233 mN
		2	1.5 - 2.5	
		4	3 - 5	

The testing was not comprehensive because of lack of sufficient raw material etc., and the fact that the expense of full testing on these preliminary samples is not justified.

1. Yellow Colours

On colour matching raw feed, the range was found to be within * 8 (grab samples provided by Mr R.W. Annett). While the results appear to be too good to be true for raw feed grab samples, we can only report the results observed. In fact, except for two samples, all fell within a 4 to 5 range.

The bulk samples were then processed to pigment by chemical treatment (acid leaching), grinding and sizing, and the resulting pigment product evaluated.

What was the procedure?

It was possible to leach down to the following analysis, although this is not necessary for normal commercial production.

	<u>ppm</u>
P :	400
NA:	373
CA:	282
MN:	197
MG:	787
AL:	807
CR:	100
NI:	TR
TI:	169
ZN:	TR
SR:	41
Pb:	TR
Cu:	TR
u:	TR
Si:	220

standard requires

TEST RESULTS

Tinctorial Strength

On the as received material, the tinctorial strength was below specification, which is to be expected because of gangue, water soluble material, sizing etc..

However on the prepared material the tinctorial strength was surprisingly good for a natural pigment. ✓

(Note: processed samples only were tested as follows:-

Colour of Tint Off White

defining

Surprisingly good.

Hiding Power ✓

Average

Water Absorption ✓

Minimal, and equivalent to most synthetic grades. However, this result is to be anticipated as we had processed to remove all such material.

Oil Absorption ✓

Normal range

requires more procedural method.

Bleeding ✓

Well within specification

Heat Resistance ✓

Superior to all standards

Flooding and Floating ✓

Superior to synthetic grades

Resistance to Alkalis ✓

Surprisingly good results were obtained

Resistance to Acids ✓

Not applicable, as only acid washed material was used ; i.e. the test result was excellent, as would be anticipated.

Reactivity ✓

Excellent

Settling ✓

A little on the high side. Will require surfactant reagent.

Ease of Dispersion ✓

Surprisingly good.

Fineness

See grinding test results.

can't find grinding test results

Other testing

Time does not permit the testing of other properties, i.e. light fastness, exterior durability, corrosion resistance etc., but we are confident from the foregoing and our other observations that our product will be adequate if not superior.

Efflorescence

clustering of cells (aggregates) with this solution being not a problem
Because we are aiming initially specifically at cement and concrete grade pigments autoclave efflorescence testing was carried out. As the first results were far better than any previously encountered, the tests were extended, and then repeated. Further work needs to be carried out to determine why the low and outstanding results, as it is possible that the filtrate from the pigment plant could be marketed as a cement and concrete additive to prevent efflorescence.

Cement and Concrete Strength

The coupons were found to be 2% to 15% stronger than those using Bayer pigment at similar concentrates.

This work needs to be repeated before any conclusive inferences can be drawn, but as all of our results were on the positive side compared to the standards, further work is justified.

Water Soluble Matter

The 8% level anticipated was not achieved even on extensive leaching of the ground material. The results were in the order of 2% to 6%. This test must be repeated on aged product.

2. Black Colour

Produced from dried goethite by direct reduction with natural gas; i.e. $\text{CH}_4 \cdot \text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O} \rightarrow \text{Fe}_3\text{O}_4$.

1. LAB Furnace < 45 Micron. < 45 Micron starting material
- no other treatment.
2. LAB Furnace. No pretreatment to feed. As comparison
with rotary kiln.
3. Raw untreated feed.
4. Pretreated yellow feed. Only the blacks resulting from
the pretreated yellow feed were submitted to the following
tests:-

Colour

The colour of all of the four samples was excellent, in fact most surprising, especially as no dumped carbon was detected.

Sample #4 had the best colour in terms of black, and this grade of black is normally only obtainable with added carbon, which is not acceptable for cement tile.

Samples 1, 2 and 3 were typically high grade iron oxide black colours.

Mass Colour

Because of the agglomeration of some of the products, a true mass colour comparison with premium grade pigment was not possible. As was anticipated, grinding these samples to fine sizes gave white speckling due to ground gangue. The perceived mass colour was however outstanding.

Tinctorial Strength

As would be anticipated, because of gangue dilution and particle agglomeration, poor for all samples except #4.

Colour of Tint Off White

Surprisingly good. In fact this result is difficult to explain.

Hiding Power

#4 was excellent, however because of agglomeration the other samples were not tested in the as received condition. After sizing and magnetic separation the hiding power was reasonable.

Water Absorption

Minimal, superior to comparative testing on Bayer pigment.
Ideal for cement products.

Oil Absorption

Well within specification

Bleeding

Outstanding, in fact there was no evidence of bleeding.

Heat Resistance

Outstanding for all samples.

Flooding and Floating

Superior.

Resistance to Alkalis

The alkali resistance of the samples was superior to any test results on record.

Resistance to Acids

Highly resistant. Superior to Bayer product.

Reactivity

Much lower than Bayer standard.

Settling

The settling rates were too high. Surfactant addition necessary.

Ease of Dispersion

Surprisingly, all of the samples could be readily dispersed following grinding and sizing.

Fineness x Kiln

All of the samples, including some fractions in sample #4 were too coarse by orders of magnitude. Ground and sized before testing.

3. Red Colour

Only two samples were prepared.

#5 Pilot kiln Black —> Red

#6 Pilot kiln Yellow —> Red

In both cases these were prepared from processed yellow not raw feed.

Despite the fact that these two colours were produced from the same feed, we managed to produce two distinct reds which would have significant market appeal. If these colours can be reproduced on a consistent basis, the market would pay premium prices for them, provided they met the other specifications.

Colour

#5 Unique and outstanding

#6 Excellent and most desirable

Mass Colour

Because these colours are not available from existing suppliers comparative testing was not possible. However, it is the opinion of the author that mass colour was good.

Tinctorial Strength

Good

Colour of Tint Off White

Surprisingly good

Hiding Power

Much better than we anticipated knowing the history of production. We currently suspect that this is due to particle shape.

Water Absorption

Very low, and superior to current commercial products.

Oil Absorption

Within specification

Bleeding

Nil

Heat Resistance

Excellent up to 680°C

Flooding and Floating

Good

Resistance to Alkalis

Outstanding

Resistance to Acids

Excellent, superior to currently available commercial products.

Reactivity

Superior to all standards

Settling

The rates were too high, which was anticipated

Ease of Dispersion

Not applicable to as produced samples. Must be ground to size.

Fineness

Unacceptable. These are colours not pigments, until ground and sized.

Efflorescence

A most unusual and desirable result, i.e., Nil at 60 hours.

Further Testing

From the above, we anticipate that weathering characteristics would be outstanding, and that it would be some time before the final result was available.

Until we produce pigment quality colour on a routine basis, such testing is not justified.

4. Brown ColourColour

Whilst the two browns that were produced are distinctly different, they are not unique in colour, and in fact match closely the browns that are available from a number of existing producers e.g. Bayer, Northern Pigments etc.. These browns currently wholesale for about \$1800/tonne ex store. However, the price we achieve would depend on the tinctorial strength we can achieve by gangue separation and sizing. It would be safe and quite conservative to assume \$1200/tonne ex works. It may be possible however to produce unique browns by blending with material from the deposit.

Mass Colour

Good on ground and sized product.

Tinctorial Strength

Surprisingly good

Colour of Tint Off White

Surprisingly good

Hiding Power

Good on refined and sized sample.

Water absorption

Marginally higher than black, but well within acceptable limits.

Oil Absorption

As above

Bleeding

Outstanding. No evidence of bleeding.

Heat Resistance

Superior to Bayer browns.

Flooding and Floating

Good

Resistance to Alkalis

Excellent

Resistance to Acids

Good and superior to Bayer browns.

Reactivity

Superior to Bayer browns.

Settling

Varied with sample fraction but acceptable.

Ease of Dispersion

O.K. following sizing.

Fineness

Unacceptable as received.

Efflorescence

Excellent, reduced tendency for efflorescence.

Cement and Concrete Strength

The anticipated reduction in strength normal with high levels of pigment addition did not occur. Warrants further investigation.

CONCLUSIONS

- A. The results achieved were most surprising, in fact, excellent colour was achieved.
- B. It can be concluded because of the scale of the experiments that colour production should be achievable on a commercial scale.
- C. Better colour was achieved than previously produced by preliminary laboratory scale experimentation.
- D. The products produced have exhibited some unique properties which should be commercially exploitable.

RECOMMENDATIONS

- A. The procedures should be repeated using systematic sampling and refined and sized feed only, to produce consistently the blacks, yellows, reds and brown colours for exhaustive in-house and distributor (customer) evaluation.
- B. The processing and capital costs must be determined, and assessed against the potential ex-works selling prices and demands (volumes) for these colours.
- C. The possibility of producing other colours should be explored once the commercial viability of the project has been substantiated.

NOTE: Tables of raw data have not been included in this report as interpretation of the data is not possible without a thorough understanding of the subject, test procedures, market norms vis-a-vis intended application etc..

RALPH E. SHACKLEFORD

DECEMBER 1989

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The evaluation of
SAVAGE RESOURCES GOETHITE
for cement, concrete, plaster and like applications

~~PART I~~

90-3158.0

R & M SHACKLEFORD PTY LTD

JANUARY 1990

0208

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INTRODUCTION

Pigments are about colour. The consistency or reproducibility of the colour. The cost, quality, service and usage properties, and uniqueness and market appeal of a colour.

This document deals very briefly with the foregoing aspects of iron oxide pigments as they apply to cement, concrete, plaster and like applications. *paints?*

While there are many registered standards for pigment evaluation, most of these were developed for paints, inks and dyes, and later adopted for masonry, bitumen and polymer filler end uses.

There are as many different test procedures as there are manufacturers and end users. Eg, Monier carry out freeze thaw tests, and a six months half roof test, whereas Calsil simply keep back one product from a previous batch and compare it with the next batch.

We will not attempt in this document to list and compare all of these tests, but we will list and properly describe these tests which will ensure proper quality control vis a vis our end users.

This is not a technical document, but a working manual, i.e. we do not describe colour in terms of a standard text. Also, the data presented in the technical and marketing reports is not repeated here. Please refer to the appropriate section of these reports for the technical data.

While chemical analysis and sizing data etc is important, except for iron content, this service is to be provided in stage two of the laboratory development, and this data is not provided here.

2. COLOUR

When a pigment user refers to colour, he is commenting on the colour in the finished product, not the pigment colour.

Colours may be referred to as dull, bright, clean or dirty, true etc.. In fact, it is only with considerable experience that an operator can equate mass colour, tinctorial strength, tint off white etc., to colour in the finished product.

For meaningful colour testing we recommend the following procedures.

- A. If one makes mistakes, always ensure that one always makes exactly the same mistake, i.e. never vary any aspect of a test procedure.
- B. Keep a large stock of properly blended material in store; i.e. the sand and cement colour and quality changes can effect a colour test result more than a subtle change in pigment colour. The same is true for plaster, talc, paint base etc..
- C. Always cure the samples in an oven at a set temperature.
- D. Never test against old standards, i.e. prepare fresh standards with each test batch and prepare them in the same way as the test samples.

These tests which are carried out by every pigment producer supplying pigment to the cement and concrete industry, are mandatory for quality control and blending to specification.

1. Test Equipment

TEST PIGMENT 11 PIGMENT

Blade blender, tumbler or shaker.

A number of 0.5m X 1m HDPE boards.

A number of rubber rings. PVC, PE or other polymer rings will do. The larger the ring, the more readable (assessable) the result.

-3-

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The test is best explained by example:

3% pigment in cement test

Weigh out sand, cement and pigment in the desired proportions and dry blend for at least 5 minutes. Eg. 2 of sand 1 of cement 3% W/V of pigment.

w/w? *gray?*

To the dry blend add exactly the desired amount of water to give a pourable slurry. Always add the same measured quantity of water. Blend for a further 5 minutes and pour into the rubber ring which has been placed on the HDPE board.

Immediately observe *described how?* the amount of float, i.e. colour rising to the surface.

Allow the coupons to set at 20°C for 24 hours and then read, i.e. observe the surface colour, colour strength, colour uniformity etc., compared to a standard and comment.

whose standard

This same test should be carried out at 4%, and 1, 2, 3 & 4% in plaster, and if necessary 3% in grey or white cement only, i.e. no sand.

After reading the surface of the coupon, read the underside, and then break and read in section.

The 3% in grey and white cement are the standard for the industry in Australia. The plaster test yields valuable information, especially in comparative testing, eg. relative tinctorial strength, real colour, float, blending properties etc..

The novice should commence by carrying out a range of pigment in plaster tests and vary not only the range of the pigment addition, but also the amount of water. The results should be read at the time of casting, the next day, and after one week, and the interpretations compared.

Colour is used for one purpose only, aesthetic appeal, and it is this quality that is being judged in colour testing.

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3. TINCTORIAL STRENGTH

The tinctorial strength of a pigment is measured for a number of reasons, but the following are the more pertinent:-

1. To determine the relative value of a pigment, eg. if we use Bayer as the standard, and we can only achieve the same colour density by using twice the amount of pigment, then our product is worth only half the value. All pigments are valued on this basis.

2. In order to assess the suitability of the pigment for the intended end use, eg. for practical reasons, there are limits as to the amount of pigment that can be added to the end product. The addition of more than 5% to 7% of pigment to concrete or cement weakens the final product. An excess of pigment in a polymer paint can cause premature flaking, and the amount of pigment filler in a polymer must be carefully controlled. The pigment addition is termed the pigment loading.

The standard method of determining the tinctorial strength is to determine the relative capacity of a pigment to impart colour to a white base.

Because so much hinges on the tinctorial strength of a pigment, we resort to a large number of different tests before forming an opinion.

(a) The first test we use is based on white plaster. By making up various strengths of the pigment under test, and a standard, in a white plaster, and casting this into buttons, and simply examiningⁱⁿ the colour one can accurately rate the tinctorial strength.

(b) Another very useful, simple and accurate test is to make up the various pigment strengths, i.e. 2% to 10% loading at 2% increments in a clear varnish, and then to comb this onto test strips. Eg. yellow onto black paper, black onto white paper, brown onto white paper and red onto yellow paper. The trick is to get the smears to exactly the same thickness. Combs

0257

with colourimeter 123257

-5-

are easily prepared by winding soft copper wire onto dowelling. The larger the wire diameter the more paint is deposited. Always read these colours in natural sunlight. There are ASTM test methods described but these are mainly for automotive finishes, whereas in Australia the market is for cement, concrete and heavy paints.

Another way to describe the tinctorial strength is hiding power. Regardless of the test system, what we are really assessing is achieving the same quality of colour as the standard over a given background. In fact, I usually assess colour quality, mass colour, tinctorial strength and hiding power in the same test series.

For determining the hiding power in cement, run the following series of tests:

1. In a blender (mixmaster) make a series of pigment water mixes.
20% pigment in water, 40% pigment in water and 60% pigment in water. Paint strips of this onto fibro cement sheet, and assess against the standards.
2. Make up cement pigment mixes of 50% (Portland Cement) grey, plus 2%, 4% and 6% pigment with water and paint onto fibro cement sheets.
3. to 10. These comparative tests can be repeated with plaster, various paints etc., and the tinctorial strength accurately assessed.

The foregoing tests are absolutely necessary if one is to gain experience in colour and tinctorial strength assessment. Once these tests have been mastered, we are then ready to set up to test to customer specifications and requirements.

Every major customer will have his specific test procedures, which are designed to ensure that colour matching is not experienced from batch to batch. The main concern of every pigment user is colour consistency. i.e. There must be no

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off white (colour off tint) and hiding power.

What is colour of tint off white?

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4. LIGHT FASTNESS

Because light fastness effects colour, this property is important on large jobs, where a number of pigment batches may be used, eg. high rise or factory, or large roof tiled area.

While this will not be a problem with our synthetic or physical pigments, some testing should be conducted, especially for Australian applications. The ultimate test is irradiation by U.V. wavelength source. After assessing the coupons from tests 2 and 3, simply place these facing a U.V. source for two weeks and assess the change if any.

Because the tests are comparative, and I know from the work I have done that our product will outperform the competition by a factor of at least 10, the U.V. radiation source specification or adhering to standard test criteria is not important. The test can be easily accelerated by increasing the test temperature from ambient to 60°C rather than by increasing U.V. radiation.

Because of the time it will take to get any meaningful outdoor exposure test results on our material, these test panels should be prepared and exposed before the end of this summer, i.e. A.S.A.P..

There is no substitute for panels consisting of product produced by potential customers using our pigment, and comparing these against those produced using our competitors product; i.e. actual roof tiles, pavers and bricks etc.. As this will not be possible before March next year, we should make up panels consisting of 2%, 3% and 4% of pigment in tile size panels of 3 parts sand and 1 part cement. It will be noted that the competitors product weathers quickly and that our product has superior weathering properties.

*Working for control
on
the
building*

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5. WATER ABSORPTION*how much?*

The ASTM test is designed for paint. For cement, we mix the pigment with 50% W/W with water for 10 minutes in a paint shaker, blender etc., and then vacuum filter through a pre-weighed sintered Gooch filter for 3 minutes after the residue appears to be free of water (i.e. no more filtrate) and weigh. We call the increase in weight water absorption for cement and concrete use. Once again, our product is so much better than the competition in this respect that minor errors are of no consequence.

6. OIL ABSORPTION

Because of the changes in paint technology, the ASTM tests are no longer of any consequence. We carry out the tests as above using a mix of 50% linseed oil plus 50% mineral turpentine. In the longer term, we will test as per our paint customers, and there are as many tests as the number of customers X 4. Suggest we test as per our procedures for the time being, or using a light mineral oil.

7. BLEEDING

This term is normally applied to paint systems. The inorganic iron oxide pigments do not bleed, i.e. they are not soluble in organic solvents. Ours is normal in this respect. What I have done is apply this test to cement and concrete products for our initial program. The test is simple, place the test coupon against a piece of fibro cement using an elastic band, and then place this in a beaker of water, and examine at regular intervals and compare with standards; i.e. the degree of staining of the fibro panel indicates the degree of bleeding.

what is the standard?

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8. HEAT RESISTANCE

This is a property which we will be called on to define from time to time, but the requirements and testing will be very specific.

We test by observing comparative colour change of the pigment in a compressed tablet using no binder, in a coupon consisting of 5% pigment in a 3 sand one cement mix, and in plaster of Paris coupons containing 2%, 3% and 5% pigment. *white or grey?*

The tests are comparative, and we hold the coupons at temperature for 4 hours before reading.

We test at 60°C, 120°C, 250°C and 380°C.

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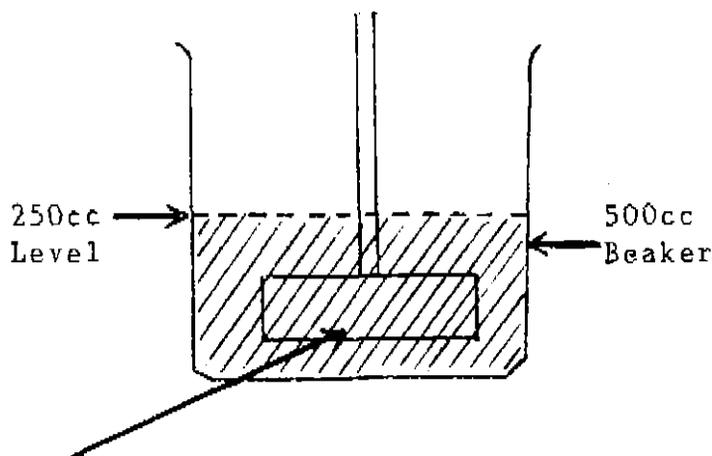
9. FLOODING & FLOATING

Because the cement acts as a pigment, i.e. it is finely ground and imparts colour to the product, we test cement as the other pigment.

This is an extremely difficult test to perform and evaluate, but we believe we have come up with a method that removes the subjective guess work.

What we do is prepare two slurries, one of 40% pigment in water and the other of 40% grey Portland cement in water. We then stir the samples together in duplicate using two stirrers with identical paddles and revolving at the same rate. We have found a 250cc test to be ideal and a stirring rate of one revolution per second for 10 seconds.

i.e.:



Relative paddle size and depth below surface

We then stop the paddle and observe the sample for ten minutes to determine the float properties. *how?*

This is an important test, and there are many variations of it for paint, including so called standard tests.

We believe that the one as described will satisfy the demands of both the cement and paint customers. For paint, simply use the intended commercial paint base in back to back tests.

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10. RESISTANCE TO ALKALI

Because we are anticipating very harsh environments we over test.

It is necessary to prepare the following samples:

1. The chosen standard pigments in distilled water.

W/V 40% black in 250ml water

W/V 40% red in 250ml water

2. Alcoa pigment as above.

3. The standard and Alcoa pigments in 1% NaOH and 10% NaOH solutions. Stand for 12, 24 and 48 hours and note discolouration etc..

DO NOT USE CALCIUM SALTS AS THEY COULD PRECIPITATE ON THE PIGMENT AND GIVE FALSE RESULTS.

11. RESISTANCE TO ACIDS

We perform the tests as above but in:-

- A. W/V 1% HCL ^{Strength of acid as the HCl pigment is 10% strength HCl)}
- B. W/V 1% H₂SO₄
- C. W/V 1% Glacial Acetic Acid

We then filter and wash and compare the wet and dried residues. We also assay for iron and compare the results.

12. REACTIVITY

Not only ^{do} we report the alkali and acid resistance under this test, but we also take note of the heat resistance and weathering tests.

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We would not carry out any further testing unless this was specifically requested.

- eg:
- i. Reaction with lime in an autoclave.
 - ii. Reaction with cement in an autoclave.
 - iii. Reaction to paint solvents.
 - iv. Behaviour in two part paint systems or thermo setting paints or UV setting coatings, i.e. iron oxide pigments can have a catalytic effect with either beneficial or disastrous results, depending on the end use. We have witnessed 45 gallon drums of solid paint.

13. SETTLING

The routine test is carried out by preparing 40% slurries of the pigment, and adding 50cc of this to 50cc of water in a 100cc measuring cylinder.

Note the following:

- i. The rate of sink.
- ii. The turbidity of the medium. This can be measured by removing 1cc samples and placing in a comparative turbidity meter.
- iii. Note the level of sink after 2, 4 and 24 hours.

14. EASE OF DISPERSION

We routinely carry out this test in the following mediums:

1. 4% ^{of AKK} in dry Portland cement. Dry the pigment under test, the standards and the cement for 24 hours at 110°C.
 1. Blend in a mixmaster for 5, 10 and 20 seconds and note; i.e. press samples into a disk and examine on a stereoscope at 100X and 800X. A quick result can be obtained by pouring the mixture into a thin

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2. Blend by rolling in a bottle for 15 minutes, taking samples at 5 minute intervals and reading as above.
3. The above tests can then be carried out wet by repeating the tests in 40% water cement slurries.
4. Because of the variability of paint mediums and natural oils we carry out our comparative oil dispersion tests using a mineral lubricating oil. As the tests are comparative and carried out under the same conditions any oil may be used provided the same grade and make is employed, eg. Mobil SAE30 or multigrade.

As it is our intention to market stable emulsions, and we will be marketing to distributors who make and sell stable emulsions the test work in this area is to be expanded and better defined. However, at this juncture the foregoing should suffice.

15. SIZING

There is no need to elaborate on this subject except to state that we should produce to a narrow range.

16. MORPHOLOGY

The morphology of the pigment is important. Because of the capital, maintenance and other routine costs associated with the equipment, this analysis should be contracted out. This is important as our material is entirely different to the acicular shapes of the synthetic iron oxides, or other naturally occurring goethites.

Much needs to be discussed regarding morphology and sizing relationships, but there is no need to do so in this report.

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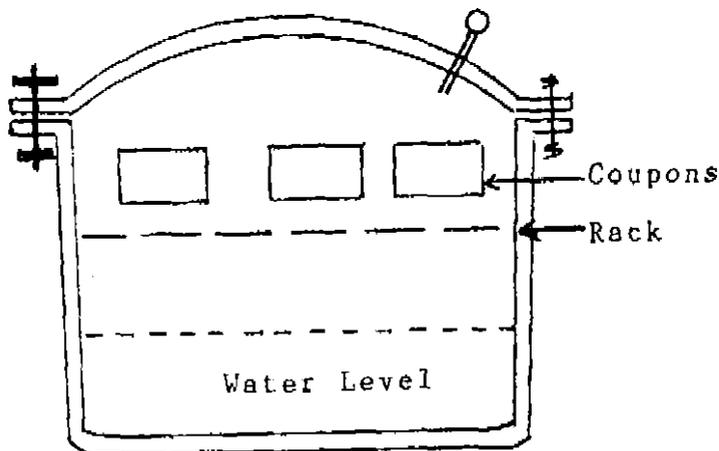
17. EFFLORESCENCE

We carry out two tests which are not reported in the literature, but are important to the use of pigments in cement and concrete products.

We note many years ago that compared to other iron oxide synthetic pigments, the Bayer pigments retard or reduce apparent and visual efflorescence. Comparative analysis showed the Bayer pigments to be higher in alumina and silica content. This is predictable because of their unique production technology.

We prepared Pfizer and Northern Pigment coupons and added fine silica and alumina and achieved the equivalent result to Bayer. Alcoa physical and synthetic iron oxide pigments contain relatively high levels of alumina and silica and display outstanding efflorescence properties. The Savage Resources pigment displays similar properties without the high Si and Al₂O₃ contents.

The test is a comparative one and consists of placing the coupons on a rack above the water level in an autoclave and testing until the onset of efflorescence, and then reading at regular intervals.



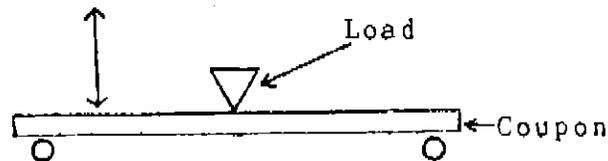
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18. COUPON BREAKING STRENGTH

Because the pigment loading adversely effects cement and concrete strength we also carry out a comparative cross breaking strength test.



The test may be carried out in a number of ways, the only important point is that the test is comparative.

Marginal differences should be ignored but a major difference could be important.

i.e.: Carry out the tests at a 2% W/W, 3% W/W, 4% W/W and 5% W/W loading.

eg.: It will be noted that our pigment may be used to a higher loading than Bayer before a notable reduction in cross breaking strength is observed.

19. GENERAL

From experience a tester will get to know the feel of a pigment, i.e. it is fluffy and lively or dead.

The colour is clean or dirty, bright or dull.

On rubbing in the palm of the hand, it feels smooth or gritty.

The pigment balls or spreads, i.e. balling pigments are difficult to disperse.

It is important from the outset to get to appreciate the look and feel of pigments, in order to spot production at an early stage.

The time to find pigment problem is before it is binned

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out, or re-processing.

20. CHEMICAL ANALYSIS

Chemical analysis is to be restricted to iron for the moment. However, it should be noted that total insoluble gangue can be determined by simply filtering the dissolved sample, ashing and weighing. A small furnace will be required for this.

Iron Analysis

There are many methods for determining total iron, and ferrous and ferric iron in ore. The introduction of atomic absorption and other instrumental techniques, i.e. spectrometry and xray fluorescence has outmoded these. However, at this juncture, simple methods are to be used. The simplest and least accurate would be gravimetric.

- i. Weigh out a quantity of dried sample, i.e. 2 grams. Dissolve in 5% HCL at about 80°C for 2 hours. Filter and wash. Dry and ash the residue, and weigh - this will give % gangue. To filtrate add a few drops of HNO₃ and boil for 5 minutes. Cool and carefully add NH₄OH with stirring, and add a slight excess, i.e. red litmus paper turns blue. Boil for five minutes, settle and filter. Ash at 800°C to 900°C, cool and weigh as Fe₂O₃.

A refinement of the above is as follows:

Gravimetric method

Dissolve the precipitate in dilute hydrochloric acid; peroxidise with a few drops of nitric acid and boil, dilute to about 200cc, add ammonia (with constant stirring) till the liquid smells of it, and heat to boiling. Wash as much as possible by decantation with hot water. Transfer to the filter, and wash till the filtrate gives no indication of soluble salts coming through.

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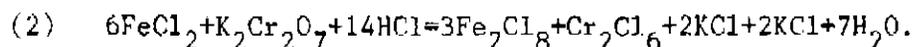
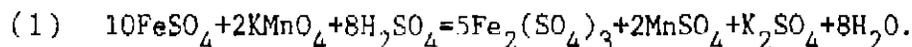
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The filtrate must be colourless and clear. The wet precipitate is very bulky, of a dark-brown colour and readily soluble in dilute acids, but insoluble in ammonia and dilute alkalis. When thrown down from a solution containing other metals it is very apt to carry portions of these with it, even when they are by themselves very soluble in ammoniacal solutions. It must be dried and ignited, the filter paper being burnt separately and its ash added. When further ignition ceases to cause a loss of weight, the residue is ferric oxide (Fe_2O_3), which contains 70% of iron. The weight of iron therefore can be calculated by multiplying the weight of oxide obtained by 0.7

The presence of ammoniac chloride causes loss of iron during the ignition, and organic matter causes an apparent loss by reducing the iron to a lower state of oxidation. When the iron in the solution much exceeds 0.2 gram the volumetric determination is generally adopted, as the bulkiness of the precipitate of ferric hydrate makes the gravimetric method very inconvenient.

Volumetric Methods (Wet)

There are a number of options and these are based on the measurement of the volume of a reagent required to bring the whole of the iron from the ferrous to the ferric state (oxidation), or from the ferric to the ferrous (reduction). Ferrous compounds are converted into ferric by the action of an oxidising agent in the presence of an acid. Either permanganate or bichromate of potash is generally used for this purpose:



Ferris compounds are reduced to ferrous by the action of:-

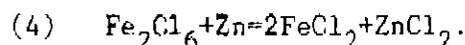
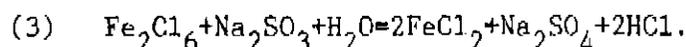
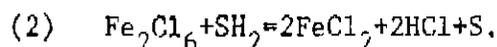
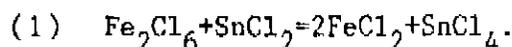
- (1) Stannous chloride;
- (2) Sulphuretted hydrogen;
- (3) Sodium sulphite; or
- (4) Zinc*.

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*



IRON

1. With Stannous Chloride

Fill a burette with a solution of stannous chloride*, and cautiously run the liquid into the hot assay solution (in which the iron is present as chloride) until the colour is discharged. A large excess of the stannous chloride must be avoided. Then add 5cc of a 2½% solution of mercuric chloride, this will cause a white precipitate (or a grey one if too large an excess of the stannous chloride has been added). Boil till the solution clears, cool, dilute, and titrate.

2. With Sulphuretted Hydrogen

Cool the solution and pass through it a current of washed sulphuretted hydrogen till the liquid smells strongly of the gas after withdrawal and shaking. A white precipitate of sulphur will be formed, this will not interfere with the subsequent titration provided it is precipitated in the cold. If, however, the precipitate is coloured (showing the presence of the second group metals), or if the precipitation has been carried out in a hot solution, it should be filtered off. Boil the solution until the sulphuretted hydrogen is driven off; this may be tested by holding a strip of filter paper dipped in lead acetate solution in the steam issuing from the flask. The presence of sulphuretted hydrogen should be looked for rather than its absence.

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It is well to continue the boiling for a few minutes after the gas has been driven off. Cool and titrate.

3. With Sodium Sulphite

Add ammonia (a few drops at a time) until the precipitate first formed redissolves with difficulty. If a permanent precipitate is formed, redissolve with a few drops of acid. To the warm solution add from 2 to 3 grams of sodium sulphite crystals. The solution will become strongly coloured, but the colour will fade away on standing for a few minutes in a warm place. When the colour is quite removed, add 20cc of dilute sulphuric acid, and boil until steam is quite free from the odour of sulphurous acid. Cool and titrate.

4. With Zinc

Add about 10 grams of granulated zinc; if the hydrogen comes off violently add water; if, on the other hand, the action is very slow, add sufficient dilute sulphuric acid to keep up a brisk effervescence. The reduction is hastened by warming, and is complete when the solution is quite colourless and a drop of the liquid tested with sulphocyanate of potassium gives no reaction for ferric iron. Filter through "glass wool" or quick filtering paper. The zinc should be still giving off gas rapidly, indicating a freely acid solution; if not, acid must be added. Wash with water rendered acid. Cool and titrate.

With regard to the relative advantages of the different methods they may be roughly summed up as follows:-

The stannous chloride method has the advantage of immediately reducing the ferric iron whether in hot or cold solution and under varied conditions in regard to acidity, but has the disadvantage of similarly reducing salts of copper and antimony, which, in a subsequent titration, count as iron. Moreover, there is no convenient method of eliminating any large excess of the reagent that may have been used; and, consequently, it either leaves too much to the judgement of the operator,

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The sulphuretted hydrogen method also has the advantage of quick reduction under varying conditions, and the further one of adding nothing objectionable to the solution; in fact it removes certain impurities. The disadvantages are the necessity for boiling off the excess of the gas, and of filtering off the precipitated sulphur, although this last is not necessary if precipitated cold.

The sodium sulphite method has the advantages of being clean and neat, and of requiring no filtration. On the other hand it required practice in obtaining the best conditions for complete reduction; and, as with sulphuretted hydrogen, there is the necessity for boiling off the gas, while there is no simple and delicate test for the residual sulphurous acid. In addition, if an excess of sodium sulphite has been used and enough acid not subsequently added, the excess will count as iron.

The advantages of the zinc method are, that it is easily worked and that the excess of zinc is readily removed by simply filtering. The disadvantages are the slowness* with which the last portions of ferric iron are reduced, the danger of loss by effervescence, the precipitation of basic salts, and, perhaps, of iron, and the loading of the solution with salts of zinc, which in the titration with bichromate have a prejudicial effect.

Generally speaking, the sulphuretted hydrogen and sodium sulphite methods are to be preferred. Carefully worked each method will yield good results.

The titration may be done with a standard solution (1) permanganate of potash, or (2) bichromate of potash.

1. With Permanganate of Potash

Prepare a standard solution by dissolving 2.82 grams of the salt and diluting to one litre. The strength of this should be 100cc = 0.5 gram of iron, but it varies slightly, and should

* The maximum reducing effect of zinc is obtained by exposing as large a surface as possible of the metal in a hot concentrated solution containing but little free acid (Thorpe).

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be determined (and afterwards checked every two or three weeks) by weighing up 0.2 gram of iron wire, dissolving in 10cc dilute sulphuric acid, diluting to about 100cc, and titrating.

The standard solution must be put in a burette with a glass stopcock, as it attacks india-rubber. The assay should be contained in a pint flask, and be cooled before titrating. The standard solution must be run in until a pinkish tinge permeates the whole solution; this must be taken as the finishing point. When certain interfering bodies are present this colour quickly fades, but the fading must be ignored. With pure solutions the colour is fairly permanent, and a single drop of the potassium permanganate solution is sufficient to determine the finishing point.

2. With Bichromate of Potash

Prepare a standard solution by dissolving 4.39 grams of the powdered and dried salt in water, and diluting to 1 litre. This solution is permanent, its strength is determined by dissolving 0.2 gram of iron wire in 10cc of dilute sulphuric acid, diluting to about a quarter of a litre, and titrating.

Also prepare a test solution by dissolving 0.1 gram of ferricyanide of potassium in 100cc of water. This solution does not keep well and must be freshly prepared.

An ordinary burette is used. The assay is best contained in a glazed earthenware dish, and may be titrated hot or cold. To determine the finishing point, place a series of drops of the ferricyanide solution on a dry white glazed plate. The drops should be of about about the same size and be placed in lines at fairly equal distances. The bichromate is run in, in a steady stream, the assay solution being continuously stirred until the reaction is sensibly slackened. Then bring a drop of the assay with the stirrer in contact with one of the test drops on the plate. The standard can be safely run in 1cc at a time, so long as the test drop shows signs of a precipitate. When only a coloration is produced run in cautiously a few drops

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Time exposed	1 hour	1 day	2 days	3 days
cc required	19.2	19.1	19.0	19.0

These results show the atmospheric oxidation in cold solutions is unimportant. With boiling solutions the results are somewhat different; a solution which at the outset required 20cc of permanganate of potassium, after boiling for an hour in an open beaker (without any precautions to prevent oxidation), water being added from time to time to replace that lost by evaporation, required 19.2cc. If the solution be evaporated to dryness the oxidising power of concentrated sulphuric acid comes into play, so that very little ferrous iron will be left. A solution evaporated in this way required only 2.2 cc of permanganate of potassium.

Effect of Varying Temperature

In these experiments the bulk was in each case 100cc, and 10cc of dilute sulphuric acid were present. The permanganate required by

1cc of ferrous sulphate was,	at 15°	1.0cc,	and at 70°	1.1cc
10cc	"	"	"	9.7
100cc	"	"	"	97.7
				9.8cc
				96.8cc

The lower result with the 100cc may be due to oxidation from exposure.

There are other conditions which may vary the result somewhat, e.g. bulk, foreign salts, excess acid, iron concentration etc., but provided we always use the same procedure the results will relate.

A quick field test for iron is to simply dissolve a standard measure of the iron in HCl in a test tube, add excess sodium sulphide solution and compare the colour (dark brown) intensity against standards which are made at the same time.

The instrumental analytical techniques will be provided when the equipment is commissioned, and the staff instructed on the equipment.

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21. EQUIPMENT LIST

- i. Because of the nature of pigment testing a dishwasher is essential.
- ii. Exhaust fan above the hot plate (stove).
- iii. False counter top of heat resisting material for sample cooling.
- iv. Mixmaster for pigment blending, sigma blade type e.g. Sunbeam.
- v. Bench grinder or power pestle and mortar; any type capable of processing about 1g per minute to minus 5 microns.
- vi. Bench centrifuge. A clinical or laboratory centrifuge capable of taking at least 2 50cc tubes would suffice.
- vii. A colourimeter.
- ix. Screens - Laboratory screens.
- x. Elutriator - Secondhand.
- xi. Bench top roller - $\frac{1}{4}$ H.P.
- xii. Muffle furnace - Secondhand.
- xiii. Dryer - Secondhand.

Miscellaneous

Beakers - squat 6 x 250cc, 20 x 500cc, 6 x 2L

Conical flasks. Will supply from R&M Shackelford P/L.

Stoppers. " "

(Second thoughts - as this will cost more for me to write up, than for me to purchase, suggest I purchase and invoice Savage

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i.e. glassware, spatulas, filter papers etc..

Balance - believe one already exists at Ballarat.

Reagents - suggest I purchase and invoice.

Do Not purchase atomic absorption unit unless you check with me, especially if you are purchasing a secondhand unit.

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22. PERSONNEL

A person with laboratory or analytical experience would be preferred.

The person must undergo a colour test before hiring.

Some calculations will be necessary, i.e. matriculation level mathematics and chemistry.

23. MODUS OPERANDI

We would assist in setting up the test facility, establishing the standards, and training the staff.

Safety goggles and screens must be provided, the staff instructed in the use of this and the other safety equipment, and the instructions clearly displayed.

24. CONCLUSION

The facility should be expanded on an as needed basis, and could eventually include some pilot facilities.

RALPH E. SHACKLEFORD
JANUARY 1990

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at a time so long as two drops of the assay gives with the test a colour which is even faintly greener than two drops of the assay solution placed alongside. The finishing point is decided and practically permanent, although it demands a little practice to recognise it. The titration with permanganate of potassium has the advantage of a more distinct finishing point and easier mode of working; its application, however, is somewhat limited by the disturbing effects of hydrochloric acid. The bichromate method has the advantage of a standard solution which does not alter in strength, and the further one of being little effected by altering conditions of assay. Hydrochloric acid has practically no effect on it. Both methods give accurate results and are good examples of volumetric methods.

The following results illustrate the extent to which the methods may be relied on; and the influence which the various conditions of experiment have on the assay.

Solutions of ferrous sulphate and of ferrous chloride were made containing 0.5 gram of iron in each 100cc, thus corresponding to the standard solutions of permanganate and bichromate of potassium. These last were prepared in the way already described. The solution of ferrous sulphate was made by dissolving 5.01 grams of iron wire in 100cc of dilute sulphuric acid and diluting to 1 litre. A similar solution may be made by dissolving 24.82 grams of pure ferrous sulphate crystals in water, adding 100cc of dilute sulphuric acid, and diluting to 1 litre.

Rate of Oxidation by Exposure to Air

This is an important consideration, and if the rate were at all rapid would have a serious influence on the manner of working since exclusion of air in the various operations would be troublesome. 20cc of the solution of ferrous sulphate were taken in each experiment, acidified with 10cc of dilute sulphuric acid, and diluted to 100cc. The solution was exposed, cold, in an open beaker for varying lengths of time, and titrated with permanganate of potassium.

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ANSTO

LUCAS HEIGHTS RESEARCH LABORATORIES

A REPORT TO
GRAMET PTY. LTD.

on

SEM EXAMINATION OF GOETHITE SAMPLES G19, G20 AND G21

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Advanced Materials Program
January 1990

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G19
315
06

SEM EXAMINATION OF GOETHITE SAMPLES G19, G20 AND G21

Three samples were examined to compare their particle size, morphology and composition. Photomicrographs in the range 25x to 50,000x are given in Figures 1 to 6, each figure presenting the three samples at the same magnification for ease of comparison. X-ray spectra for bulk powders and individual fine particles are shown in Figures 7, 8 and 9. Table 1 gives approximate (standardless) bulk compositions of powders calculated from the X-ray spectra.

Microstructure

* Sample G19

At low magnifications (Figures 1a to 3a; 25x to 1000x) almost all of the larger particles visible consist of angular fragments of quartz in the range 5-10 μ m up to ~100 μ m, frequently coated by a layer of much finer goethite particles. A few highly spherical "particles" are also found (for example at the bottom of Figure 3a), which actually consist entirely of very fine goethite. These are probably just smaller equivalents of the very soft loosely bound balls of powder easily produced by rolling the sample around in its container. Particle size and shape for the fine fraction, which actually makes up the bulk of the sample, is illustrated in Figures 4a to 6a (10,000 to 50,000x). The fine fraction consists almost entirely of very small rounded particles of goethite about 100nm in diameter, but electrostatic attraction between these extremely small particles has resulted in their combination into aggregates numbering tens to hundreds, producing a continuous range of aggregate sizes up to 1 to 2 microns.

* Sample G20

The low magnification images (Figures 1b to 3b) show that angular quartz fragments are generally larger than in G19, ranging up to 300 μ m, although the finest sizes (5-10 μ m) present in G19 can still be found. The proportion of quartz fragments also appears to be higher than in G19 for all of the quartz particle sizes. However higher magnification images (Figures 4b to 6b) show that there are no significant differences between the fine goethite fractions of G19 and G20, except that rare flakes of clay or mica are visible (Figure 6b).

* Bulk sample. For more information see 90-31588

Sample G21 ^{Bayer} (Commercially available synthetic pigment)
 Bayer 318

Sample G21 differs from G19 and G20 in two ways. Firstly, the low magnification images of this sample (Figures 1c to 3c) show that large particles are absent, and secondly the high magnification images show that G21 consists entirely of small crystallites of acicular and prismatic goethite up to 2 μ m in length. Some of the crystallites are arranged in small radiating clusters. The appearance of G21 indicates that the goethite has probably been precipitated from a liquid and that the sample has not been ground.

Composition of samples

TABLE 1
 STANDARDLESS BULK ANALYSES OF POWDERS (Wt%)
 (average of two 1cm² areas normalized to 100%)

Sample	^{off} G19	^{v/f} G20
SiO ₂	28	35
TiO ₂	1	1
Al ₂ O ₃	22	18
Fe ₂ O ₃	45	41
MgO	2	3
K ₂ O	1	1
SO ₃ *	1	1

* sulphur is from the mounting tape beneath the sample

Approximate bulk compositions of the samples can be obtained by rastering the electron beam over about 1cm² of powder. The resulting X-ray spectra (Figures 7a and 8a) and calculated analyses (Table 1) for G19 and 20 show that only about half of the material actually consists of goethite. There is also considerable SiO₂ and Al₂O₃ present. Some of the SiO₂ occurs as quartz, and the higher SiO₂ content of G20 compared to G19 is a reflection of the higher proportion of quartz fragments present in G20. However analyses of much smaller areas in both samples containing only the extremely fine fraction using a stationary beam (Figures 7b and 8b) show that except for slightly lower SiO₂ (no large quartz fragments included in the analysis) the

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small "goethite" particles also contain significant Al and Si. Many natural goethite occurrences actually consist of extremely fine grained mixtures of goethite and hydrated aluminium oxides, along with chemically precipitated silica or quartz. This also appears to be the case for G19 and 20, although the relatively high silica content probably results from the presence of some extremely finely ground quartz as well. Another possible host for Al and Si is kaolinite (an aluminium silicate clay), but this is unlikely because only one clay-like flake was located (Figure 6b).

Sample G21 (Figure 9) consists of almost pure goethite. The slightly darker colour of G19 and 20 compared to the pure goethite is probably due to the presence of small amounts of TiO_2 .

Discussion

The fine goethite fractions of G19 and 20 appear to be very similar. The two samples differ in the maximum grainsizes of the coarser quartz fragments, but the separation of coarser quartz from G19 has been far from complete. Grinding for a longer period will not alter the grainsize or character of the fine goethite, and it may not significantly shift the grainsize distribution of the quartz fragments because of the "cushioning" effect of the more abundant extremely fine grained and softer goethite. Although it should be confirmed by examination of an uncrushed sample, it is likely that prior to crushing the quartz was present at much larger grainsizes than the goethite as primary grains left over from weathering of the parent rock. During weathering the goethite probably grew as micron sized crystals, but the resulting material would have been denser than the finely ground material now present in G19 and 20. If the presence of quartz particles of the sizes shown above is undesirable then it might be easier to remove while coarser grained, after initial crushing and prior to fine grinding, when both the quartz crystals and relatively dense polycrystalline goethite fragments have a similar grainsize range and a greater difference in density.

Figure 1

Photomicrographs of G19, 20 & 21, x25. General view of the three goethite samples. G19 and G20 contain a large number of angular particles of quartz, G21 does not.

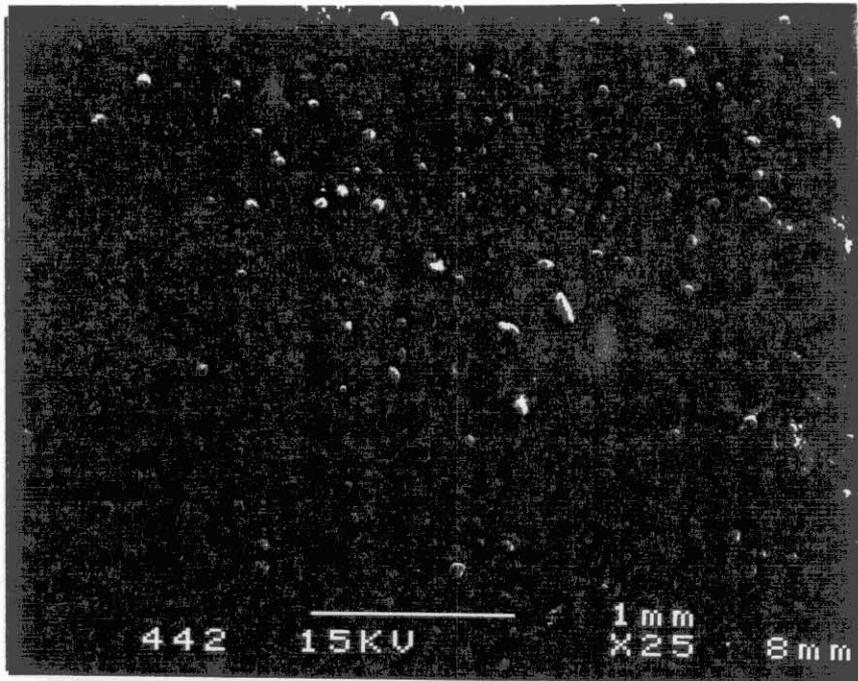
(a) G19

(b) G20

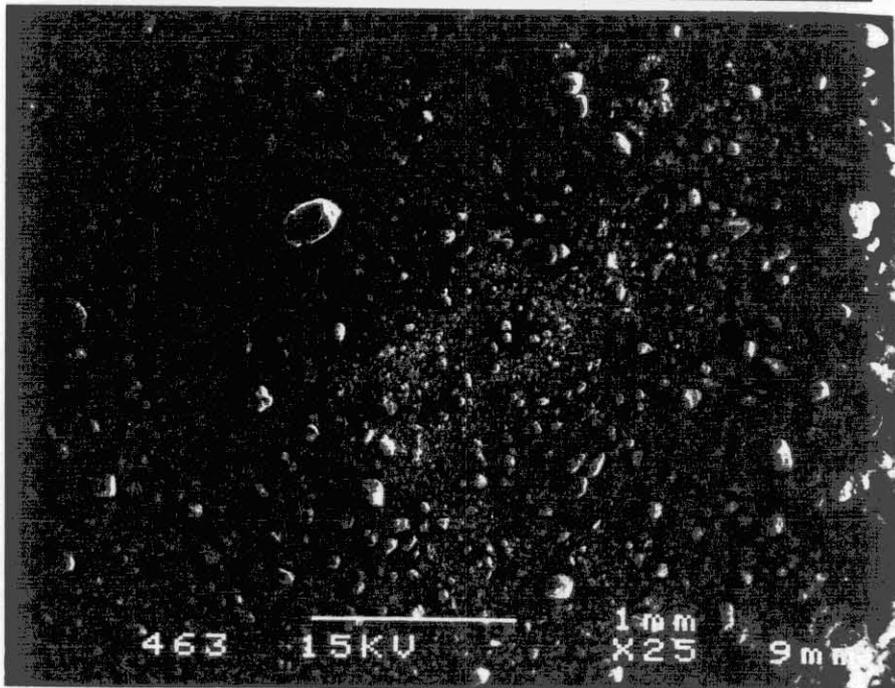
(c) G21

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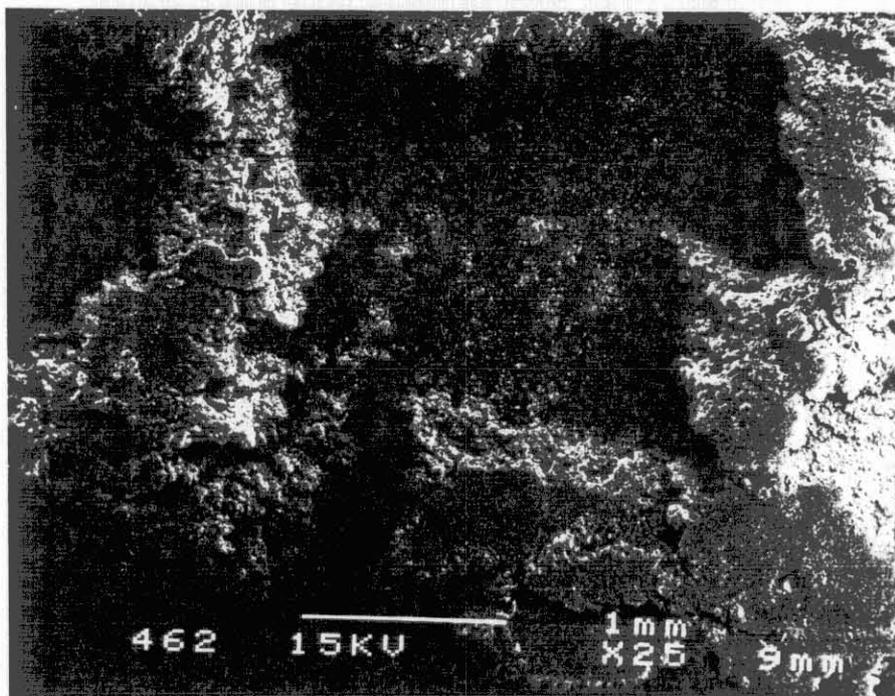
123284



(a)



(b)



(c)

Figure 2

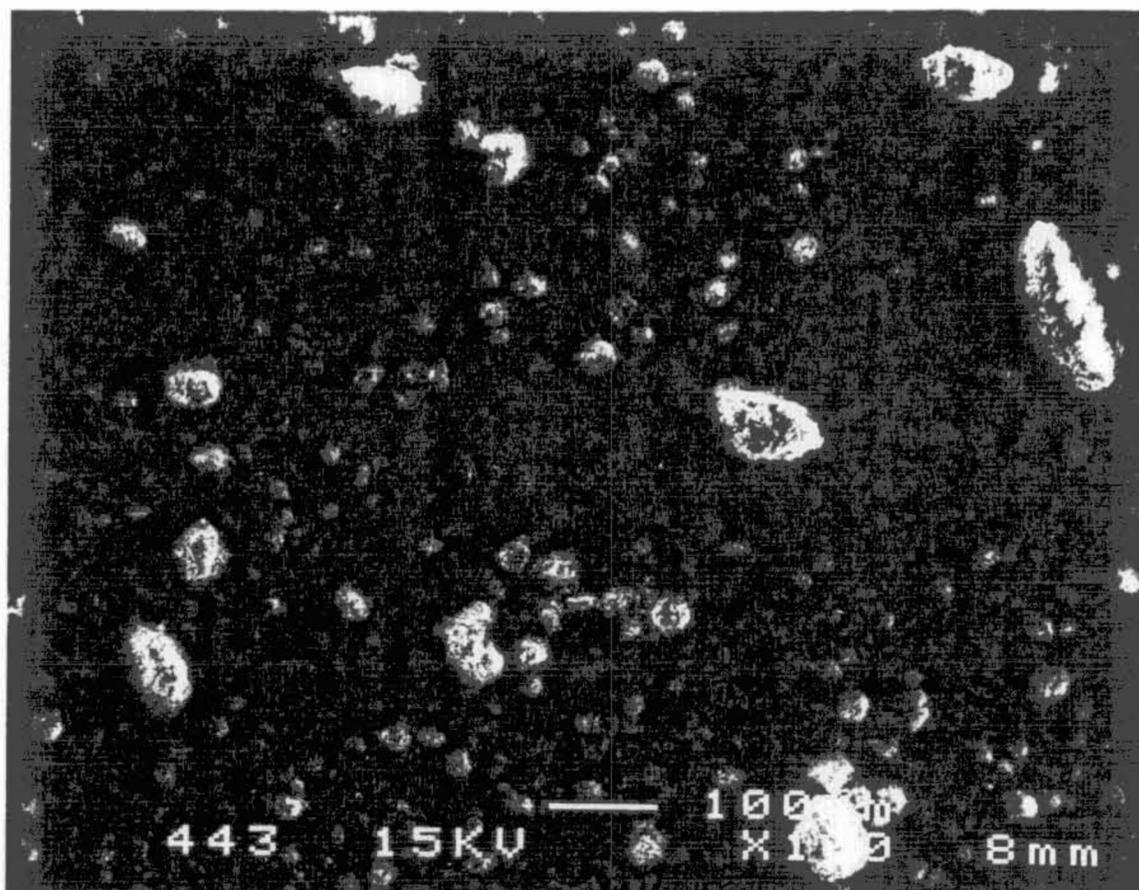
Photomicrographs of G19, 20 & 21, x100. The large angular quartz fragments in G19 and G20 are coated by fine goethite particles. Large fragments are absent from G21.

(a) G19

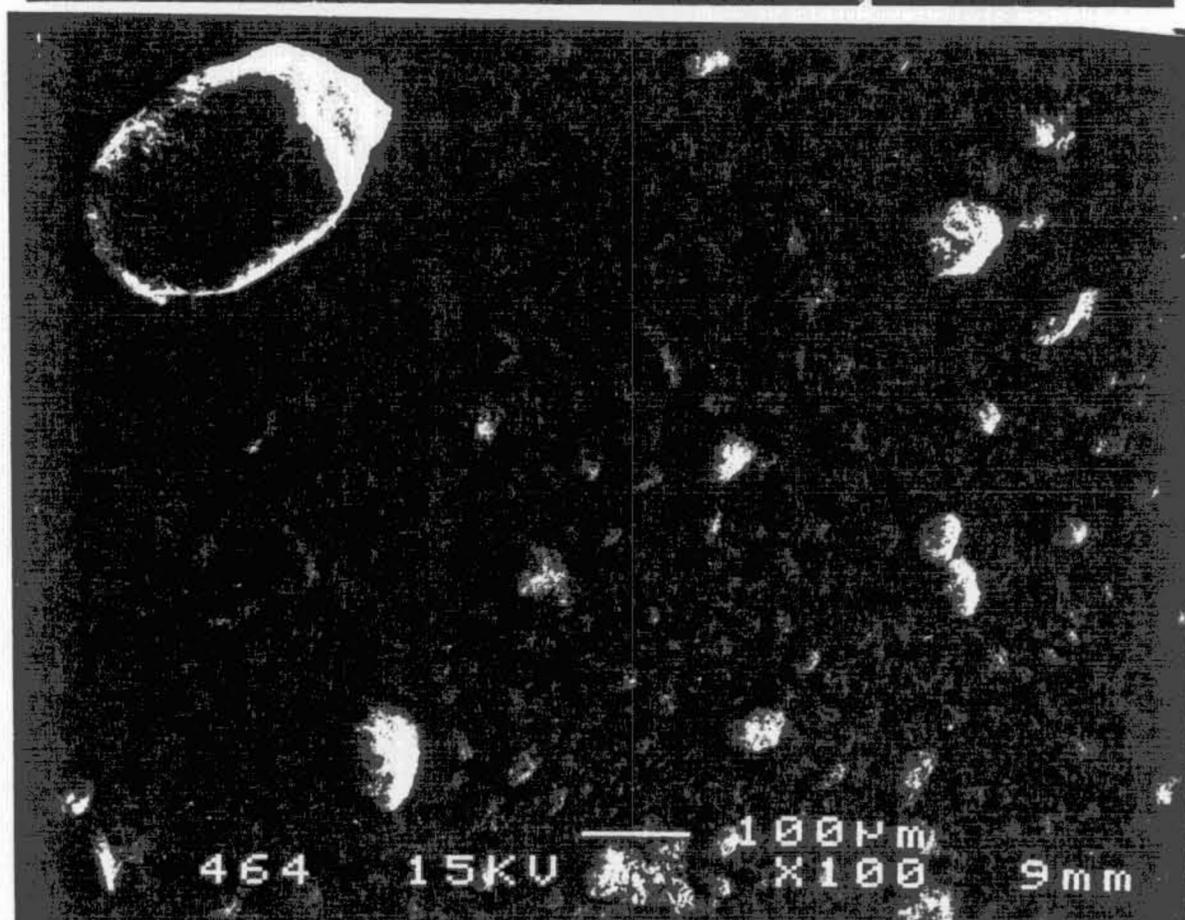
(b) G20

(c) G21

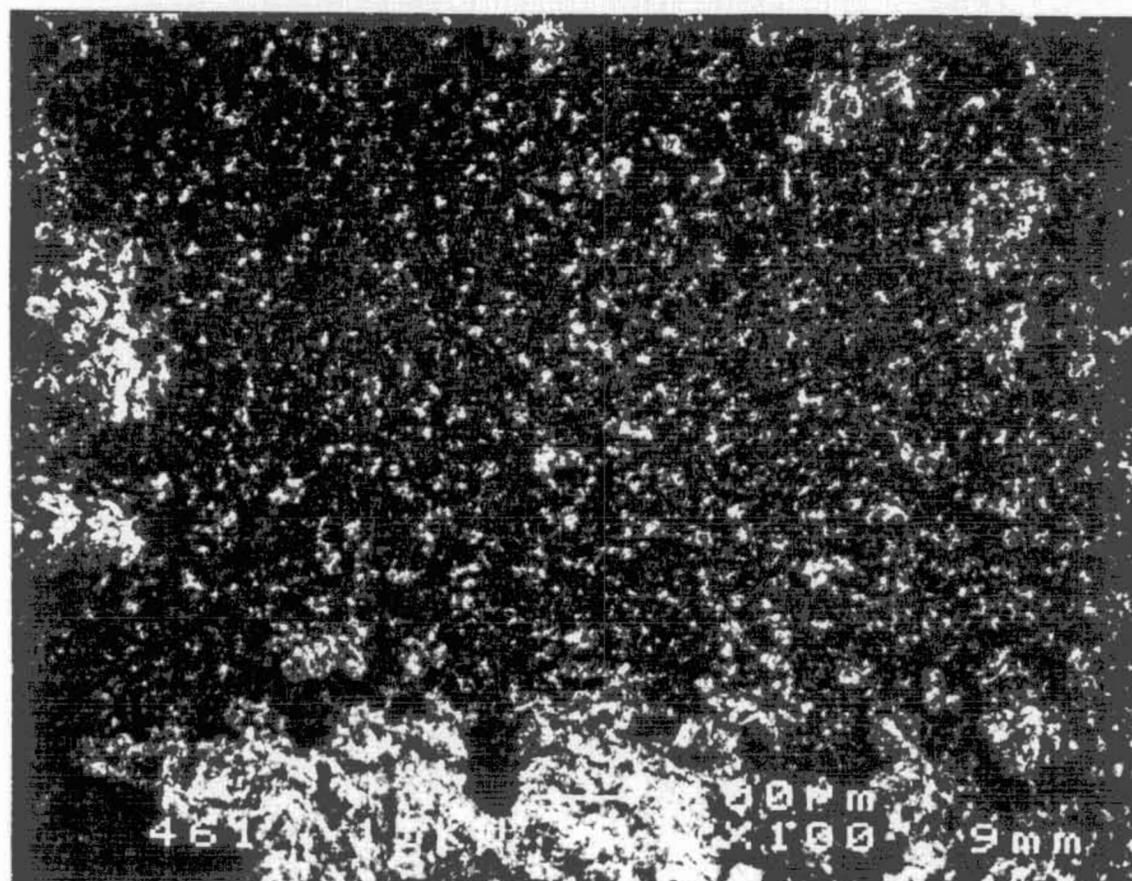
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(a)



(b)



(c)

Figure 3

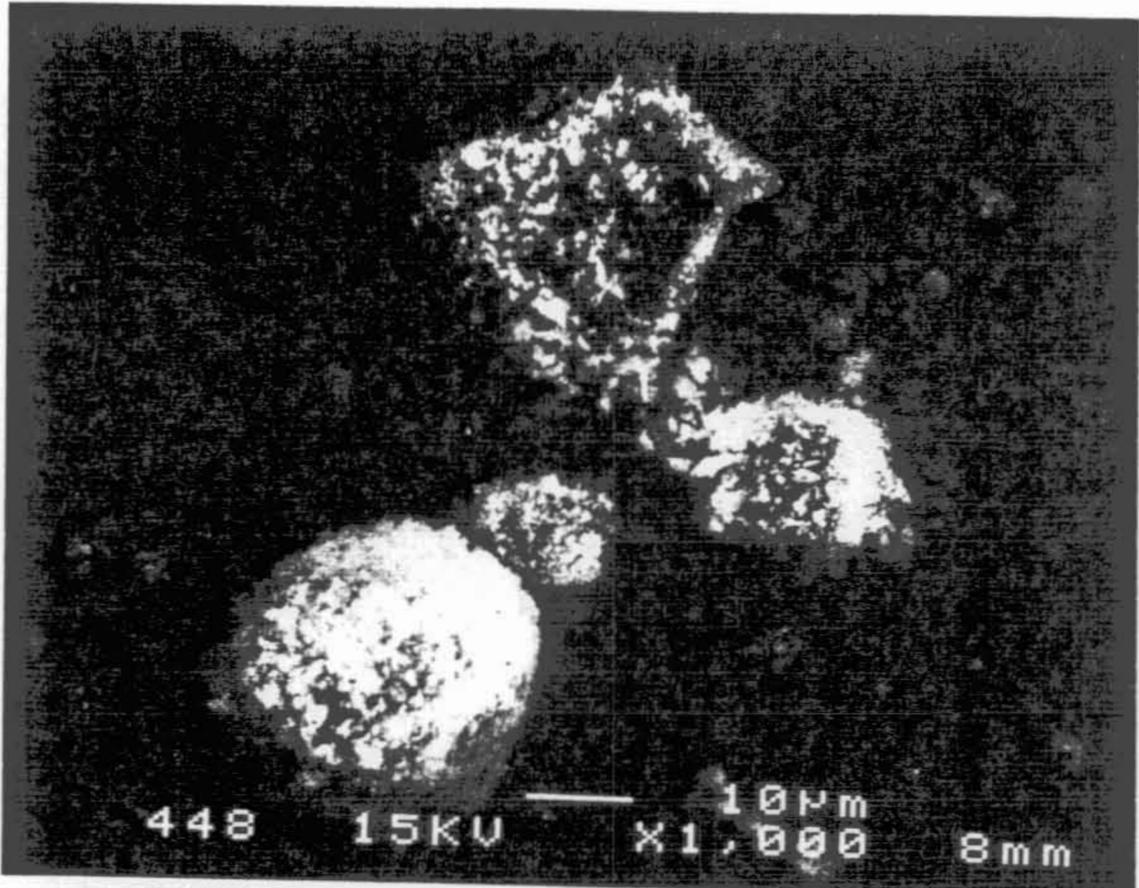
Photomicrographs of G19, 20 & 21, x1,000. Quartz fragments in G19 and G20 are coated in fine goethite, but rounded aggregates consisting entirely of loosely bound fine goethite are also present (a large example is shown at the bottom of 3a). Large fragments are absent from G21.

(a) G19

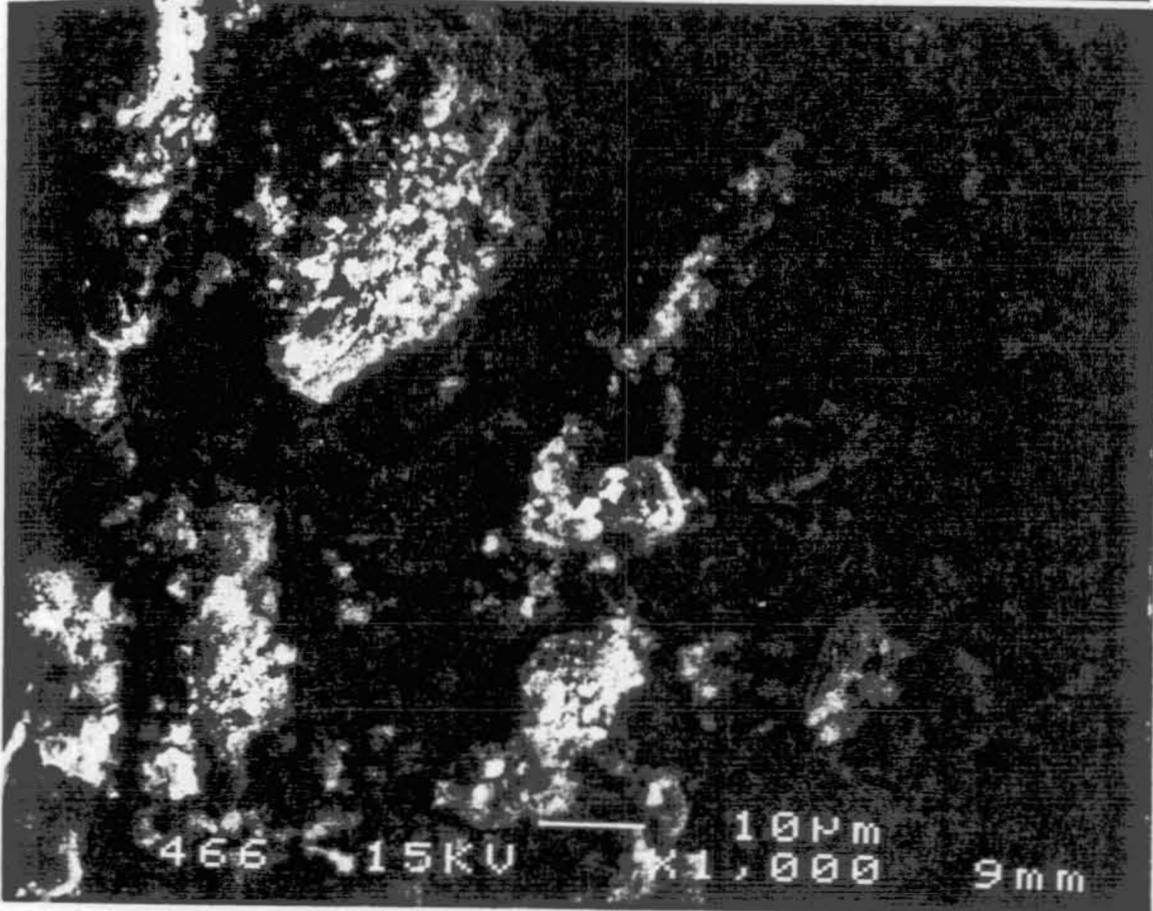
(b) G20

(c) G21

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(a)



(b)



(c)

02-19

Figure 4

Photomicrographs of G19, 20 & 21, x10,000. (a) and (b) illustrate the similarity of the aggregates of small rounded goethite particles in G19 and G20, and (c) shows the contrast with the larger crystallites of G21.

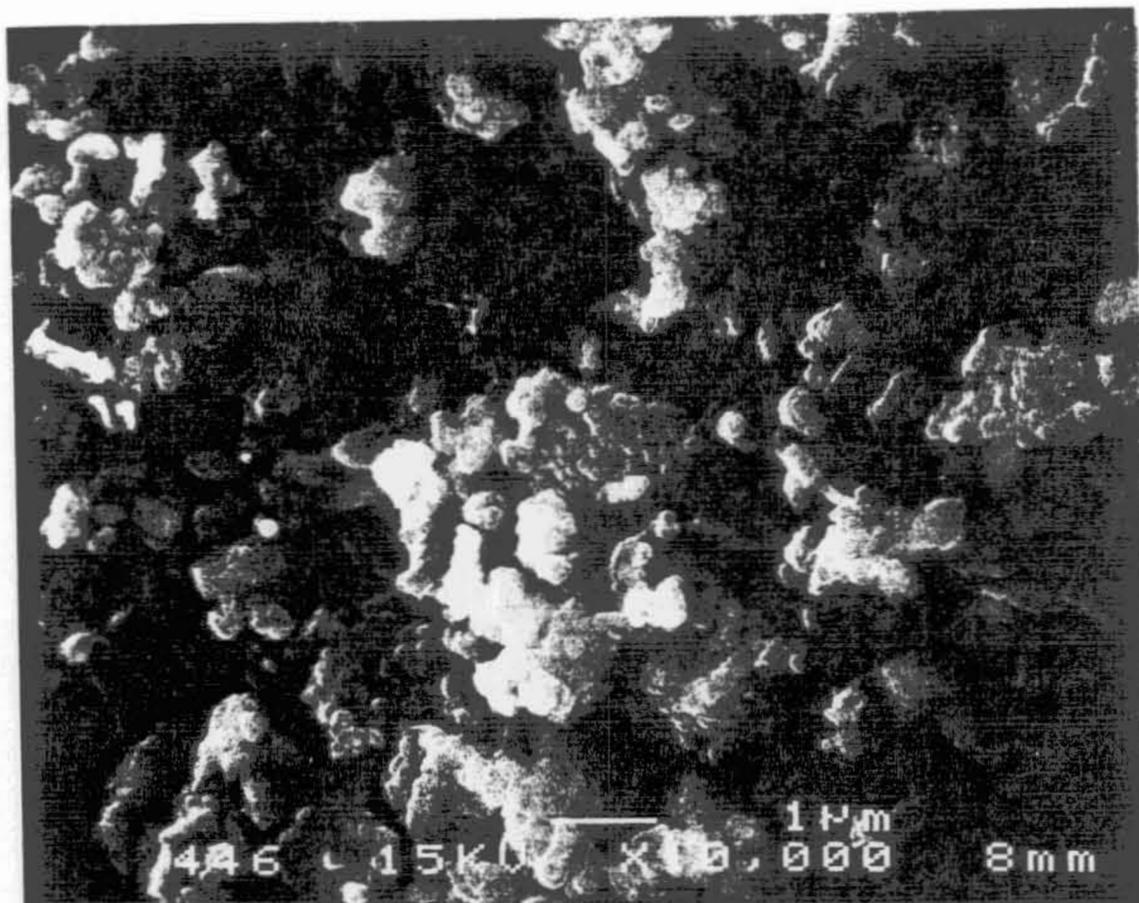
(a) G19

(b) G20

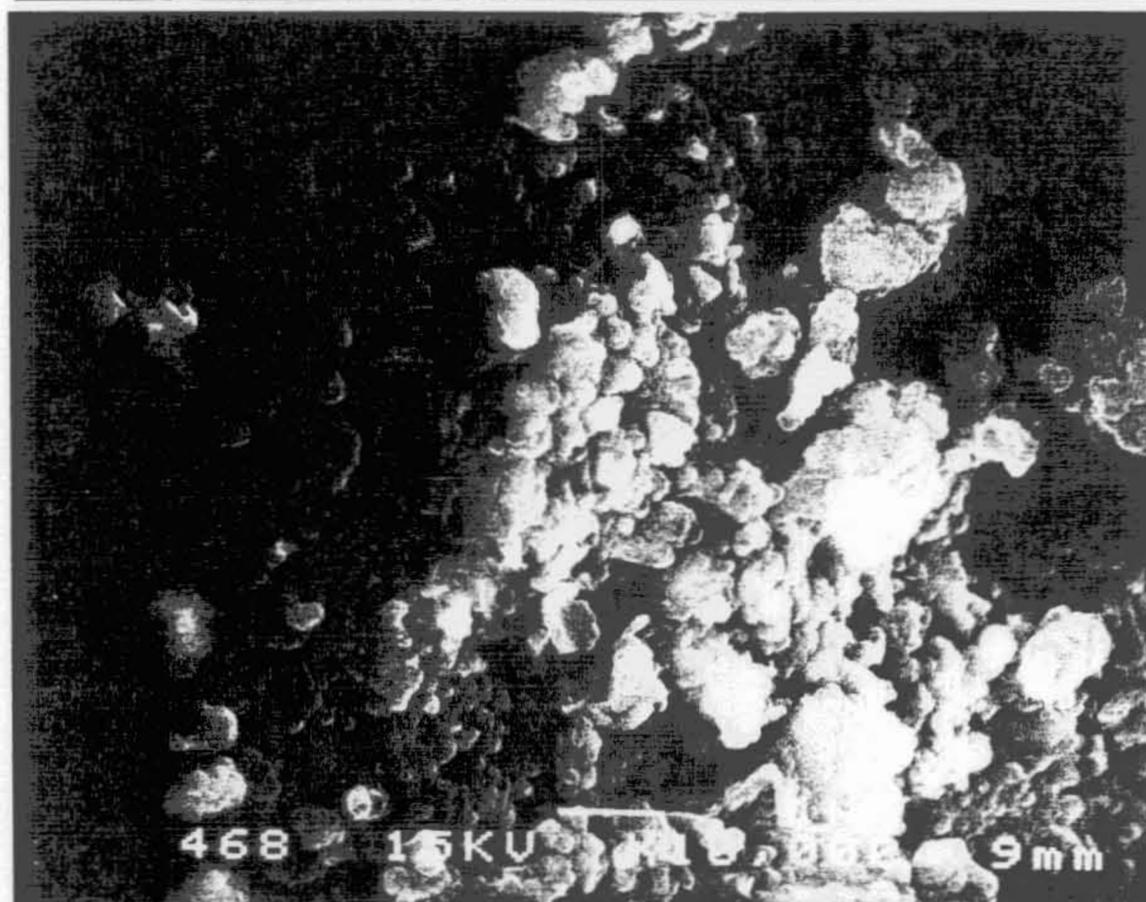
(c) G21

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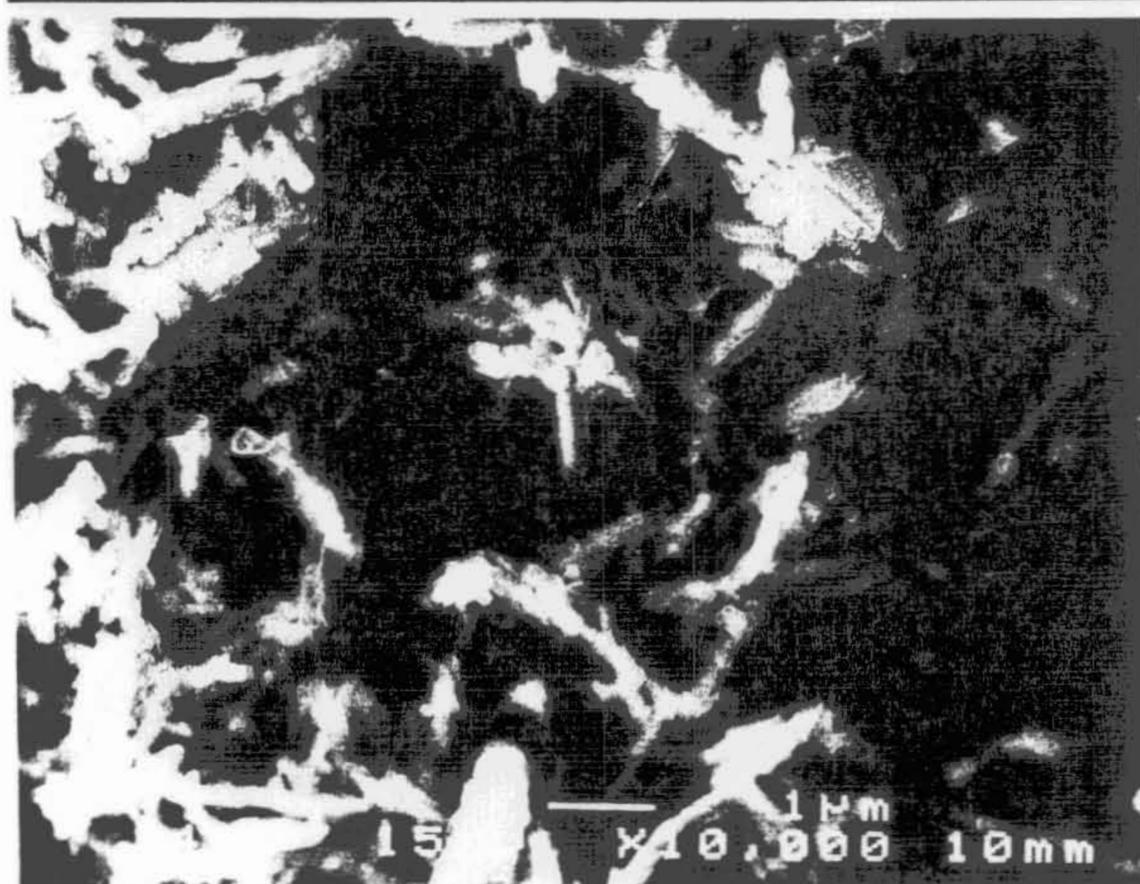
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(a)



(b)



(c)

123291

Figure 5

Photomicrographs of G19, 20 & 21, x25,000, showing more detailed images of the areas in Figure 4.

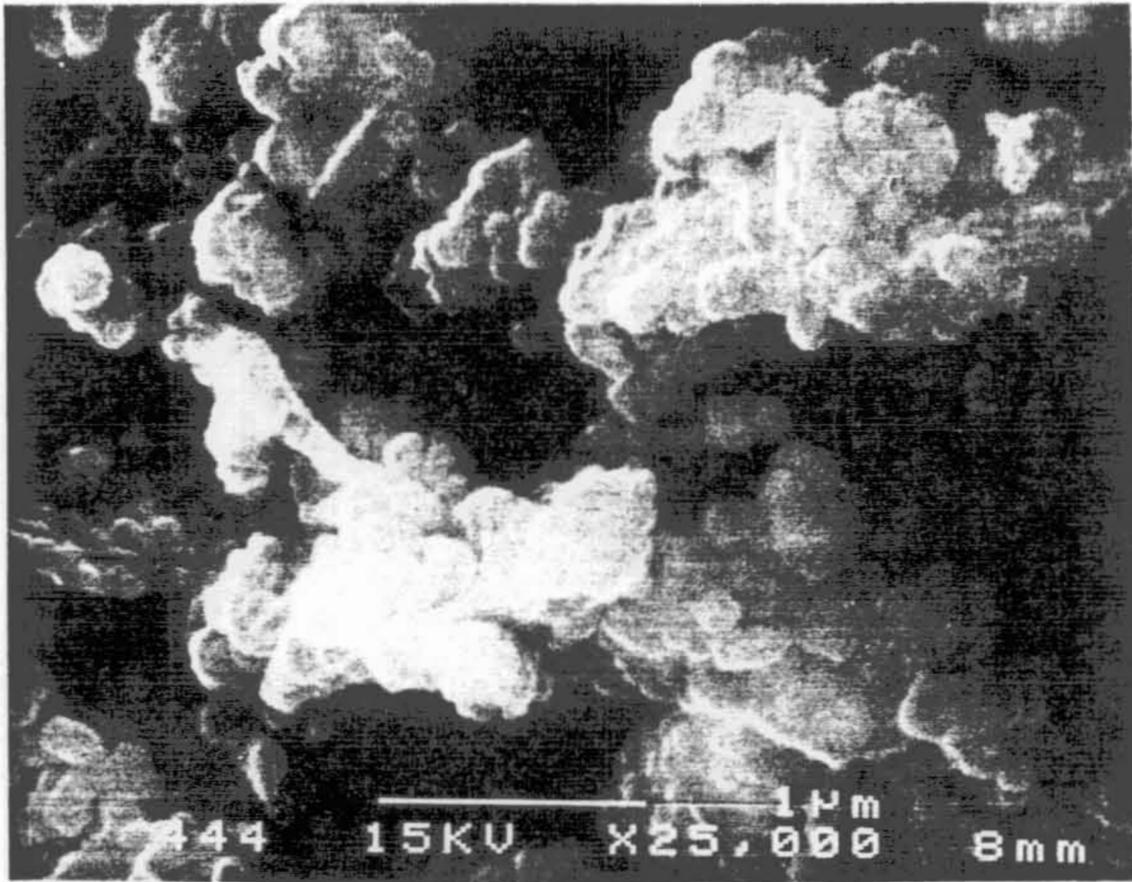
(a) G19

(b) G20

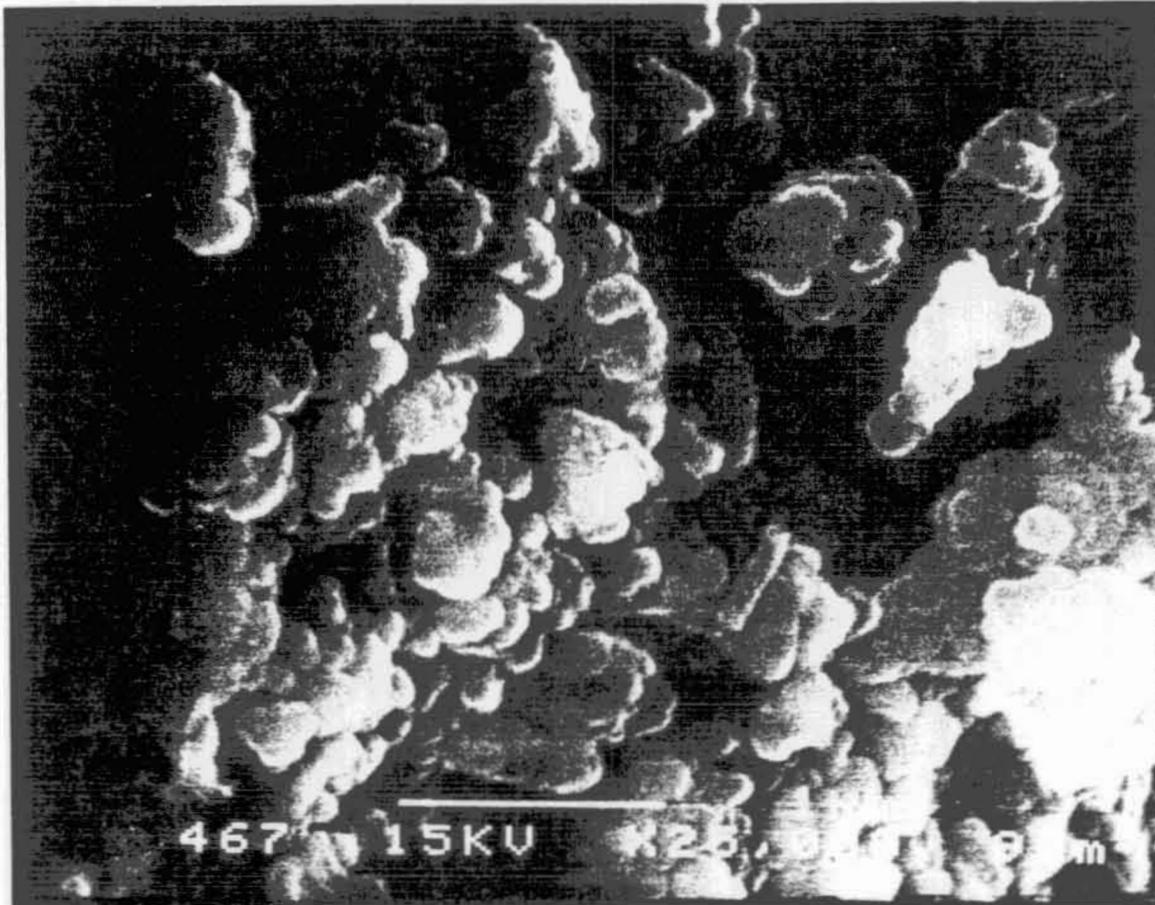
(c) G21

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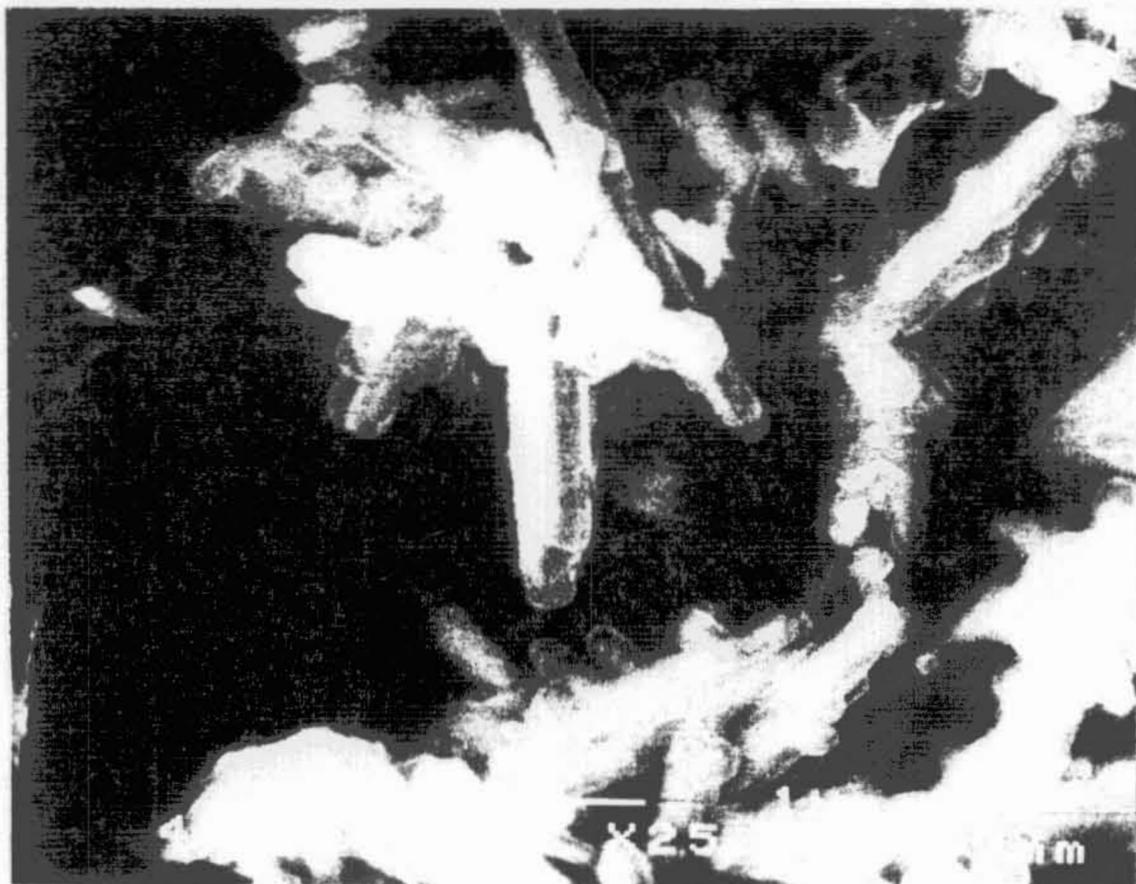
123292



(a)



(b)



(c)

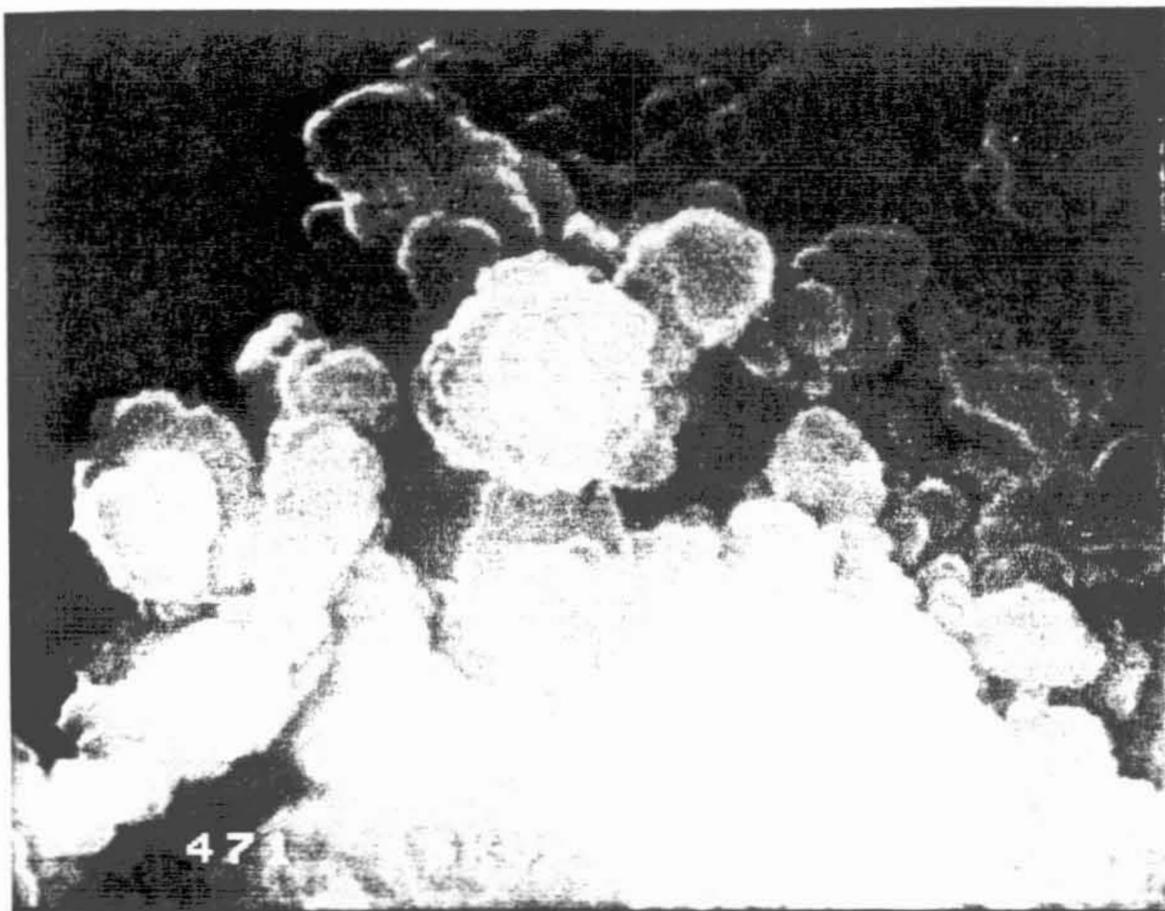
Figure 6

Photomicrographs of G19, 20 & 21, x50,000. In a some of the 2-300nm particles can be seen to consist of tightly coalescing aggregates of smaller ~100nm particles. The centre of **b** shows a fragment of a very small clay or mica flake. **c** is a detail of the centre of 5c showing a radiating cluster of prismatic goethite.

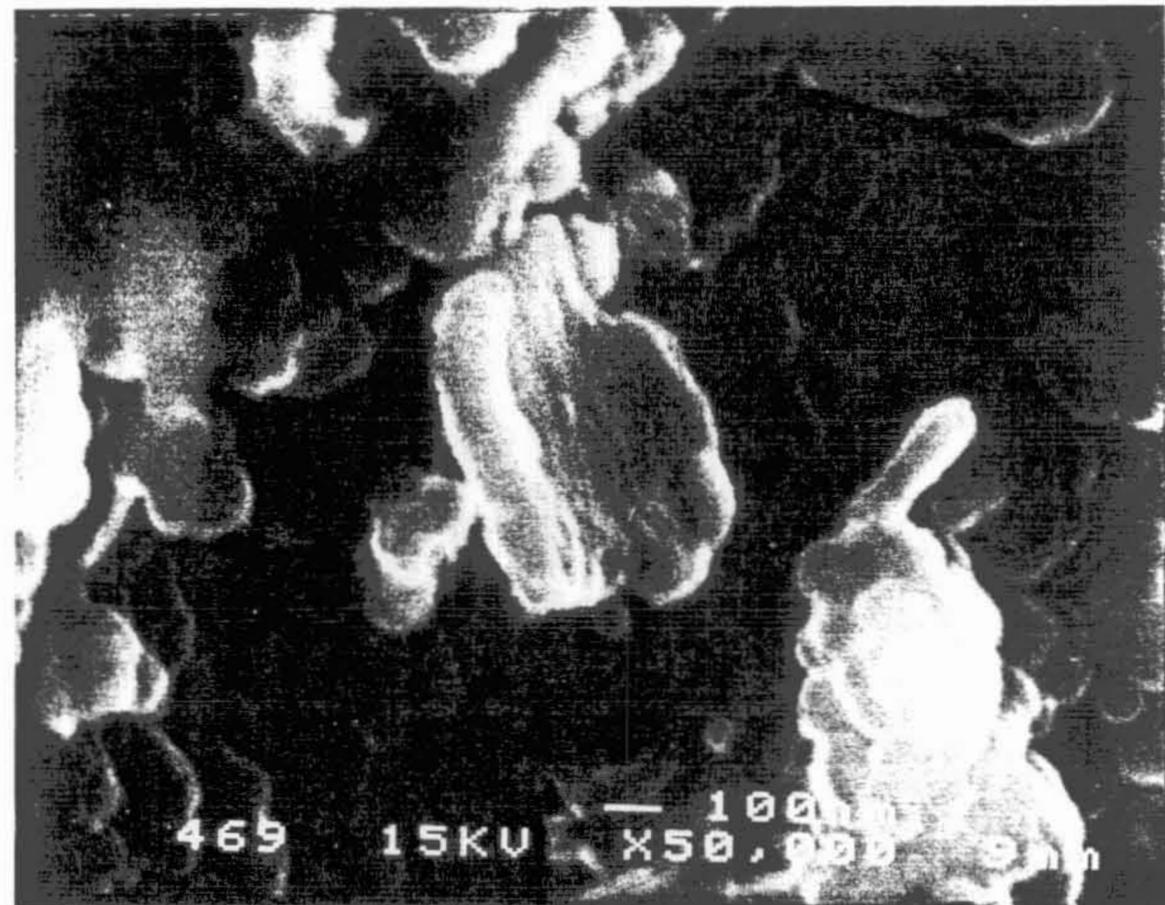
(a) G19

(b) G20

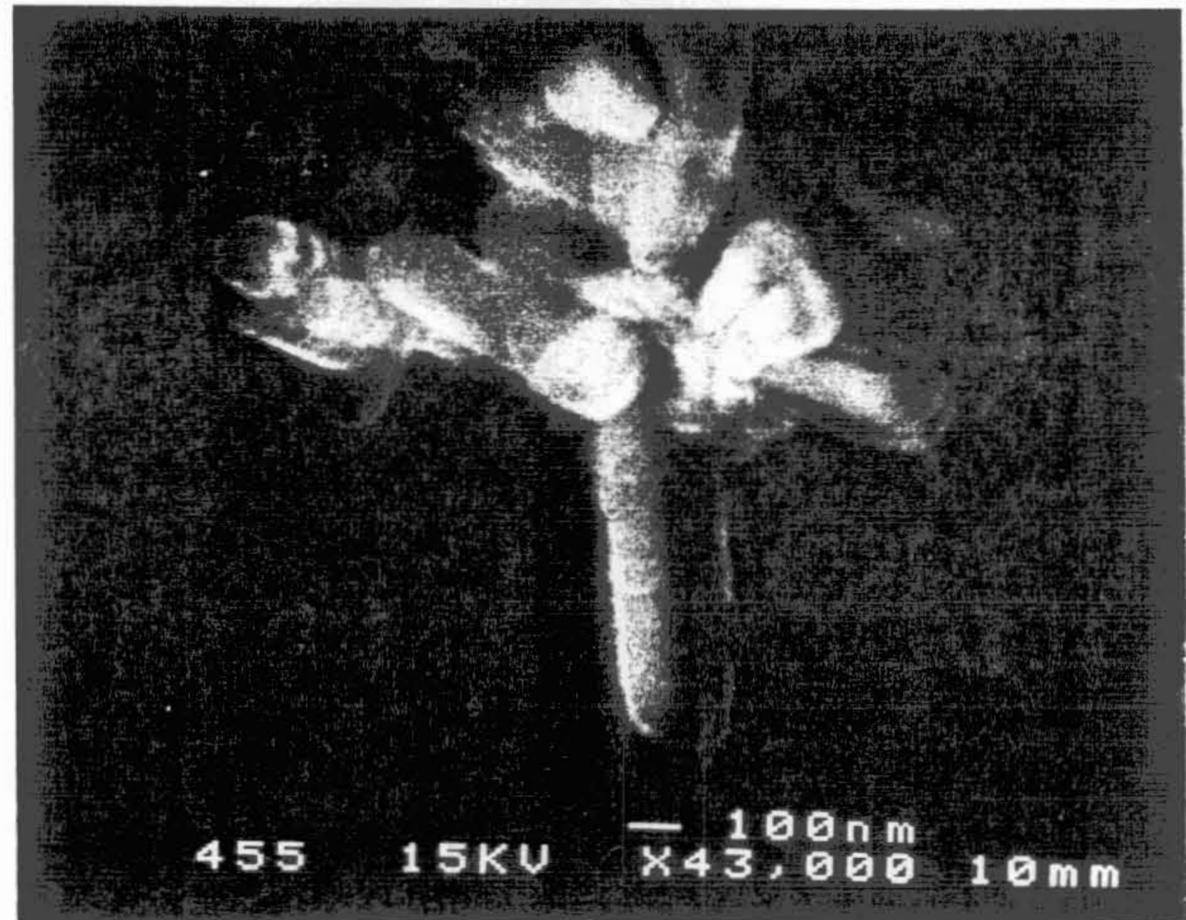
(c) G21



(a)



(b)



(c)

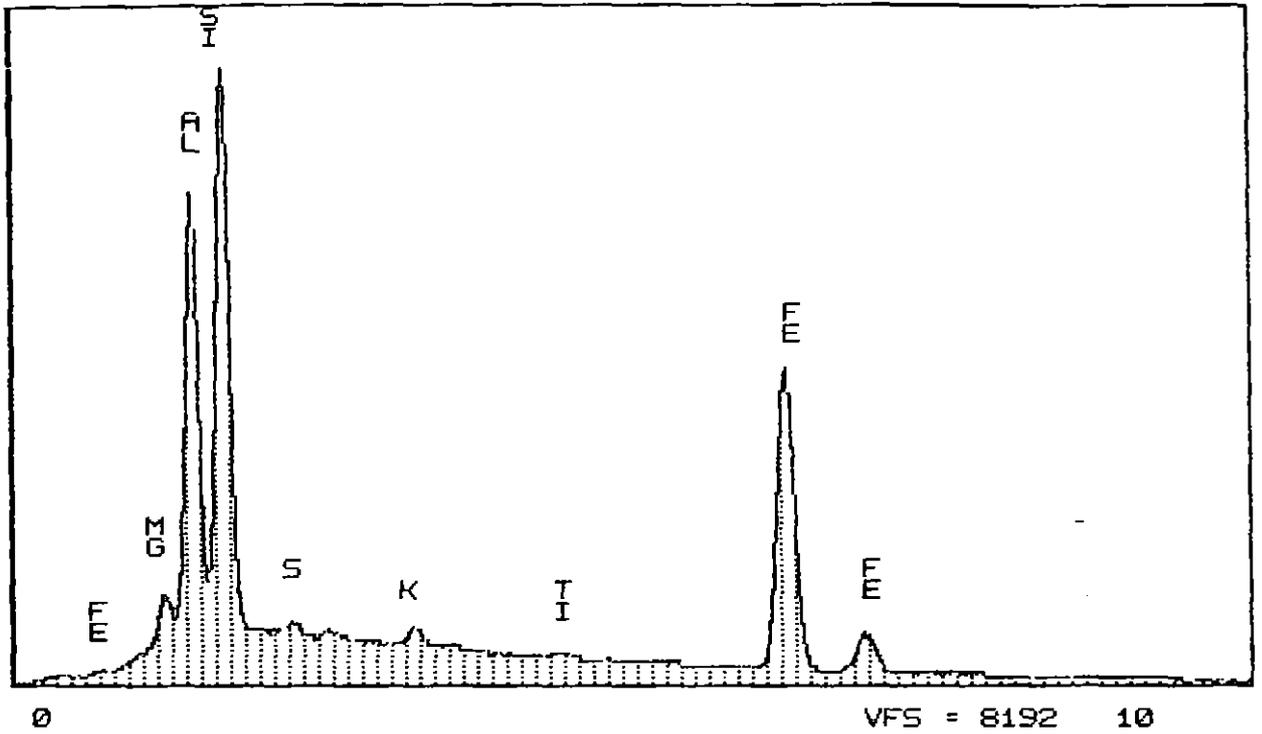


FIG 7A. BULK ANALYSIS OF G19, (AREA 1X1CM)

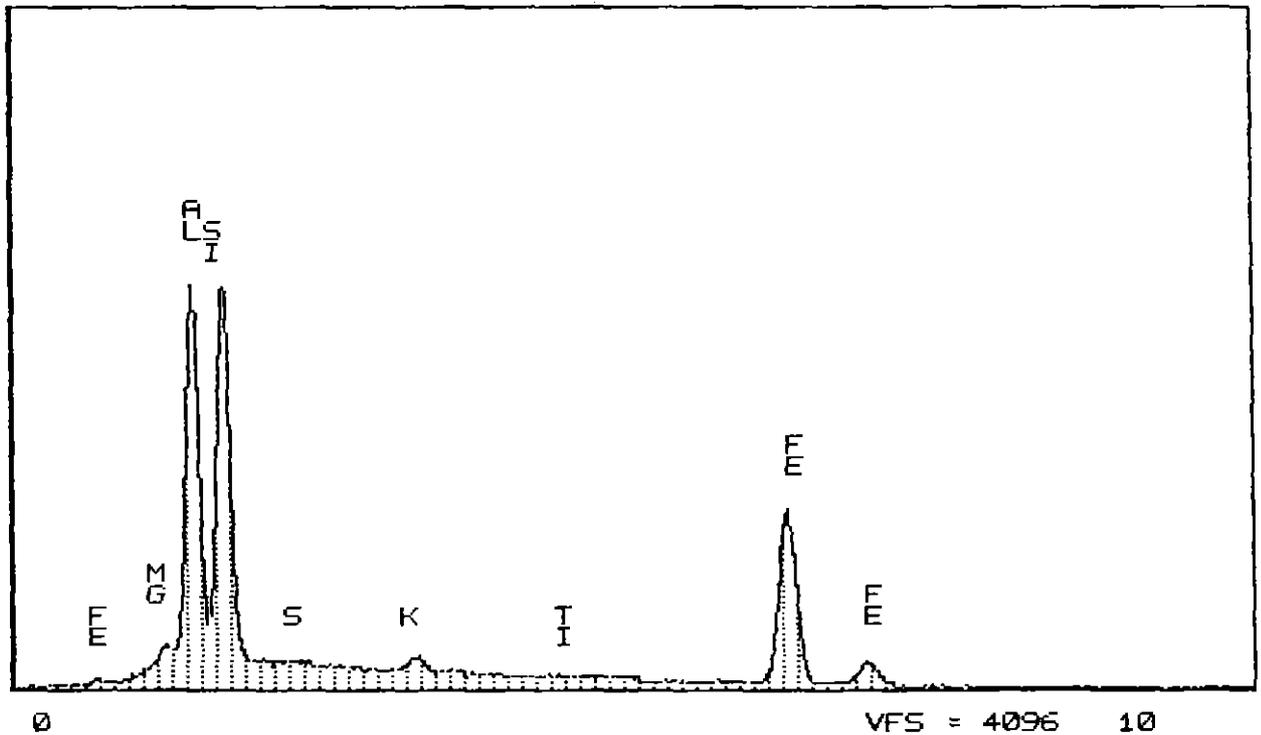
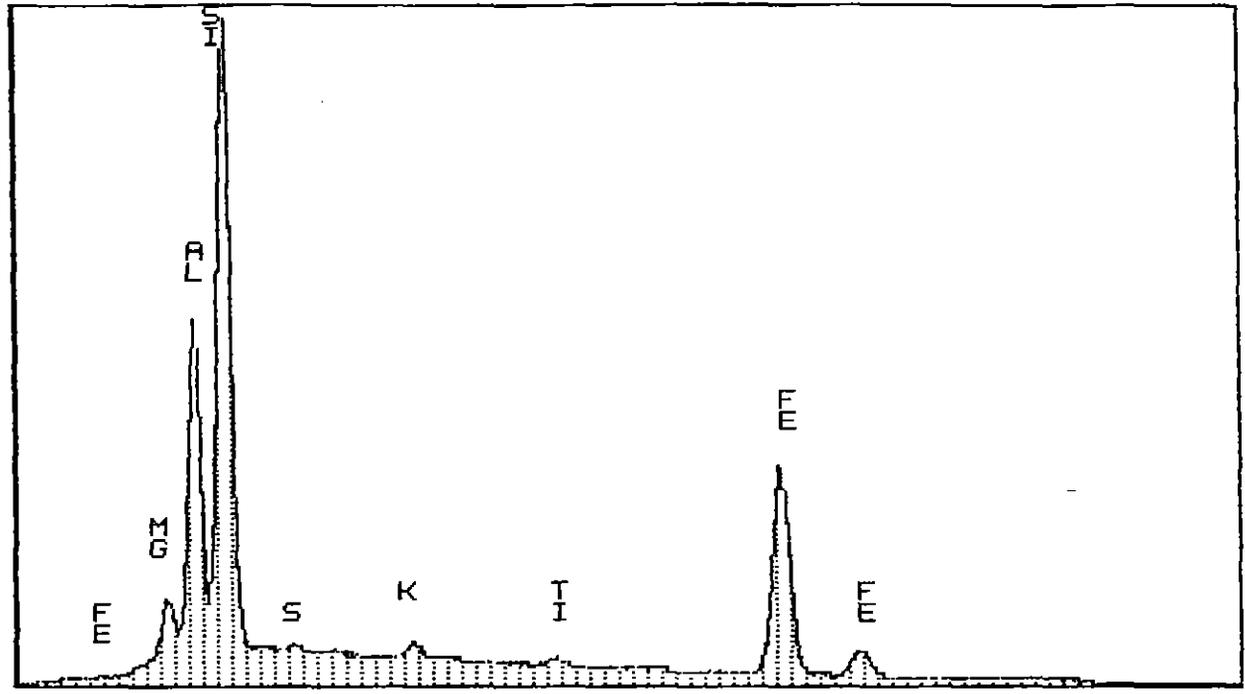


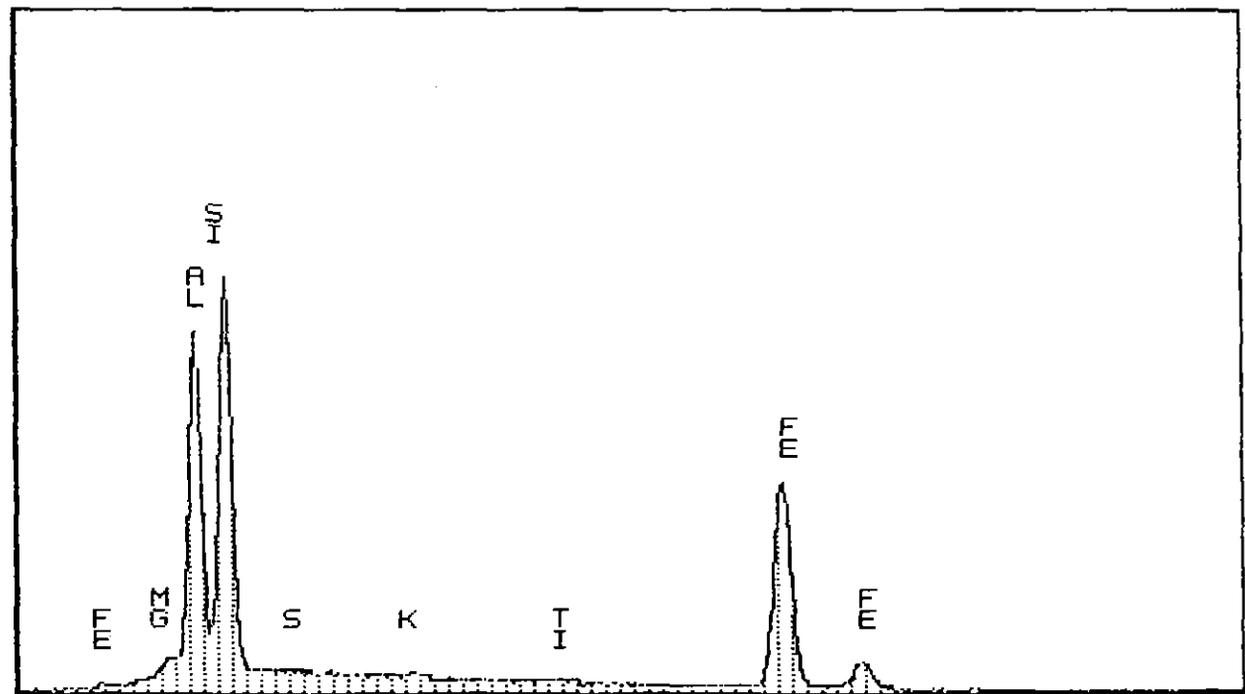
FIG 7B. SMALL PARTICLES IN G19, (AREA 1X1UM)

ANSTO ADVANCED MATERIALS PROGRAM



0 VFS = 8192 10

FIG 8A. BULK ANALYSIS OF G20, (AREA 1X1CM)



0 VFS = 4096 10

FIG 8B. SMALL PARTICLES IN G20, (AREA 1X1UM)

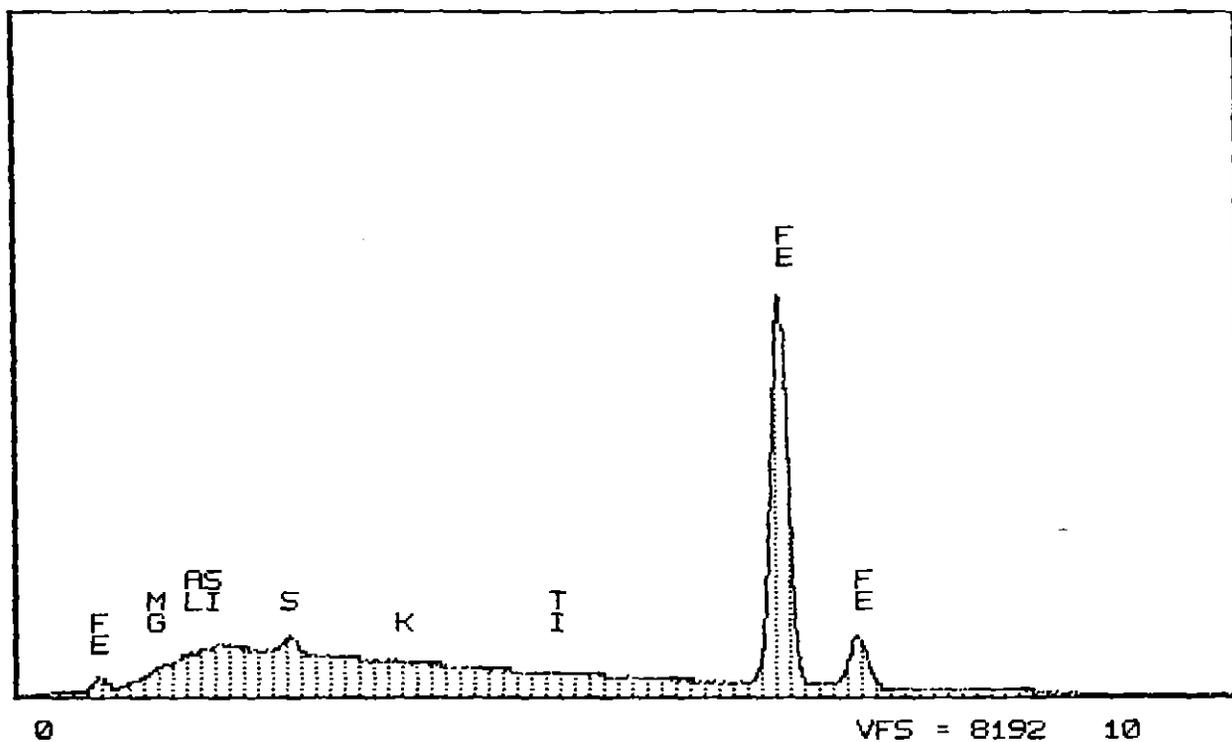


FIG 9. BULK ANALYSIS OF G21, (AREA 1X1CM)

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ANSTO/C131



Ansto

LUCAS HEIGHTS RESEARCH LABORATORIES

**A REPORT TO
GRAMET PTY. LTD.**

on

**SEM EXAMINATION OF GOETHITE SAMPLES
G30 to G38**

by

R.A. Day

Advanced Materials Program
March 1990

90-3158.E

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* HCl/586 is the parent material for samples G30-38

sample	overflow	underflow	blunge 1	blunge 2	HCl rinse 18	HCl rinse 32	HCl rinse 52
G30	Yes			Yes			
G31	Yes			Yes	Yes		
G32	Yes		Yes				
G33	Yes		Yes		Yes		
G34	Yes		Yes		Yes	Yes	
G35	Yes		Yes		Yes		Yes
G36		Yes	Yes				
G37		Yes		Yes			
G38		Yes	(Heavies)				

drill hole	sample	interval	AMC Collar
HCl	5	5-6	346552mE 5400234mN
	6	6-9	

HCl is located within the Main Creek deposit

SEM EXAMINATION OF GOETHITE SAMPLES G30 to G38

Nine samples consisting of cyclone overflows (some washed in 1, and then 3 or 5% HCl) and underflows from -0.1 mm primary and scavenge extractions were examined to determine their mineralogy, particle sizes and morphology, with emphasis on the nature of the goethite. Details of the samples are given in Table 1. General micrographs in the range 25x to 25,000x are shown in Figures 2 to 7, each figure presenting relevant samples at the same magnification for ease of comparison. X-ray spectra for minerals and bulk powders are shown in Figures 8 and 9 respectively, and bulk analyses calculated from the spectra of Figure 9 are in Table 2.

TABLE 1
* SPECIMEN INFORMATION

G30 - Scavenge extraction, -0.1 mm, cyclone O/F, dried @ 110°C.
G31 - Scavenge extraction, -0.1 mm, cyclone O/F, washed with 1% HCl, dried @ 110°C.
G32 - Primary extraction, -0.1 mm, cyclone O/F, dried @ 110°C.
G33 - Primary extraction, -0.1 mm, cyclone O/F, washed with 1% HCl, dried @ 110°C.
G34 - Primary extraction, -0.1 mm, cyclone O/F, washed 1% HCl, 3% HCl, then dried.
G35 - Primary extraction, -0.1 mm, cyclone O/F, washed 1% HCl, 5% HCl, then dried.
G36 - Primary extraction, -0.1 mm, cyclone U/F, dried @ 110°C.
G37 - Scavenge extraction, -0.1 mm, cyclone U/F, dried @ 110°C.
G38 - Primary extraction, -0.1 mm, cyclone U/F, dense mineral tail from G36.

Summary of mineralogy, particle sizes and morphology

Removal of quartz in the primary and scavenge extraction overflows has been successful (Figures 2a to c; 3a to f) with most appearing in the underflows (Figures 2d; 3g & h), particularly the "dense mineral tail" (Figure 3i). Only a few quartz particles were found in the scavenge overflows (e.g., Figure 5a), while none were located in the primary overflows indicating that quartz is either absent or only present as rare very small particles.

Both primary and scavenge extraction overflows are dominated by extremely abundant flakes of weathered Mg chlorite and a smaller

proportion of sericite ("white mica") (Figures 4 & 5 a to c). No carbonate particles were found. Almost all of the goethite appears to be present as bulbous cryptocrystalline or amorphous coatings on the extremely abundant weathered chlorite flakes. Examples of weathered chlorite covered by bulbous deposits of goethite dominate the micrographs of all overflow samples at 10,000x and 25,000x (Figures 6 & 7), but a particularly clear example is shown in Figure 6f. Close examination of all of the cyclone overflow extractions shows that there is some variation in the extent of goethite coating on individual chlorite flakes from virtually no coating to severe cases where the original form of the chlorite can barely be distinguished beneath a thick layer of goethite. Initial stages of this process can be observed on the least weathered chlorites, for example Figures 1a and b show an unusual example of an almost unweathered chlorite flake free of goethite except for two isolated dome-like masses visible on its upper surface. Fragments consisting entirely of massive goethite or cemented aggregates of ~1 μm rounded goethite particles (Figures 1c and d) form a small proportion (always <5% of the total) in both overflows and underflows. Weathered chlorite and sericite flakes also form an important component of the underflows (Figures 4 & 5 d) but they are joined by significant amounts of quartz, some goethite particles, and accessory amounts of tourmaline, rutile, magnetite, corundum, Mn oxides and rare zircon (Figures 2d; 3g & h).

The "dense mineral tail" from the G36 cyclone underflow sample is not really a heavy mineral concentrate but it is characterized by an almost total absence of chlorite and sericite (Figure 3i). It is dominated by quartz but tourmaline is also common. Accessory minerals are the same as G36 and G37 with the addition of very rare monazite.

All cyclone overflows have similar particle sizes and morphologies, except that there are more large flakes of chlorite and sericite (up to ~50 μm) in the scavenge extraction overflows than in the primary (up to ~20 μm) (Figures 3a to f). However the vast majority of particles fall into the 1-10 μm and 1-15 μm ranges for the primary and scavenge overflows respectively (Figures 4a to c), with much sub-micron material also present (Figures 5a to c; 6a to f). The primary and scavenge underflows are indistinguishable from each other and considerably coarser than the overflows, with the majority of the material in the 10 to 100 μm range (Figures 3g & h) and a distinct lack of sub-micron sizes which when present are found adhering to the much larger particles (Figures 4 & 5 d).

The "dense mineral tail" has an extremely uniform grainsize and almost all of the particles are close to 100 μm in diameter (Figure 3i). Acid washing at 1, and then 3 or 5% HCl has had no visible effect on particle sizes or morphologies in any of the samples.

Bulk compositions

Table 2 gives approximate bulk compositions of the samples calculated from the X-ray spectra of Figures 9a to i. Acid washing of overflows (G31, and G33, 34 and 35) has no detectable effect on the bulk compositions, consistent with the absence of carbonates. Iron abundances generally reflect goethite content, although some Fe can also be detected in the chlorite, even when it is not coated in goethite (Figure 8a). The four primary extraction overflow samples have the highest iron, and all underflows have the lowest. Virtually all Mg in all samples is due to the weathered Mg chlorite (Figure 8a), and likewise almost all K is located in sericite (Figure 8b). Most Si and Al in the overflow samples is due to chlorite and sericite while higher Si and lower Al in the underflows reflects increasing quartz and decreasing chlorite and sericite. The underflows have more Ti as a result of rutile, and G38 has detectable Na due to the relative abundance of tourmaline.

TABLE 2
BULK ANALYSES OF POWDERS (WT% OXIDES)¹

2

Sample	G30	G31	G32	G33	G34	G35	G36	G37	G38
SiO ₂	35	35	34	34	34	34	40	41	61
TiO ₂	1	0.5	0.5	0.5	0.5	0.5	2	2	1
Al ₂ O ₃	27	27	27	27	27	27	24	23	14
Fe ₂ O ₃	25	27	29	29	30	29	24	22	20
MnO	1	1	1	1	1	1	1	1	1
MgO	10	9	8	8	7	8	8	10	2
K ₂ O	1	0.5	0.5	0.5	0.5	0.5	1	1	0.5

¹. These analyses are "standardless" and normalized to 100%, made by rastering the beam over about 1 cm² of loosely mounted powder. They are of low accuracy and should be used for comparative purposes only.

². A small amount of Na₂O is also present in G38.

Comparison of cyclone overflow extractions (G30 to 35) with G19 and G20 (see ANSTO report to GRAMET, January 1990).

The large quartz fragments of G19 and G20 are absent from G30 to 35, and small flakes of sericite (or chlorite?) are rare and only found in G20. G19 and G20 also have lower bulk Mg and much more Fe. These contrasts indicate that the parent material for G19 and G20 has undergone more extensive weathering resulting in breakdown of chlorites, leaching of Mg, and accumulation of oxidized Fe.

Effect of weathered chlorite and sericite on colour

Unweathered chlorites are generally green because their iron is present in the Fe^{2+} state. However it is almost certain given the extent of oxide coatings that the chlorites are sufficiently oxidized internally for the Fe present to convert to an Fe^{3+} state, which would result in a brown colour similar to that of the goethite. Unlike chlorite, sericite is a very weakly coloured mineral and the small amount of Fe that it can contain is already in the Fe^{3+} state. It probably does not contribute greatly to the colour of G30 to 38.

Figure 1

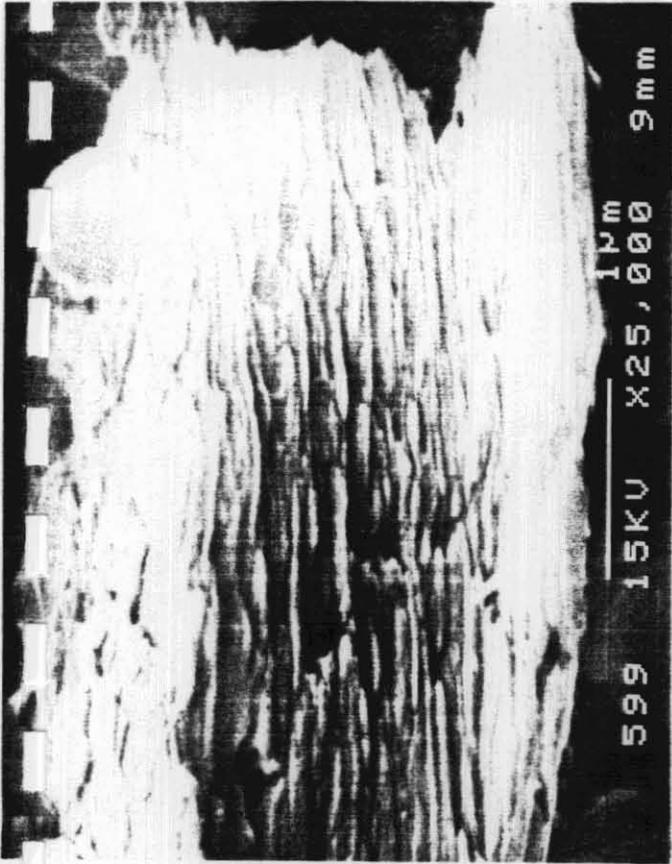
Occurrence of goethite:

(a) & (b) G35 Primary extraction cyclone O/F, 1% then 5% HCl. Two small dome-like masses of amorphous or cryptocrystalline goethite growing on the upper cleavage surface of a large unweathered Mg chlorite flake illustrate the initial stage in development of goethite coatings. Note the well developed basal cleavage characteristic of chlorite. More typical examples of goethite coatings on chlorite dominate the micrographs of all overflow samples at 10,000 and 25,000x in Figures 6 and 7.

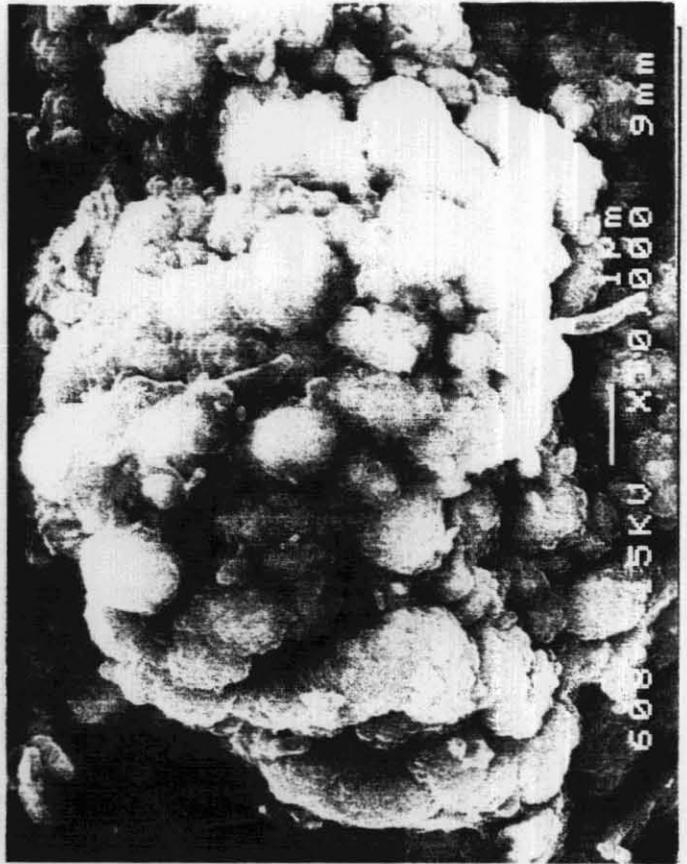
(c) & (d) G37 Scavenge extraction cyclone U/F, dried at 110°C. Large cemented aggregate of ~1 μm rounded goethite particles. In d the particles appear to consist of even smaller tightly coalescing ~100 nm spheres. Fragments composed entirely of goethite form only a small proportion (<5%) of the total in all overflow and underflow samples and are not typical.

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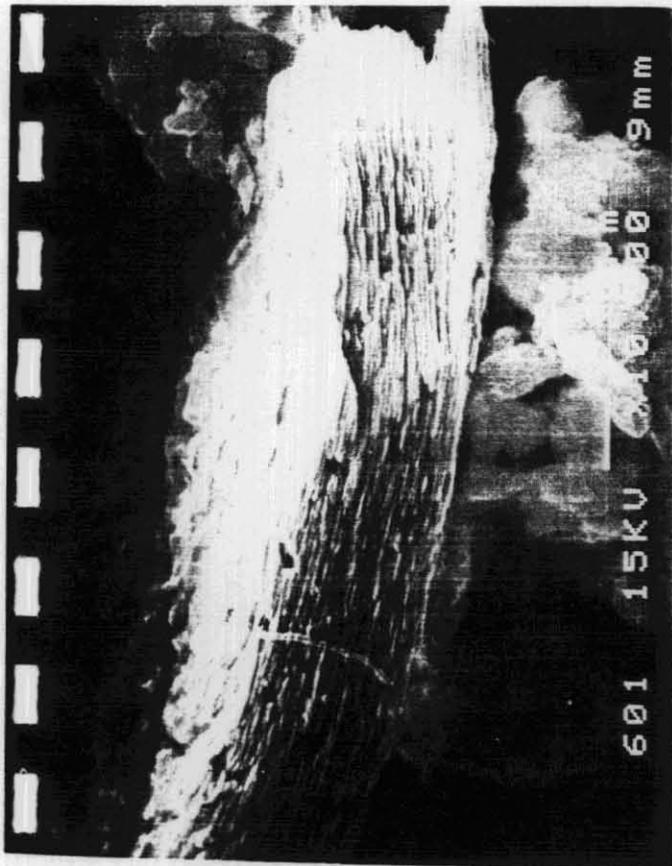
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(b)



(d)



(a)



(c)

Figure 2

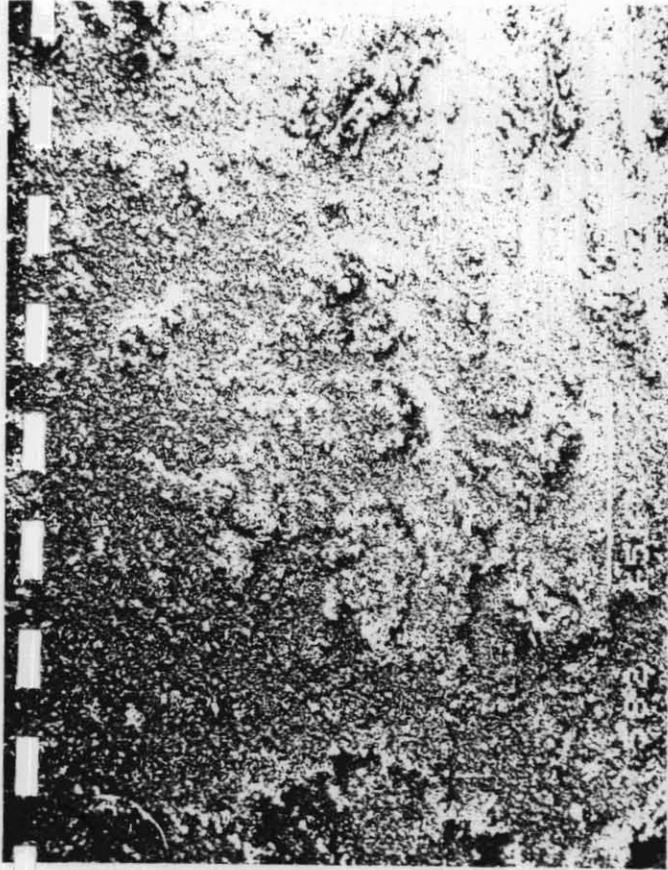
Representative micrographs of overflow samples (a, b & c) and an underflow sample (d) at x25 magnification. In the overflow samples the largest particles visible at this magnification are almost exclusively flakes of weathered Mg chlorite and sericite. Maximum particle sizes are much larger in the underflow sample and consist of larger flakes of chlorite and sericite together with a significant amount of quartz and some tourmaline.

(a, b & c) Scavenge extraction overflows G30 and G31, and primary extraction overflow G32 respectively. The other primary extraction overflow samples G33, G34 and G35 are identical at this magnification. The large light coloured patches in c are due to specimen charging.

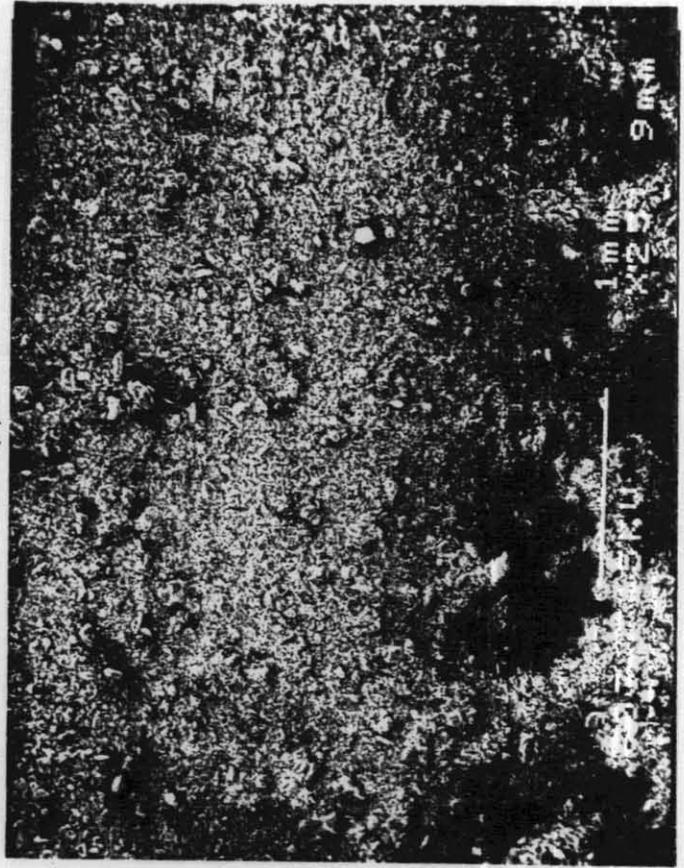
(d) Primary extraction underflow G36. The other underflow sample G37 is identical.

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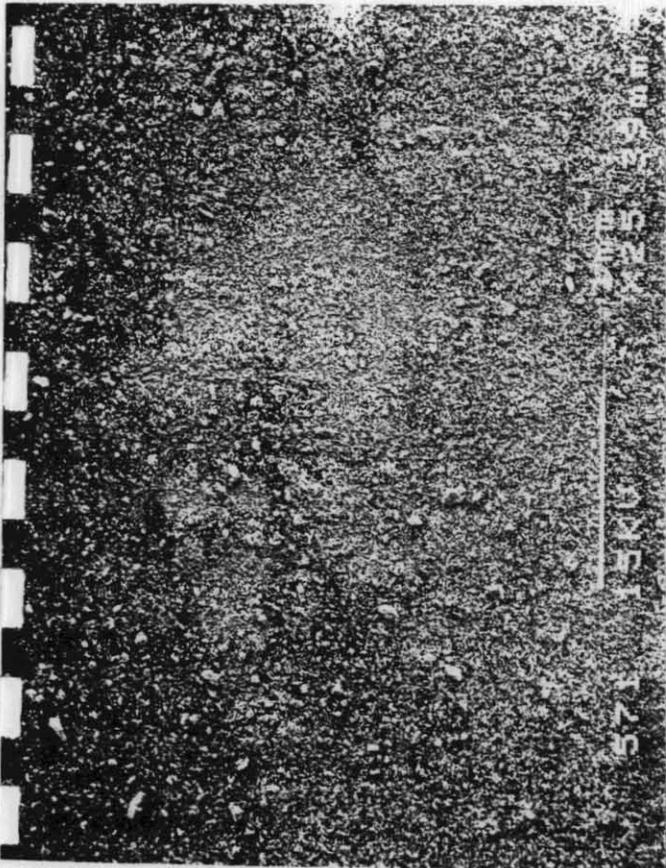
123306



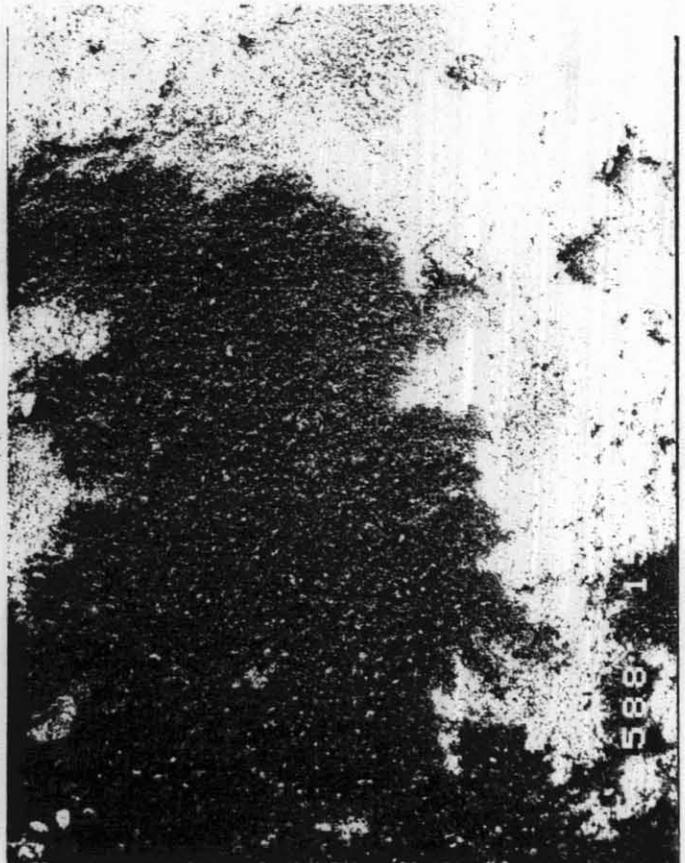
(b)



(d)



(a)



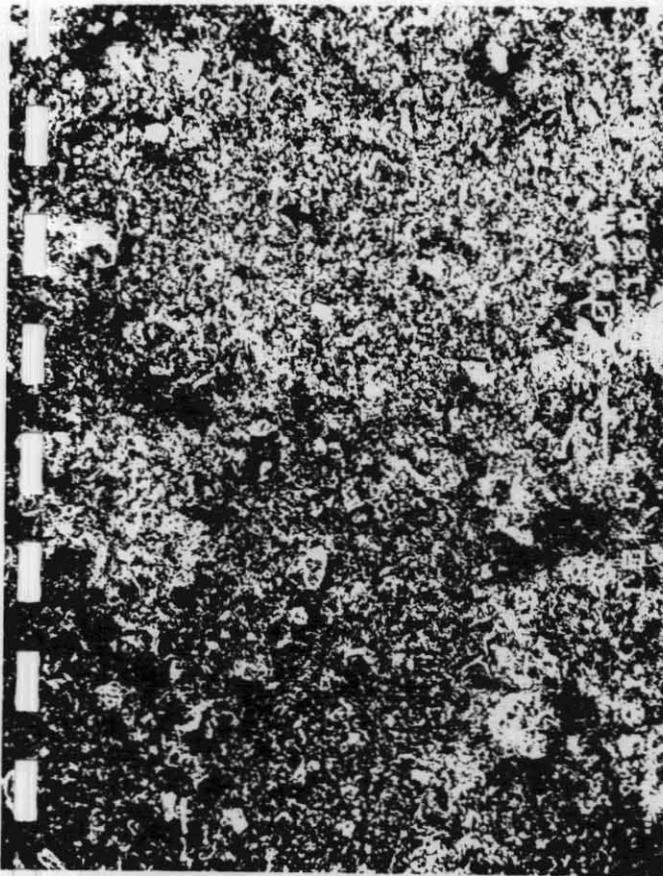
(c)

Figure 3

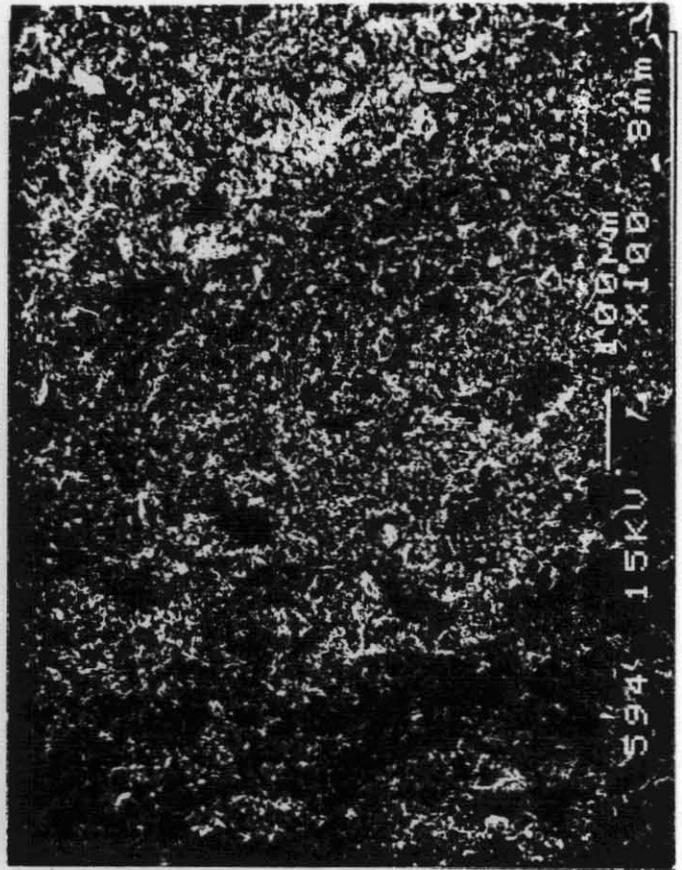
Representative micrographs of all samples at x100 magnification. The two scavenge extraction overflows (a & b) are identical despite acid washing of b. Likewise, all of the acid washed primary extraction overflows (d, e & f) are identical to c despite acid washing under various conditions. In all overflows virtually all of the largest particles visible are weathered Mg chlorite and sericite, with larger maximum sizes for the scavenge extractions (up to ~50 μm) than the primary (up to ~20 μm). Primary and scavenge extraction underflows (g & h respectively) are identical, and much coarser grained than the overflows with the majority of particles in the 10 to 100 μm range. The "dense mineral tail" (i) derived from g has an extremely uniform grainsize at around 100 μm corresponding to the maximum particle size in the underflows.

(a & b) Scavenge extraction overflows G30 and G31. The plate-like particles are flakes of Mg chlorite and sericite. Bright patch in a is due to charging.

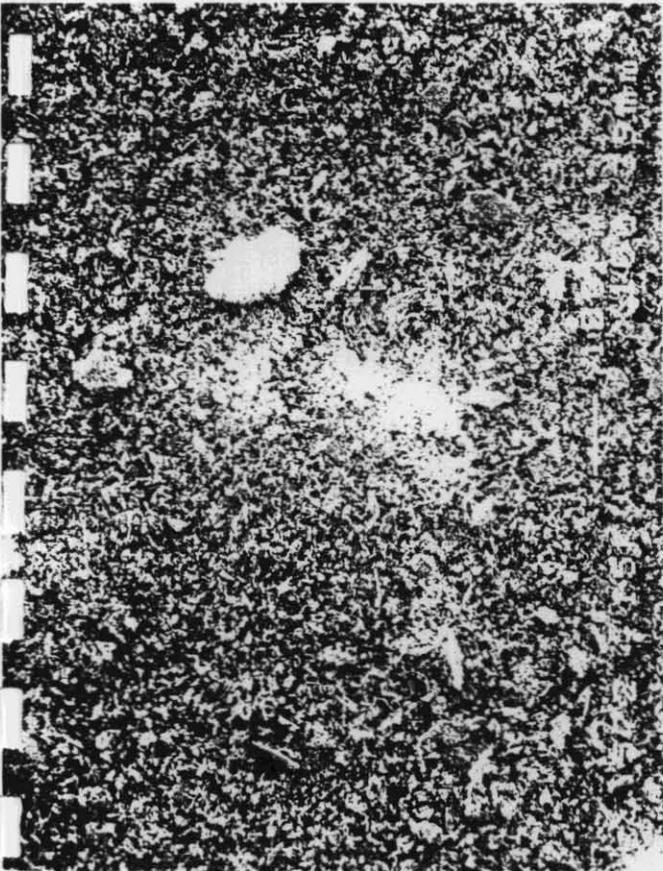
(c & d) Primary extraction overflows G32 and G33. The plate-like particles are flakes of Mg chlorite and sericite.



(b)



(d)



(a)



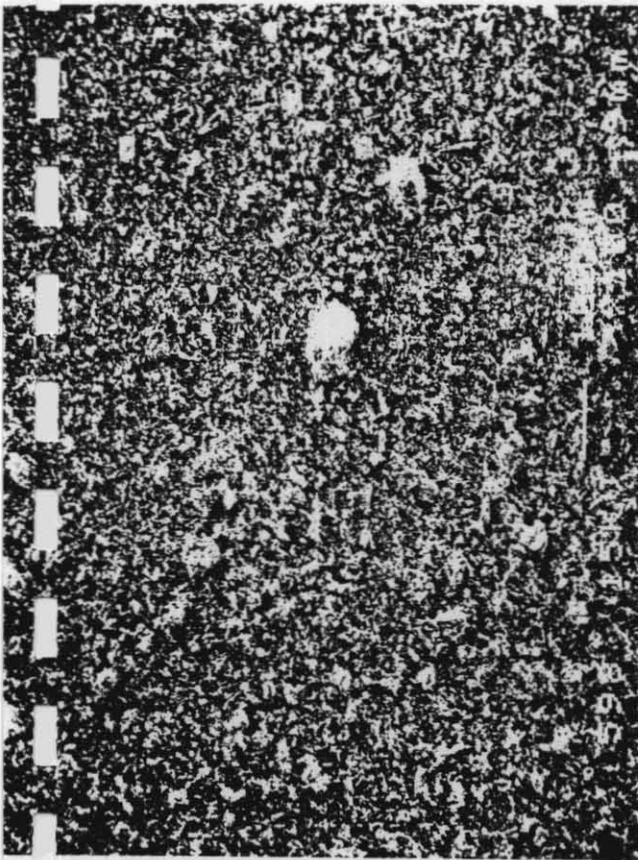
(c)

Figure 3 (continued)

(e & f) Primary extraction overflows (continued) G34 and G35. These samples are indential to G32 and G33.

(g) Primary extraction underflow G36. The large plate-like particles are flakes of Mg chlorite and sericite and the angular particles are mainly quartz fragments. The prismatic crystal in the centre of the micrograph is tourmaline. Other minerals occurring in this sample include rutile, magnetite, corundum, Mn oxides and rare zircon.

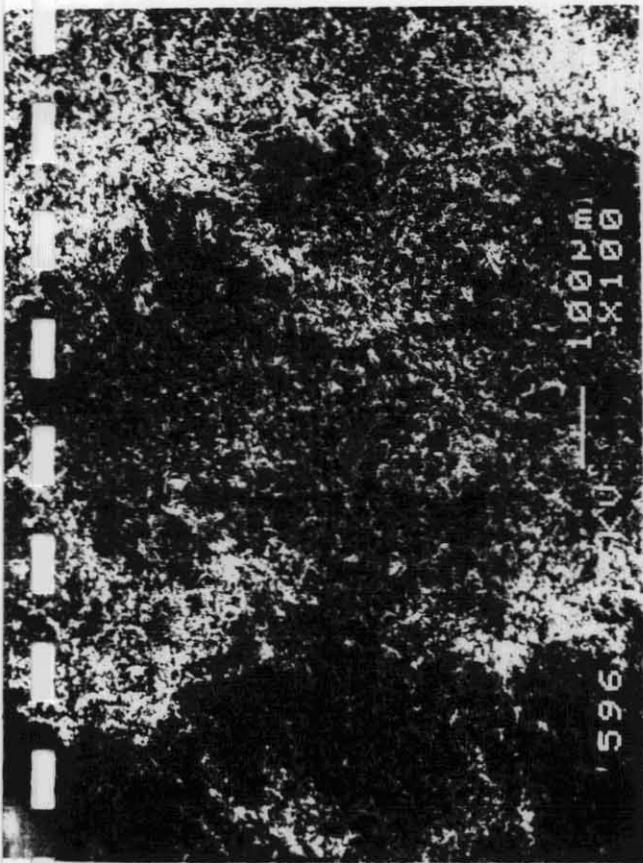
(h) Scavenge extraction underflow G37. Identical to G36.



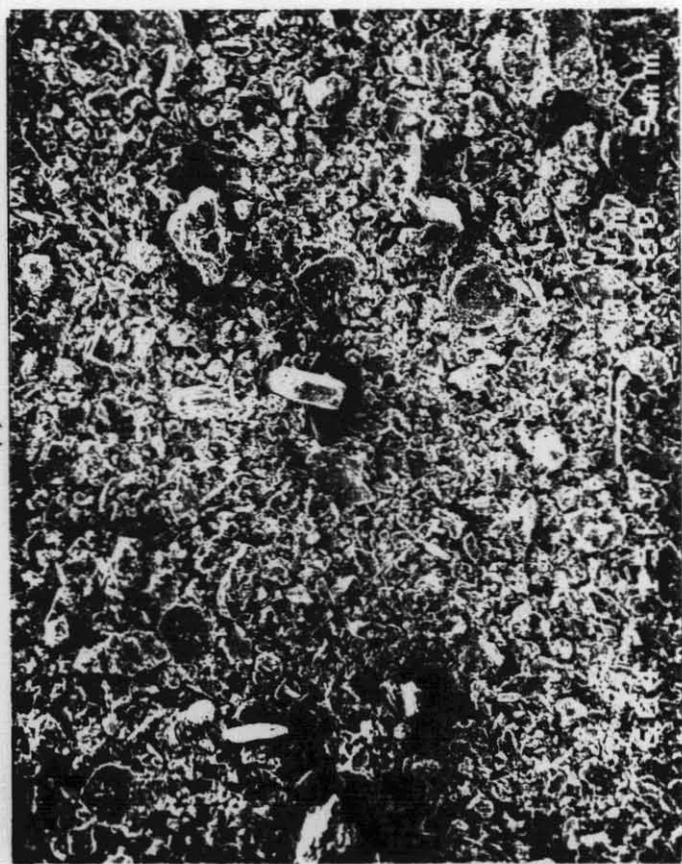
(f)



(h)



(e)



(g)

Figure 3 (continued)

(i) Primary extraction "dense mineral tail" G38. The large angular particles are almost entirely quartz fragments, and a few prismatic tourmaline crystals (well developed crystal faces) can also be seen. Tourmaline is more common than in G36 and G37, and all of the other minerals are present with the addition of very rare monazite.

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123312



(i)

Figure 4

Micrographs of the two scavenge extraction overflows (a & b), a primary extraction overflow (c) and a primary extraction underflow (d) at x1,000 magnification. The two scavenge extraction overflows are identical despite acid washing of b. In a to c virtually all of the particles visible are weathered Mg chlorite and sericite, with particle sizes in the range ~1 to 15 μm for the scavenge overflows and ~1 to 10 μm for the primary overflows. In the primary extraction underflow minimum particle size for most material is about 10 μm , with many small angular quartz fragments present in addition to larger flakes of chlorite and sericite.

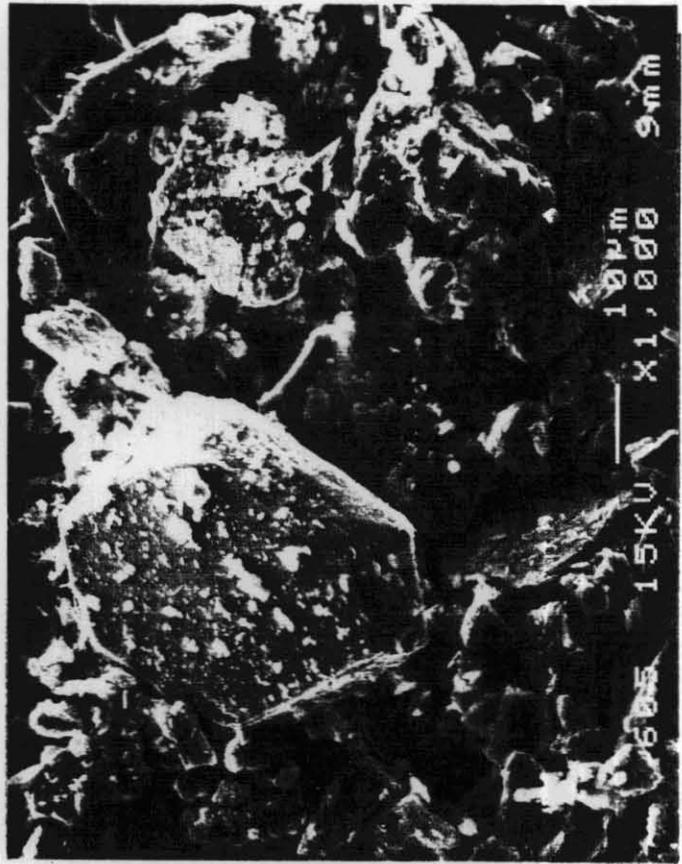
(a & b) Scavenge extraction overflows G30 and G31. The plate-like fragments are flakes of Mg chlorite and sericite.

(c) Primary extraction overflow G32. The other primary extraction overflows G33, G34 and G35 are identical and all have finer maximum grainsizes than the scavenge extraction overflows.

(d) Primary extraction underflow G36. The scavenge extraction underflow G37 is identical. The large pseudo-hexagonal plate is sericite, slightly smaller thin flakes nearby are Mg chlorite, and the small angular particles are quartz.



(b)



(d)



(a)



(c)

Figure 5

Micrographs of the the two scavenge extraction overflows (a & b), a primary extraction overflow (c) and the primary extraction underflow (d) at x5,000 magnification. At this magnification the largest of the Mg chlorite and sericite flakes have not been included in the fields, so that the primary extraction overflow appears identical to the scavenge extraction overflows. In all overflows the minimum particle size for most material is about 1 μm , but many sub-micron particles are also visible. In the primary extraction underflow very little sub-micron material is present, and almost all of any that is can be found adhering to much larger particles.

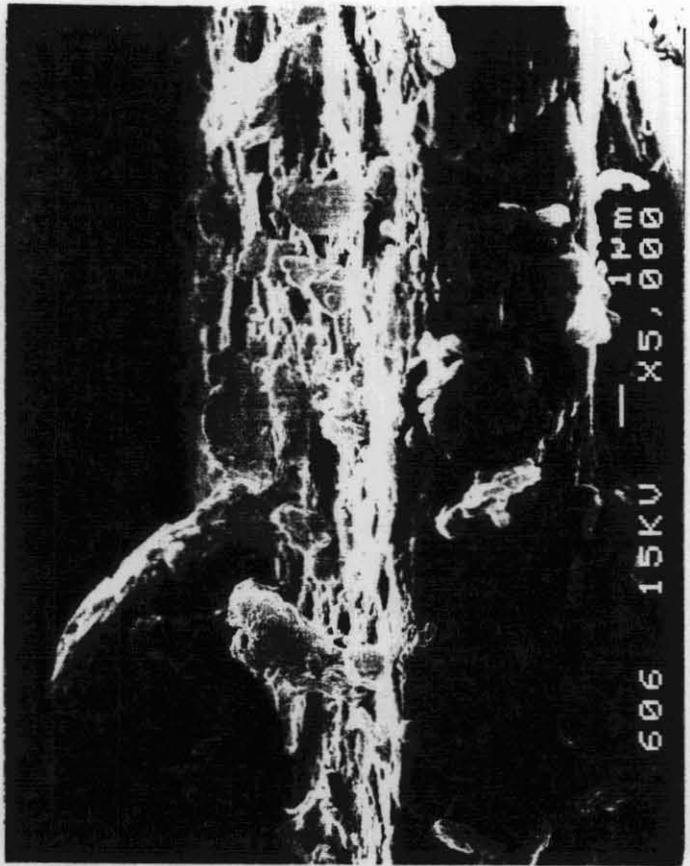
(a & b) Scavenge extraction overflows G30 and G31. Some of the Mg chlorite flakes have visible goethite coatings, although this is much more apparent at higher magnification. The rounded particle at the left of a is a small quartz grain (rare in the scavenge overflow).

(c) Primary extraction overflow G32. The other primary extraction overflows G33, G34 and G35 are identical.

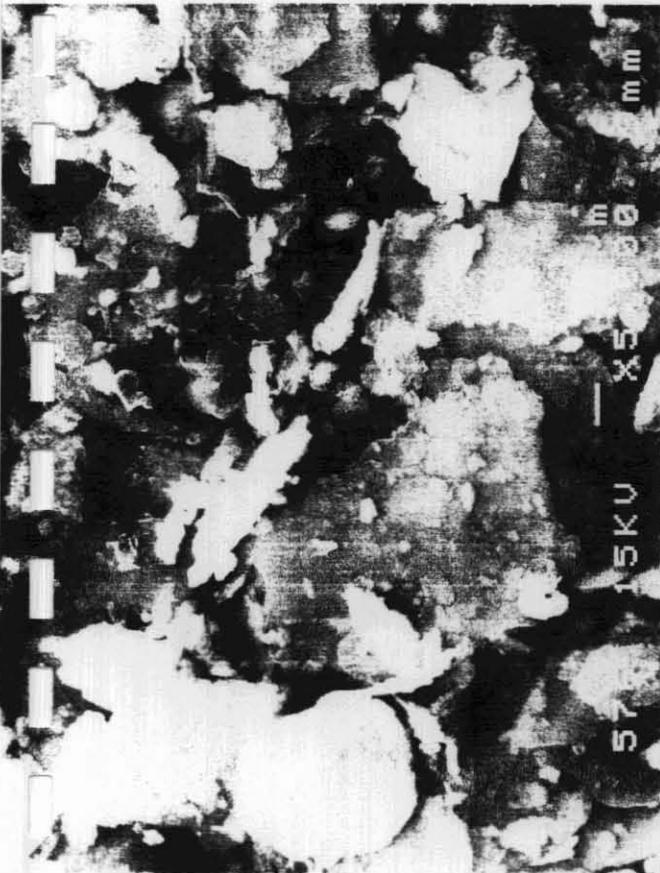
(d) Primary extraction underflow G36. Small flakes of chlorite or sericite adhering to a much larger Mg chlorite flake.



(b)



(d)



(a)



(c)

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Figure 6

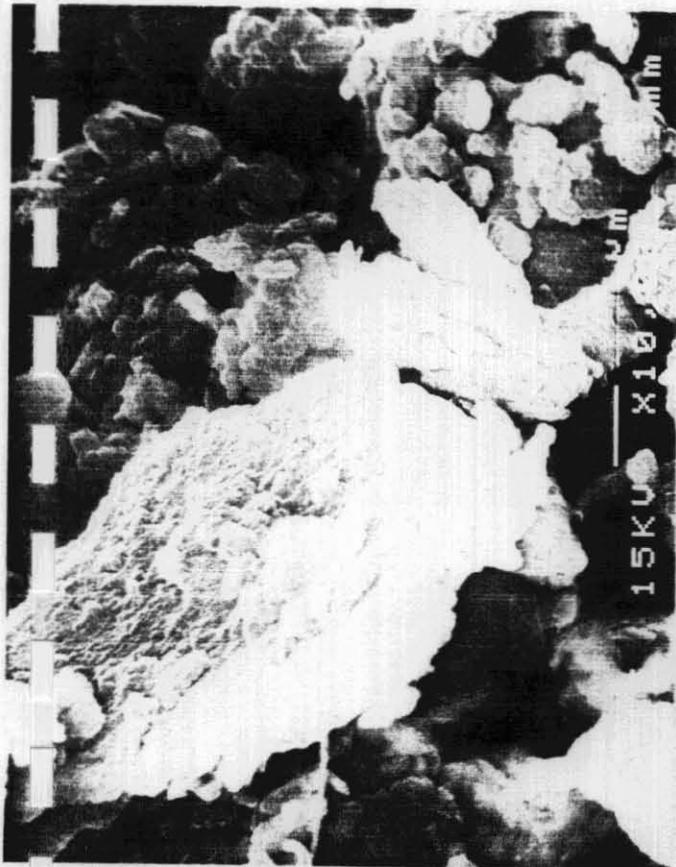
Micrographs of Mg chlorite from all overflows at x10,000 magnification showing the extent of goethite coatings. There is some variation in the thickness of the goethite coating on individual chlorite flakes within each sample, but all samples are the same and acid washing has no visible effect on the chlorite or goethite.

(a & b) Scavenge extraction overflows G30 and G31. a Without acid treatment, and b washed in 1% HCl.

(c & d) Primary extraction overflows G32 and G33. c Without acid treatment, and d washed in 1% HCl.

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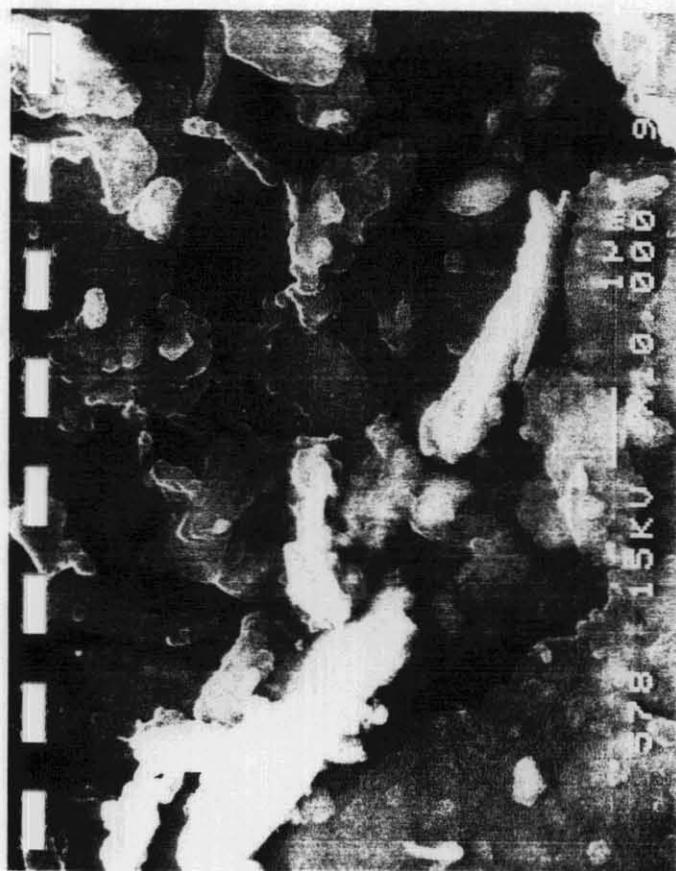
0319



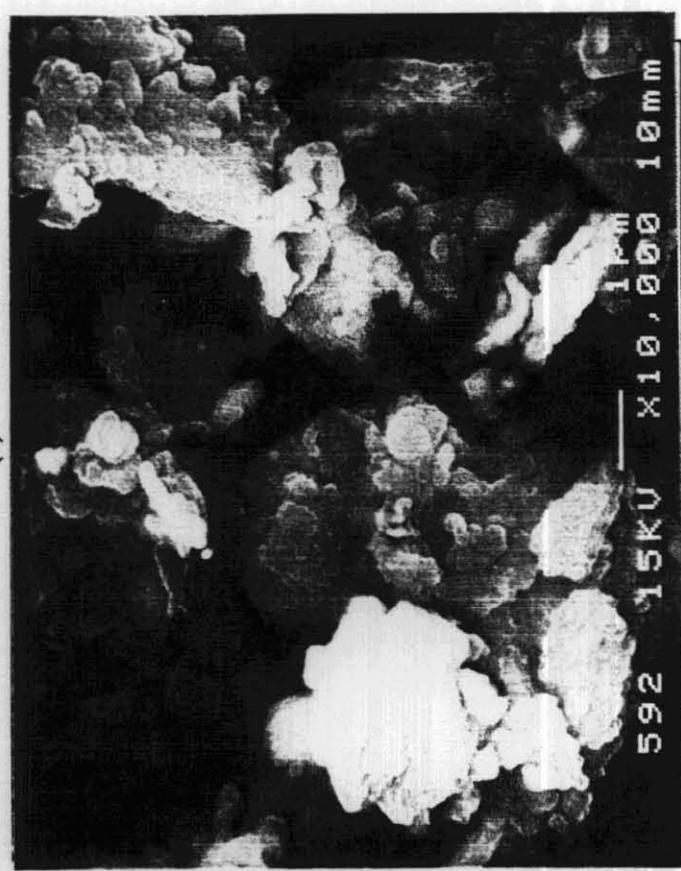
(b)



(d)



(a)



(c)

0320

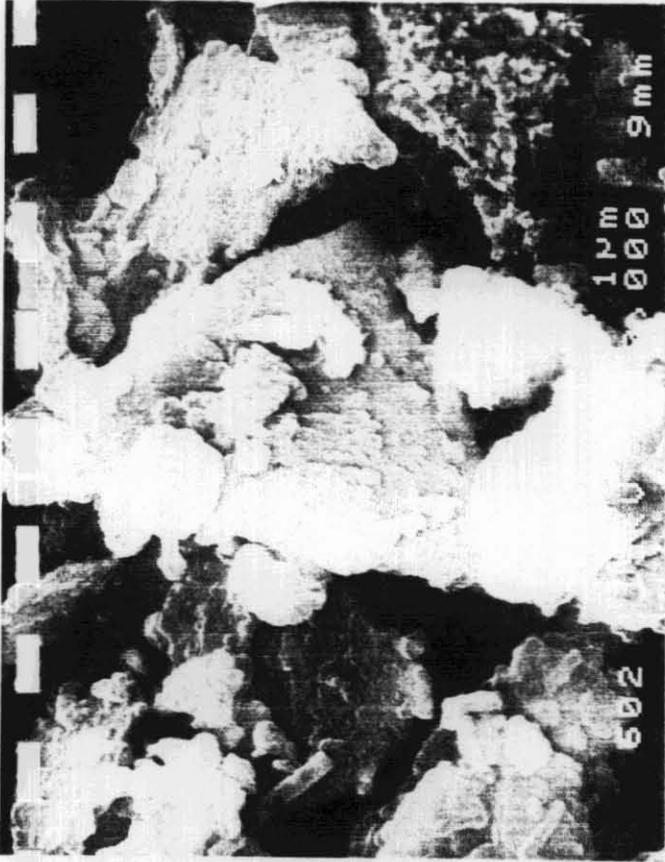
Figure 6 (continued)

(e & f) Primary extraction overflows G34 and G35. e Washed in 1% HCl, and then 3% HCl. f Washed in 1% HCl, and then 5% HCl. The angular particle in the bottom right hand corner of f consists of massive and acicular goethite, but this forms only a small fraction of the total sample.

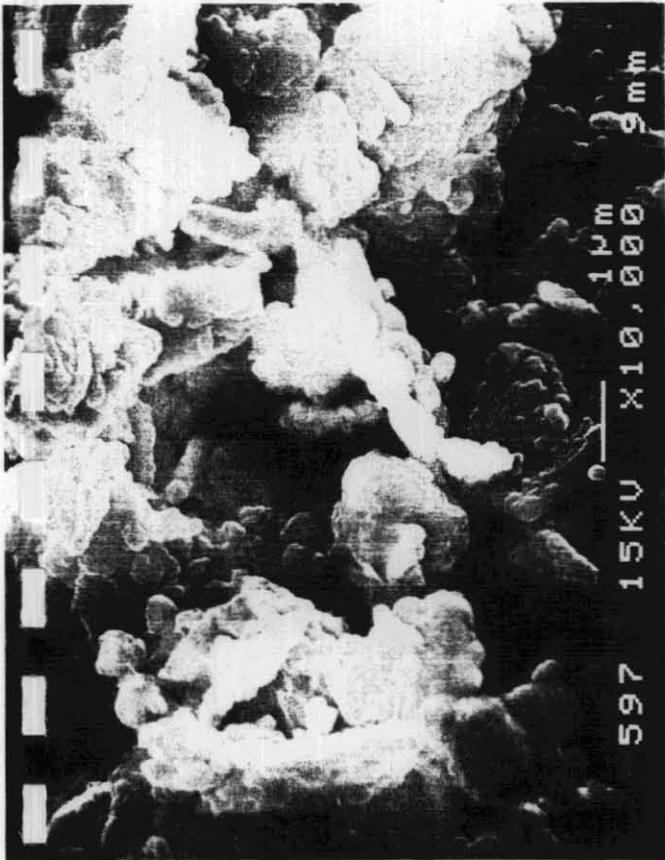
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(f)



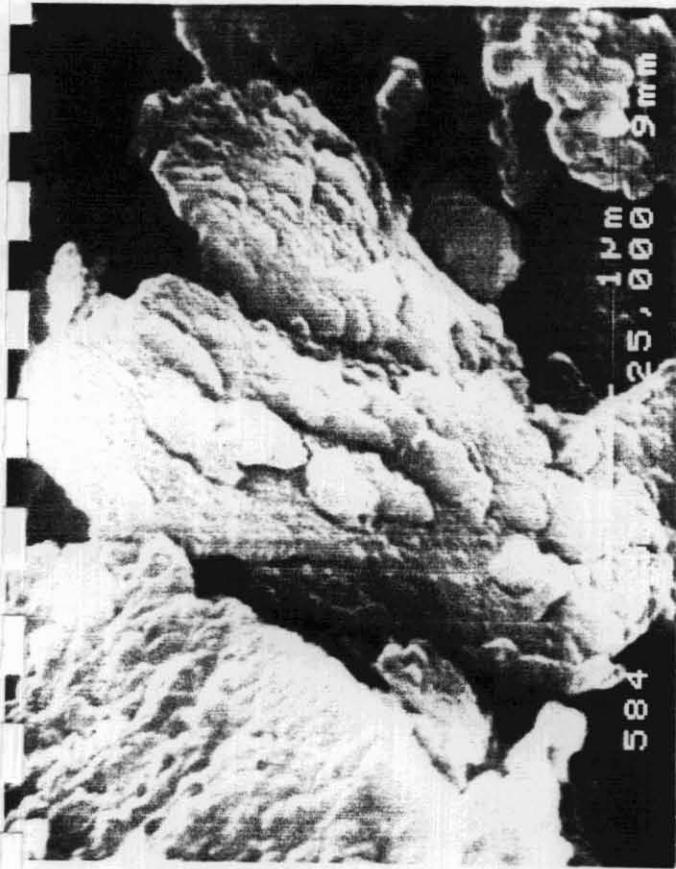
(e)

Figure 7

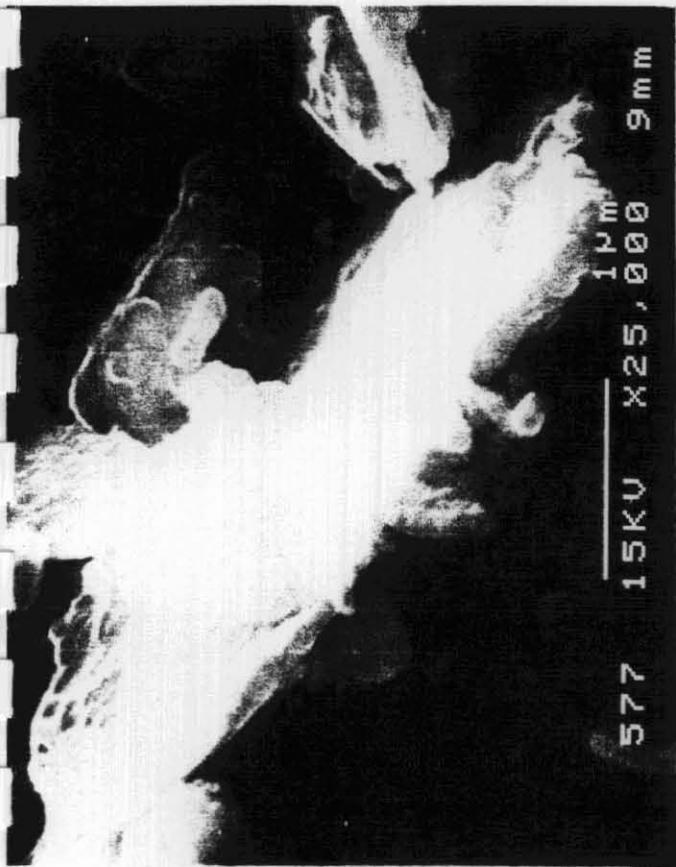
Micrographs of Mg chlorite from the two scavenge extraction overflows (a & b) and a primary extraction overflow (c) at x25,000 magnification showing the development of bulbous goethite coatings on chlorite. The flake in a does not have as thick a coating as those shown in b and c.

(a & b) Scavenge extraction overflows G30 and G31.

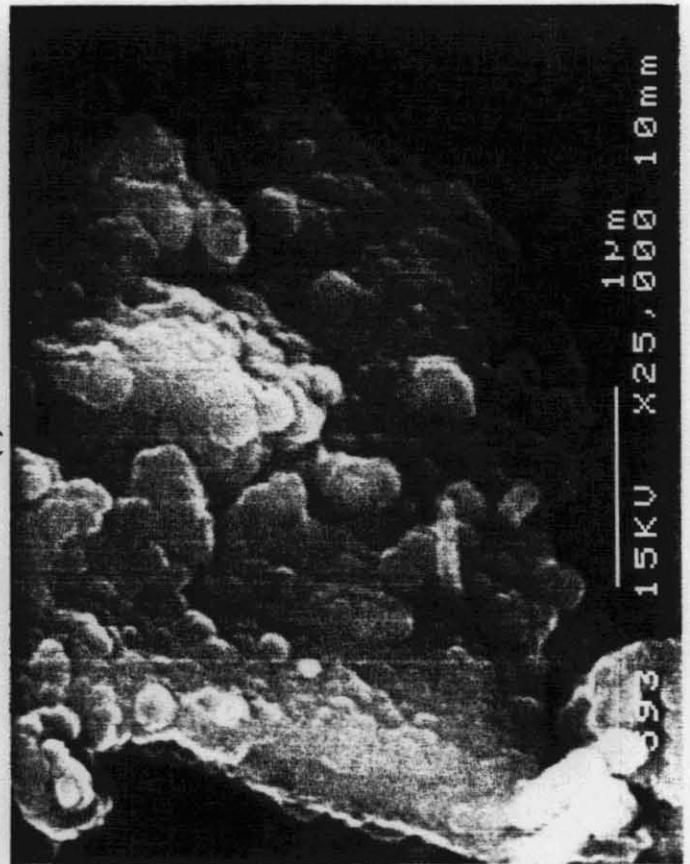
(c) Primary extraction overflow G32. The other primary extraction overflows G33, G34 and G35 are the same.



(b)



(a)



(c)

033

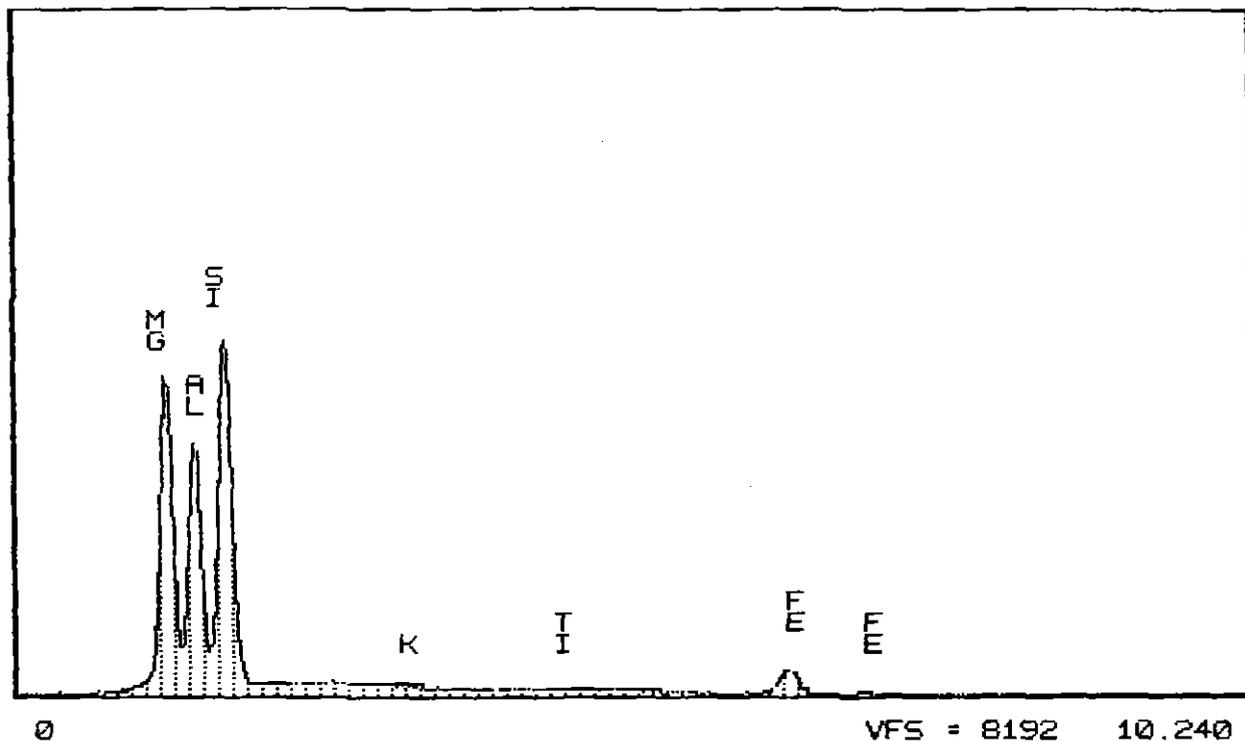


Fig. 8a. Weathered Mg chlorite in G30.

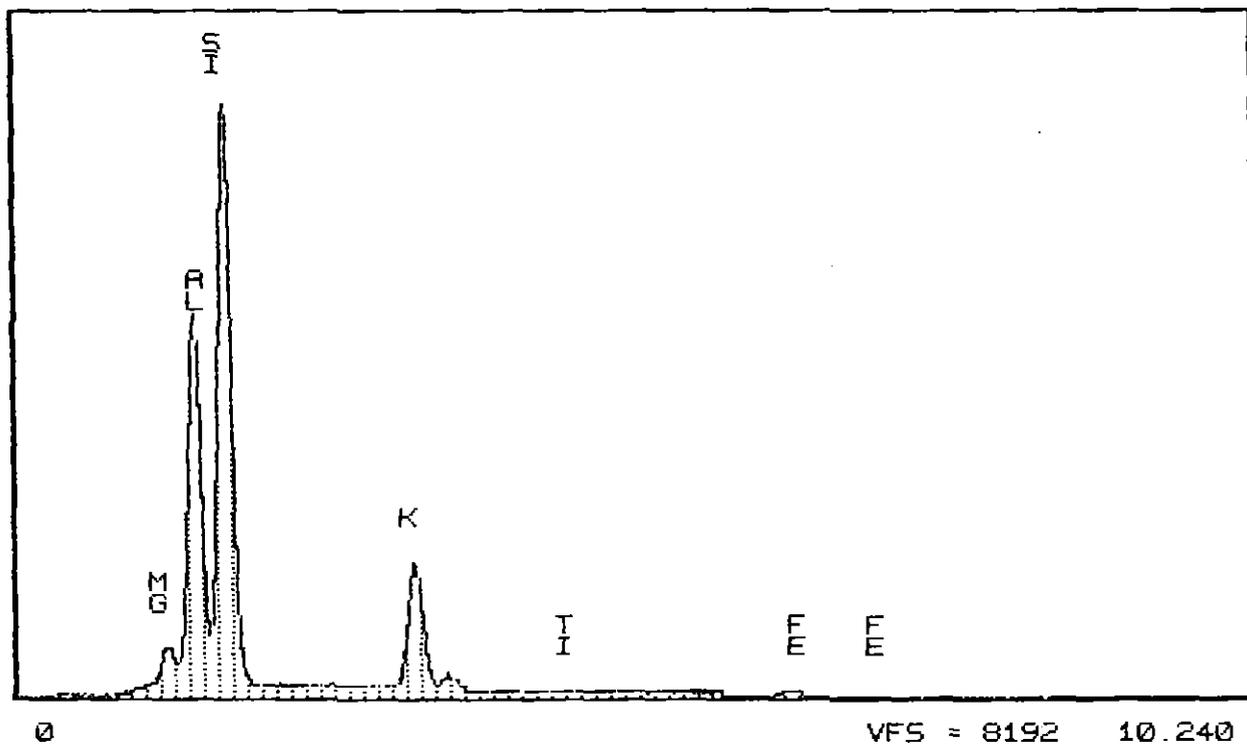


Fig. 8b. Sericite in G30.

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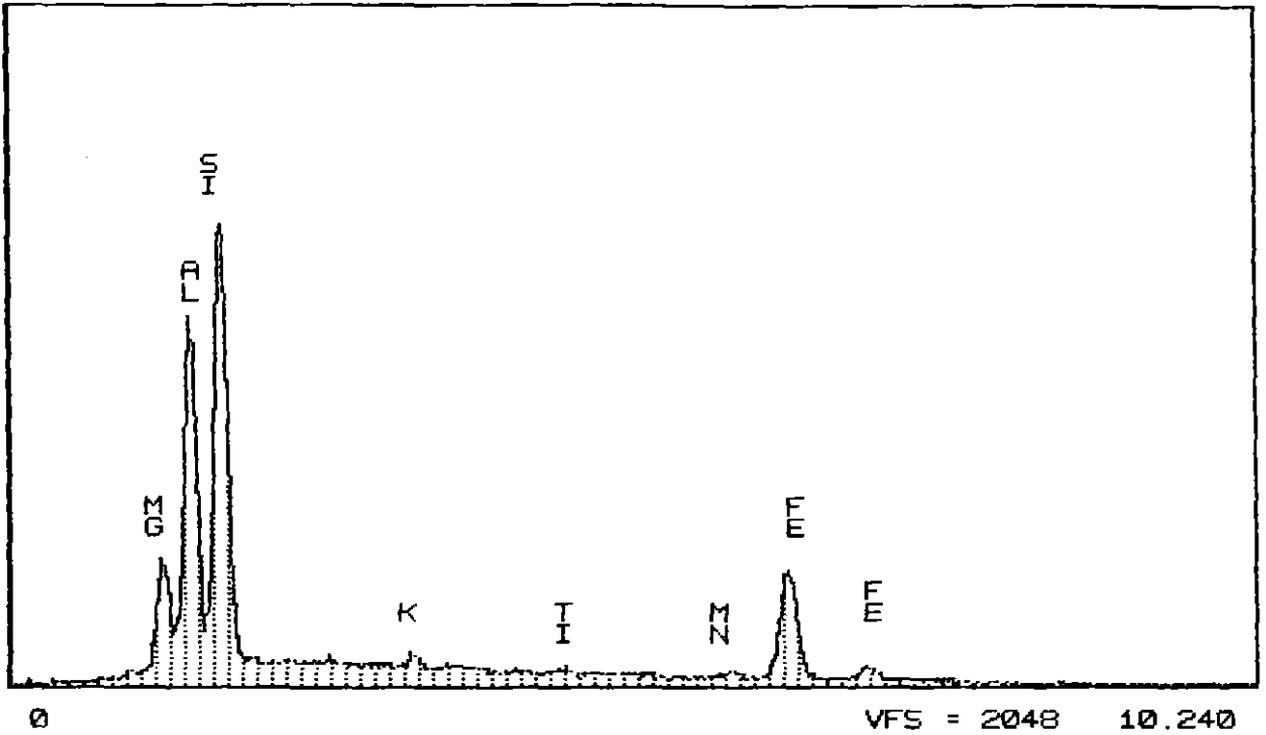


Fig. 9a. Bulk analysis of G30, (area 1X1 cm)

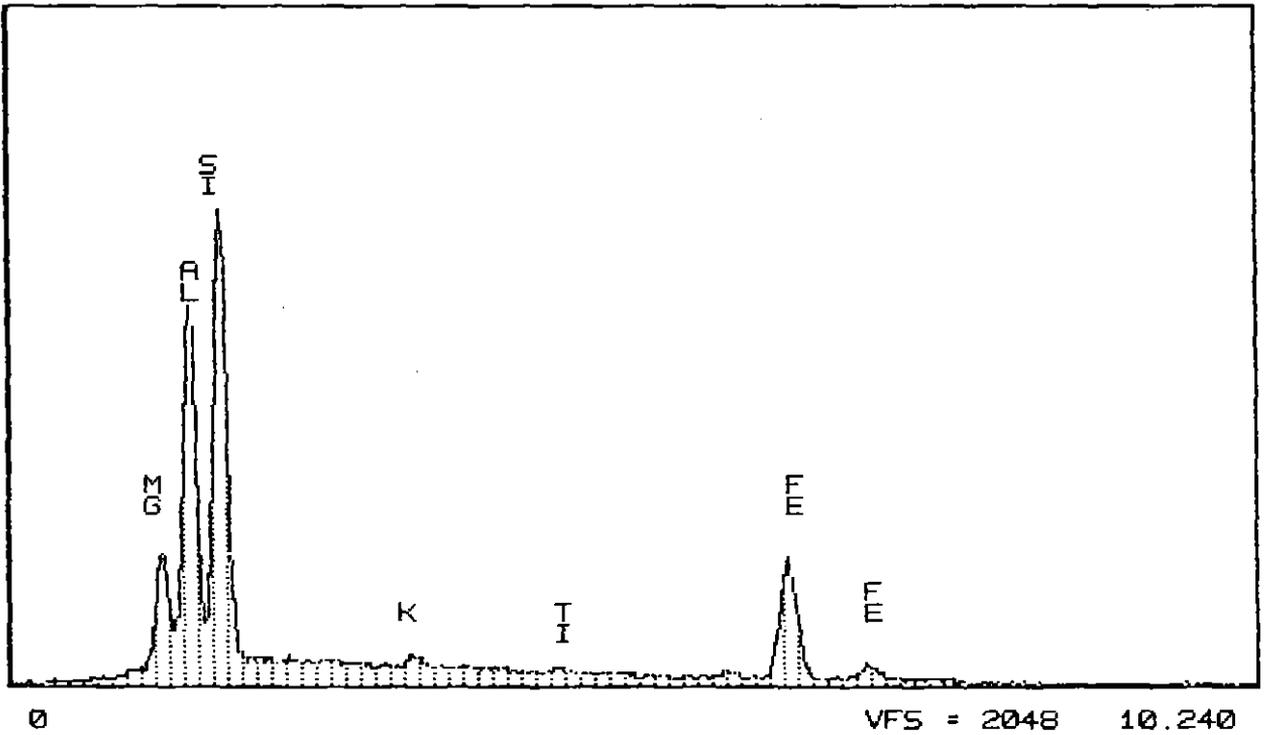


Fig. 9b. Bulk analysis of G31, (area 1X1 cm)

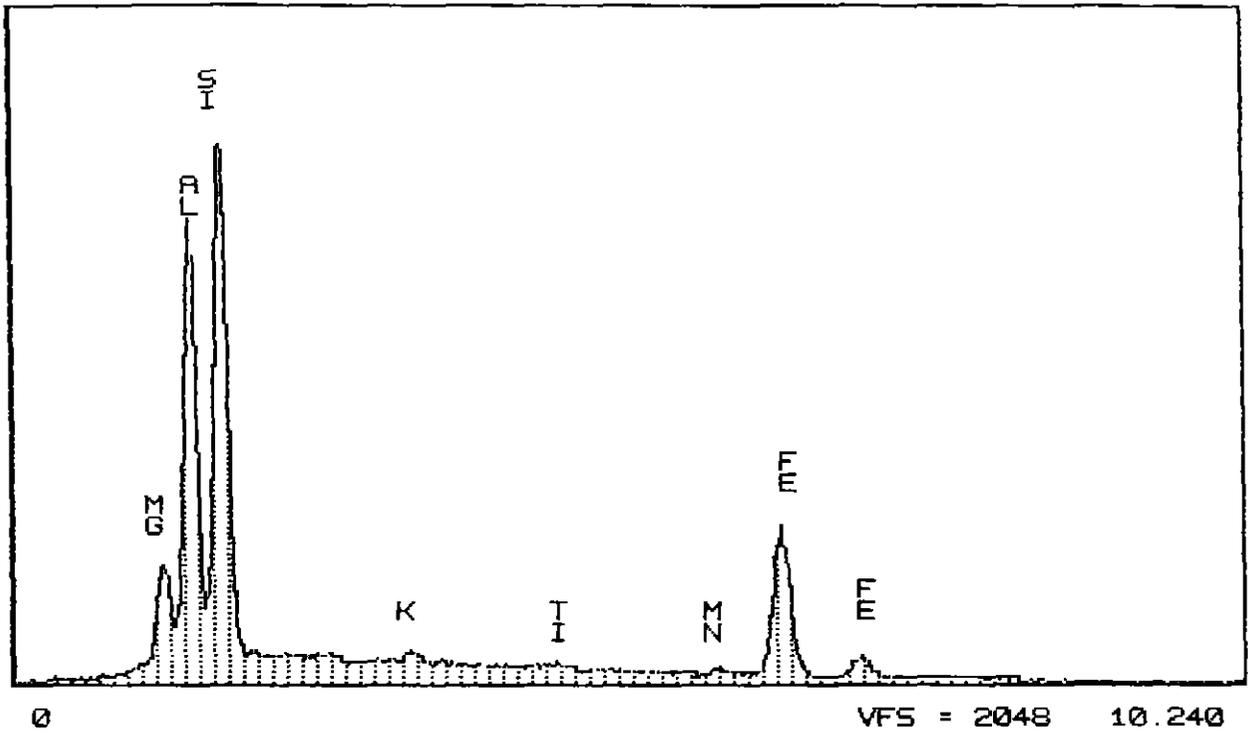


Fig. 9c. Bulk analysis of G32, (area 1X1 cm)

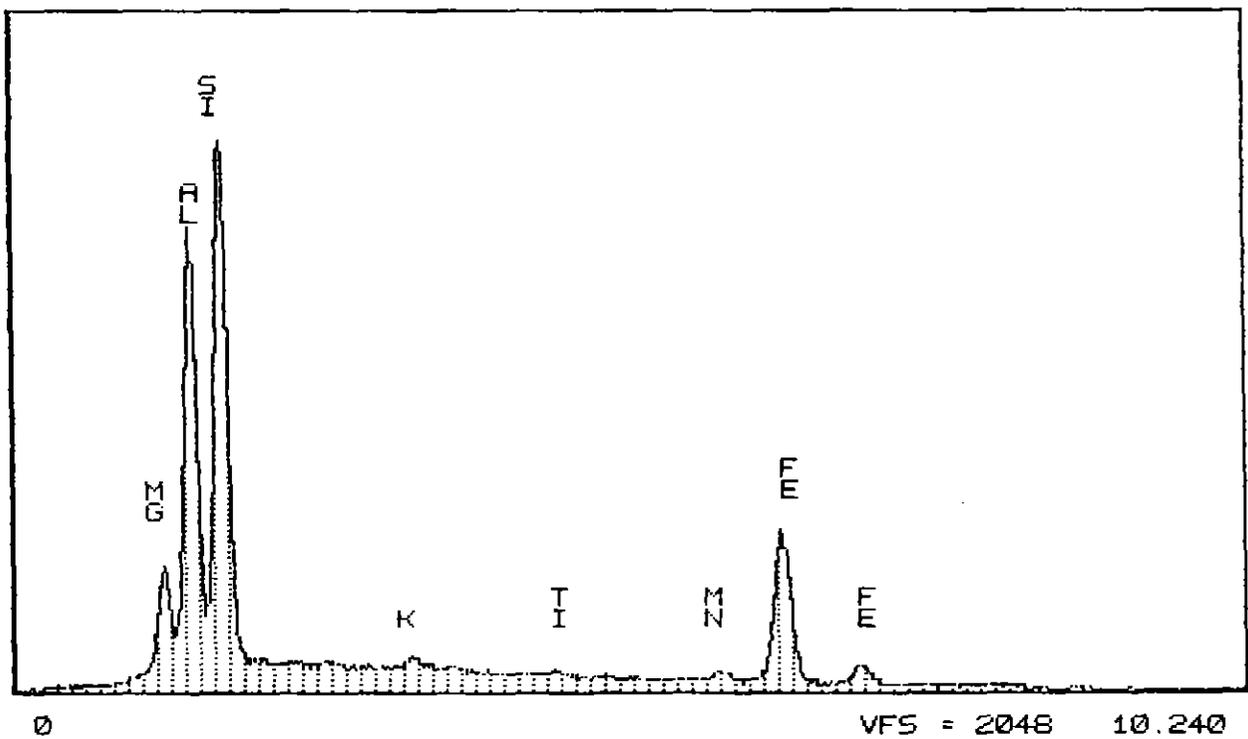


Fig. 9d. Bulk analysis of G33, (area 1X1 cm)

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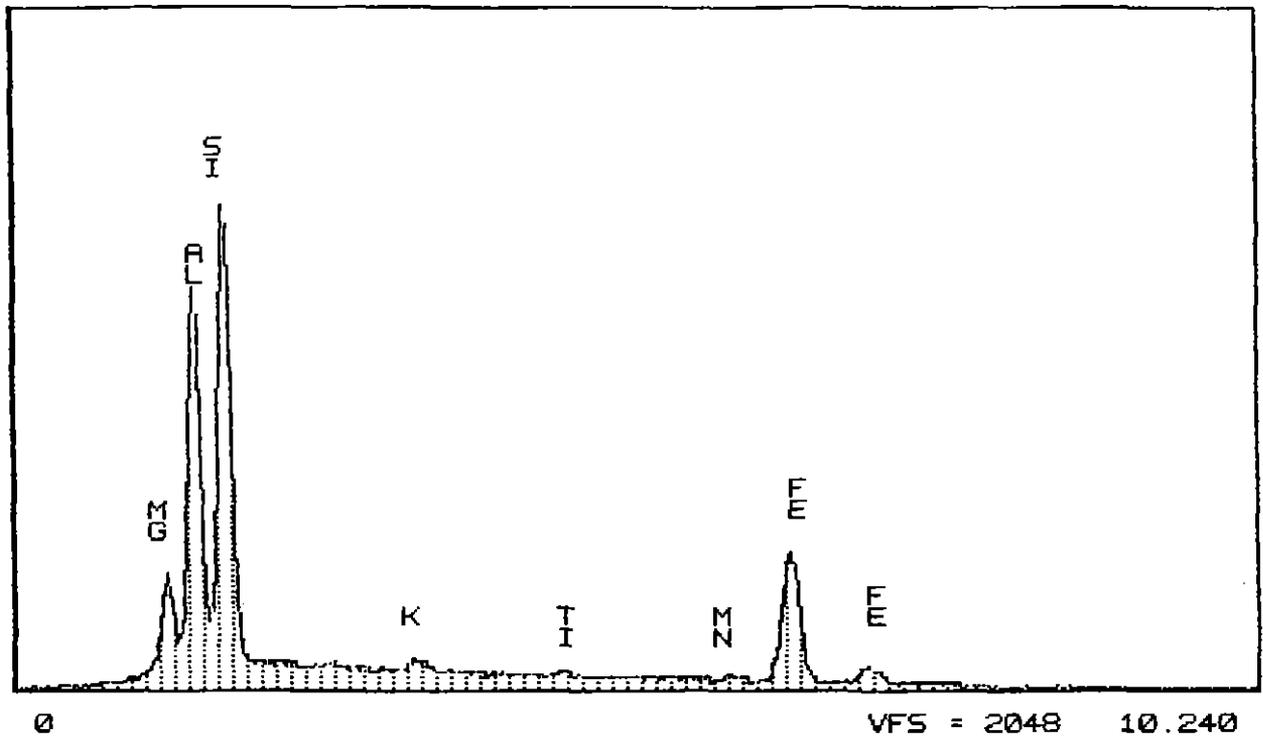


Fig. 9e. Bulk analysis of G34, (area 1X1 cm)

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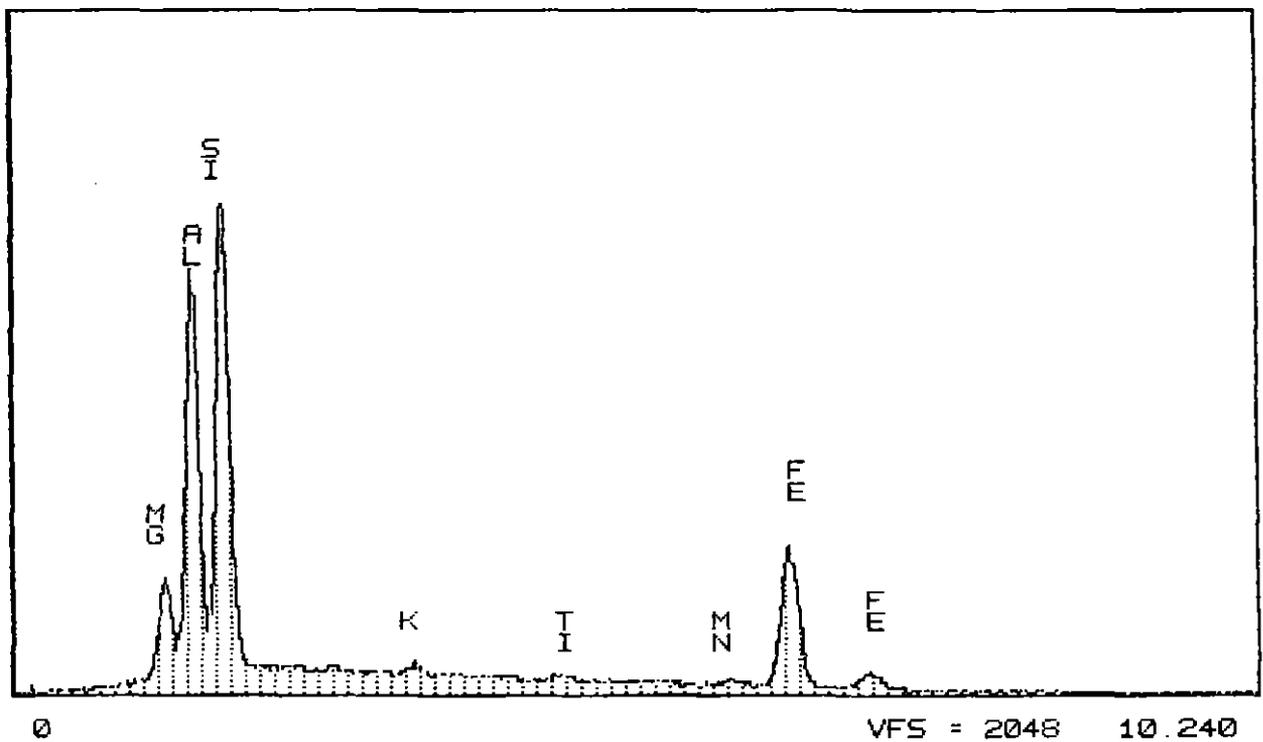


Fig. 9f. Bulk analysis of G35, (area 1X1 cm)

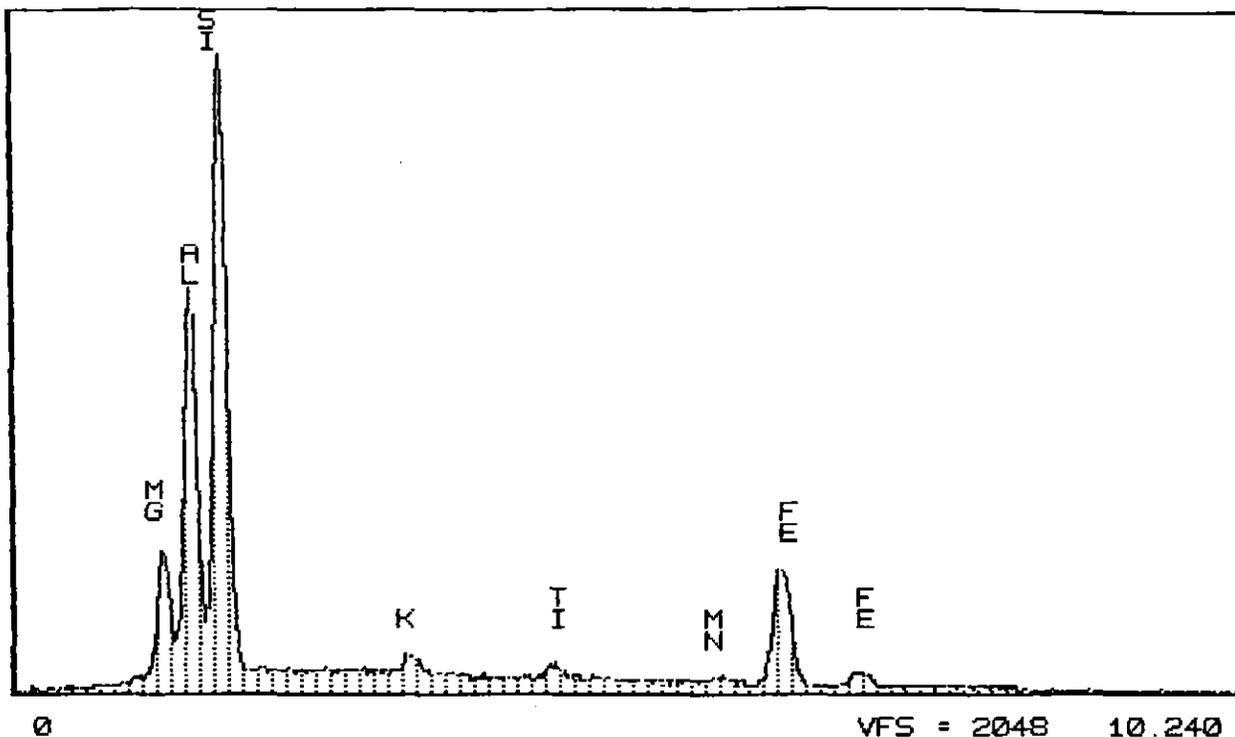


Fig. 9g. Bulk analysis of G36, (area 1X1 cm)

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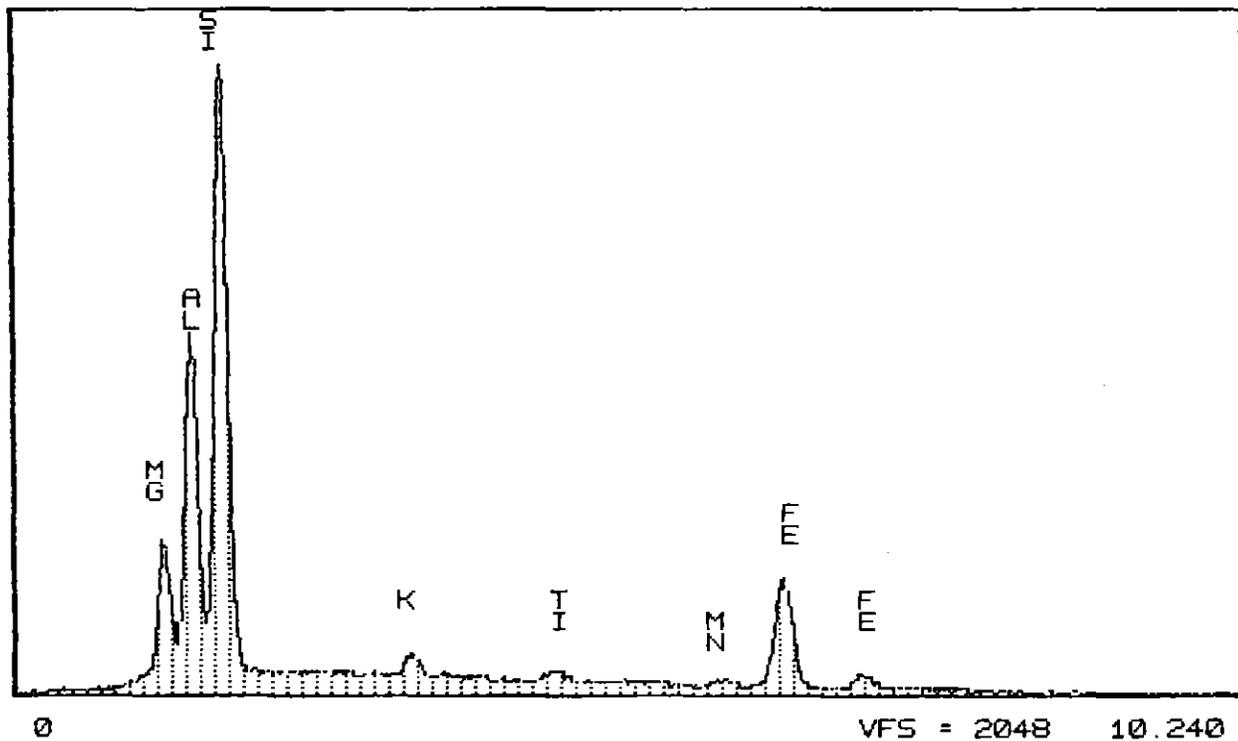


Fig. 9h. Bulk analysis of G37, (area 1X1 cm)

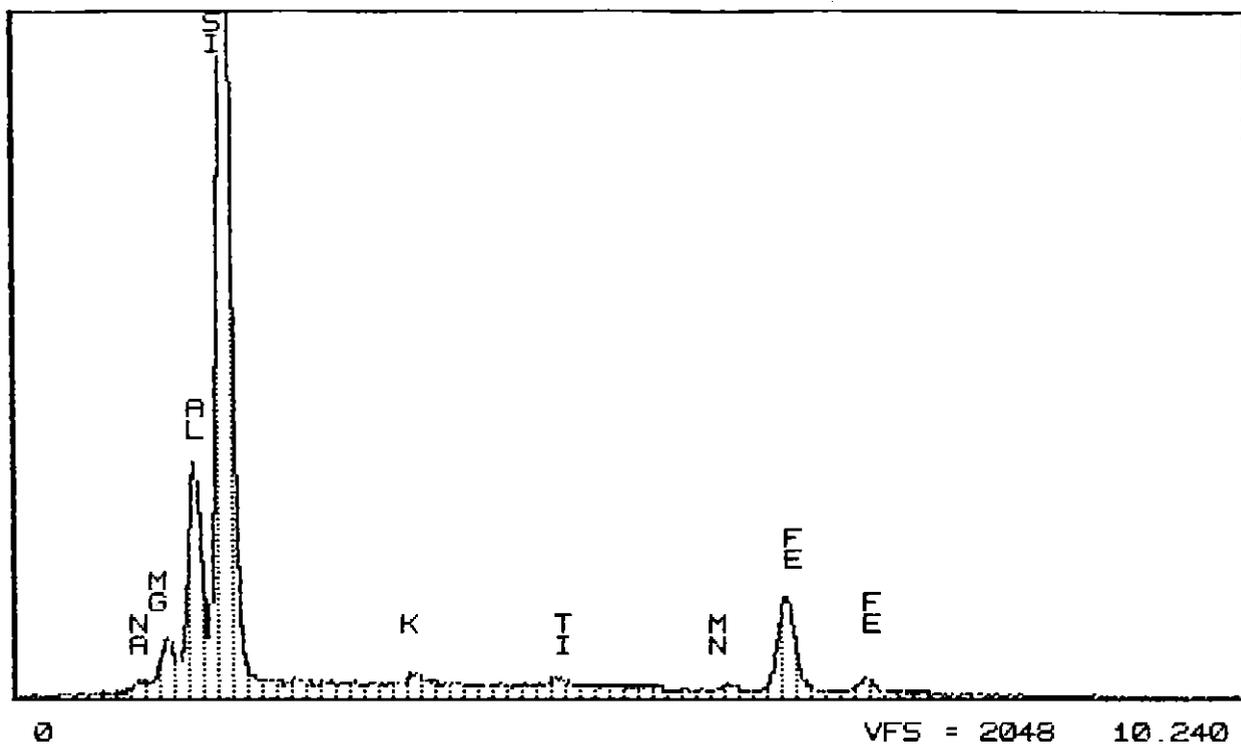


Fig. 9i. Bulk analysis of G38, (area 1X1 cm)