APPENDIX A1. CLAY PRETREATMENTS.

Removal of carbonates. (Jackson,1969)

1. Prepare the buffered sodium acetate-acetic acid buffer by dissolving 82 g of sodium acetate in 900 ml of distilled water, add 27 ml of glacial acetic acid and adjust to pH 5 by means of adding acetic acid. Dilute to 1 L.
2. Add 10 g of powdered sample to a beaker containing 250 mL of the buffered solution. Allow to react at room temperature for 30 min or until no further CO_2 gas is evolved, stirring occasionally. Place a cover glass over the beaker and digest on a hot place set low enough to avoid boiling. If the reaction is too violent place the beaker in a water bath. Digest for about 1 hour.
3. Wash the residue in distilled water by centrifugation at 2000 rpm for 5 min three times, discarding the supernatant solution in each case.
4. The sample is now ready to proceed to the next stage.

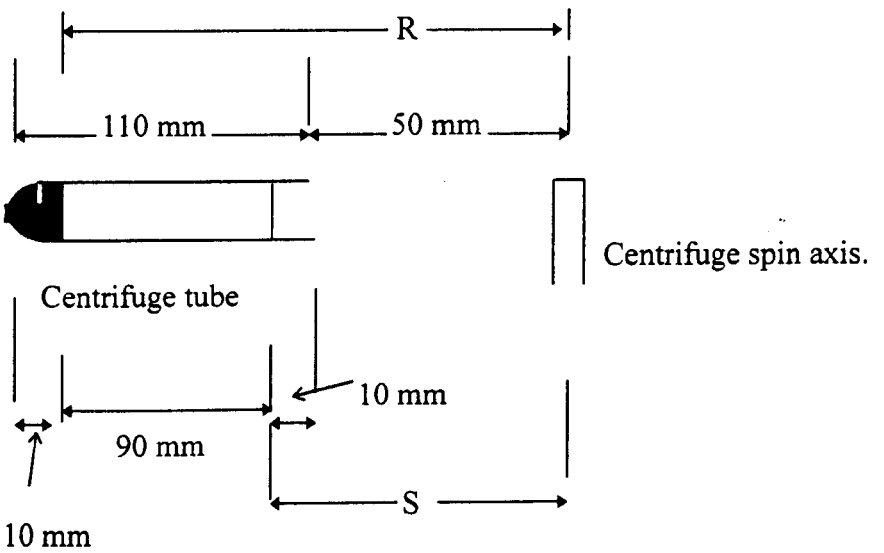
Removal of iron oxides. (Mehra & Jackson,1959)

1. Place 4-5 g of powdered sample in a small beaker, to this add 40 mL of 0.3 M sodium citrate solution and 5 mL of 1 M $NaHCO_3$ solution. Heat at 80°C in a water bath for about 10 min. Add 1 g of solid $Na_2S_2O_4$ and stir constantly for 1 min and then occasionally for 15 min.
2. At the end of the digestion period add 10 mL of saturated NaCl solution and 10 mL of acetone to promote flocculation.
3. Mix the solution for about 1 min in the water bath, then transfer the contents of the beaker into 100mL centrifuge tubes and centrifuge at 2000 rpm for 5 min. Discard the supernatant solution and wash twice with distilled water by centrifugation.
4. The sample is now ready to proceed to the next stage.

Removal of organic material. (Moore & Reynolds, 1989)

1. Place 5 g of powdered sample into a beaker, add 50 mL of 15% NaOCL that has been adjusted to pH 9.5 with HCL.
2. Heat the mixture on a hot plate located in a fume cupboard for about 30 min.
3. Transfer the contents of the beaker to 100 mL centrifuge tubes and centrifuge at 2000 rpm for 5 min discarding the supernatant liquid.
4. This procedure may be repeated until organic matter is sufficiently removed, as evident by a change in sample colour from dark grey to white, light grey or red. The sample is now ready to proceed to the next stage.

Calculation of centrifuge speeds using the model MSE Centaur 2.(Jackson, 1969)



$$t_{min} = [(63 \times 10^8) \times (\eta) \times (\log_{10} R/S)] / [(Nm)^2 \times (D\mu)^2 \times (\Delta s)]$$

where:- η – viscosity of water.

Nm - centrifuge speed in rpm.

$D\mu$ - particle diameter in microns.

Δs - difference in the specific gravity of the sample and water.

20°C - $\Delta s = 1.652$ $\eta = 0.01005$

21°C - $\Delta s = 1.652$ $\eta = 0.00981$

22°C - $\Delta s = 1.652$ $\eta = 0.00958$

23°C - $\Delta s = 1.652$ $\eta = 0.00936$

S = 60mm R = 150mm.

Worked example:-

At 20°C, rpm of 900 to separate the 2μm clay size fraction -

$$t_{min} = [(63 \times 10^8) \times (0.01005) \times \log_{10}(150/60)] / [(900^2) \times (2^2) \times (1.652)]$$

= 4.7 minutes.

APPENDIX A2. WHOLE ROCK XRD PLOTS.

Key to whole rock mineral scan annotations.

Ch - Chlorite.	Q - Quartz.	G - Goethite.
I - Illite (including muscovite).	PF - Plagioclase feldspar.	C - Calcite
I/S - Mixed layer illite/smectite.	OF - Orthoclase feldspar.	D - Dolomite.
K - Kaolinite.	P - Pyrite.	S - Siderite.
Sm - Smectite.	Pa - Paragonite.	H - Heamatite.

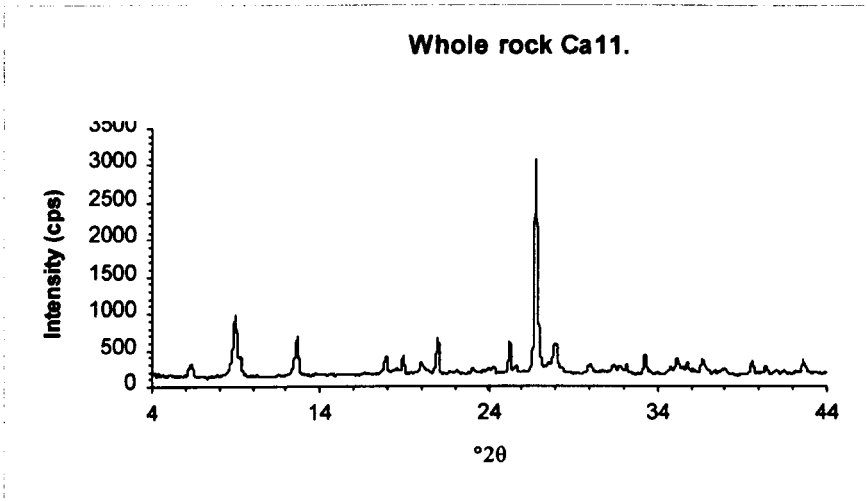


Figure 5.1a . Sample Ca.1.1 whole rock scan.

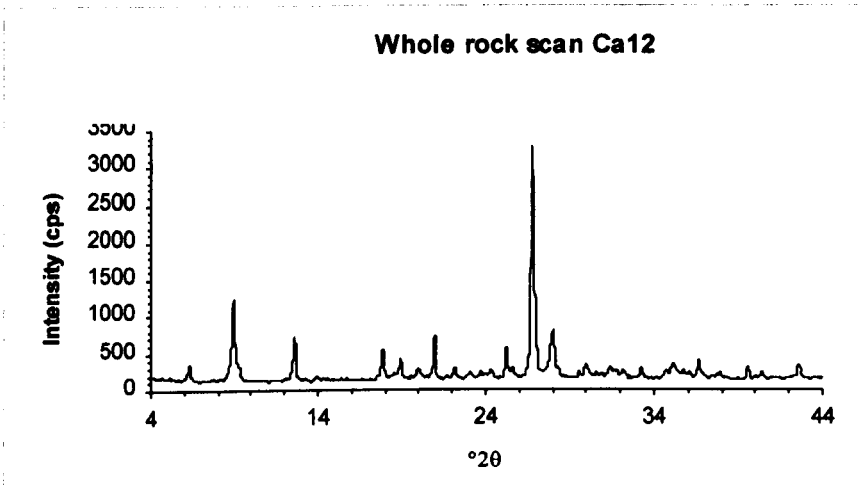


Figure 5.2a . Sample Ca.1.2 whole rock scan.

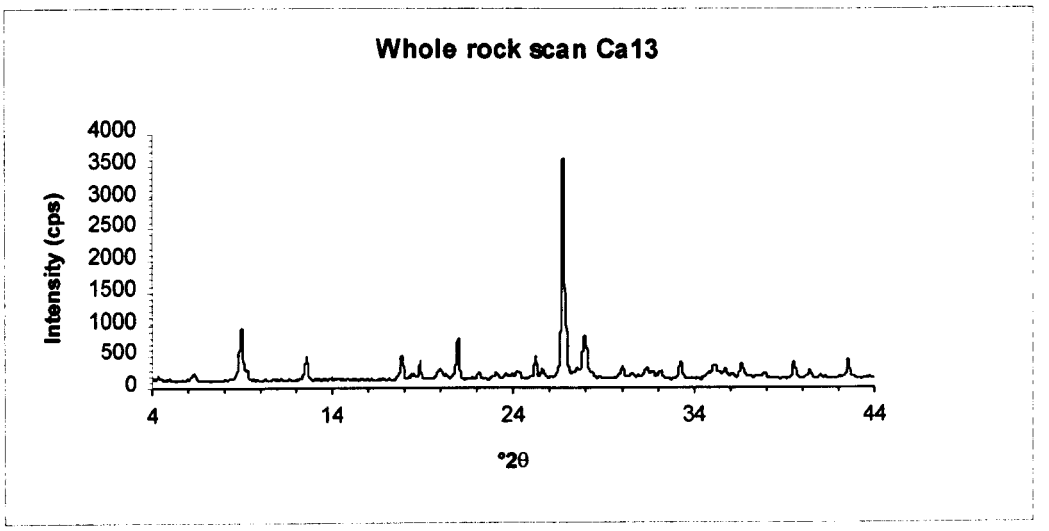


Figure 5.3a . Sample Ca.1.3 whole rock scan.

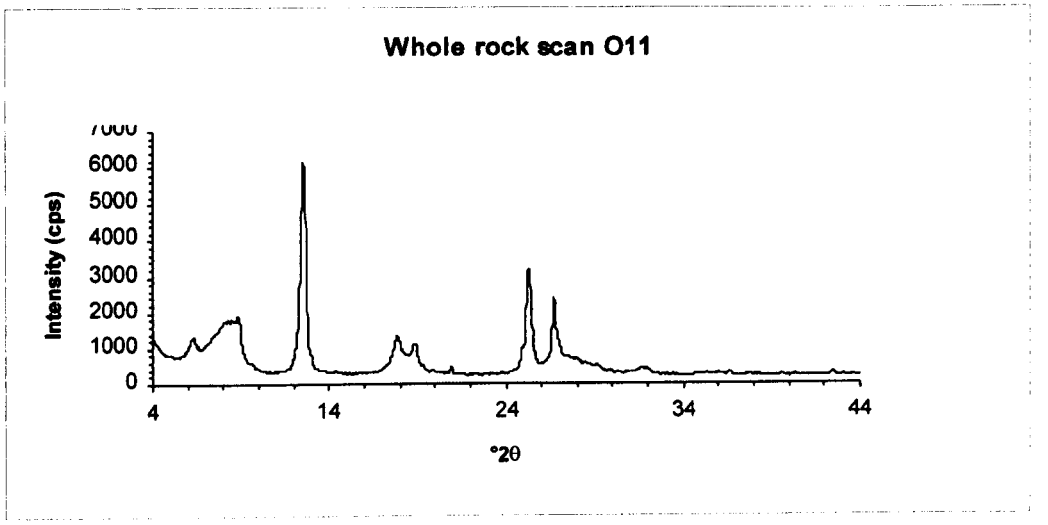


Figure 5.4a . Sample O.1.1 whole rock scan.

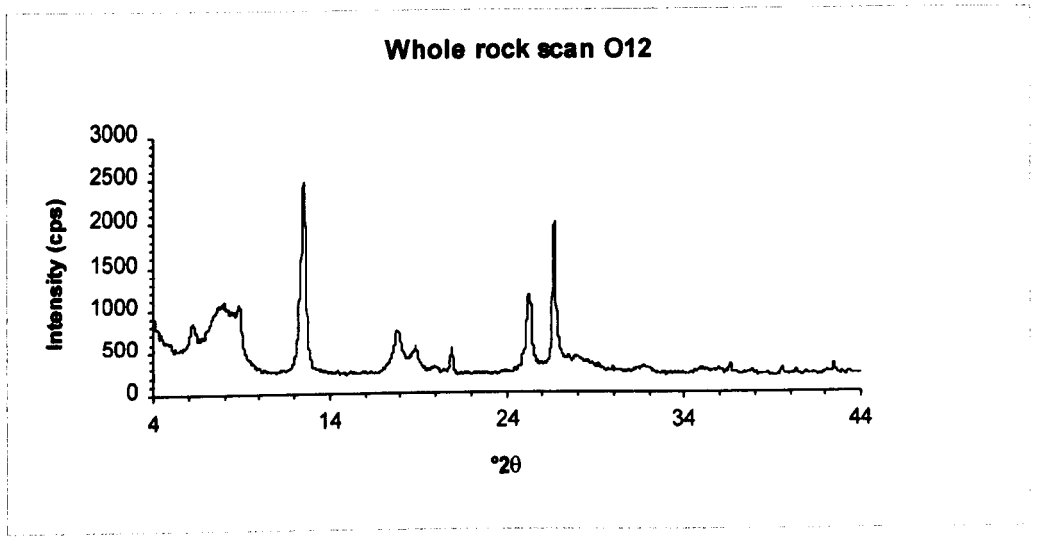


Figure 5.5a . Sample O.1.2 whole rock scan.

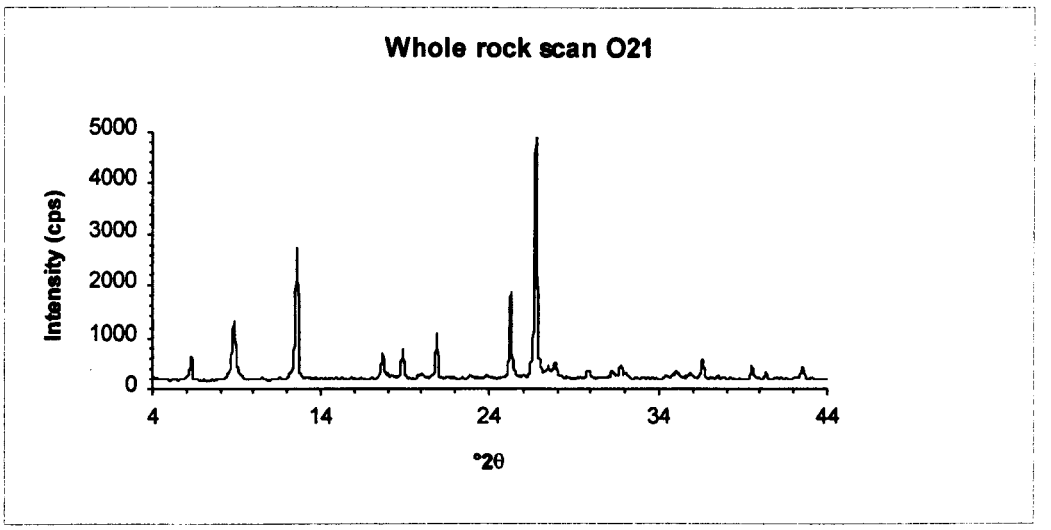


Figure 5.6a . Sample O.2.1 whole rock scan.

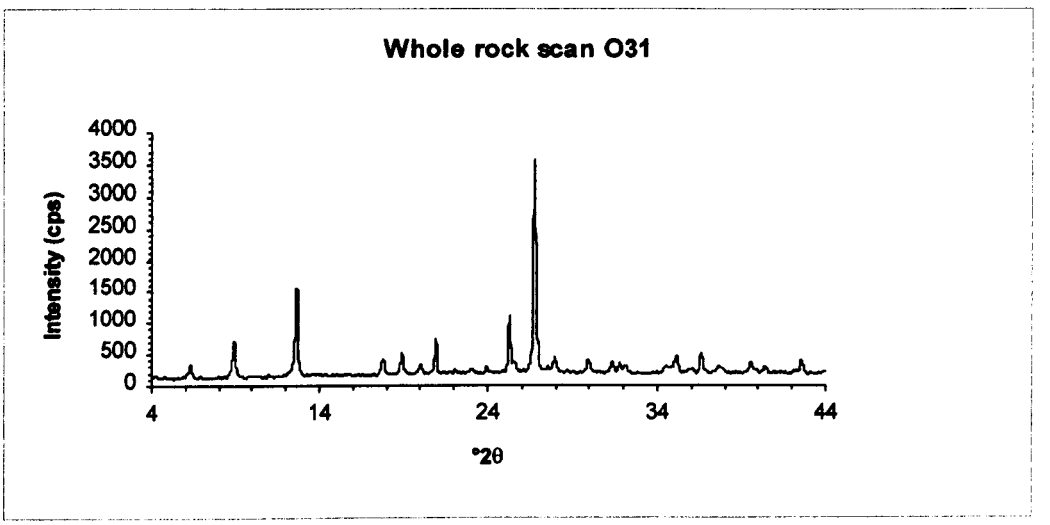


Figure 5.7a . Sample O.3.1 whole rock scan.

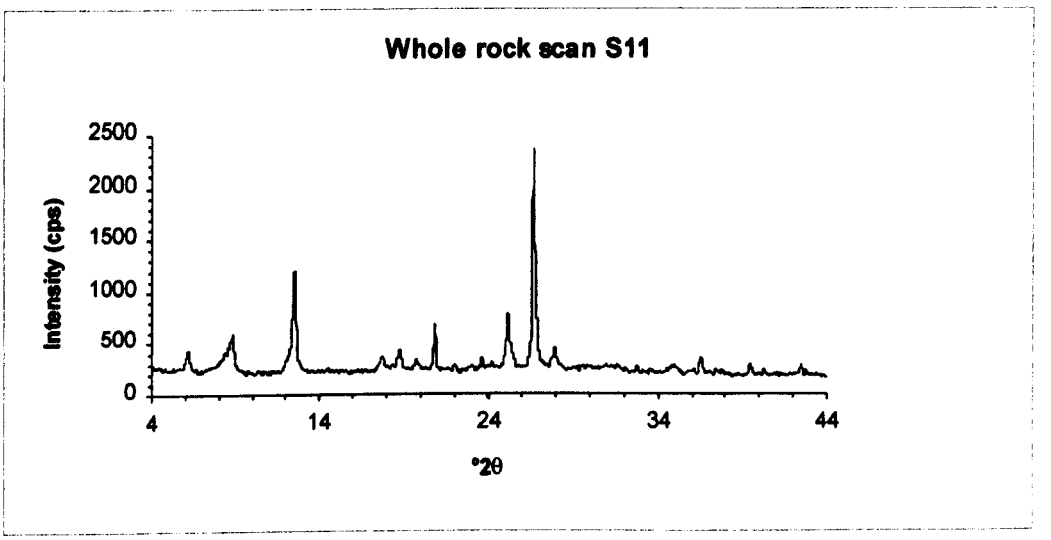


Figure 5.8a . Sample S.1.1 whole rock scan.

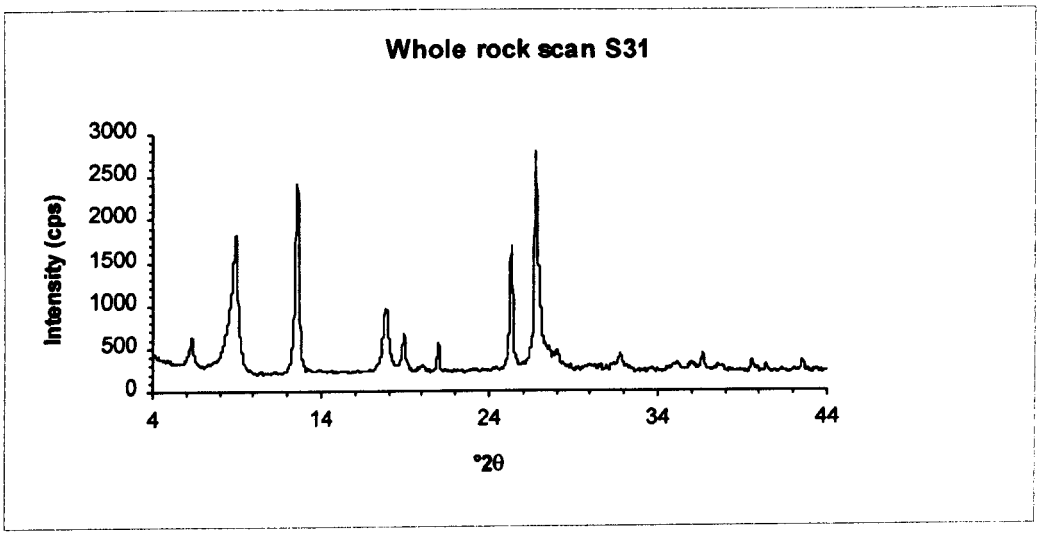


Figure 5.9a . Sample S.3.1 whole rock scan.

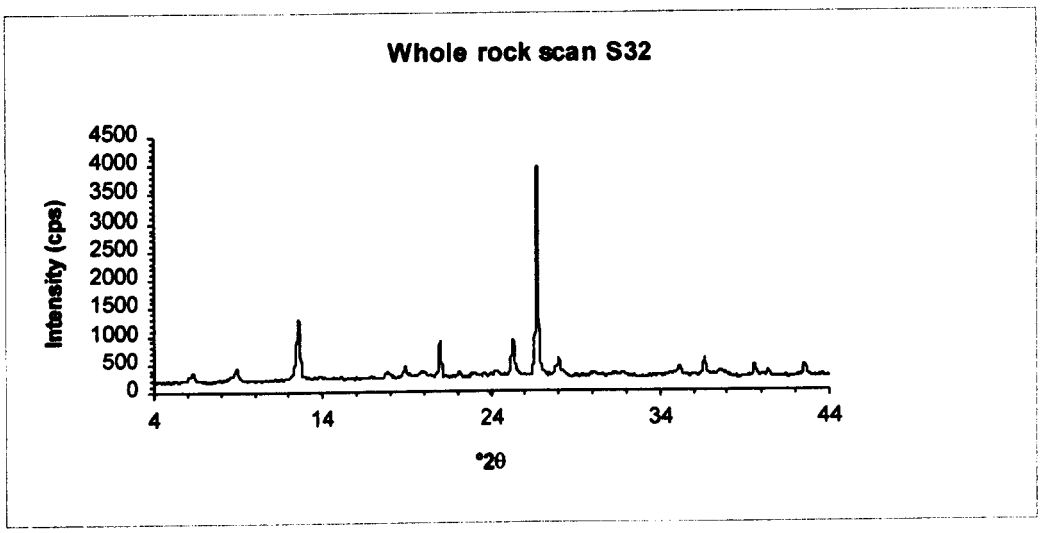


Figure 5.10a . Sample S.3.2 whole rock scan.

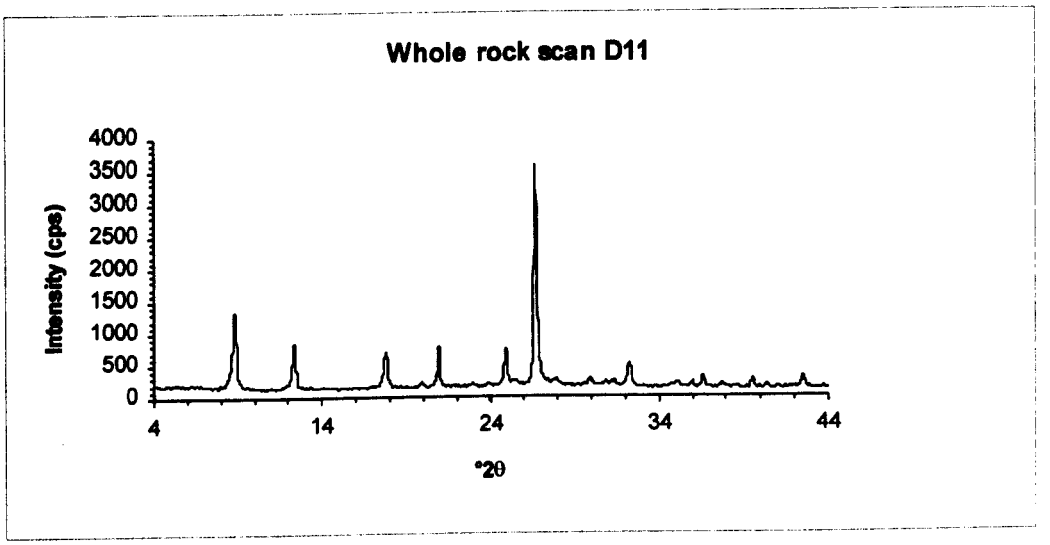


Figure 5.11a . Sample D.1.1 whole rock scan.

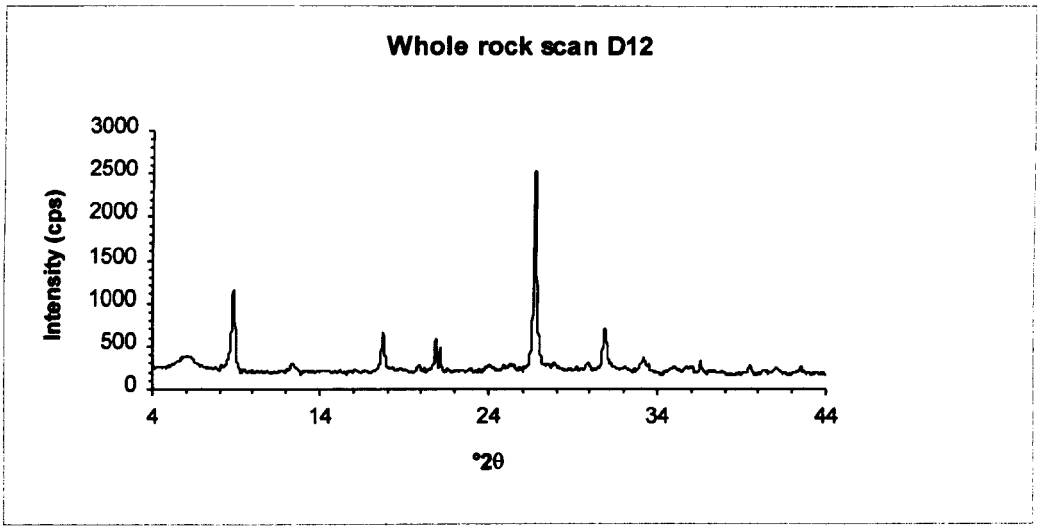


Figure 5.12a . Sample D.1.2 whole rock scan.

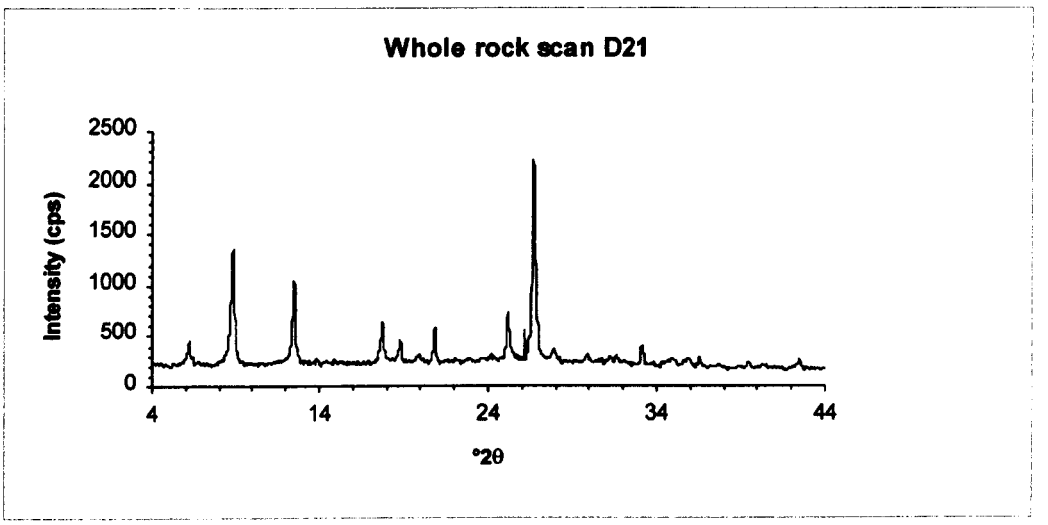


Figure 5.13a . Sample D.2.1 whole rock scan.

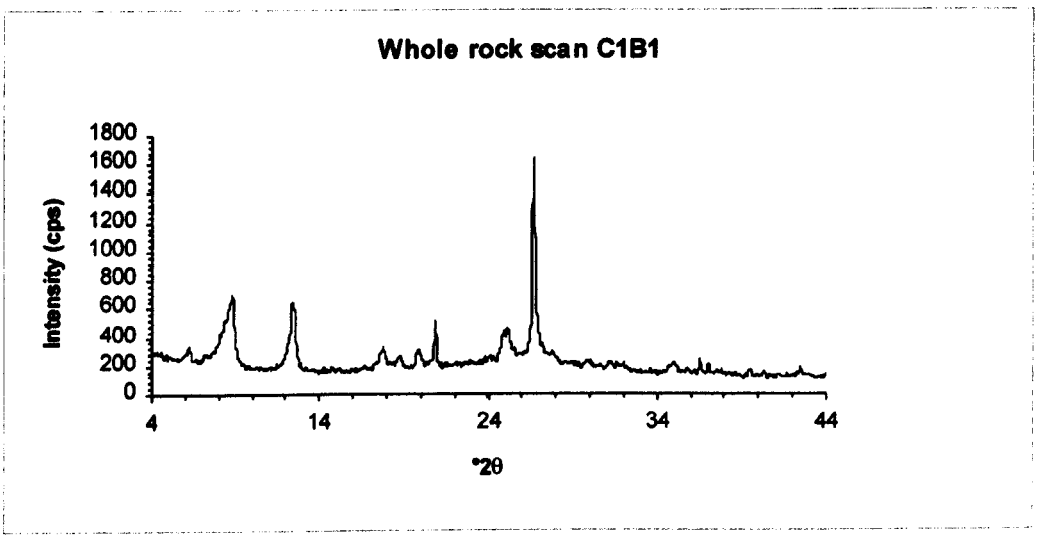


Figure 5.14a . Sample C.1.B.1 whole rock scan.

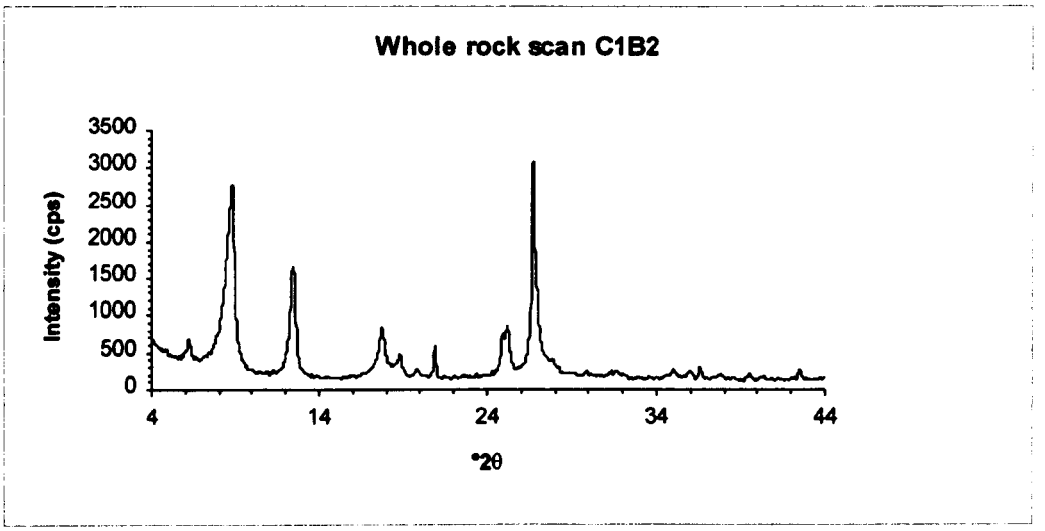


Figure 5.15a . Sample C.1.B.2 whole rock scan.

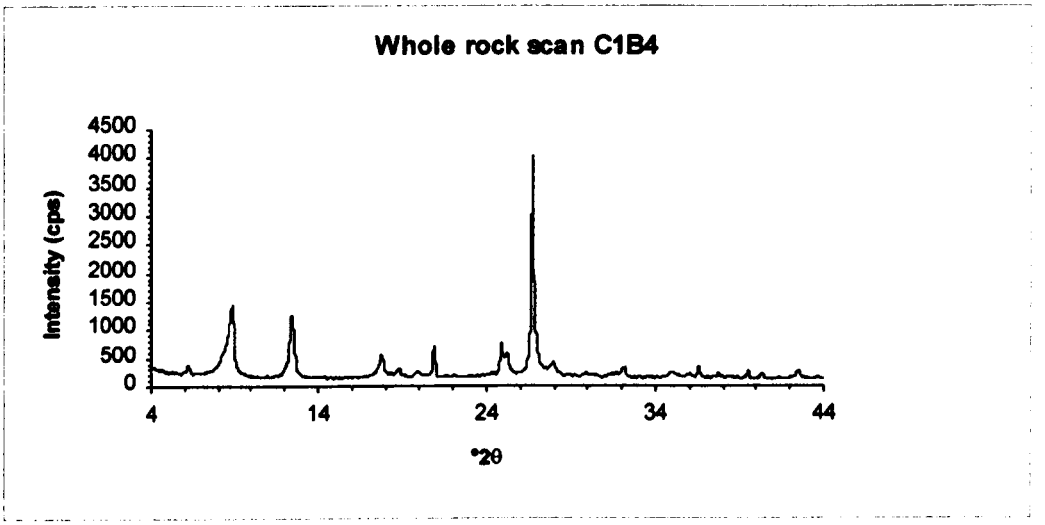


Figure 5.16a . Sample C.1.B.4 whole rock scan.

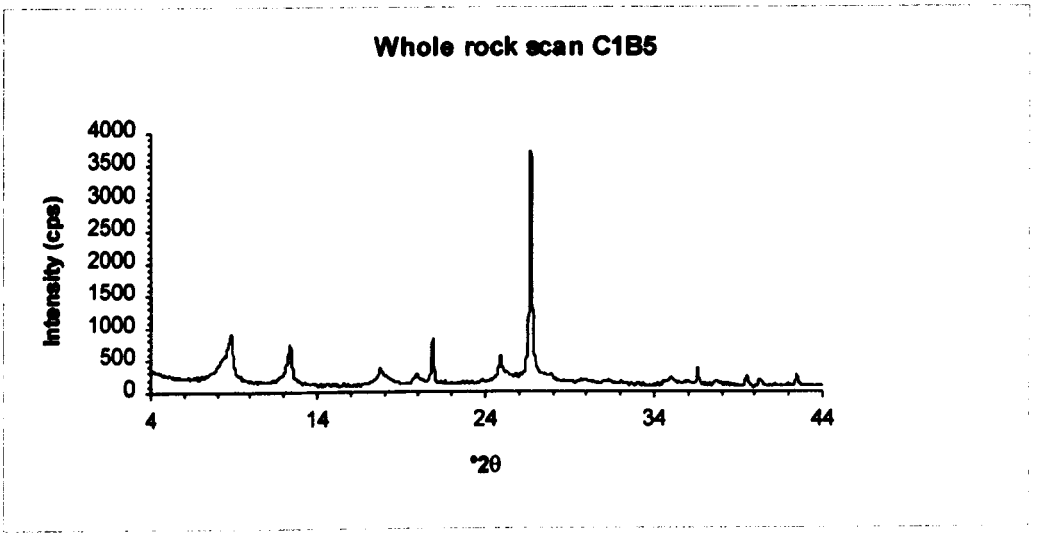


Figure 5.17a . Sample C.1.B.5 whole rock scan.

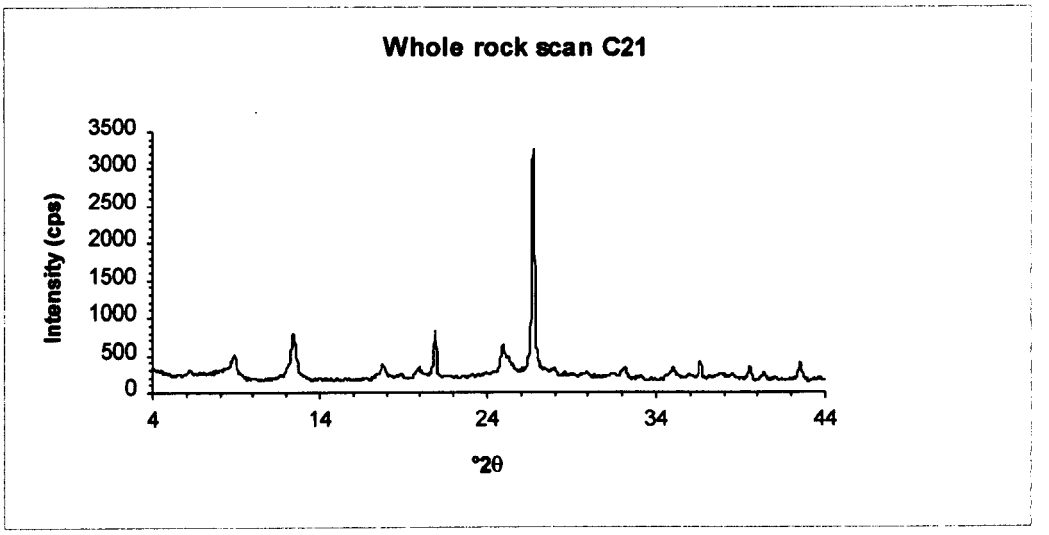


Figure 5.18a . Sample C.2.1 whole rock scan.

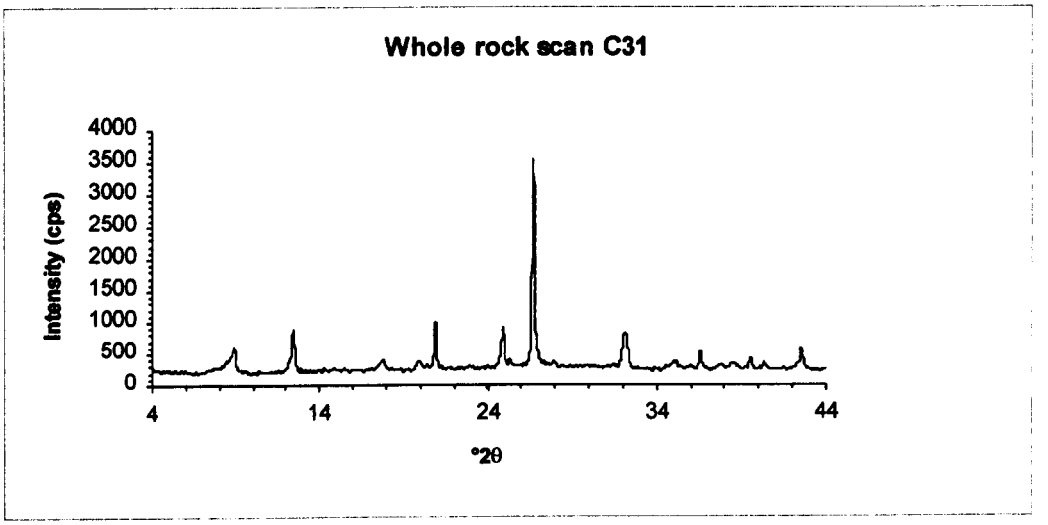


Figure 5.19a . Sample C.3.1 whole rock scan.

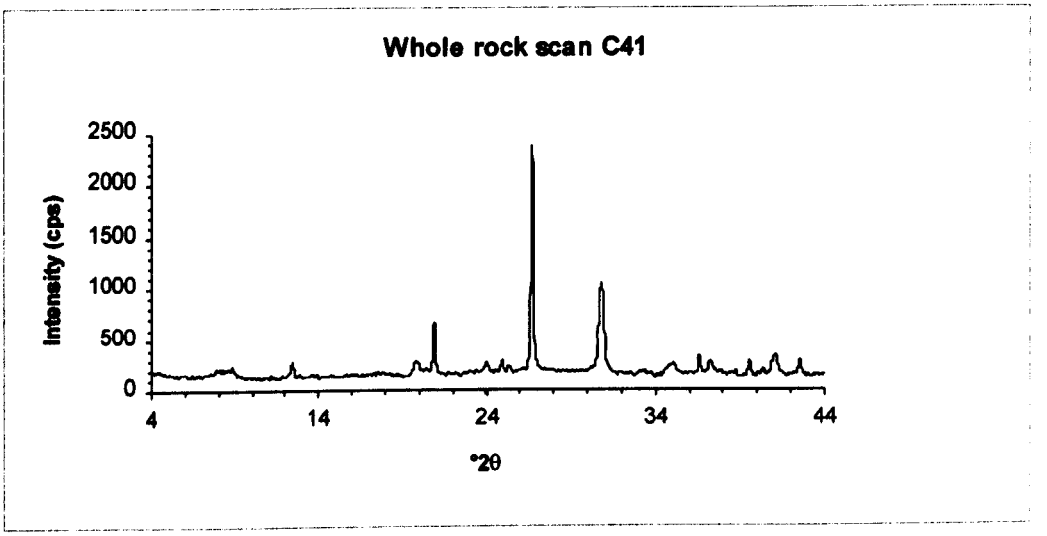


Figure 5.20a . Sample C.4.1 whole rock scan.

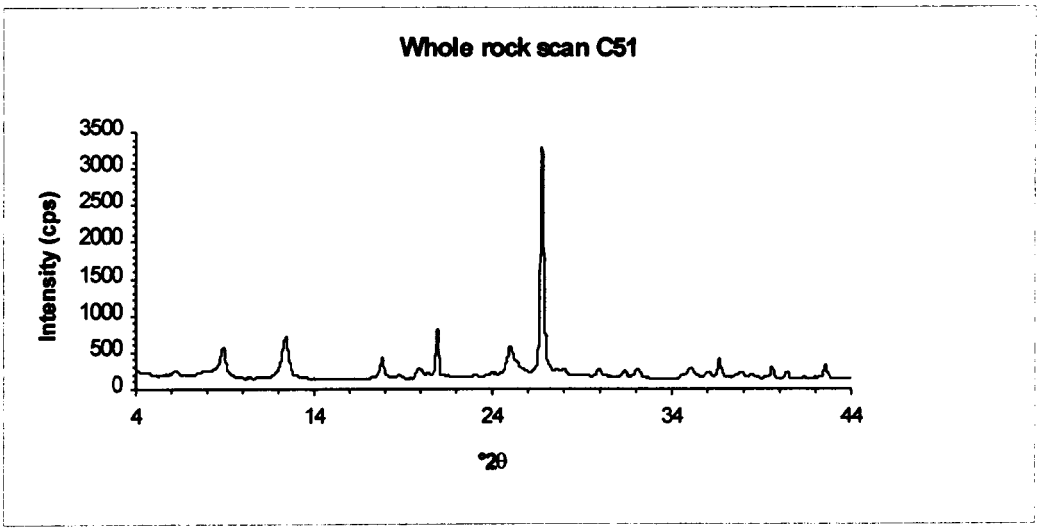


Figure 5.21a . Sample C.5.1 whole rock scan.

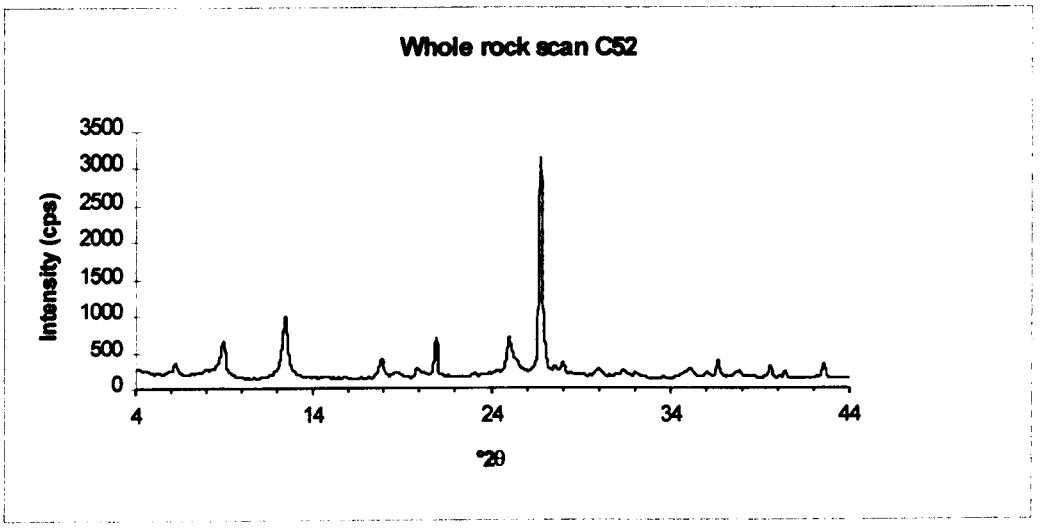


Figure 5.22a . Sample C.5.2 whole rock scan.

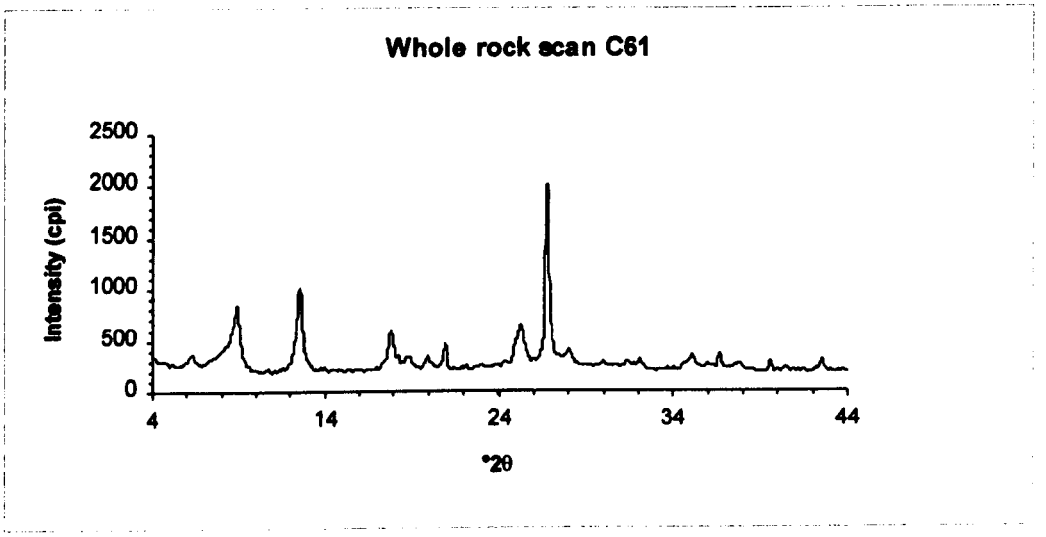


Figure 5.23a . Sample C.6.1 whole rock scan.

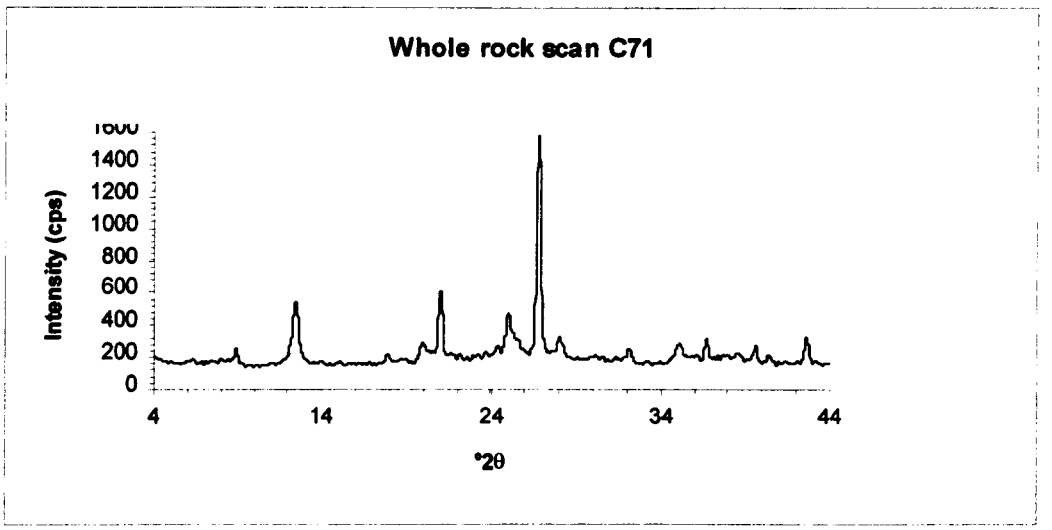


Figure 5.24a .Sample C.7.1 whole rock scan.

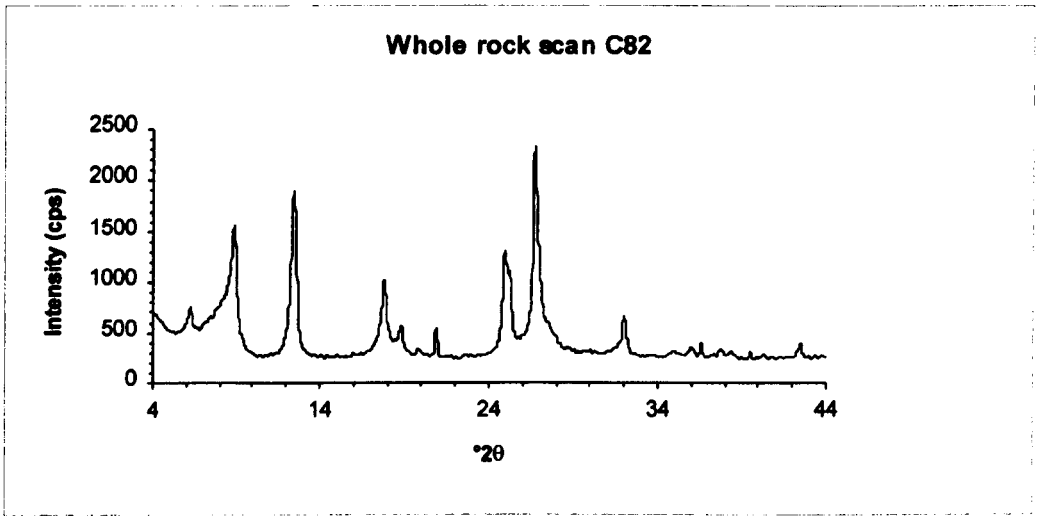


Figure 5.25a . Sample C.8.2 whole rock scan.

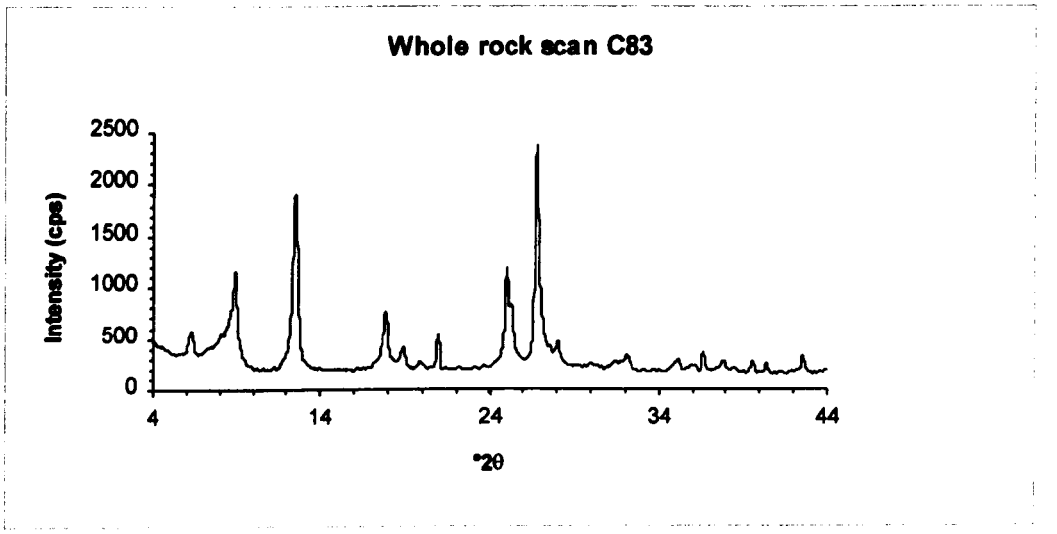


Figure 5.26a .Sample C.8.3 whole rock scan.

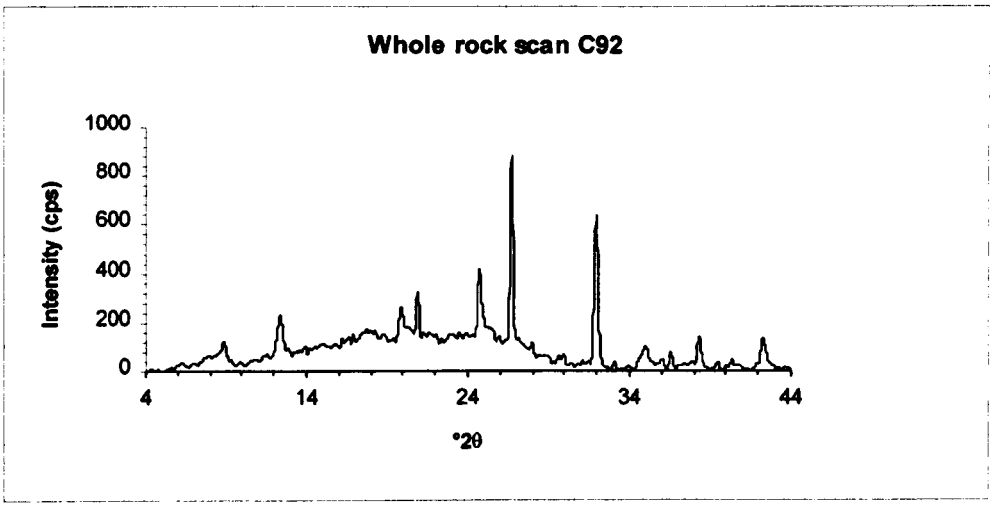


Figure 5.27a . Sample C.9.2 whole rock scan.

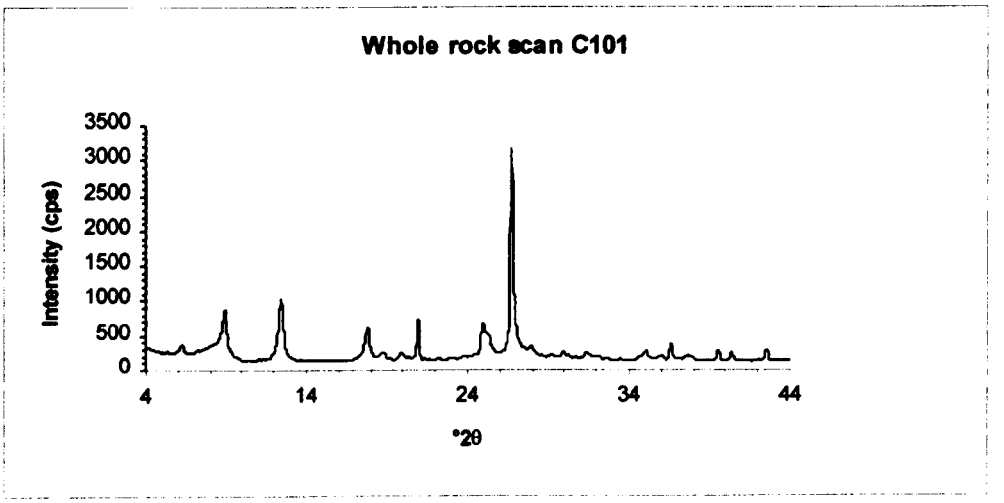


Figure 5.28a . Sample C.10.1 whole rock scan.

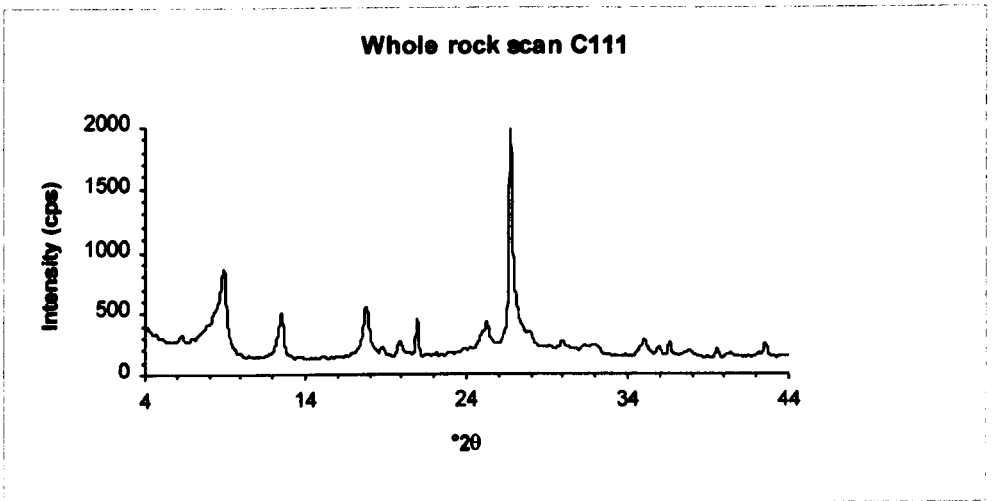


Figure 5.29a . Sample C.11.1 whole rock scan.

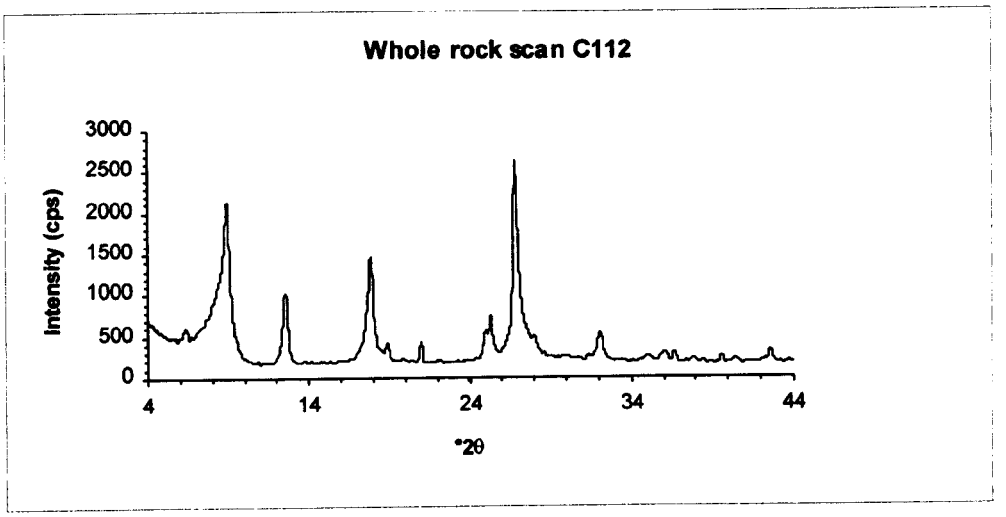


Figure 5.30a . Sample C.11.2 whole rock scan.

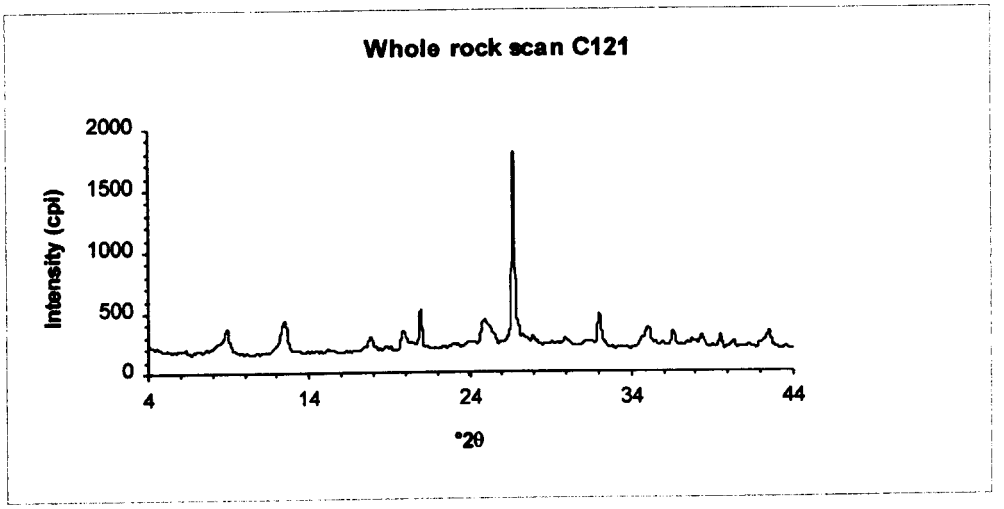


Figure 5.31a . Sample C.12.1 whole rock scan.

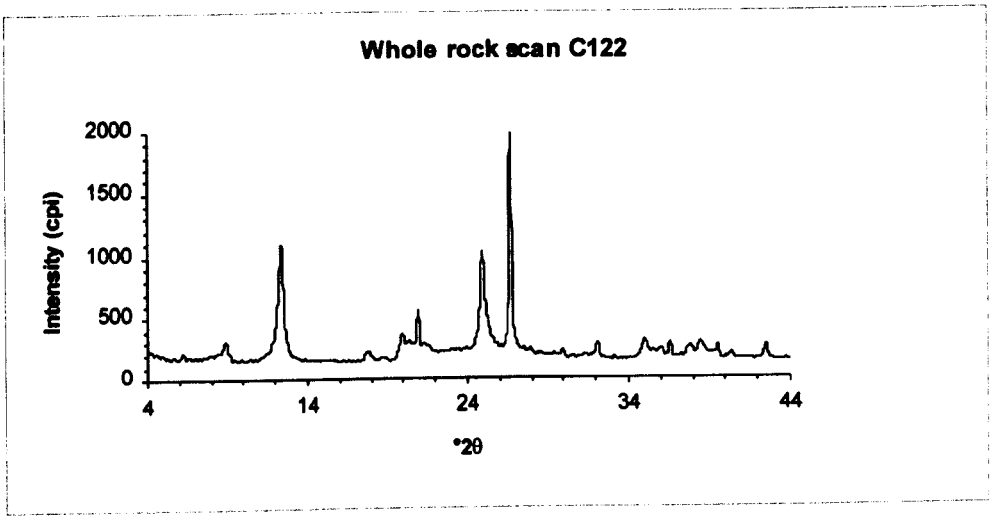


Figure 5.32a . Sample C.12.2 whole rock scan.

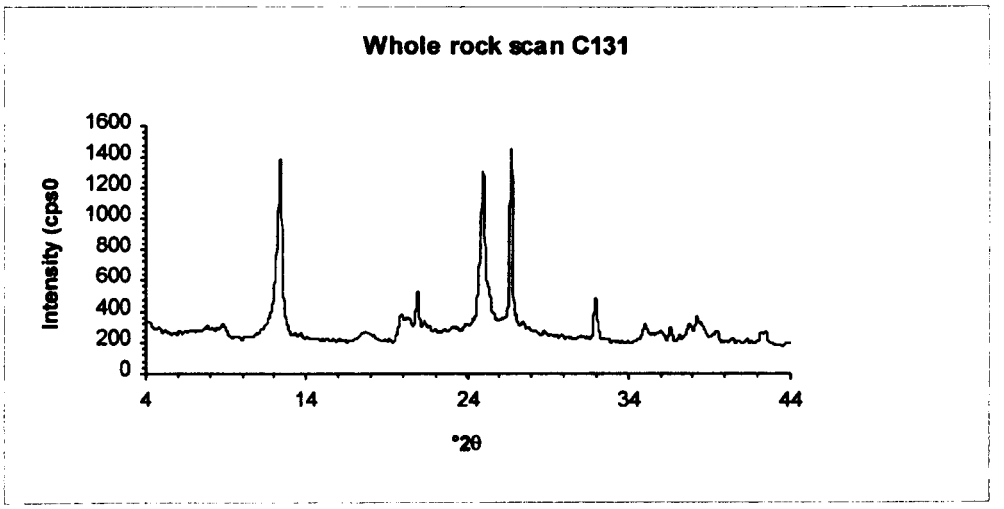


Figure 5.33a . Sample C.13.1 whole rock scan.

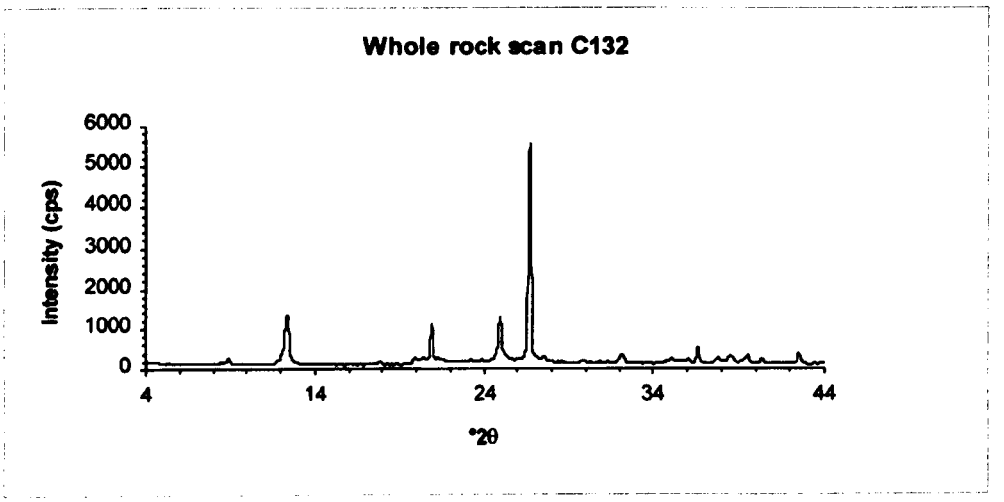


Figure 5.34a . Sample C.13.2 whole rock scan.

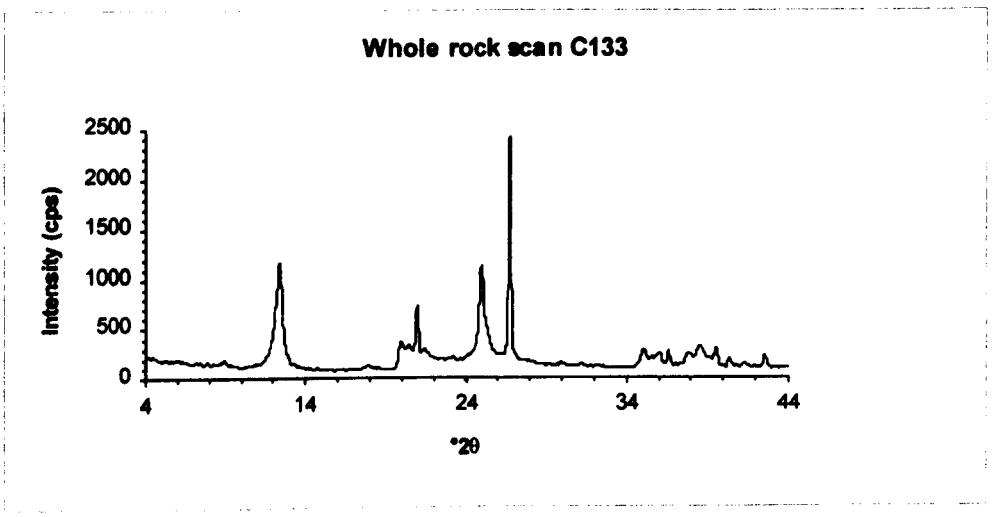


Figure 5.35a . Sample C.13.3 whole rock scan.

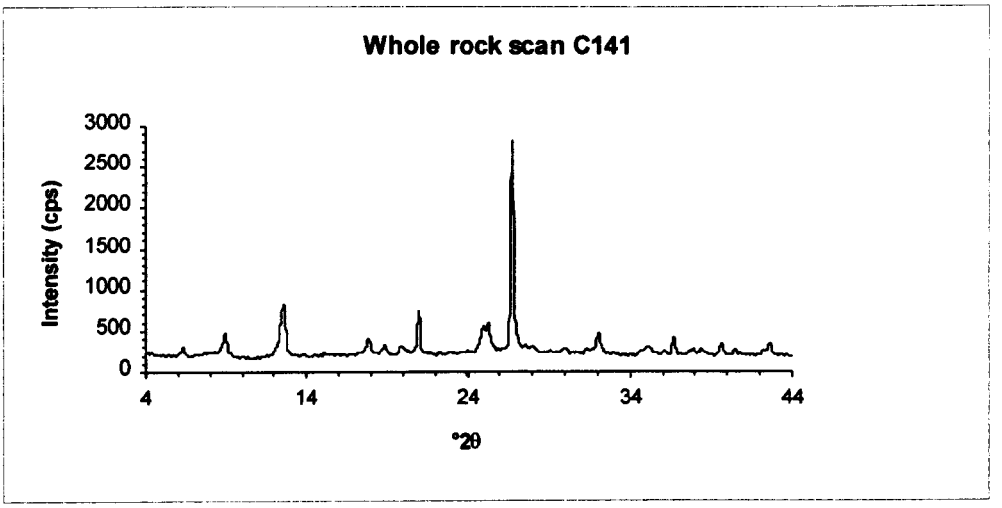


Figure 5.36a . Sample C.14.1 whole rock scan.

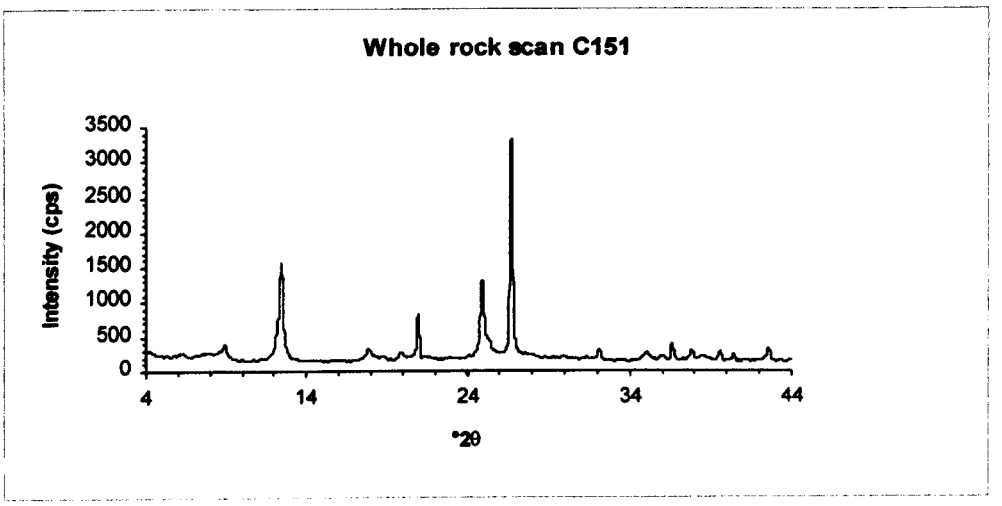


Figure 5.37a . Sample C.15.1 whole rock scan.

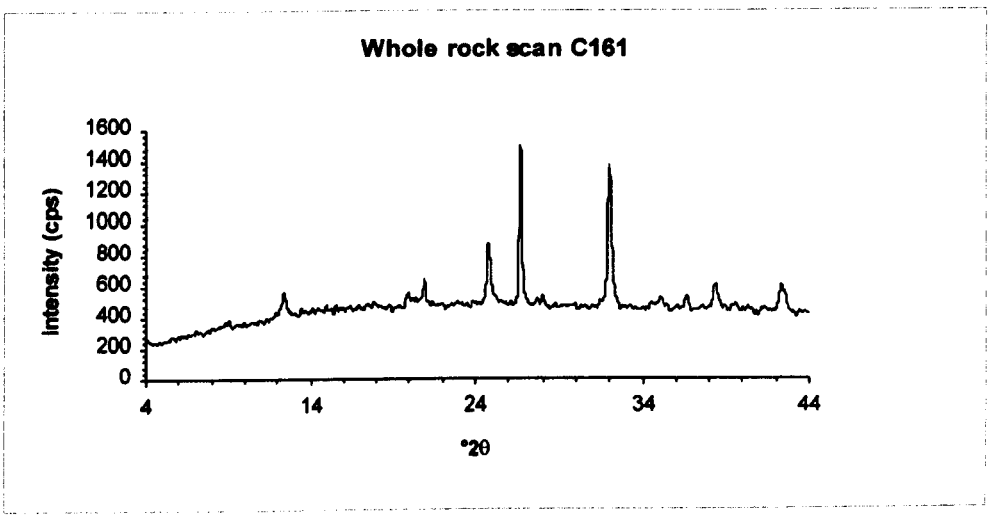


Figure 5.38a . Sample C.16.1 whole rock scan.

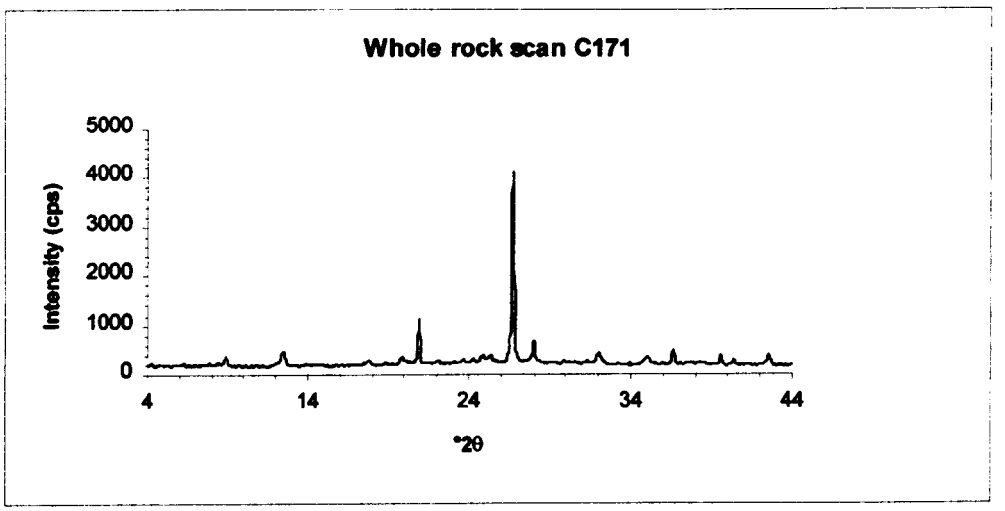


Figure 5.39a . Sample C.17.1 whole rock scan.

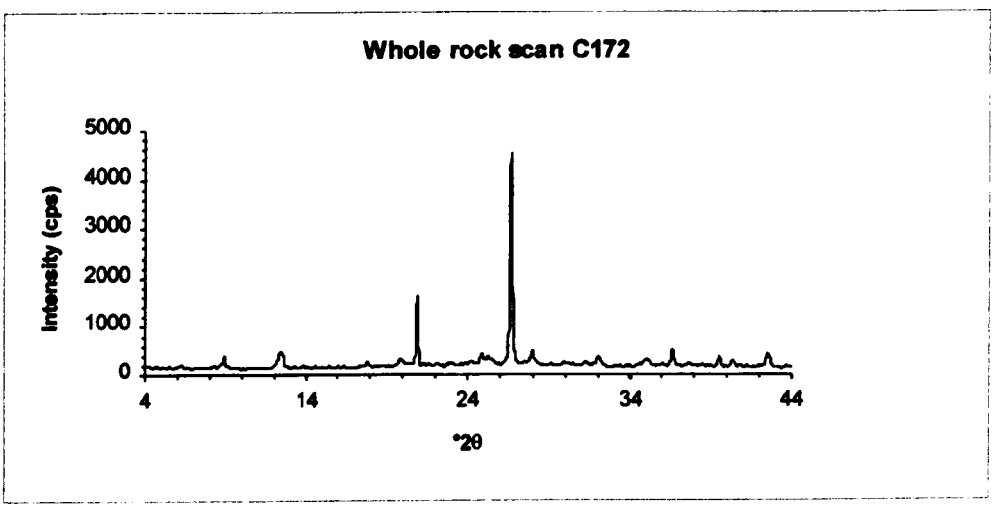


Figure 5.40a . Sample C.17.2 whole rock scan.

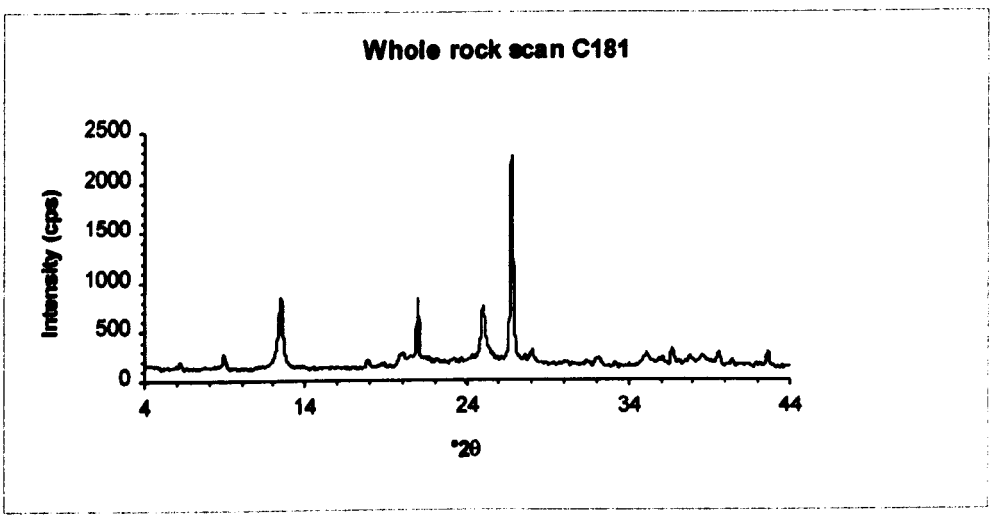


Figure 5.41a . Sample C.18.1 whole rock scan.

APPENDIX A3. CLAY MINERALOGY XRD PLOTS.

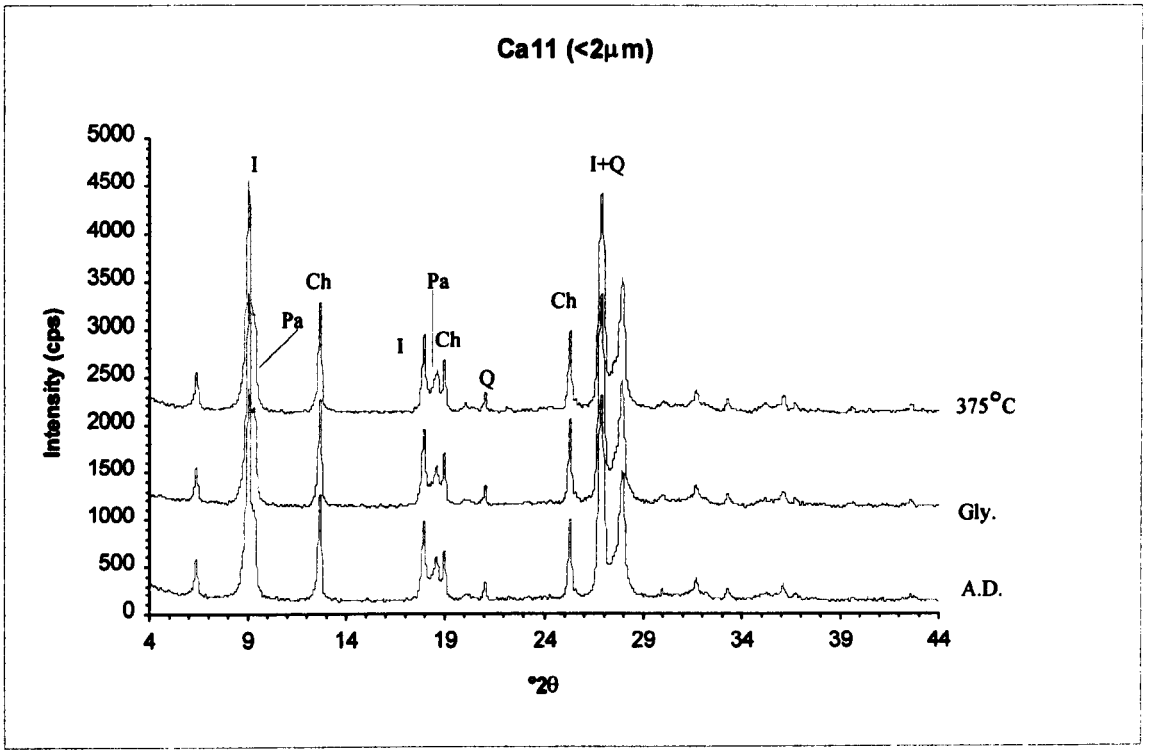


Figure 5.42a . Sample Ca.1.1.

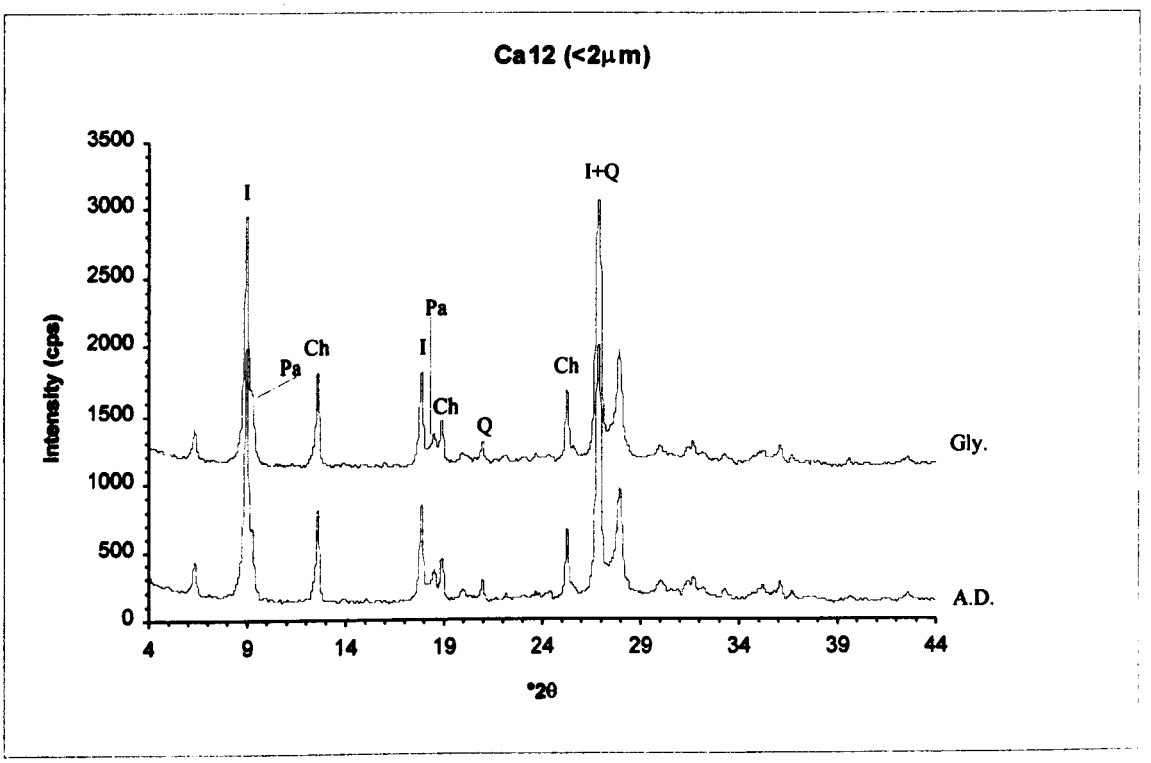


Figure 5.43a . Sample Ca.1.2.

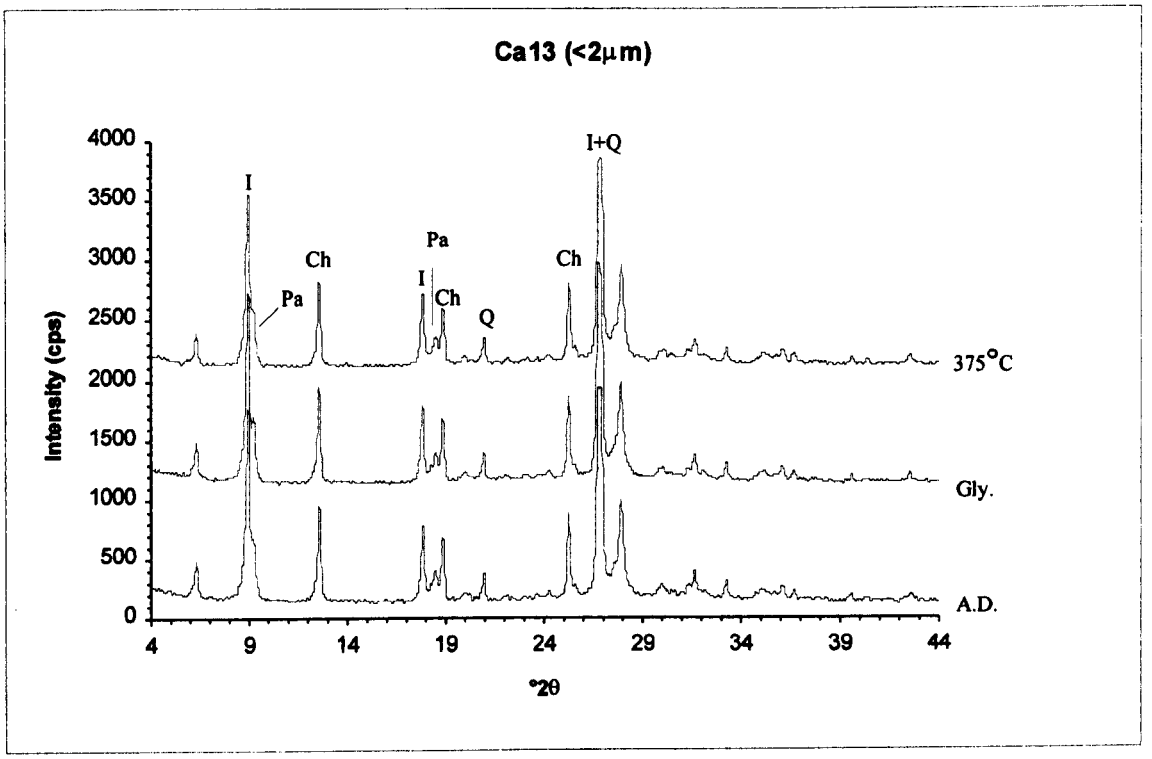


Figure 5.44a . Sample Ca.1.3.

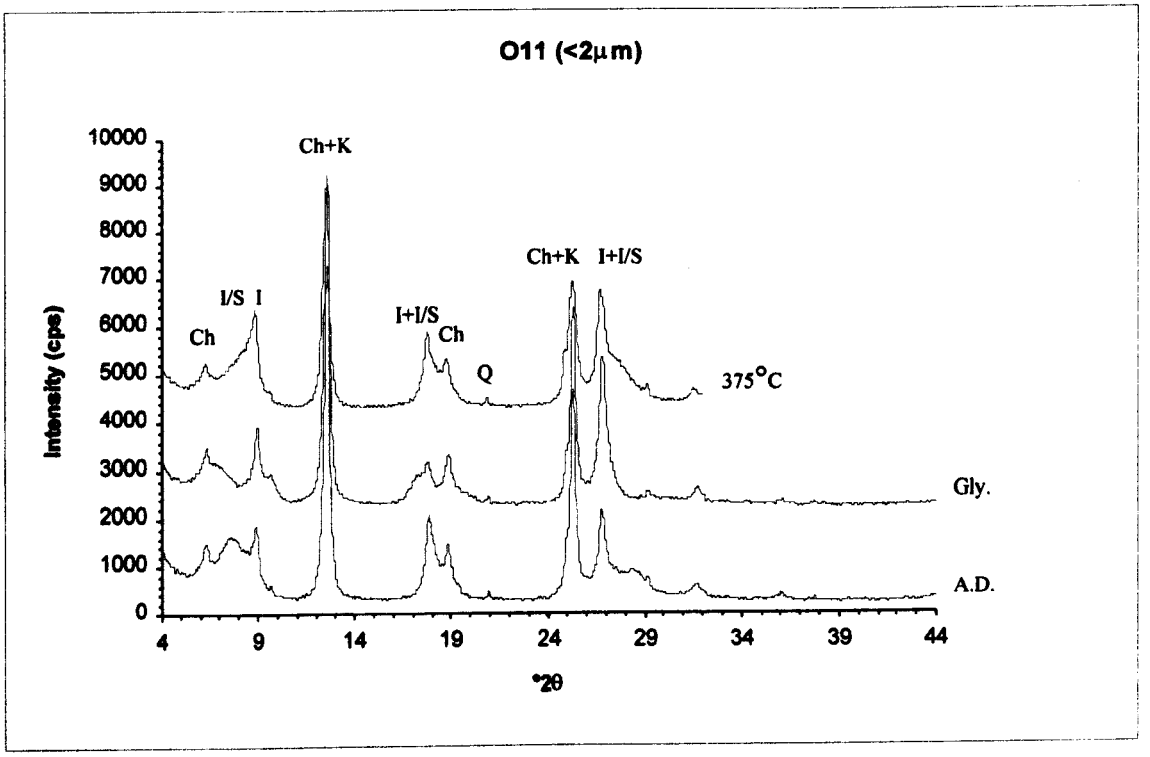


Figure 5.45a . Sample O.1.1.

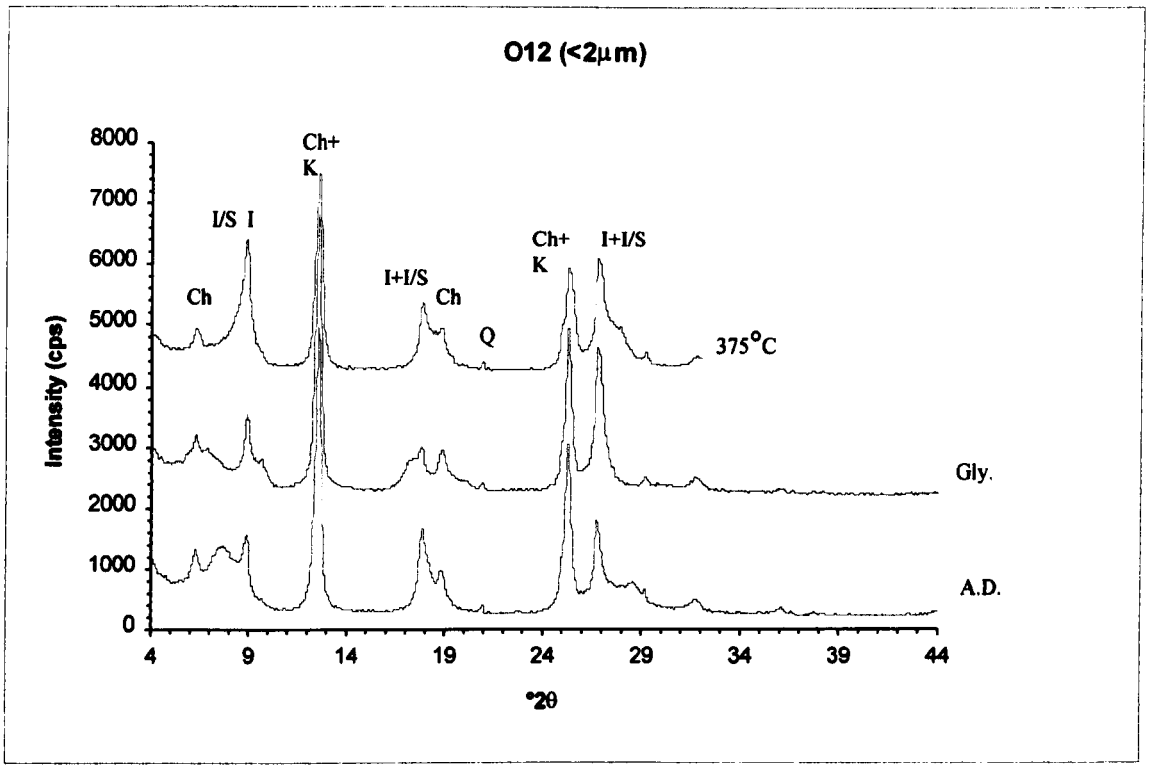


Figure 5.46a . Sample O.1.2.

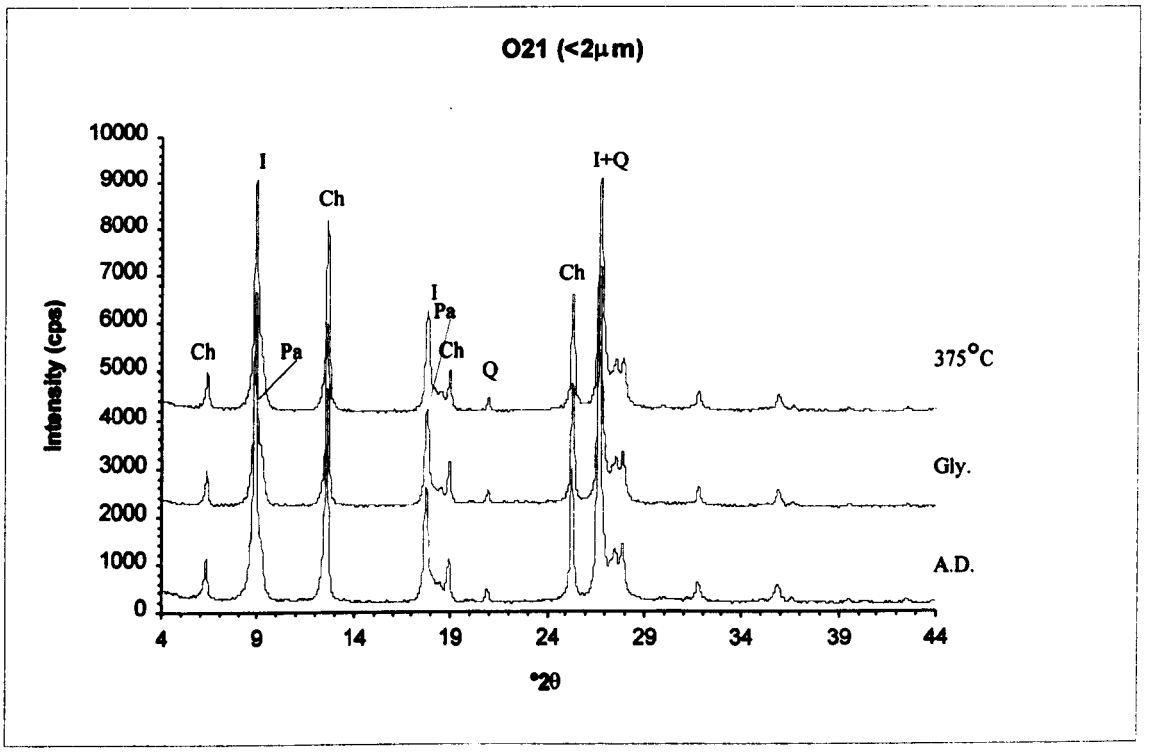


Figure 5.47a . Sample O.2.1.

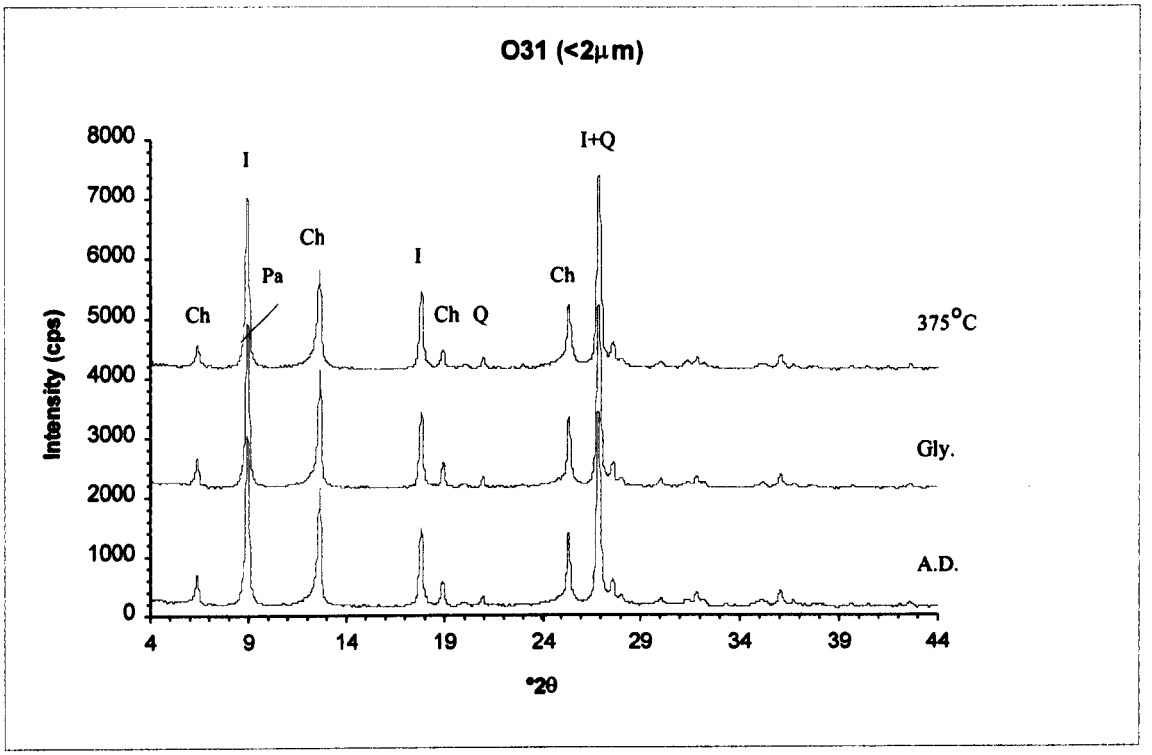


Figure 5.48a . Sample O.3.1.

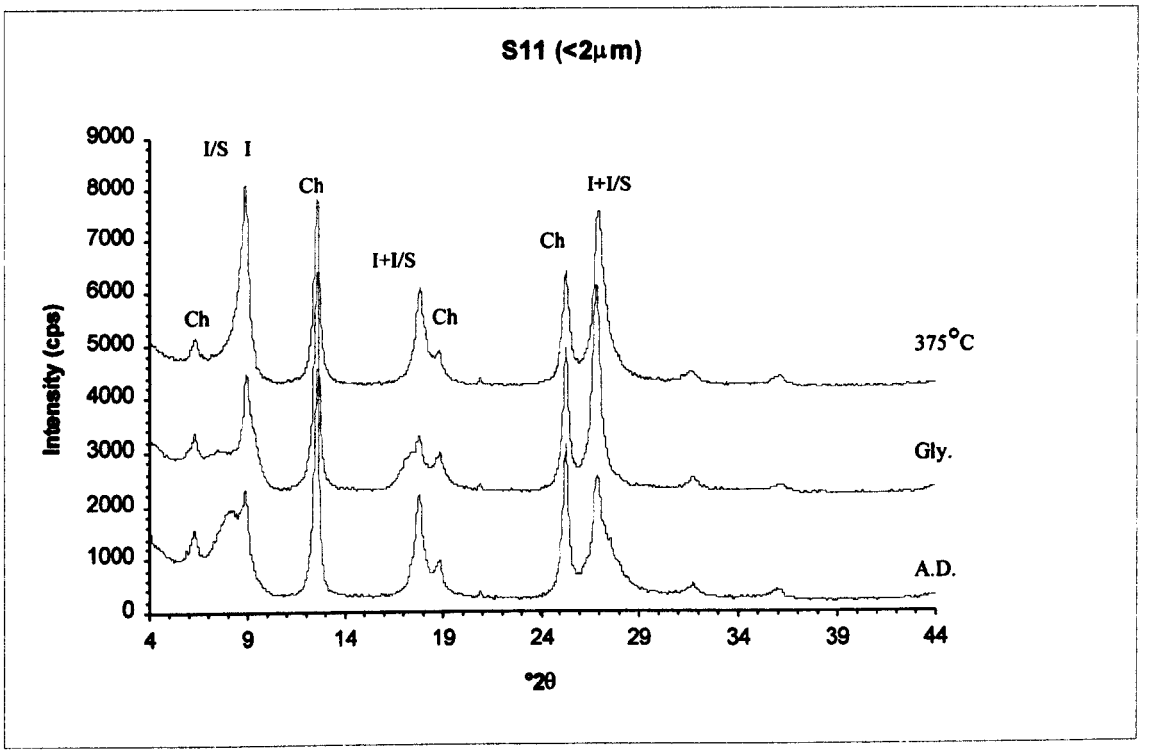


Figure 5.49a . Sample S.1.1.

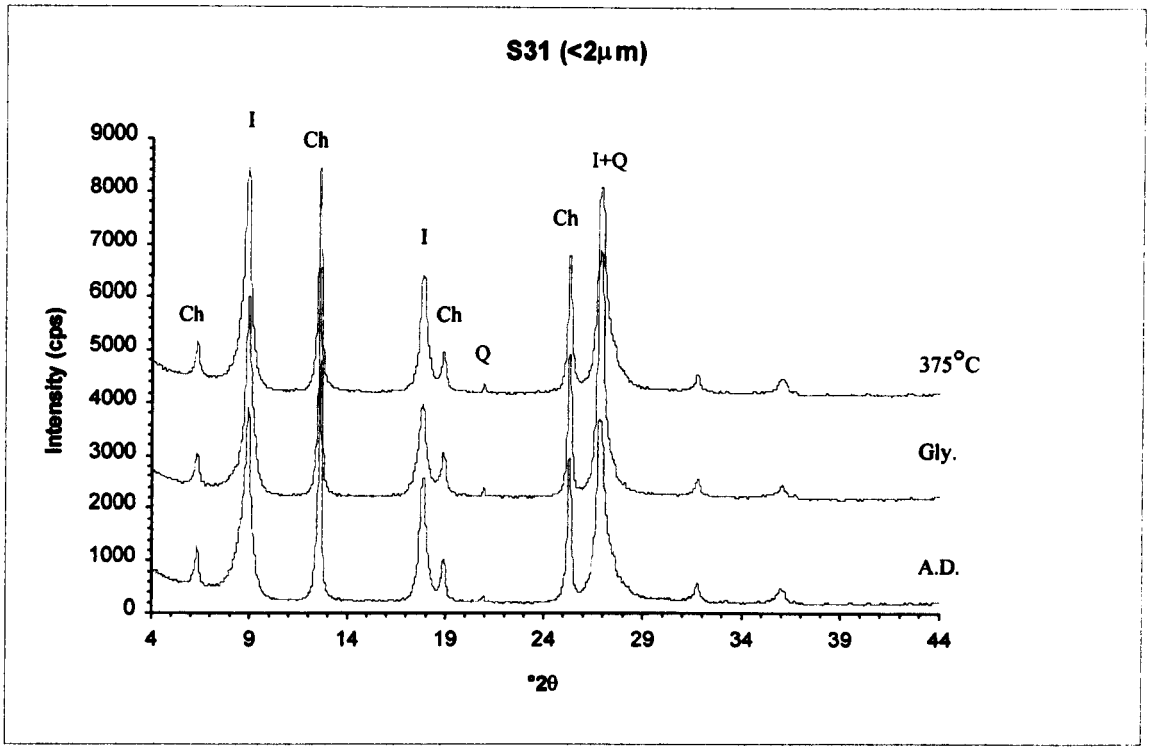


Figure 5.50a . Sample S.3.1.

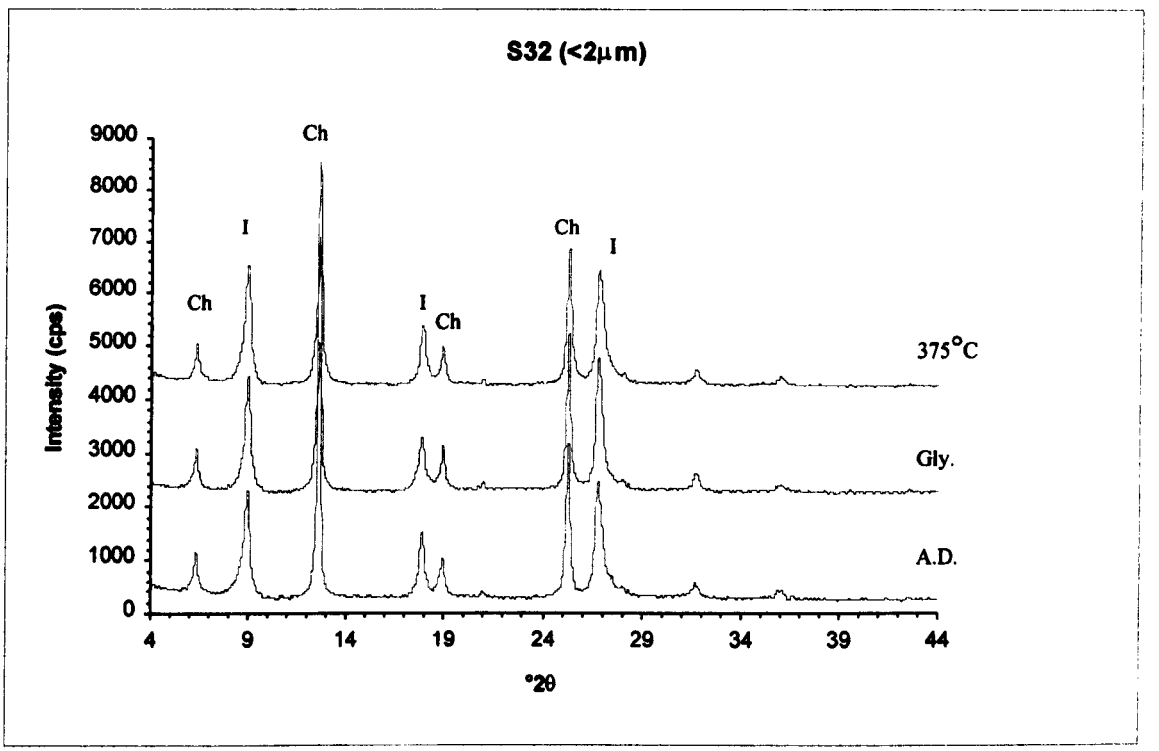


Figure 5.51a . Sample S.3.2.

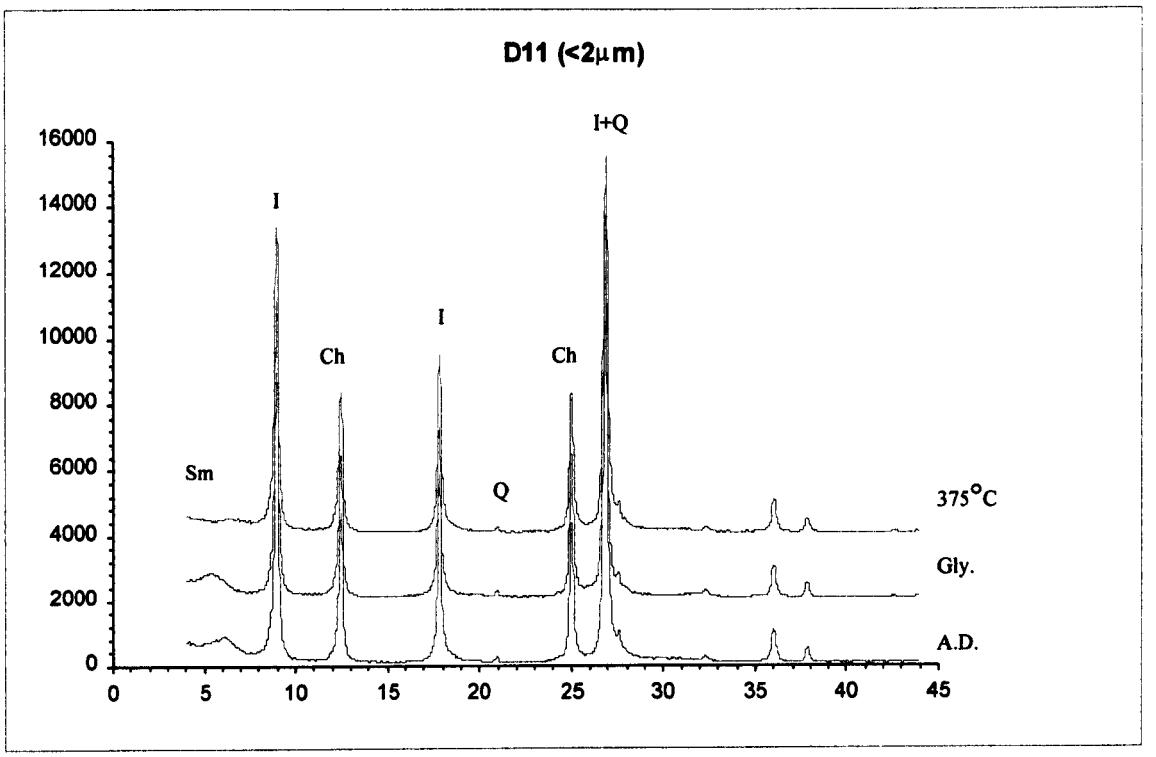


Figure 5.52a . Sample D.1.1.

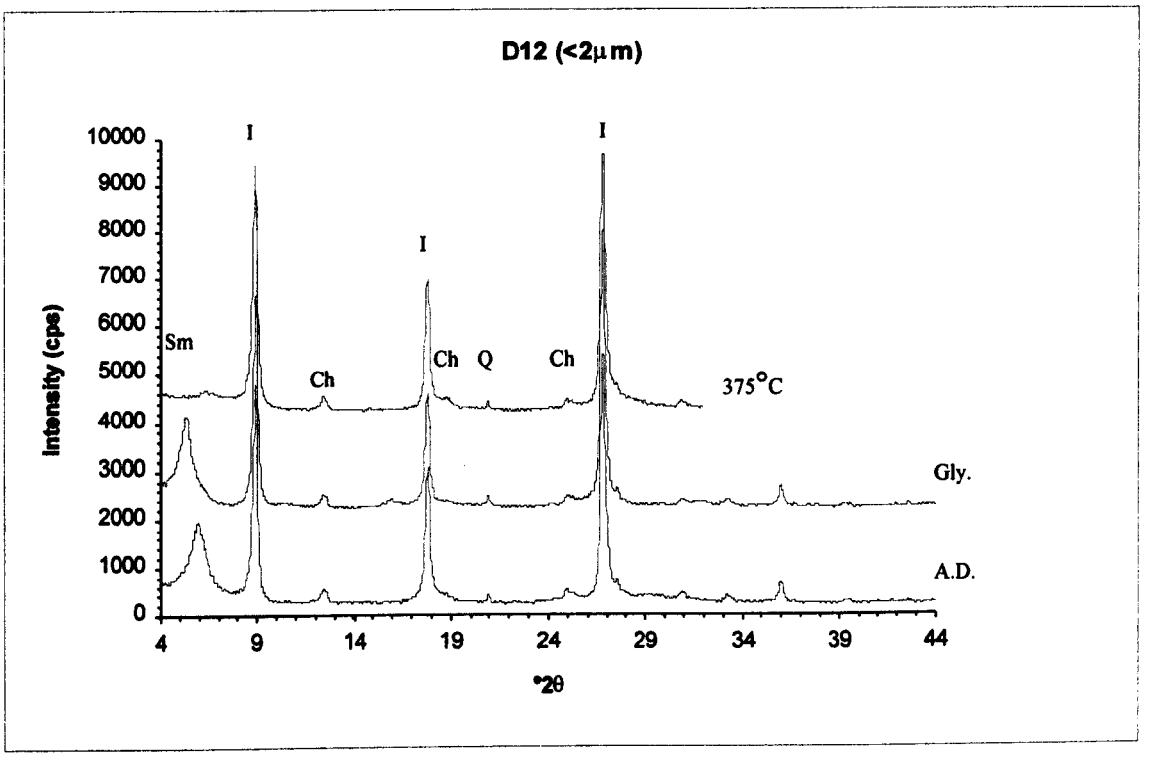


Figure 5.53a . Sample D.1.2.

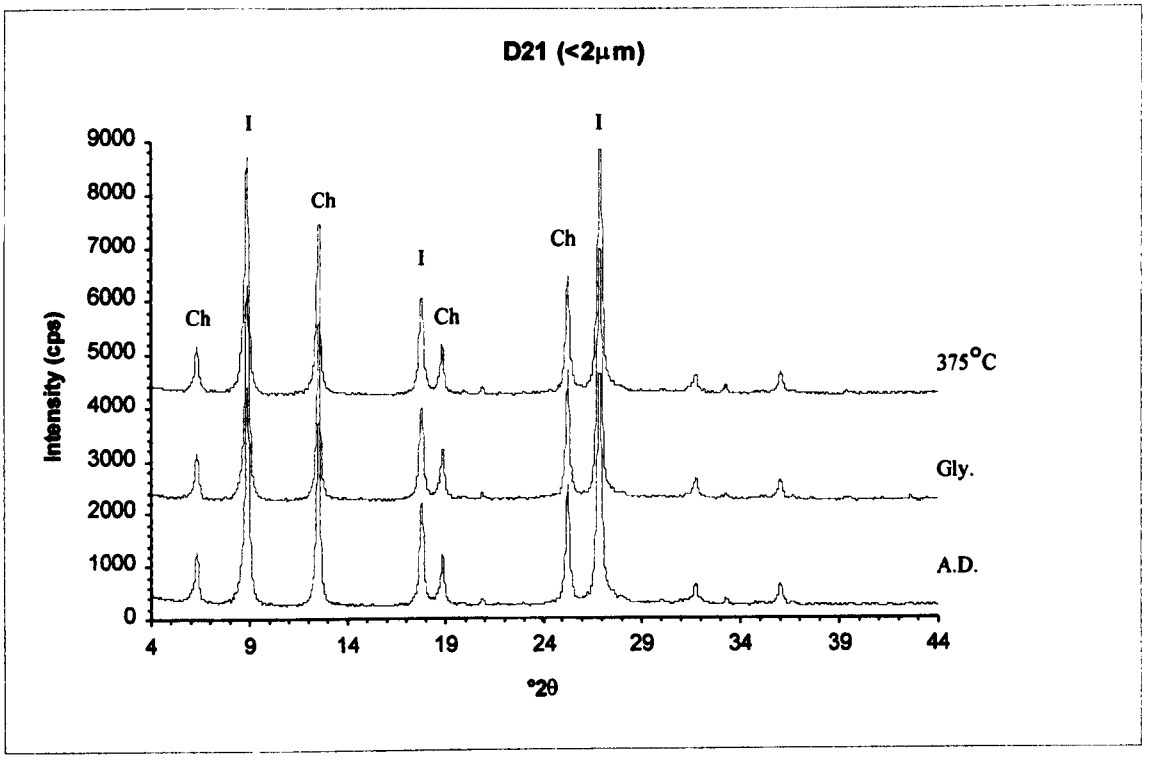


Figure 5.54a . Sample D.2.1.

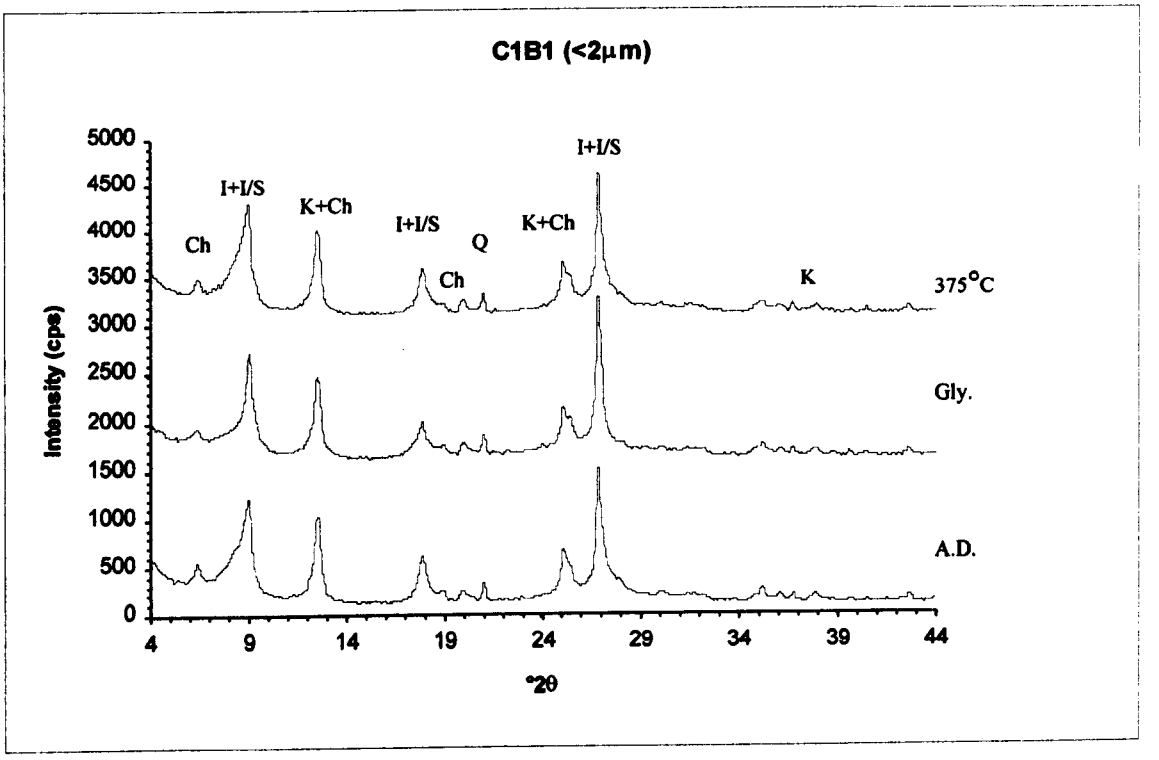


Figure 5.55a . Sample C.1.B.1.

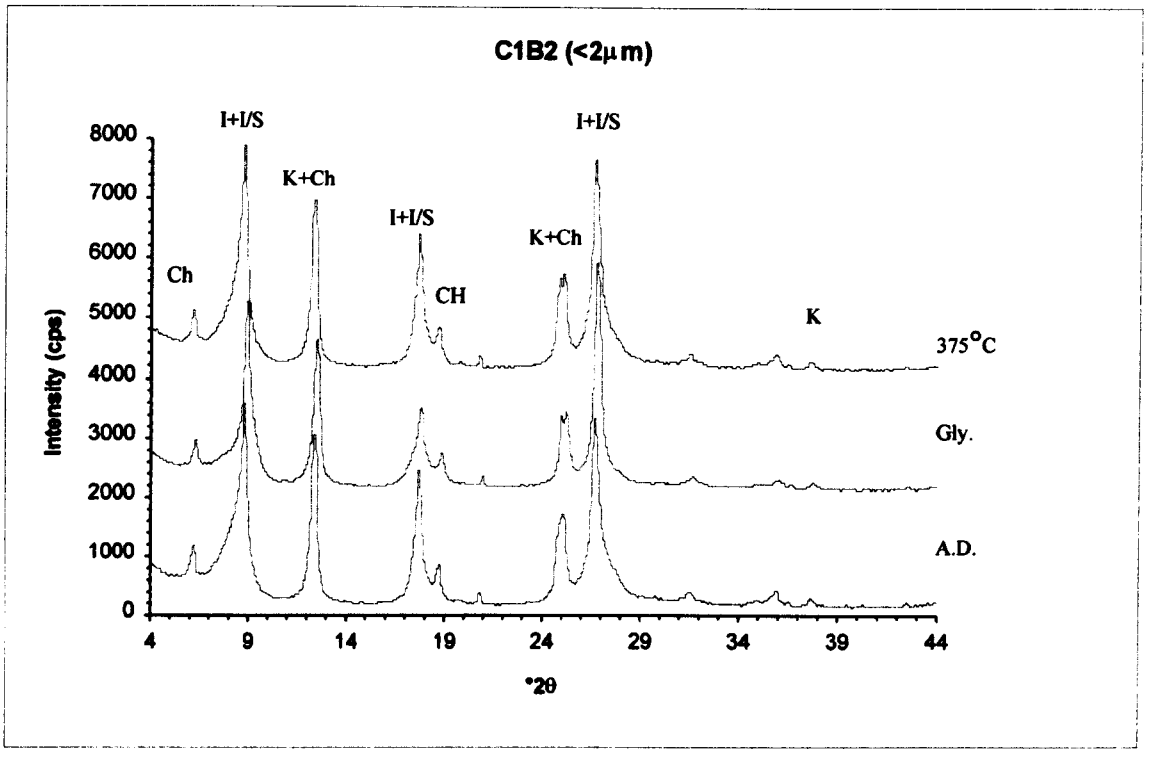


Figure 5.56a . Sample C.1.B.2.

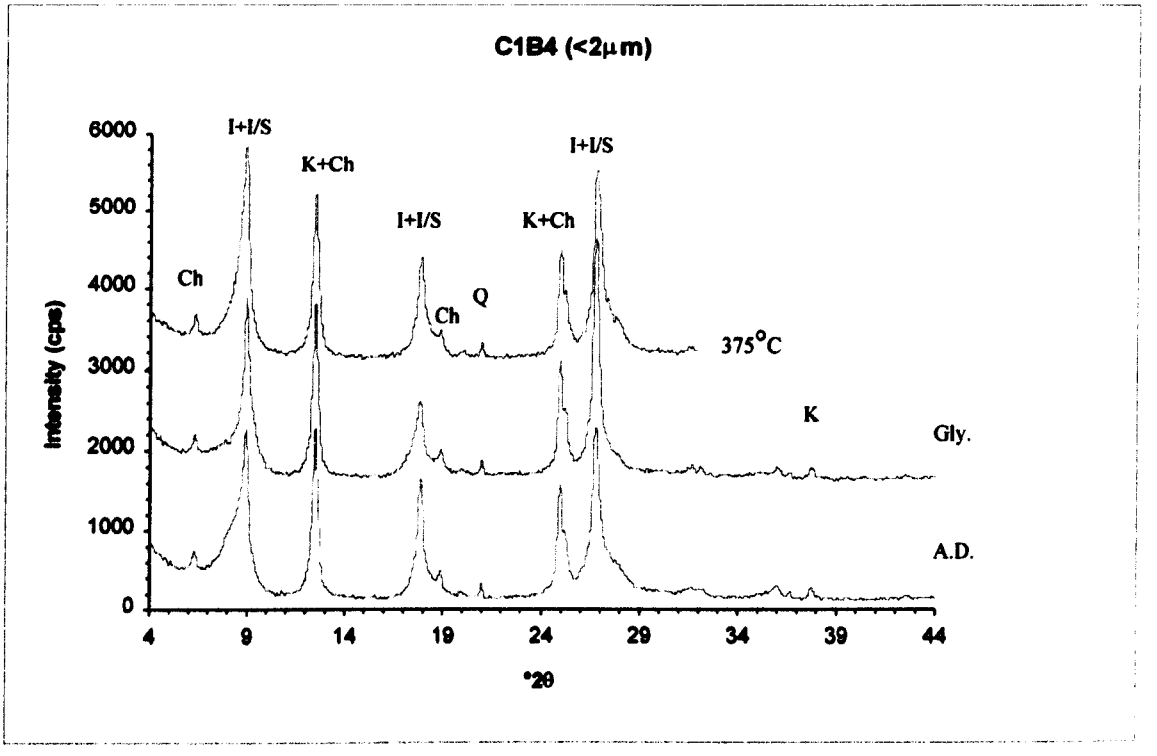


Figure 5.57a . Sample C.1.B.4.

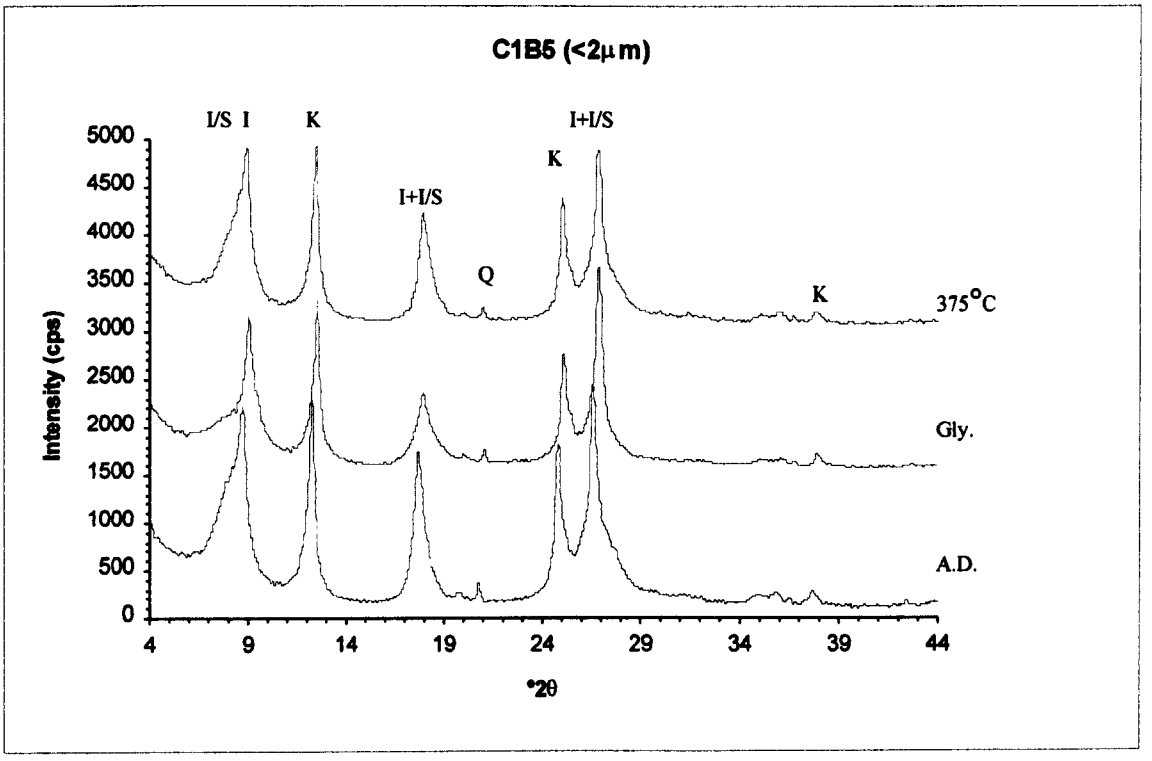


Figure 5.58a . Sample C.1.B.5.

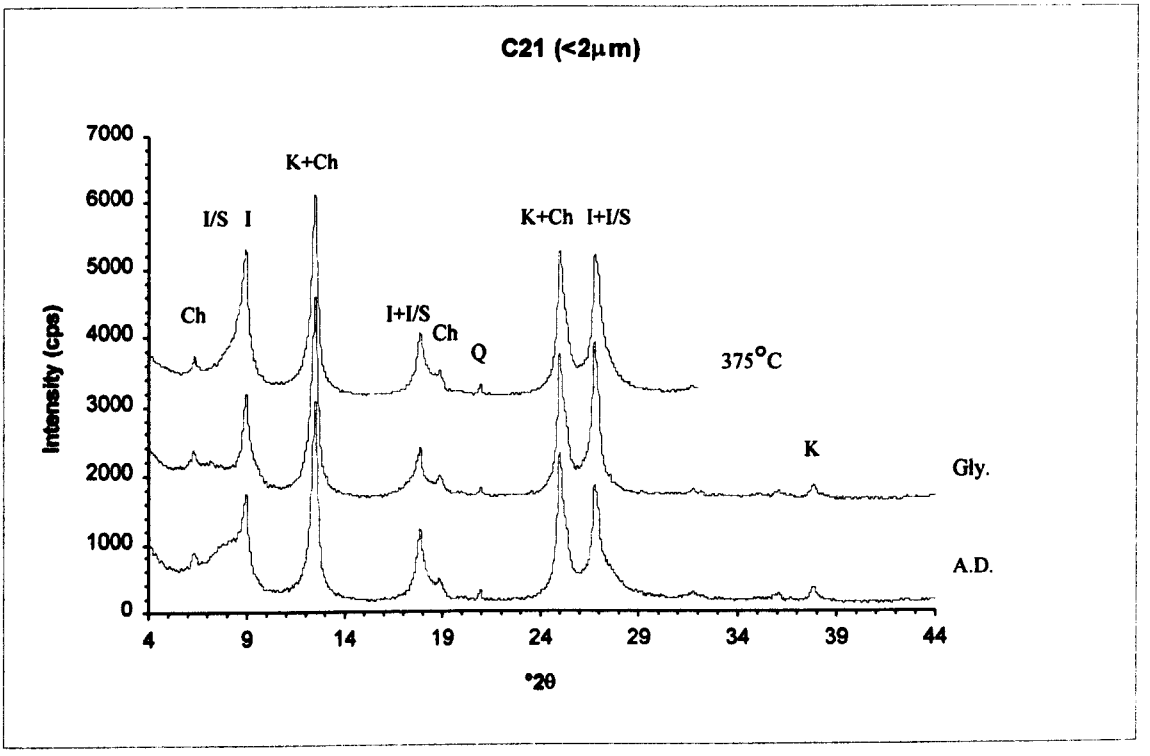


Figure 5.59a . Sample C.2.1.

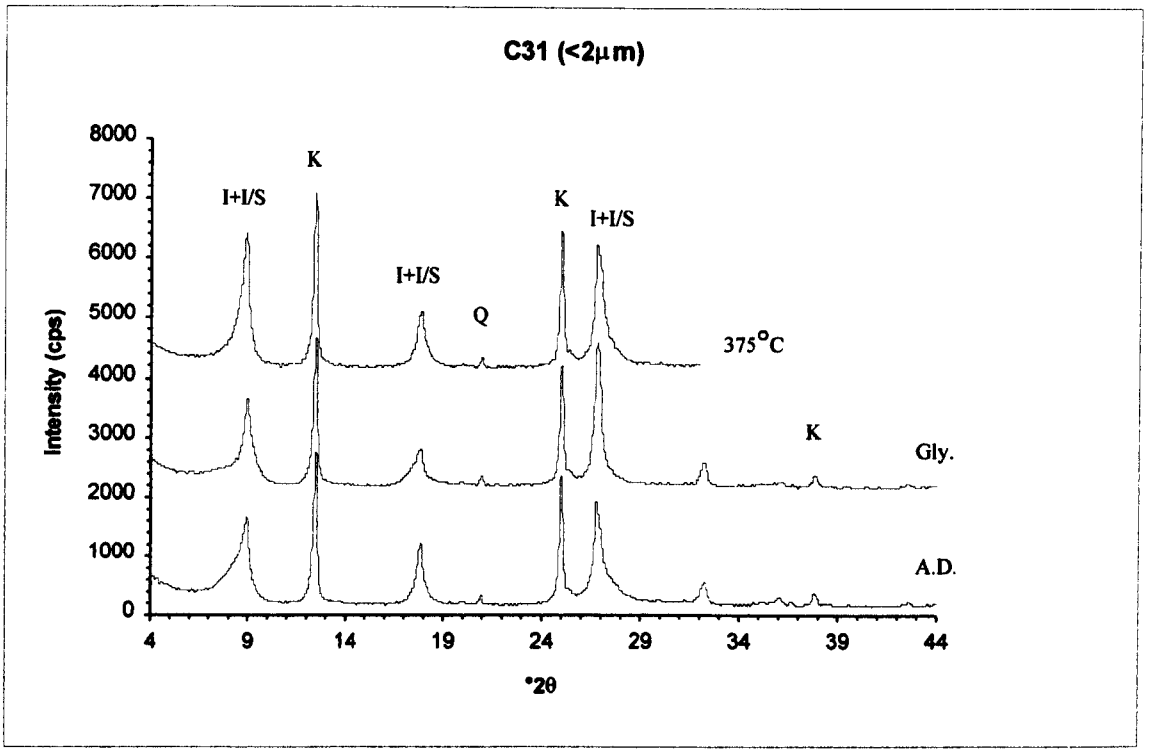


Figure 5.60a . Sample C.3.1.

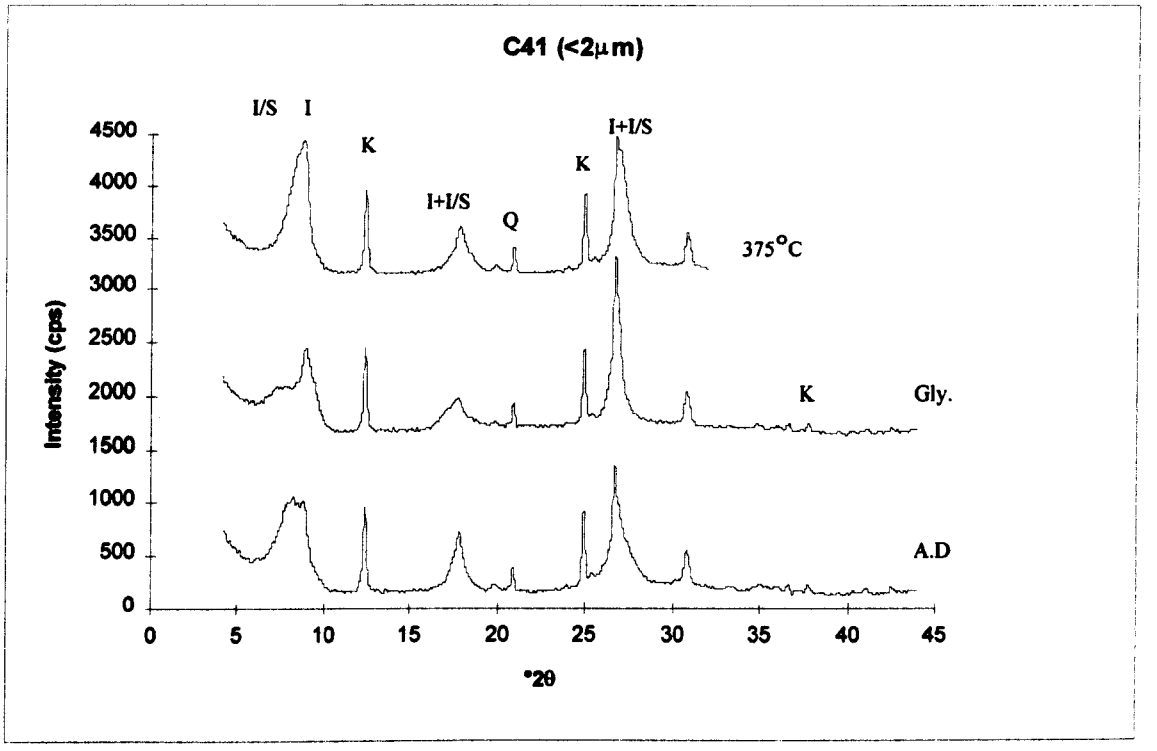


Figure 5.61a . Sample C.4.1.

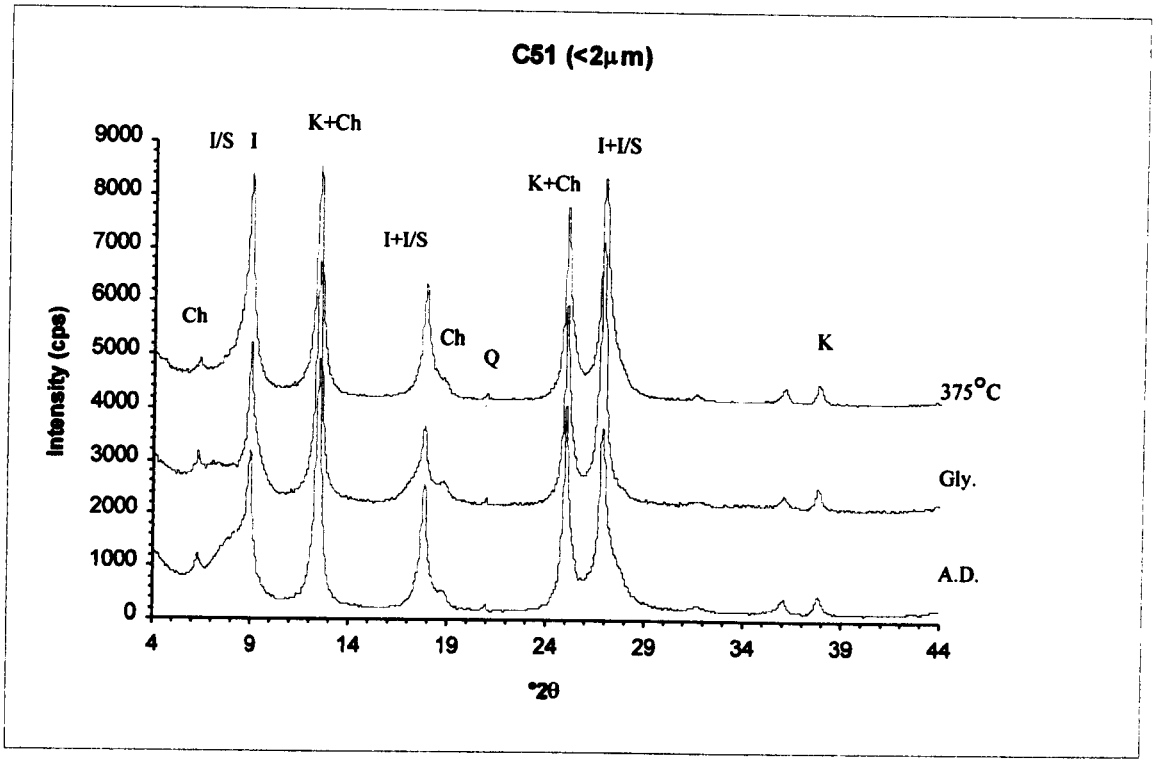


Figure 5.62a . Sample C.5.1.

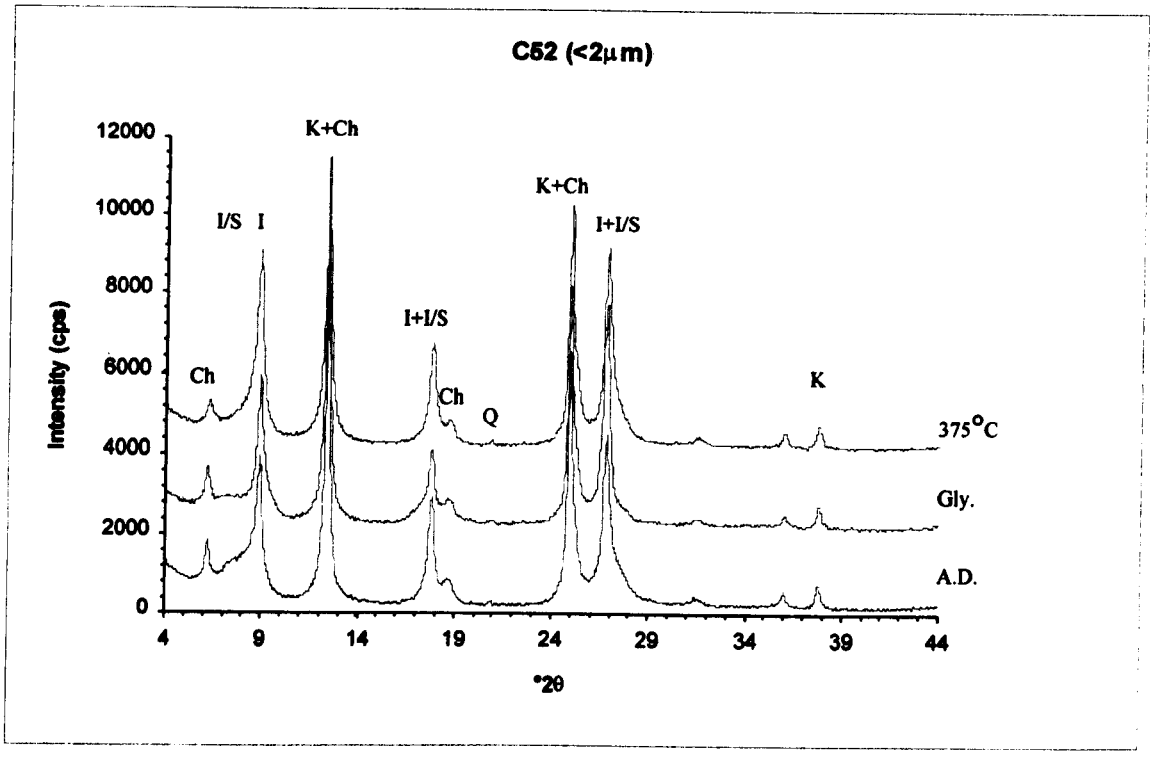


Figure 5.63a . Sample C.5.2.

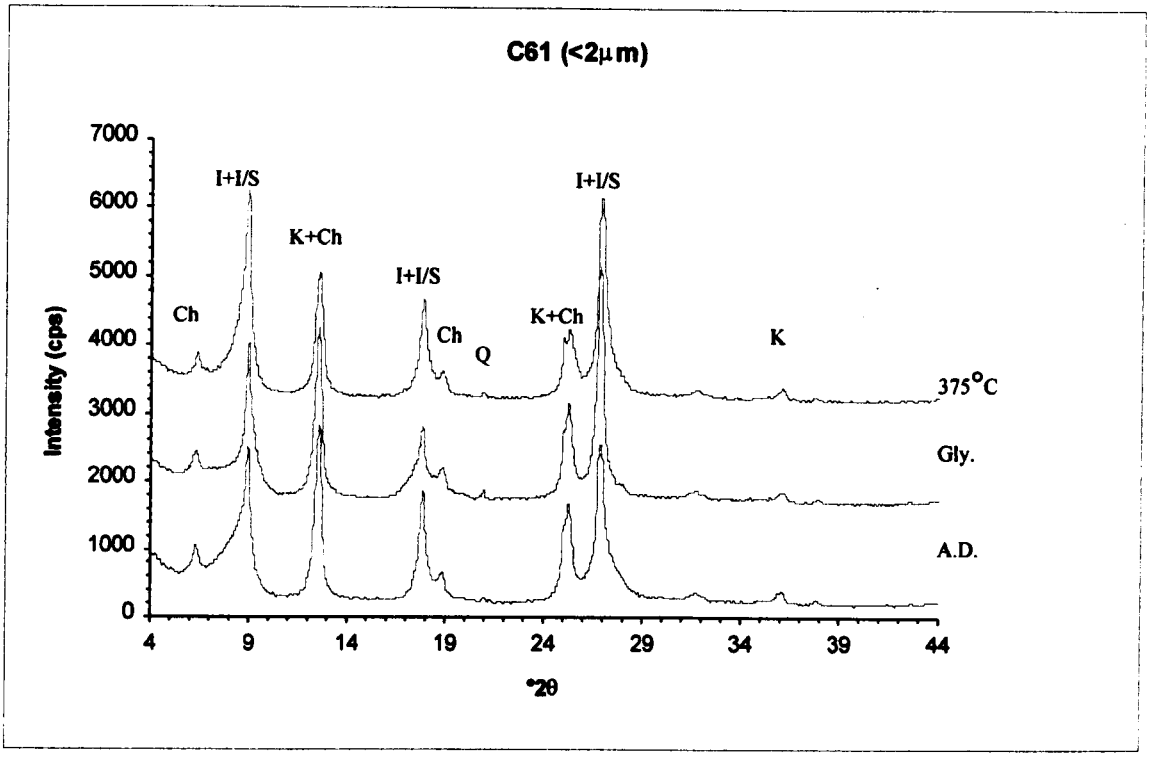


Figure 5.64a . Sample C.6.1.

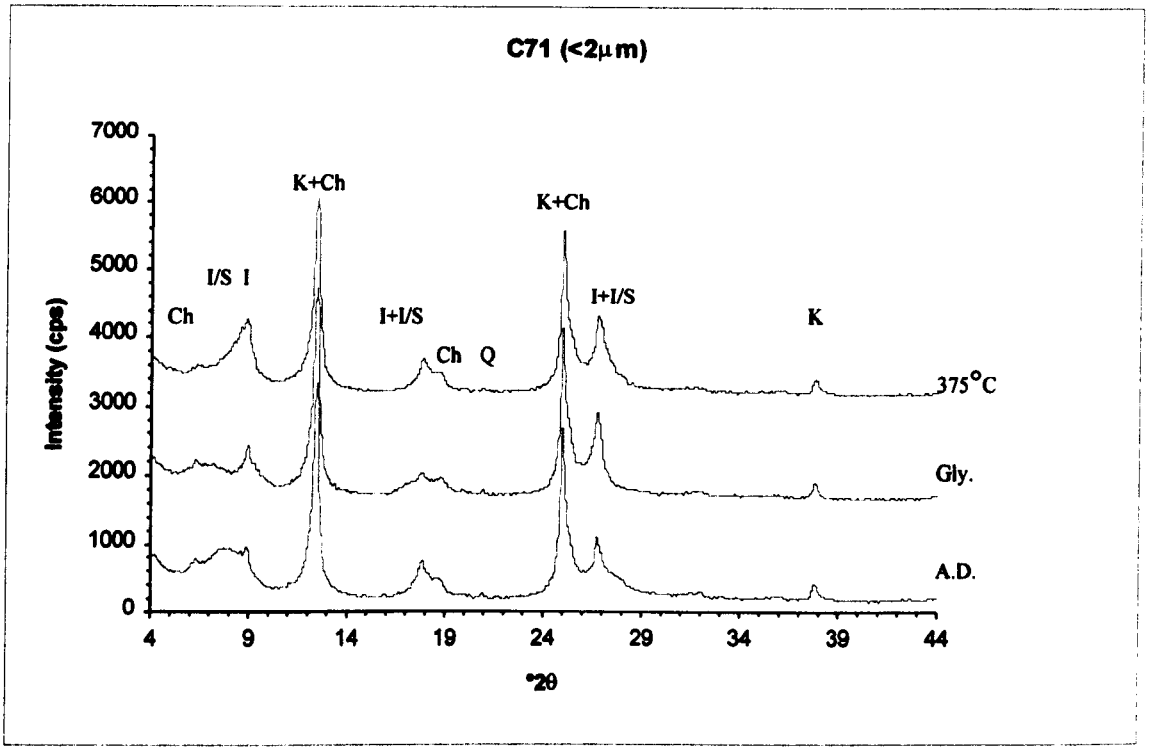


Figure 5.64a . Sample C.7.1.

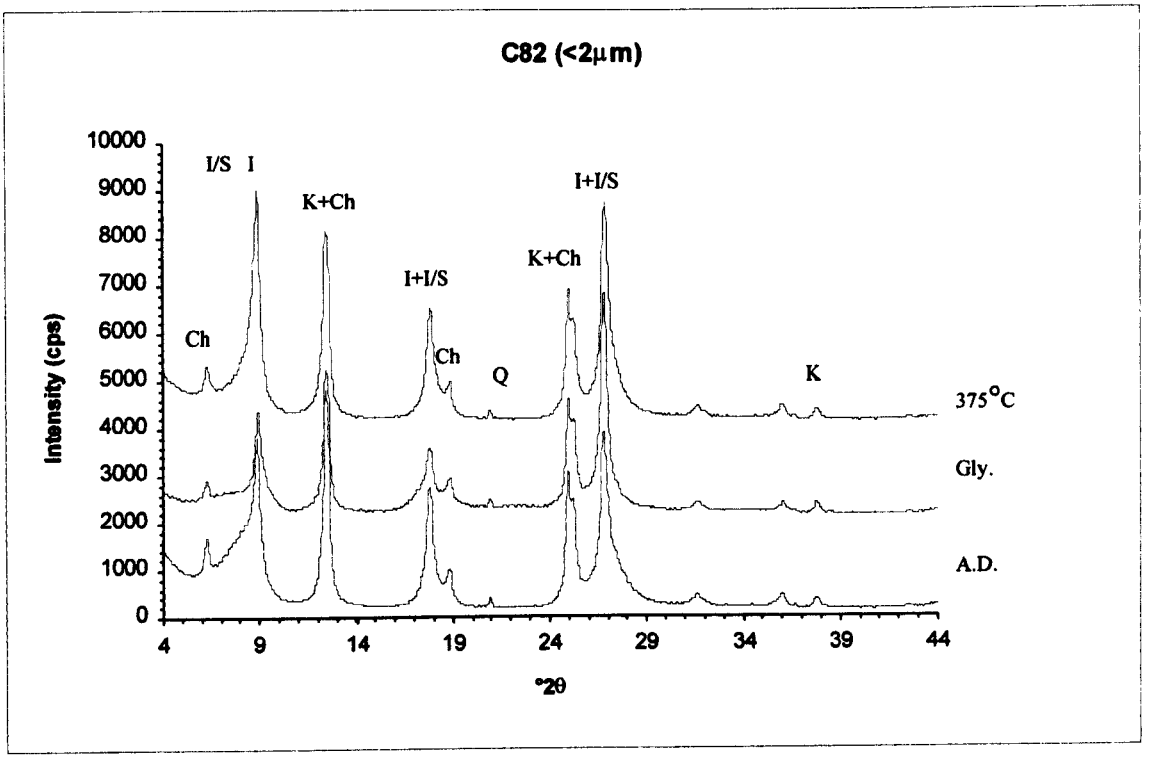


Figure 5.65a . Sample C.8.2.

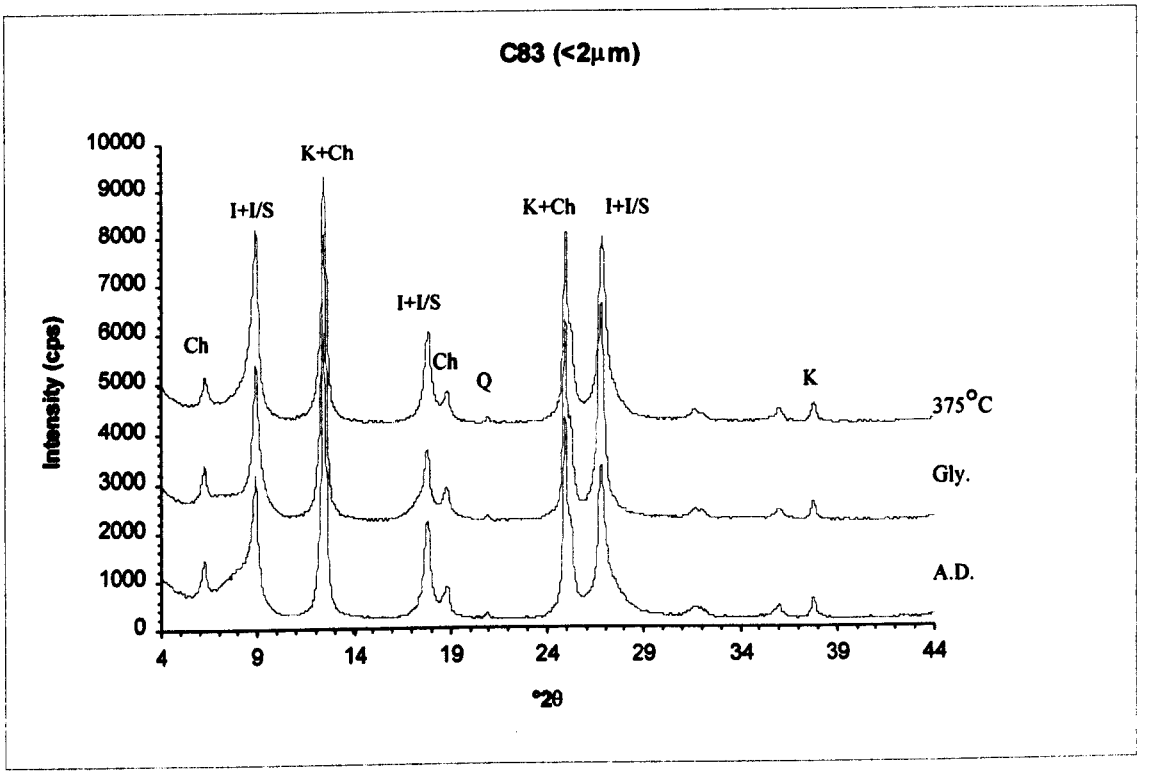


Figure 5.66a . Sample C.8.3.

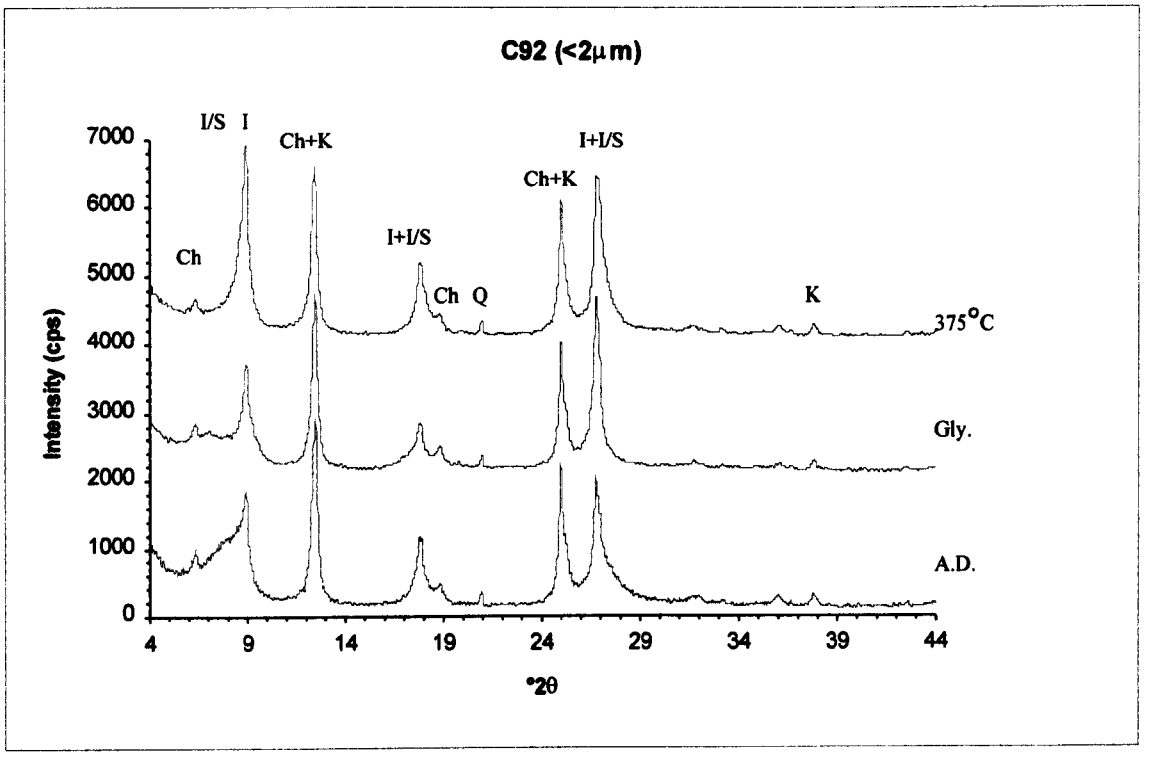


Figure 5.67a . Sample C.9.2.

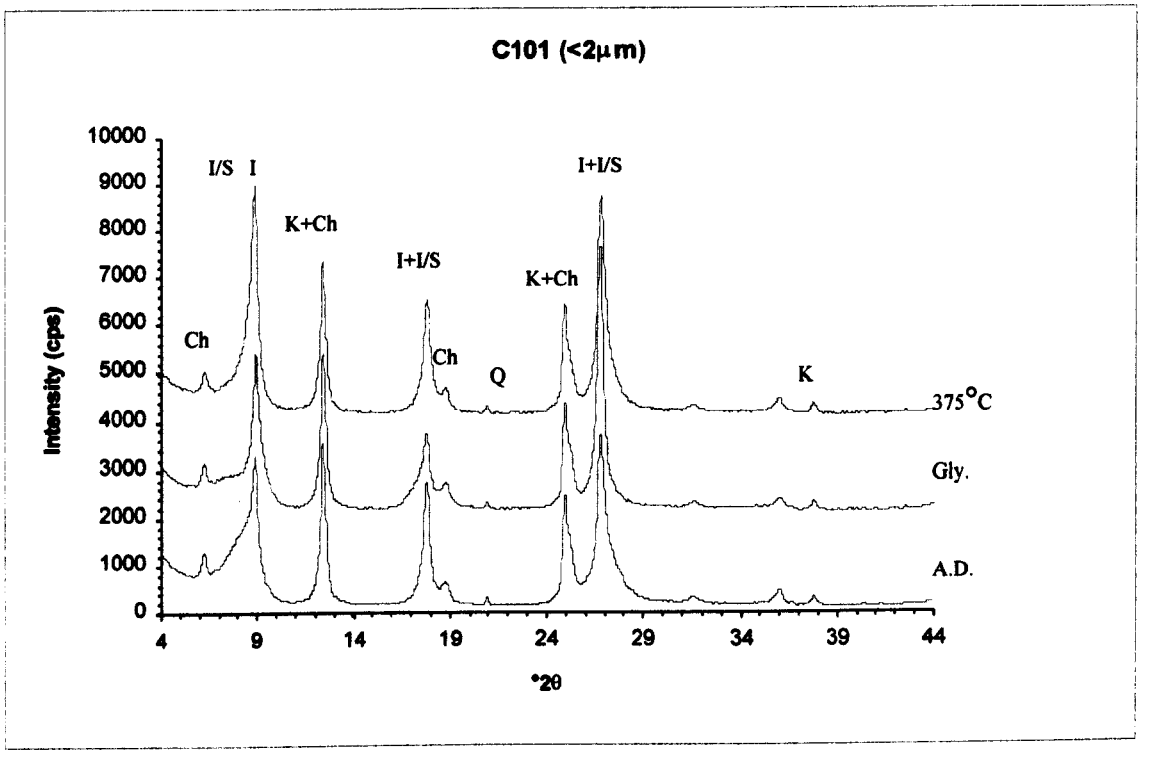


Figure 5.68a . Sample C.10.1.

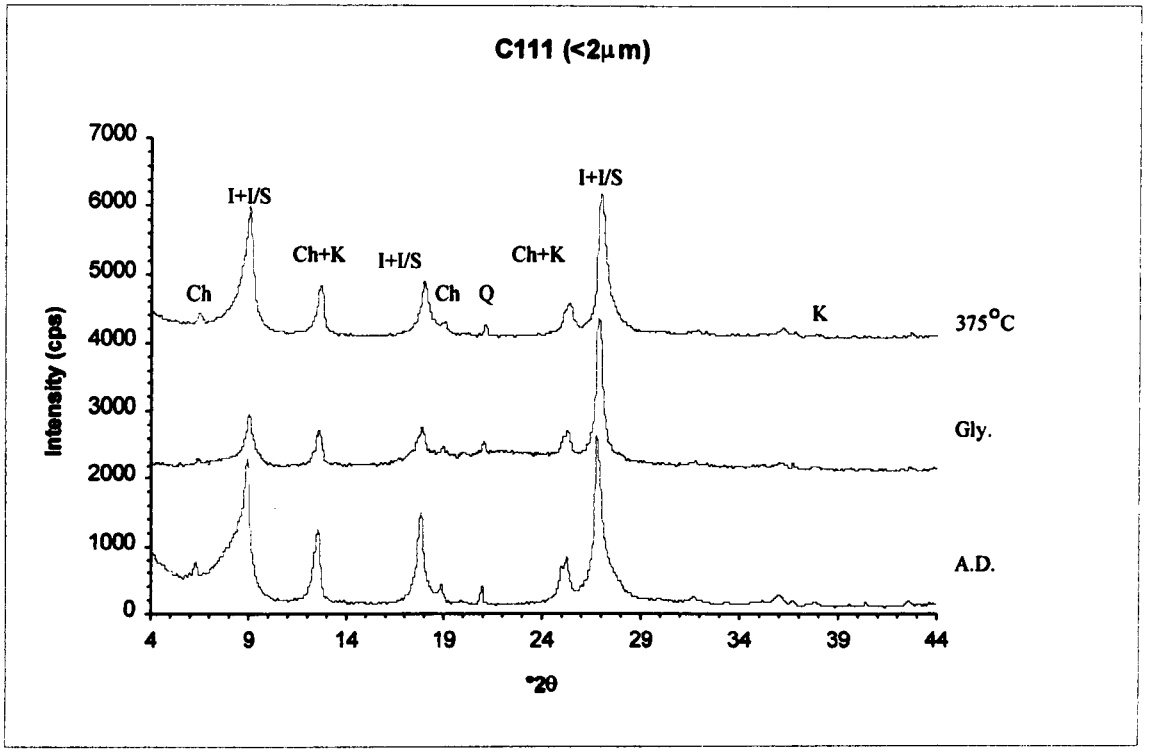


Figure 5.69a . Sample C.11.1.

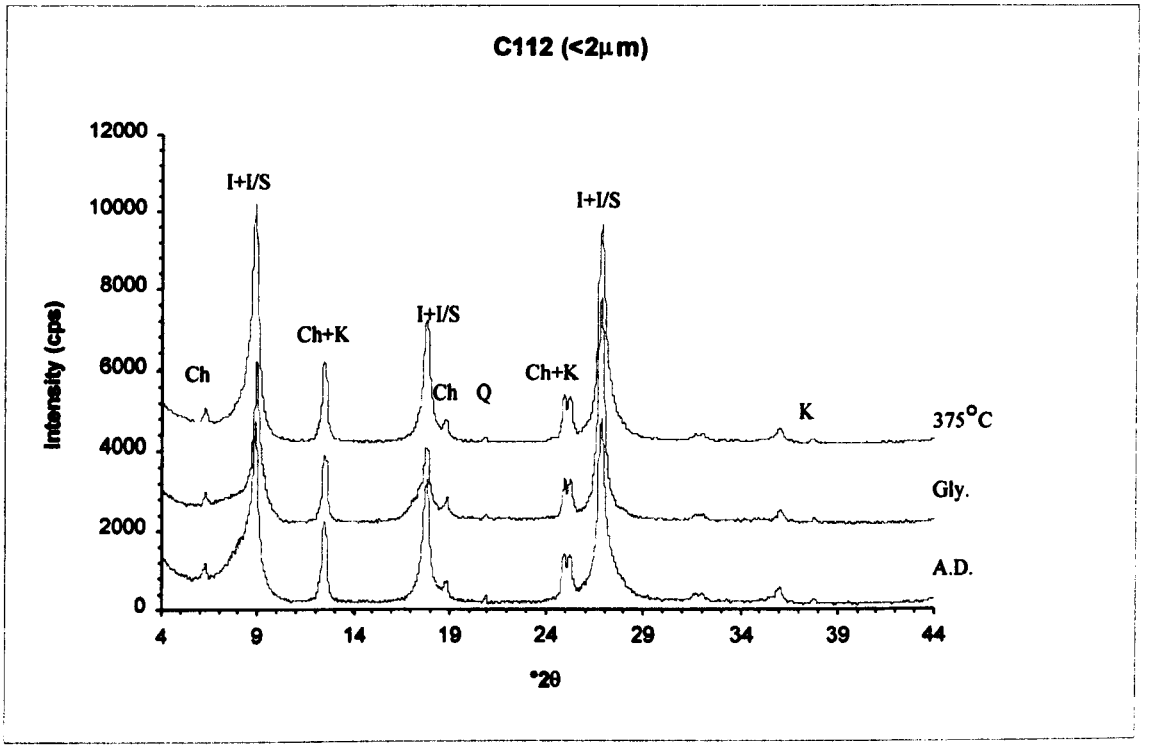


Figure 5.70a . Sample C.11.2.

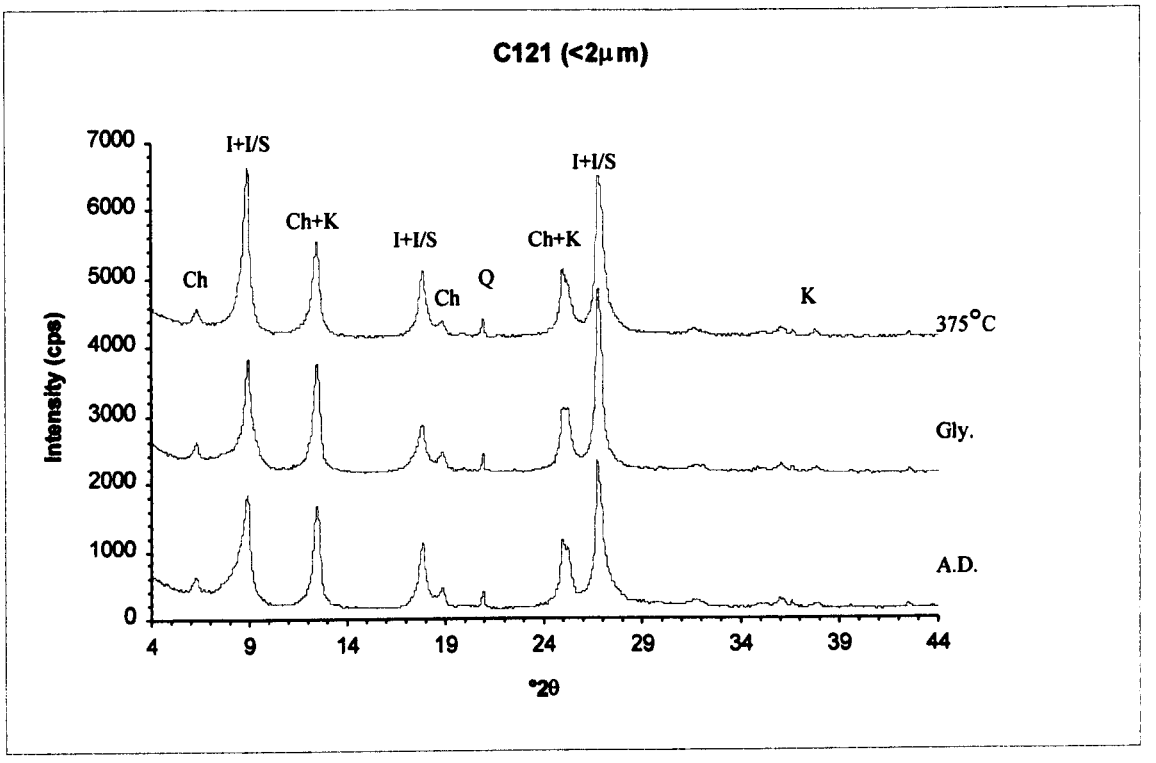


Figure 5.71a . Sample C.12.1.

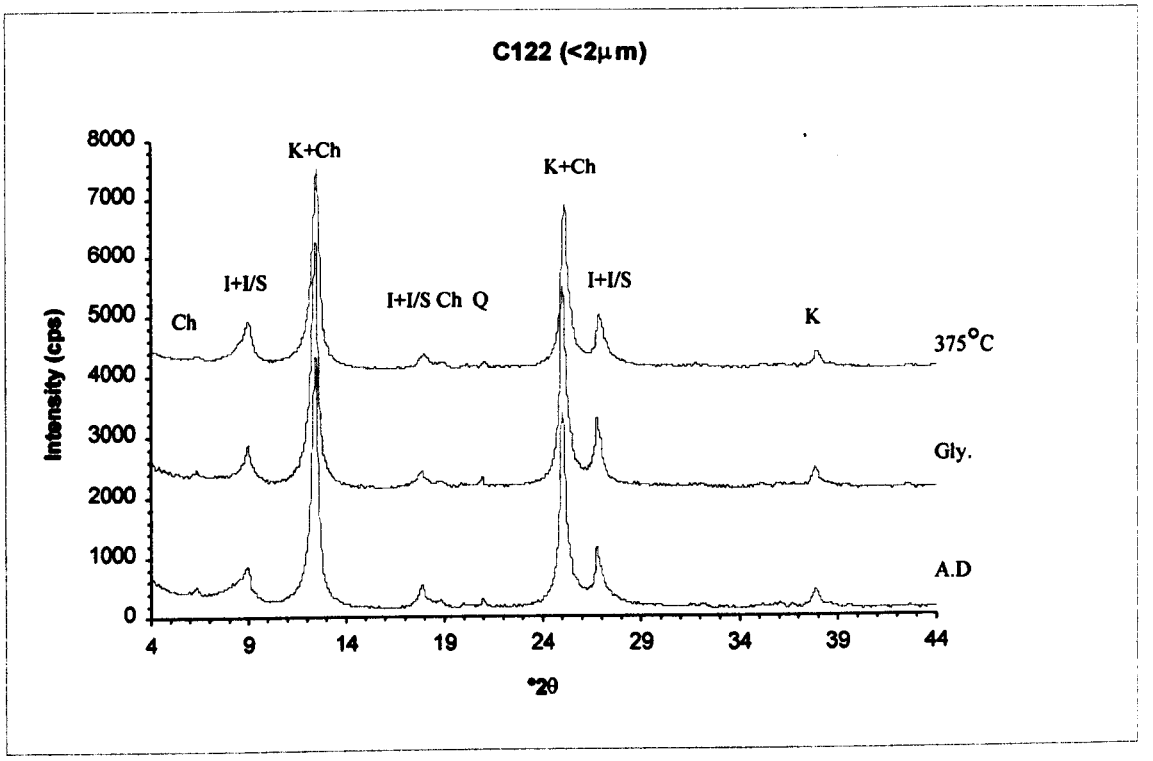


Figure 5.72a . Sample C.12.2.

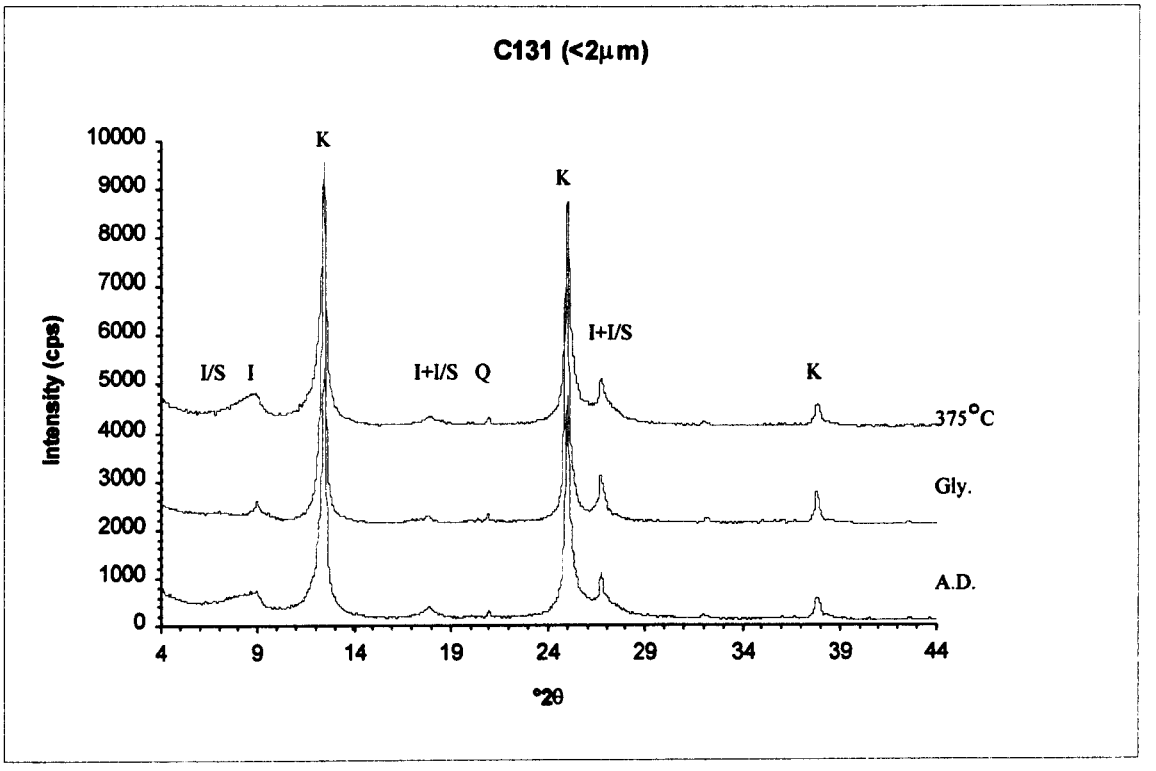


Figure 5.73a . Sample C.13.1.

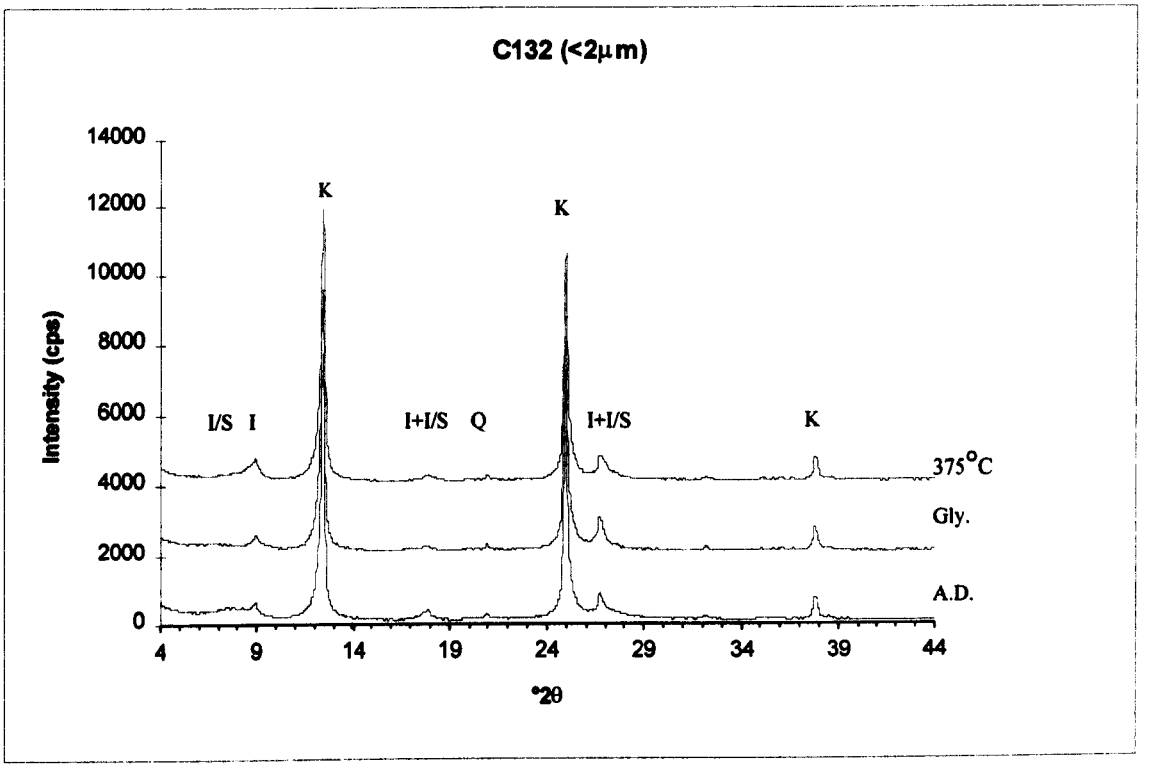


Figure 5.74a . Sample C.13.2.

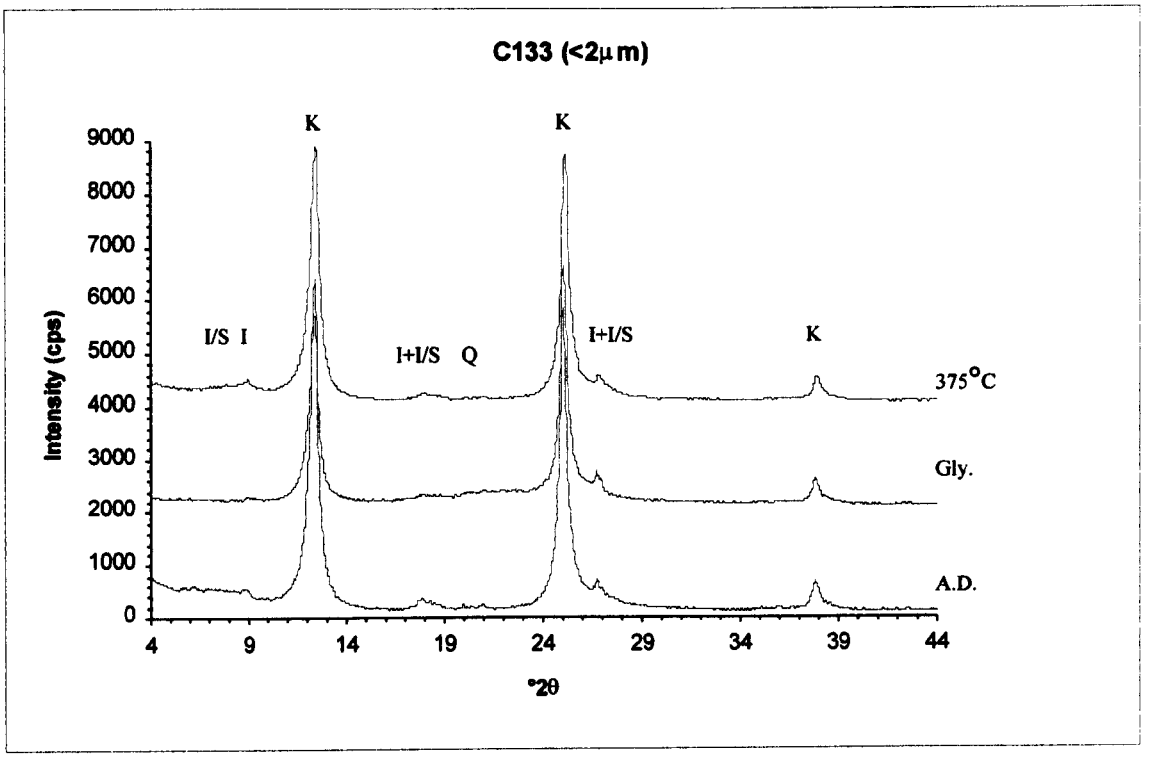


Figure 5.75a . Sample C.13.3.

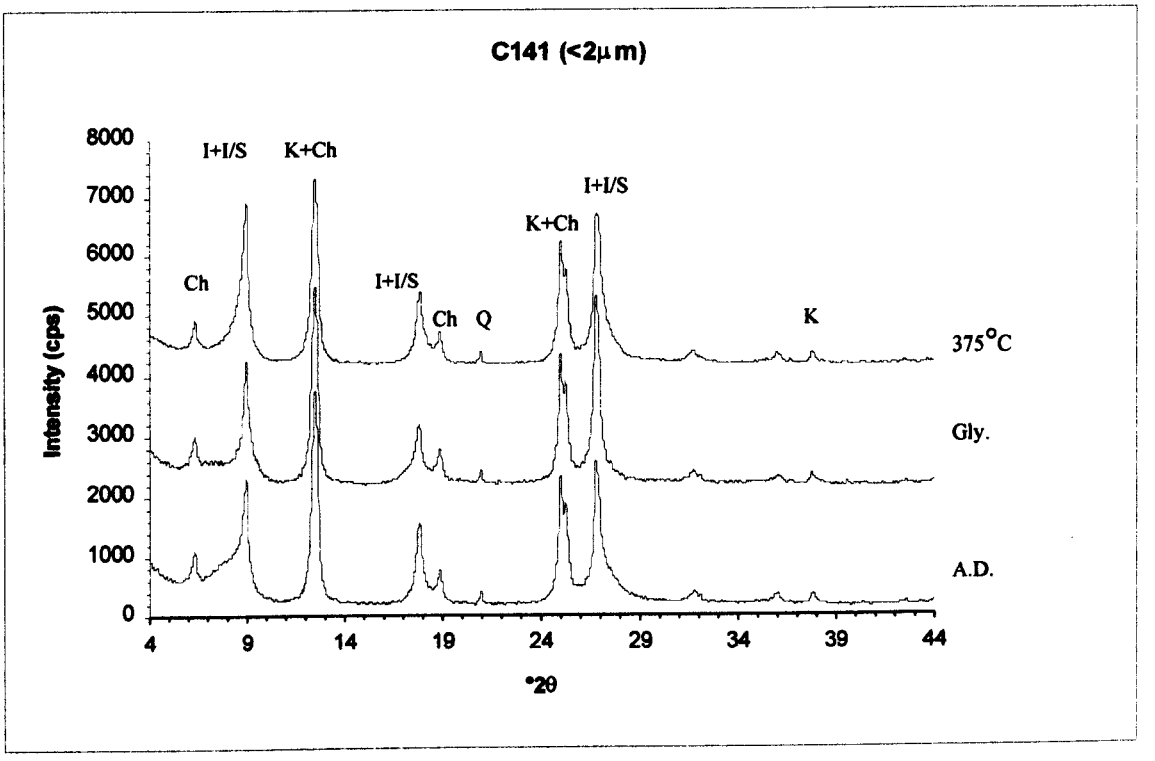


Figure 5.76a . Sample C.14.1.

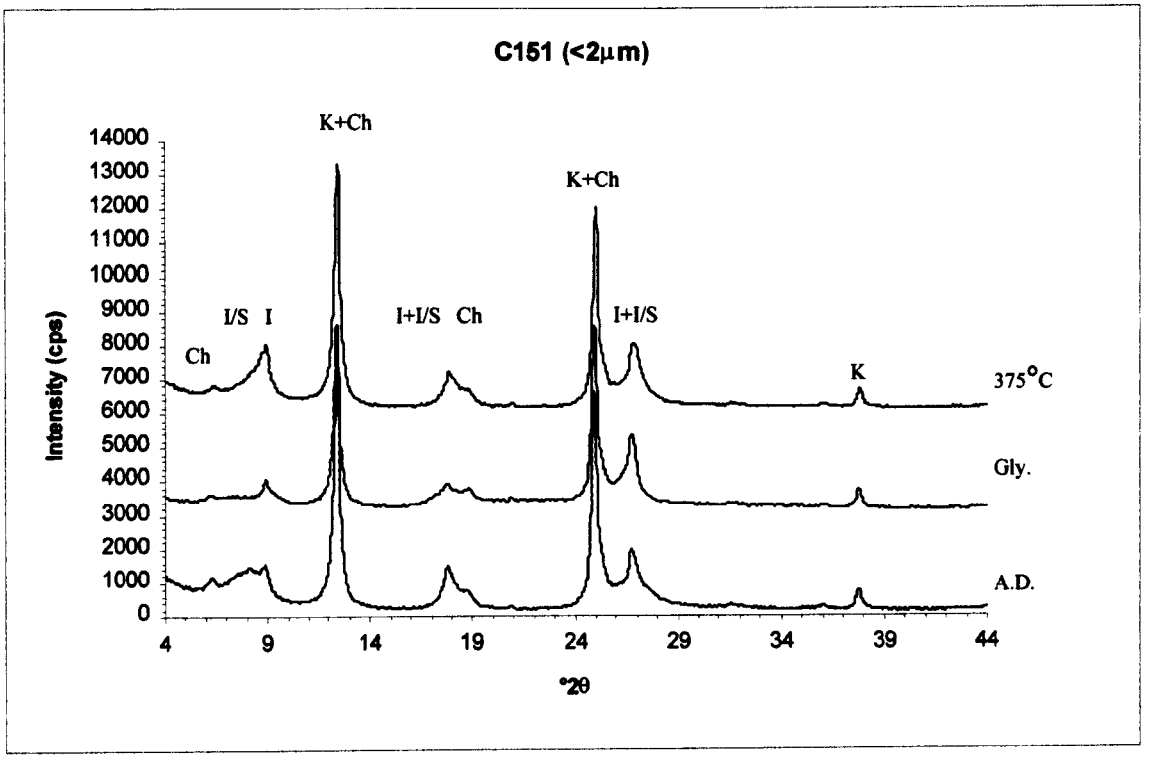


Figure 5.77a . Sample C.15.1.

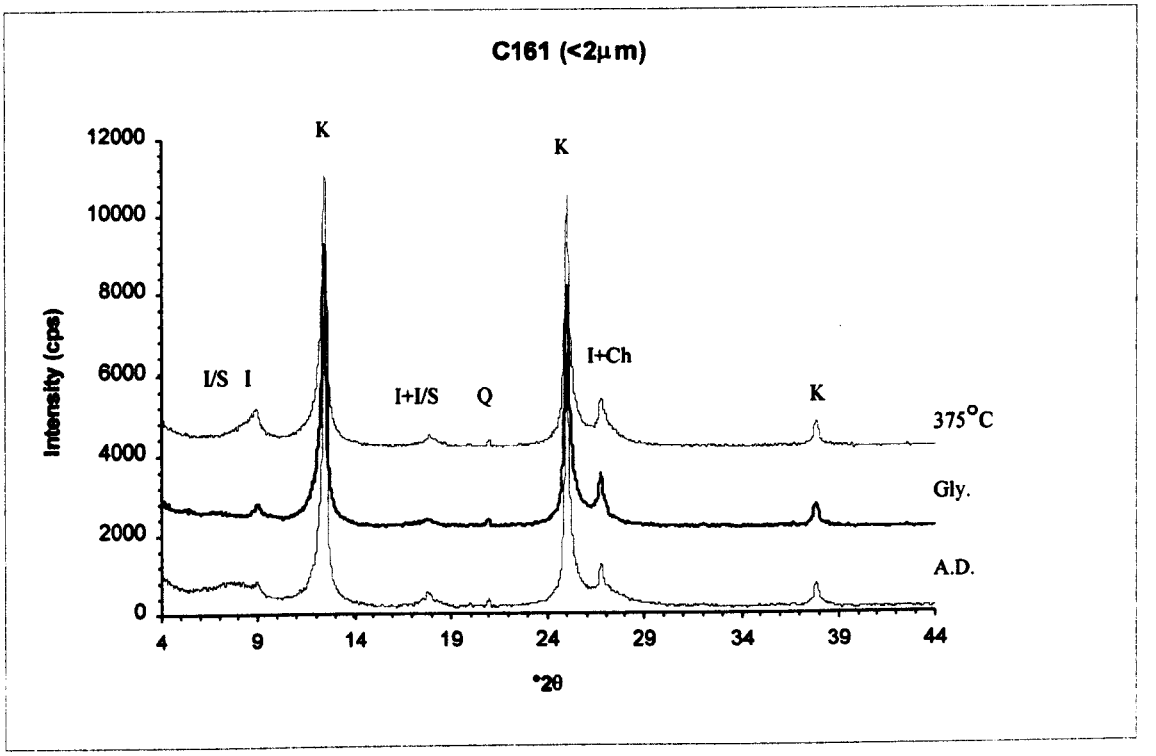


Figure 5.78a . Sample C.16.1.

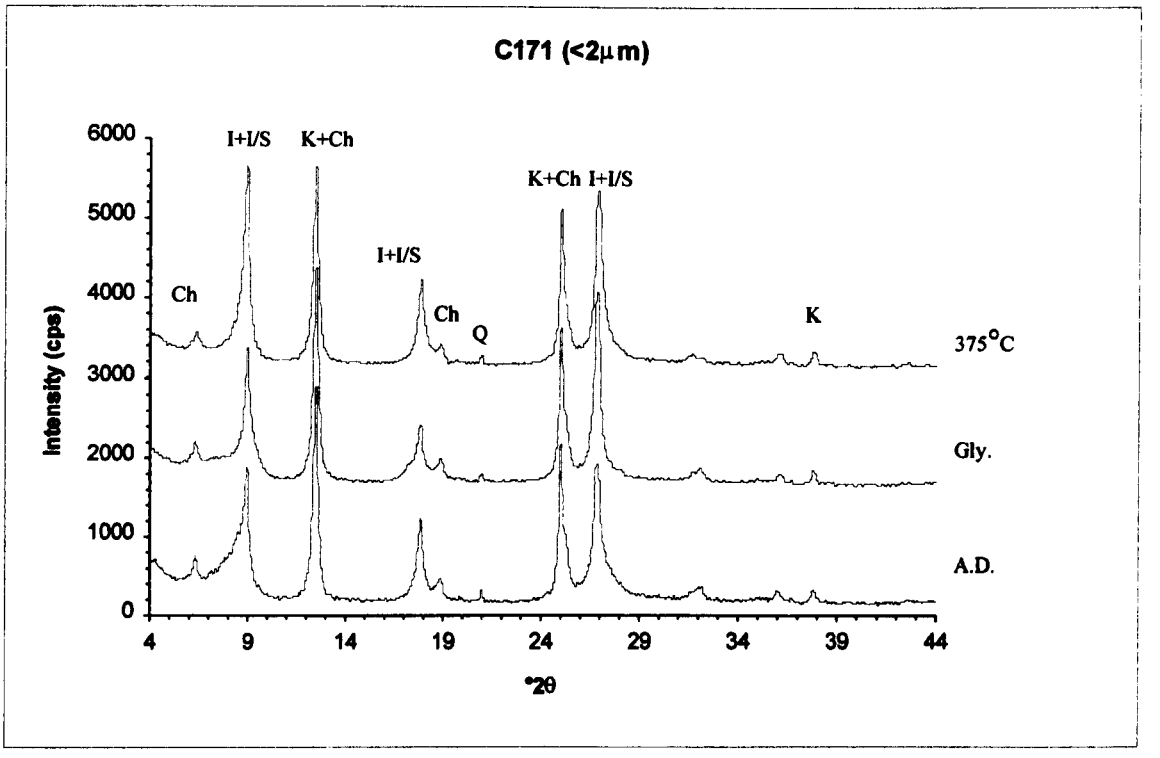


Figure 5.79a . Sample C.17.1.

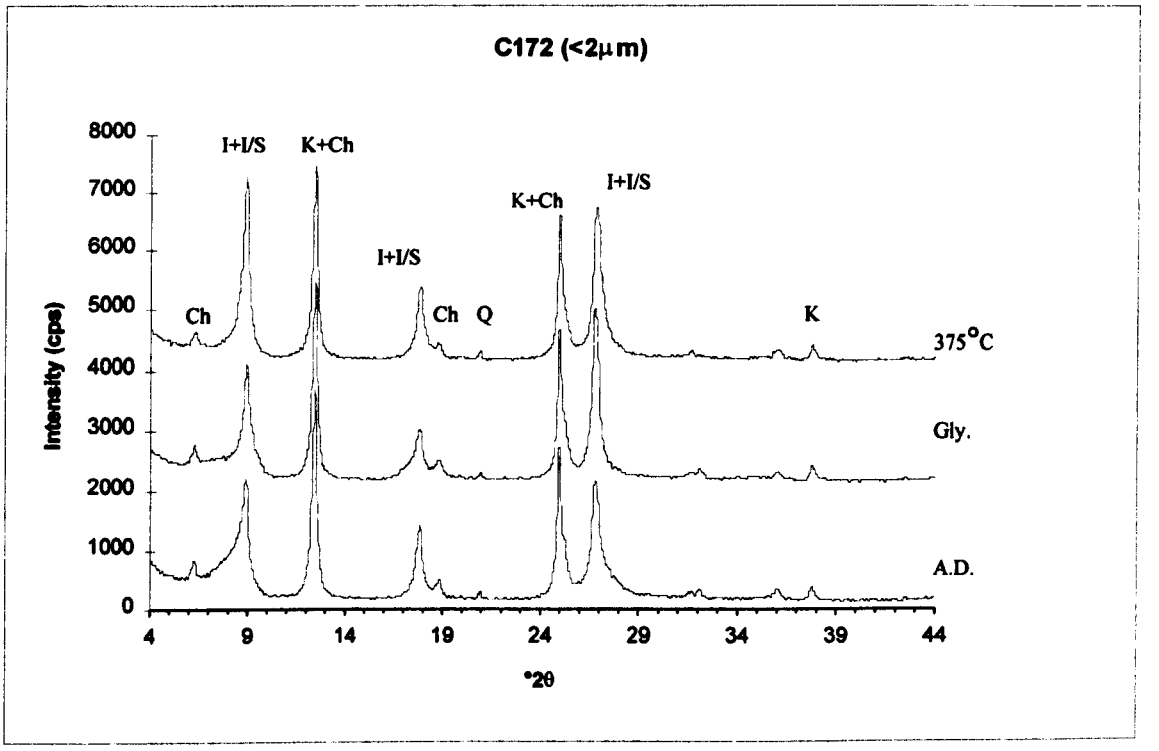


Figure 5.80a . Sample C.17.2.

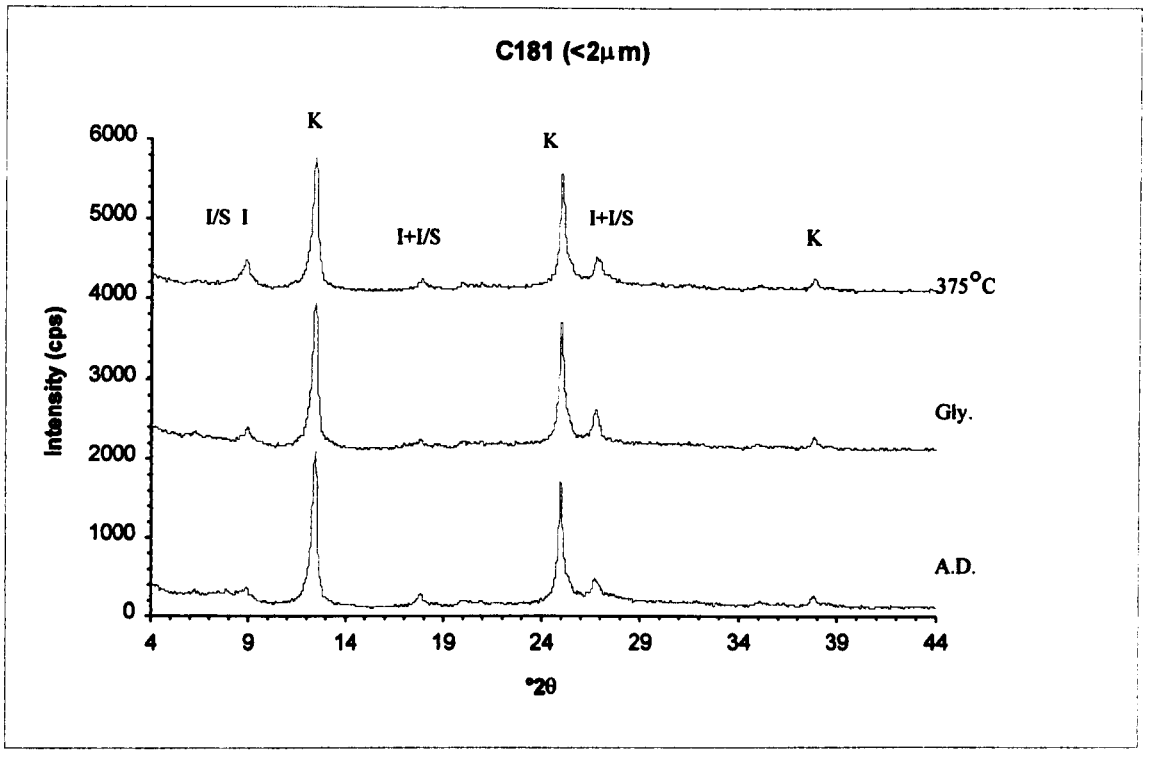


Figure 5.81a . Sample C.18.1.

APPENDIX A4: RAW DATA FOR SEMIQUANTITATIVE CLAY DETERMINATIONS.

Sample	Qtz	(I+I/S)-Q	Chlorite	Kaolinite	Paragonite	Smectite	Gly: Ill	Htd:Ill
Ca11	19.125	413.94	37.83	-----	280	-----		
Ca12	19.25	391	33.93	-----	228	-----		
Ca13	29.75	329.12	62.5	-----	187.69	-----		
O11	12.9	121.1	34.82	-----	-----	-----	76	143.75
O12	43	285.94	70.31	-----	-----	-----	51.5	93.25
O21	13.125	322.12	37.5	-----	112	-----		
O31	35.475	346.09	36.61	-----	-----	-----		
S11	40.312	699.94	46.87	-----	-----	-----	66.5	97.5
S31	30.637	546.86	62.5	-----	-----	-----		
S32	21.5	280.37	47.77	-----	-----	-----		
D11	11.825	382.55	-----	57.14	-----	2.53		
D12	45.15	385.91	9.37	-----	-----	37.1		
D21	25.53	441.72	93.75	-----	-----	-----		
C1B1	54.556	616.44	22.77	67.86	-----	-----	310.25	365.75
C1B2	146.737	376.51	26.78	100	-----	-----	101.75	122
C1B4	69.606	460.64	19.2	89.29	-----	-----	176.5	216.75
C1B5	56.437	641.81	5.36	166.7	-----	-----	151.75	205.25
C21	41.925	414.07	23.99	153.9	-----	-----	84	136
C31	56.437	451.94	-----	157.7	-----	-----	120.25	176.75
C41	161.787	538.84	10.71	91.1	-----	-----	156	265.75
C51	15.05	581.95	21.87	136.9	-----	-----	395.9	1260.8
C52	16.93	367.19	18.58	133.9	-----	-----	102.25	142.5
C61	33.86	541.14	20.7	57.14	-----	-----	148	213.5
C71	30.1	269.9	44.64	142.86	-----	-----	66	133.25
C82	16.12	243.31	22.1	47.62	-----	-----	174.75	375.5
C83	11.82	213.17	20.76	50	-----	-----	183.5	228.75
C92	129	1034.25	34.82	220.24	-----	-----	187.5	331.5
C101	51.6	1007.15	37.5	104.76	-----	-----	141.75	204
C111	64.5	131.06	18.30	42.86	-----	-----	110.75	254.5
C112	25.8	512.32	24.11	133.33	-----	-----	209.25	354
C121	93.52	435.85	38.84	104.8	-----	-----	239.5	323.5
C122	70.95	77.05	10.05	366.68	-----	-----	43.5	59
C131	38.7	61.3	-----	327.38	-----	-----	17.75	32.5
C132	35.47	94.02	-----	252.38	-----	-----	17.75	30.5
C133	------	110	-----	283	-----	-----	40.75	96.25
C141	99.97	680.52	44.2	138.09	-----	-----	166.5	250.75
C151	19.35	127.65	19.64	190.48	-----	-----	33	89.75
C161	38.7	56.3	-----	242.86	-----	-----	16	36.25
C171	38.7	430.3	36.16	130.95	-----	-----	217.75	281.25
C172	32.25	493.75	29.46	136.9	-----	-----	194	292.75
C181	55.9	98.16	22.3	163.69	-----	-----	23	36.25

APPENDIX A5. QUANTITATIVE DETERMINATION OF FREE QUARTZ BY SODIUM PYROSULPHATE FUSION.

Reagents

A- 40g NaOH - 1000cc. H_2O - 1N.

20g NaOH - 1000cc. H_2O - 0.5N.

B- [Conc. HCL - 10.5-12 N]

1N HCL - 90cc. conc. HCL - 1000cc. H_2O.

3N HCL - 270cc. conc. HCL - 1000cc. H_2O.

Method.

1. Weigh 200mg. sand/silt size fraction, dried at 105°C into a 50ml. vitreous silica crucible and 10-15g. of sodium or potassium pyrosulphate [$X_2S_2O_7$] powder, mix thoroughly using a glass rod.
2. Fuse the mixture under a fume hood using a low flame to start, until vigerous bubbling of melt ceases, then a full flame of the meker burner is applied. When a heavy Na_2SO_4 crust covers the surface at full heat the fusion is complete. Whilst cooling the crucible is swirled to spread the melt onto the crucible sides.
3. The solidified melt is transfered as a cake to a 150cc. beaker with 60cc. 3N. HCL. using a rubber tipped glass rod. The cake is slaked by gentle boiling and the resultant suspension is transferred to a 70cc. pointed centrifuge tube. Seperate the insoluble material by centrifugation and discard the supernatant liquid, wash a further 2 times with 3N. HCL. each time discarding the supernatant liquid.
4. Transfer the residue from the tube to a 500cc. nickel or stainless steel beaker with 0.5N. NaOH making a total volume of 100-150cc. Bring the suspension to a rapid boil then boil for 2.5min., then cool rapidly in a cold water bath.

5. Transfer the suspension to 2 x 70cc. pointed centrifuge tubes (transfer solid residue quantitatively). The residue is seperated and washed 3 times using 3N. HCL. (care to wash lip of tube) and once with distilled water.

6. Transfer residue to a polyethylene centrifuge tube, add 5-10cc. of 30% hydrofluosilicic acid (H_2SiF_6 treated with pure quartz to remove any HF) stir contents twice daily keep in a dark place between 15-20°C (to prevent HF formation) for 3 days.If sample has much feldspar repeat with fresh acid for further 3 days.

7. After acid treatment wash and centrifuge 3 times with 50cc. portions of distilled water and transfer to a pre-weighed platinum or teflon crucible. Obtain weight of crucible and residue after total evaporation of water overnight at 105°C - check residue by XRD or under microscope for purity.

Calculation:-

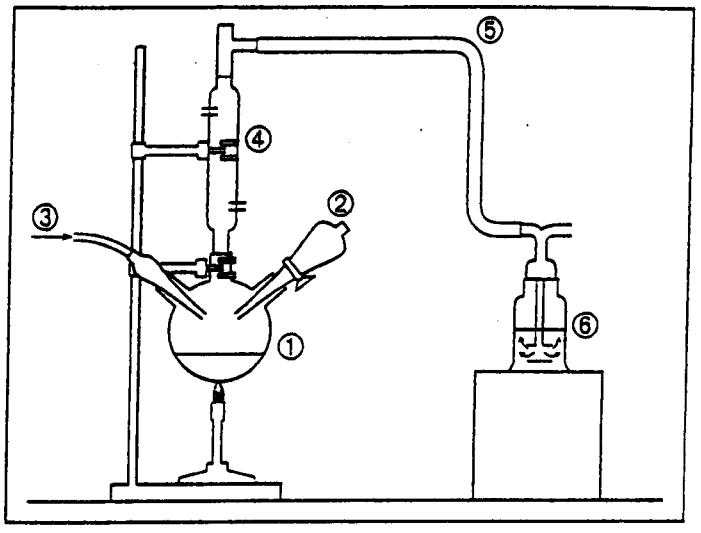
%Free quartz = [Wt.residue ÷ Wt.sample] × 100.

APPENDIX A6: RAW DATA FOR XRD QUARTZ DETERMINATION.

Sample	%B	Hr:Q/B	%Q	%B	Hr:Q/B	%Q	LOI%	Q1-corr	Q2-corr
Ca11	10.18	0.76	16.23	10.35	0.75	16.27	3.32	15.7	15.7
Ca12	9.48	0.992	20.06	10.15	0.91	19.63	2.85	19.5	19.1
Ca13	9.29	1.04	20.66	9.29	1.06	21.07	2.99	20.0	20.4
O11	10.4	0.528	11.17	10.4	0.44	9.11	6.99	10.4	8.5
O12	12.28	0.361	8.58	12.28	0.324	7.56	7.92	7.9	7.0
O21	10.25	1.08	23.71	10.25	1.102	24.22	4.62	22.6	23.1
O31	10.06	0.897	19.14	11.07	0.808	18.85	4.44	18.3	18.0
S11	10.54	0.872	19.46	10.54	0.897	20.05	4.0	18.7	19.2
S31	9.97	0.966	20.51	9.97	0.887	18.74	4.22	19.6	18.0
S32	9.64	1.263	26.26	9.64	1.333	27.78	4.48	25.1	26.5
D11	9.88	0.874	18.29	9.88	0.956	20.10	8.51	16.7	18.4
D12	10.99	0.53	11.85	10.99	0.58	13.08	11.66	10.5	11.6
D21	11.81	0.412	9.6	11.81	0.479	11.38	4.18	9.2	10.9
C1B1	10.07	0.25	4.52	10.07	0.23	4.07	26.64	3.3	3.0
C1B2	8.94	0.69	12.85	8.938	0.73	13.65	5.86	12.1	12.9
C1B4	9.21	1.09	21.51	9.21	1.053	20.75	6.18	20.2	19.5
C1B5	9.92	1.195	25.51	9.92	1.218	26.02	5.63	24.1	24.6
C21	10.03	0.907	19.31	10.03	1.05	22.53	16.0	16.2	18.9
C31	10.45	1.69	38.49	10.45	1.74	39.67	11.24	34.2	35.2
C41	8.98	0.396	6.98	8.98	0.365	6.35	20.08	5.6	5.1
C51	10.44	0.744	16.27	10.44	0.867	19.16	7.55	15.0	17.7
C52	11.135	1.3	31.26	11.135	1.36	32.76	4.95	29.7	31.1
C61	10.4	0.558	11.87	10.4	0.551	11.70	5.60	11.2	11.0
C71	11.64	0.68	16.47	11.64	0.69	16.73	9.96	14.8	15.1
C82	10.11	0.395	7.83	10.11	0.436	8.77	11.38	6.9	7.8
C83	9.96	1.129	24.14	9.96	1.26	27.07	5.77	22.7	25.5
C92	9.93	0.35	6.69	9.93	0.317	5.96	56.45	2.9	2.6
C101	10.31	0.957	21.00	10.31	1.03	22.69	5.12	19.9	21.5
C111	10.03	0.346	6.67	10.03	0.303	5.7	13.08	5.8	5.0
C112	9.97	1.15	24.63	9.97	1.20	25.75	7.03	22.9	23.9
C121	13.8	0.316	8.25	13.8	0.27	6.82	9.56	7.5	6.2
C122	11.10	0.417	9.15	11.10	0.462	10.27	16.36	7.7	8.6
C131	12.11	0.226	4.79	12.10	0.239	5.14	21.54	3.8	4.0
C132	10.65	1.094	24.97	10.65	1.002	22.77	8.81	22.8	20.8
C133	10.93	0.52	11.54	10.93	0.523	11.61	11.19	10.2	10.3
C141	11.92	0.622	15.31	11.92	0.688	17.08	8.72	14.0	15.6
C151	10.035	0.81	17.13	13.035	0.766	20.96	8.53	15.7	19.2
C161	12.235	0.307	7.06	12.235	0.314	7.26	23.66	5.4	5.5
C171	11.22	1.574	38.41	11.221	1.423	34.60	7.04	35.7	32.2
C172	12.43	1.095	29.17	12.43	1.053	28.00	6.41	27.3	26.2
C181	10.51	0.80	17.70	10.51	0.85	18.88	9.2	16.1	17.1

APPENDIX A7. DETERMINATION OF PYRITE BY CHROMIUM REDUCTION.

Experimental Apparatus.



(1) Reaction flask : (2) Reagent inlet port and treservoir : (3) Argon inlet port : (4) Condenser : (5) Bev - O-Line tubing™. (6) Trapping vessel.

Reagents.

Chromic chloride hexahydrate.

Conc. HCL.

Ethanol (95%).

2% Copper sulphate solution.

Argon gas.

For the Jones reductor:-

Granulated zinc (20-30 mesh).

Mercuric nitrate.

Method.

1. Prepare the Jones reductor (see Vogel,1978 p.395) by packing the zinc which has been amalgamated (usingan acidic 2% mercuric nitrate solution) into a glass column.
2. Draw the 1 M chromic chloride solution (which has been acidified to 0.5 N with HCl) under vaccum through the Jones reductor. On reduction the green chromic(III) solution changes valence state to blue chromic (II). Due to atmospheric oxidation this solution is unstable and should be prepared every two days. Store the prepared solution in a glass vessel out of direct light.
3. Weigh out 1 g of the powdered sample into the digestion flask, add 10 ml of ethanol, connect to the condenser and flush with argon for a few minutes. To the trapping vessel add 75 mL of 2% $CuSO_4$ solution, in addition retain a 10 mL fraction as a stock solution for analysis.
4. Through the side arm add 40 mL of the $CrCl_2$ solution and 20 mL of concentrated HCl apply a bunsen flame and boil the mixture for two hours.
5. When the digestion has been completed, filter the contents of the trapping vessel, thus removing any CuS precipitate from the solution and retain 25 mL of the reacted copper sulphate solution for ICP-AES analysis.

Calculation example.

Reaction- $FeS_2 + 2H_2 = 2H_2S + 2CuSO_4 = 2CuS + 2H_2SO_4$.

Therefore by atomic weights:- CuS = S/Cu =0.504.

$$FeS_2 = FeS_2/S_2 = 1.871.$$

$\therefore$ Blank $CuSO_4$ solution by ICP-AES = 9640 ppm Cu.

$\therefore$ Test $CuSO_4$ solution by ICP-AES = 8750 ppm Cu.

Convert concentrations of the solutions used into concentration of copper in test quantity ie. 75 mL and convert ppm (concentration) into mg (weight) where 0.001 mg/g = 1 ppm.

$\therefore$ In the 75 mL stock solution = (9640 × 75)/1000 = 723 mg Cu.

In the 75 mL test solution = (8750 × 75)/1000 = 656.25 mg Cu.

Therefore the reaction uses up (723 - 656.25) = 66.75 mg of Cu.

S used = Cu(66.75 mg) × 0.504 = 33.68 mg.

FeS_2 detected = S(33.68) × 1.871 = 63 mg.

Therefore in 612.5 mg of test sample there is 63 mg of FeS_2 (pyrite)

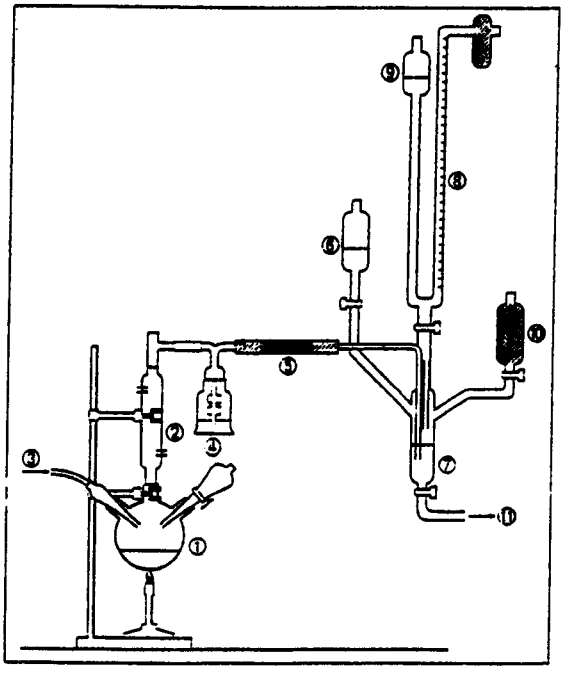
$\therefore$(63 × 100)/612.5 = 10.3% pyrite.

Notes.

1. It is advisable to split the gas supply line into two or four outlets so that multiple digestions may be run at the same time.
2. Make sure the reaction digestion vessel is washed out as soon as it is cooled enough to be handled as the contents solidify.
3. Only use H_2S- resistant line (ie. Bev-A-Line IV®) as the connection to the absorption cell as other rubber lines will react giving off sulphur gas.
4. Care must be taken with the ICP analysis, the equipment must be carefully calibrated against a standard and checks run to make sure there are no instrument fluctuations which may result in errors.
5. If ICP or AA are not available the absorbant solution may be titrated with 0.1 M EDTA (see Vogel 1978).

APPENDIX A8. DETERMINATION OF NON ORGANIC CARBON (CO_2) AND ORGANIC CARBON (C_{org}) IN MUDROCKS.

Experimental apparatus.



(1) Reaction flask : (2) Condenser : (3) Argon inlet : (4) Arnold bubbler : (5) Glass bead water trap : (6) Absorbant solution reservoir : (7) Reaction cell : (8) Micro burette : (9) Titrant solution reservoir : (10) Gas outlet port.

Reagents.

Concentrated orthophosphoric acid.(H_3PO_4)

Chromic acid (analar).

Silica gel (self-indicating).

Soda asbestos 6-12 mesh.

Absorbant solution:- 300mls of dimethyl formamide mixed with 10 mls of ethanolamine and 3mls of thymolphthalain indicator solution (0.1% in dried methanol).

Titrant:- 0.1 N Tetra-n-Butyl Ammonium hydroxide.

Method.

1. Weigh out the appropriate amount of sample (<0.5g depending on carbon content), place the sample into a clean dry distillation flask. Stop the carrier gas flow and attach the distillation flask to the condenser, restart the gas flow, then blank for 5 minutes. Titrate the absorbent with the titrant to the first permanent blue colour. (R1)
2. Stop the gas flow, add 25mls of concentrated H_3PO_4 through the gas entry port. Restart the gas flow at a steady rate and commence to boil with a 2.5cm high bunsen flame. Boil for 15 minutes then titrate back to a blue end point which is permanent. (R2)
3. Let the flask cool for a few minutes then add 5 grams of chromic acid through the gas entry port. Continue to heat for a further 30 minutes then titrate back to the blue end point. (R3)
4. Stop the gas, wash and dry the distillation flask as soon as it is cool enough to handle as the contents solidify on cooling.

Calculations.

$\%CO_2 = [R_2\text{-}R_1(\text{mls}) \times 4.4] / [\text{Wt. of sample(gms)} \times 10]$

$\%C_{org} = [R_3\text{-}R_2(\text{mls}) \times 1.2] / [\text{Wt. of sample(gms)} \times 10]$

Notes.

1. Do not get any traces of moisture into the absorbent cell.
2. Before proceeding with the determinations blank until stable, and run a known CO_2 standard.

3. Ensure that the silica trap is blue; the soda asbestos is brown; the chromic acid is red; the absorbent is clear.
4. Be careful of the burette tap. It is stiff because it must be greaseless.
5. If more than about 10mls of titrant are used the results become less accurate therefore repeat on a smaller sample weight.

APPENDIX A9: RAW DATA FOR CARBONATES AND ORGANIC CARBON DETERMINATIONS.

		$\%CO_2$				$\%C_{org}$	
Sample	Run 1	Run 2	Ave %.	Carbonate Min. Ratios.	Run 1	Run2	Ave %.
Ca11	0.12	0.14	0.13	D	0.18	0.17	0.2
Ca12	0.37	0.35	0.36	D	0.1	0.1	0.1
Ca13	0.08	0.10	0.09	D	0.11	0.13	0.1
O11	1.19	1.23	1.21	C	0.18	0.17	0.2
O12	0.96	1.01	0.985	C	0.37	0.32	0.3
O21	0.07	0.06	0.065	C	0.49	0.50	0.5
O31	0.11	0.27	0.19	S:C=1.7 : 1	0.35	0.41	0.4
S11	0.55	0.58	0.565	C	0.3	0.28	0.3
S31	1.25	0.70	0.975	D	0.48	0.67	0.6
S32	0.47	0.49	0.48	C	0.67	0.79	0.7
D11	5.21	4.73	4.97	S:D=5.5 : 1	0.21	0.79	0.5
D12	7.2	8.7	7.95	D:C=4.6 : 1	0.19	0.17	0.2
D21	0	0	0	----------	0.17	0.2	0.2
C1B1	4.8	5.28	5.04	C	14.94	15.17	15.0
C1B2	1.28	2.49	1.885	C	0.45	0.87	0.7
C1B4	1.77	1.96	1.865	C	0.71	0.73	0.7
C1B5	0	0	0	----------	0.75	0.79	0.8
C21	1.1	1.6	1.35	S:C=2.27 : 1	7.74	7.25	7.5
C31	9.58	9.15	9.365	S	1.28	1.23	1.2
C41	13.85	14.54	14.195	D	3.19	2.22	2.7
C51	2.32	2.95	2.635	S:C=1.26 : 1	0.40	0.43	0.4
C52	0.11	0.13	0.12	C:S=1.9 : 1	0.39	0.28	0.3
C61	1.0	1.0	1.0	S:C=1.82 : 1	0.86	0.87	0.9
C71	1.34	1.28	1.31	S:C=3.2 : 1	2.35	3.6	3.0
C82	5.77	5.78	5.775	S	1.02	1.38	1.2
C83	2.05	1.99	2.02	S:C=3.33 : 1	1.70	2.75	2.2
C92	5.65	7.72	6.685	S	41.96	40.98	41.5
C101	0	0	0	----------	0.67	0.58	0.6
C111	1.1	0.76	0.93	C:S=1.04 : 1	6.0	5.79	6.0
C112	4.31	3.4	3.855	S	0.92	0.66	0.8
C121	4.41	4.21	4.31	S:C=4.35 : 1	1.60	1.27	1.4
C122	1.44	1.39	1.415	S:C=2.1 : 1	6.2	6.09	6.1
C131	1.04	2.49	1.765	S	9.91	9.71	9.8
C132	1.51	3.04	2.275	S	1.14	1.15	1.1
C133	0	0	0	----------	2.56	1.39	2.0
C141	1.92	2.06	1.99	S:C=4.21 : 1	2.05	2.10	2.1
C151	1.61	1.88	1.745	S:C=4.43 : 1	1.01	0.81	0.9
C161	14.11	14.28	14.195	S	6.5	6.3	6.4
C171	3.6	3.72	3.66	S:C=3.6 : 1	1.04	1.05	1.0
C172	2.36	2.42	2.39	S:C=2.21 : 1	0.83	0.80	0.8
C181	1.46	1.38	1.42	S:C=1.87 : 1	1.2	1.12	1.2

C= Calcite ; D= Dolomite ; S= Siderite.

APPENDIX A10. THE METHYLENE BLUE ADSORPTION TEST.

Method.

1. Prepare the methylene blue solution:- oven dry the methylene blue crystals ($C_{16}H_{10}N_3SCl$) for several hours at 105°C to expel water as methylene blue is hygroscopic. Prepare a 0.0094 N solution ie. 3.0 g crystals in 250 mL distilled water, then dilute to 1 L. (Molecular Wt. of dry methylene blue is 319.9 g/mol.).
2. Prepare the rock by drying, crushing in a TEMA mill and sieving (<75μm) a representative sample. If the sample has a high organic content then pretreat by low temperature thermal oxidation. This involves heating the sample to 380°C for a minimum of 16 hours, or overnight (Keeling, 1962). Make a suspension of the rock powder by accurately weighing out ~2.0 g of the aggregate and diluting in 50 mL of distilled water. Place the suspension in a water bath for 30 min.
3. Add 2 mL of methylene blue solution to the aggregate slurry from a 50 mL burette, shake the solution using a magnetic stirrer for 2 min. After the first 2 mL titration place a drop of the slurry using a glass rod onto the edge of a piece of filter paper (Whatmans No. 40) if a sharp boundary between the spot and the water halo is evident then continue adding the titrant and allow at least 2 min of stirring. When after placing a drop of the slurry onto the filter paper a diffused halo around the coloured spot is evident then suspend the titration for 2-5 min continuing mixing, after this period place another drop of the slurry onto the filter paper if the halo is still diffused then the end point has been reached, if not then continue the titrations (<2 mL) until the end point is reached. Take a reading of the titrant volume used (Vcc).

Calculations

MBA is normally expressed in grams of methylene blue adsorbed by 100g of sample material, also given as g%. If a value is given in mL/g then a solution of 10g. of methylene blue in 1 L of water was used. MBA values expressed in (g/100g), (g%) or (ml/g) are numerically equivalent.

$$MBA=[(X(g) \div Y(mL) \times p(mL.\ MB)] \div (A\ (g \div 100g))\ [g\%].$$

Since the normality of the MB(methylene blue) solution is known, the net cation exchange capacity (CEC) can be calculated.

$$CEC=[(100 \times n \times p\ (mL.\ MB)] \div A\ (g)\ \ [mEq/100g].$$

X= Weight of dry methylene blue crystals used.

Y= Volume of dilute methylene blue solution used.

p= Volume of methylene blue solution added.

A= Weight of rock powder used.

n= Normality of the methylene blue solution.

APPENDIX B1. RESULTS FOR THE WATER ADSORPTION AND ABSORPTION TESTS.

Sample	Water AD1 %	Water AD2 %	Water AB1 %	Water AB2 %	Water AB3 %
Ca11	0.01	0.08	0.21	0.19	0.19
Ca12	0.00	0.09	0.05	0.07	0.17
Ca13	0.07	0.09	0.16	0.15	0.15
O11	1.95	2.13	5.27	5.42	5.34
O12	2.67	2.28	7.37	6.69	7.16
O21	0.55	0.09	1.12	1.03	1.04
O31	0.15	0.19	2.16	2.20	2.18
S11	2.06	2.04	3.89	3.90	3.97
S31	0.55	0.53	2.24	2.60	2.32
S32	0.13	0.11	1.12	0.63	0.91
D11	0.68	0.37	4.71	4.72	4.76
D12	1.24	1.20	3.68	3.69	3.68
D21	0.73	0.58	1.37	1.47	1.44
C1B1	1.13	1.19	2.52	2.72	2.66
C1B2	0.95	1.00	2.36	2.34	2.32
C1B4	0.81	0.79	1.49	1.50	1.51
C1B5	0.54	0.61	2.42	2.37	2.45
C21	1.84	1.12	6.54	11.13	9.26
C31	0.78	0.73	1.74	1.87	1.84
C41	1.14	1.13	7.22	6.60	6.52
C51	1.68	2.10	8.85	8.79	8.82
C52	0.60	0.63	4.11	4.63	4.37
C61	0.97	1.33	3.92	3.96	3.97
C71	1.42	1.21	6.28	5.20	5.67
C82	1.99	1.98	7.00	7.07	6.79
C83	0.77	0.75	3.54	3.56	3.56
C92	0.20	0.30	2.40	2.43	2.41
C101	1.62	1.49	6.05	5.87	5.86
C111	2.47	2.51	12.08	14.87	12.31
C112	1.49	1.50	3.85	4.06	4.02
C121	1.89	1.85	5.67	5.65	5.70
C122	1.75	1.51	2.97	2.51	2.80
C131	2.76	2.66	5.84	5.99	5.84
C132	1.61	0.71	2.96	2.82	3.00
C133	0.82	1.00	4.10	4.32	4.20
C141	1.85	2.08	9.68	10.35	10.26
C151	1.59	1.60	4.00	4.20	4.11
C161	0.80	0.88	6.41	6.08	6.25
C171	1.04	1.00	4.14	4.15	4.15
C172	1.04	0.93	2.59	2.69	2.66
C181	1.18	1.48	3.56	3.70	3.60

AD. = Adsorption. AB. = Absorption.

APPENDIX B2. RESULTS FOR THE SPECIFIC GRAVITY AND DRY DENSITY DETERMINATIONS.

Sample	Gs. 1.	Gs. 2.	Gs. 3.	γd. 1.	γd. 2.	γd. 3.
Ca11	2.90	2.92	2.91	2.82	2.82	2.82
Ca12	2.88	2.87	2.88	2.81	2.81	2.80
Ca13	2.88	2.89	2.88	2.83	2.83	2.84
O11	2.79	2.80	2.84	2.62	2.64	2.65
O12	2.82	2.80	2.79	2.61	2.61	2.62
O21	2.90	2.87	2.88	2.71	2.73	2.71
O31	2.85	2.85	2.85	2.72	2.72	2.71
S11	2.76	2.77	2.77	2.56	2.57	2.56
S31	2.83	2.83	2.83	2.67	2.66	2.67
S32	2.81	2.82	2.82	2.73	2.73	2.73
D11	2.78	2.80	2.79	2.64	2.65	2.64
D12	2.76	2.77	2.74	2.62	2.64	2.60
D21	2.76	2.77	2.79	2.59	2.59	2.59
C1B1	2.30	2.32	2.31	2.20	2.20	2.21
C1B2	2.73	2.74	2.74	2.65	2.65	2.65
C1B4	2.76	2.75	2.76	2.66	2.66	2.66
C1B5	2.69	2.69	2.69	2.61	2.62	2.61
C21	2.48	2.48	2.48	2.30	2.30	2.31
C31	2.81	2.81	2.81	2.66	2.66	2.65
C41	2.70	2.70	2.70	2.50	2.50	2.50
C51	2.73	2.73	2.73	2.53	2.53	2.52
C52	2.63	2.65	2.64	2.46	2.46	2.46
C61	2.67	2.82	2.74	2.63	2.62	2.63
C71	2.65	2.67	2.66	2.52	2.52	2.51
C82	2.79	2.80	2.78	2.49	2.50	2.49
C83	2.70	2.79	2.75	2.48	2.47	2.49
C92	1.87	1.79	1.83	1.76	1.76	1.77
C101	2.73	2.75	2.74	2.52	2.53	2.54
C111	2.58	2.59	2.59	2.49	2.49	2.50
C112	2.73	2.79	2.75	2.50	2.51	2.50
C121	2.77	2.75	2.76	2.57	2.57	2.56
C122	2.46	2.48	2.47	2.39	2.38	2.39
C131	2.45	2.45	2.44	2.39	2.40	2.39
C132	2.62	2.66	2.64	2.48	2.48	2.48
C133	2.59	2.60	2.60	2.49	2.49	2.48
C141	2.78	2.76	2.78	2.50	2.50	2.50
C151	2.72	2.70	2.71	2.51	2.50	2.51
C161	2.70	2.71	2.73	2.60	2.60	2.60
C171	2.73	2.70	2.71	2.59	2.59	2.58
C172	2.71	2.71	2.71	2.61	2.62	2.61
C181	2.65	2.66	2.66	2.51	2.51	2.50

Gs = Specific gravity. γd = Dry density.

Appendix B3:PSD plots for the slake durability test debris.

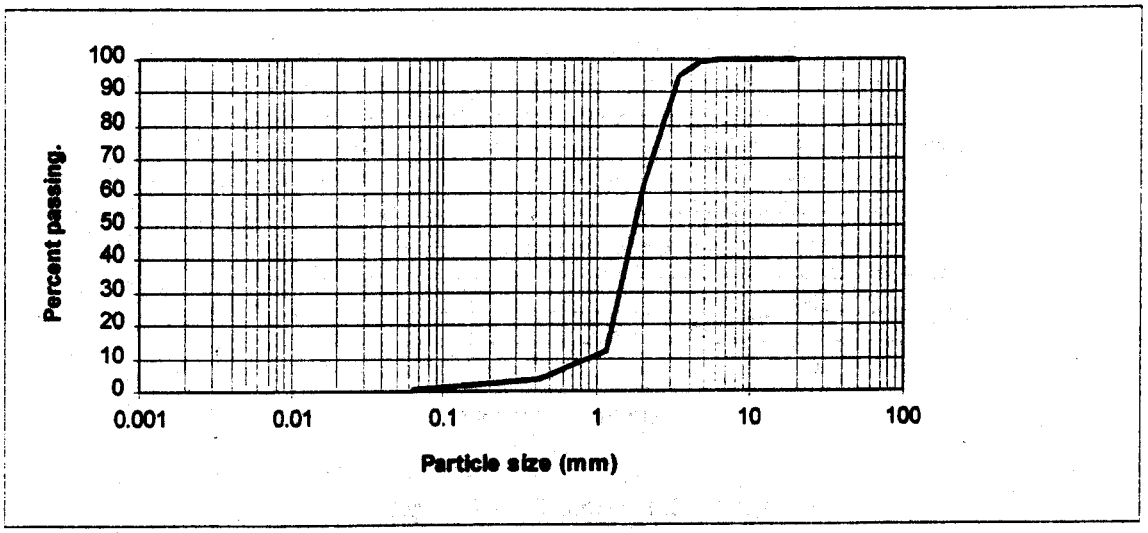


Figure 6.1b . Sample O.1.1. Platy and elongated shards.

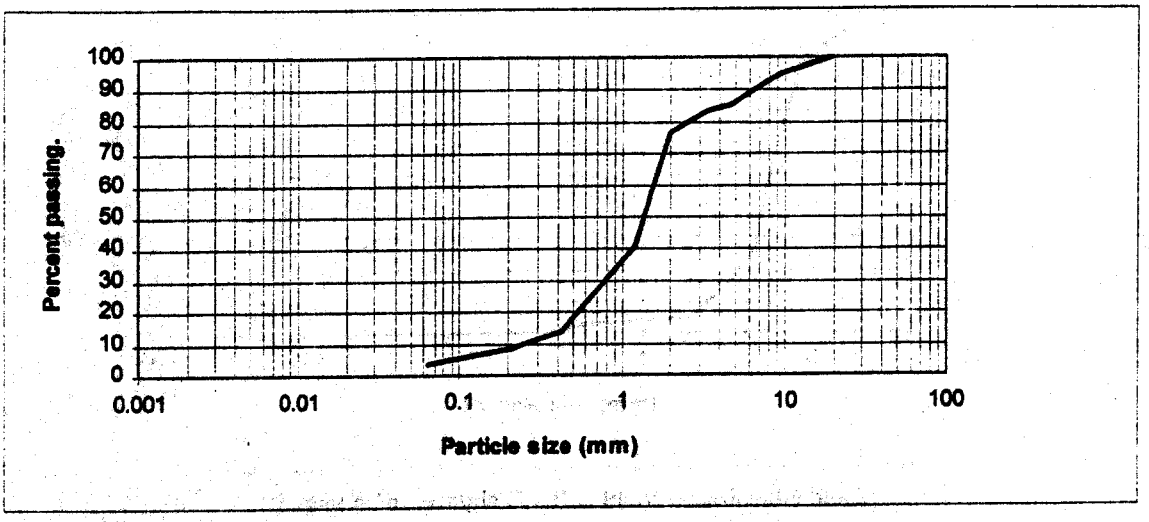


Figure 6.2b . Sample O.1.2. Blocky, almondy rare platy.

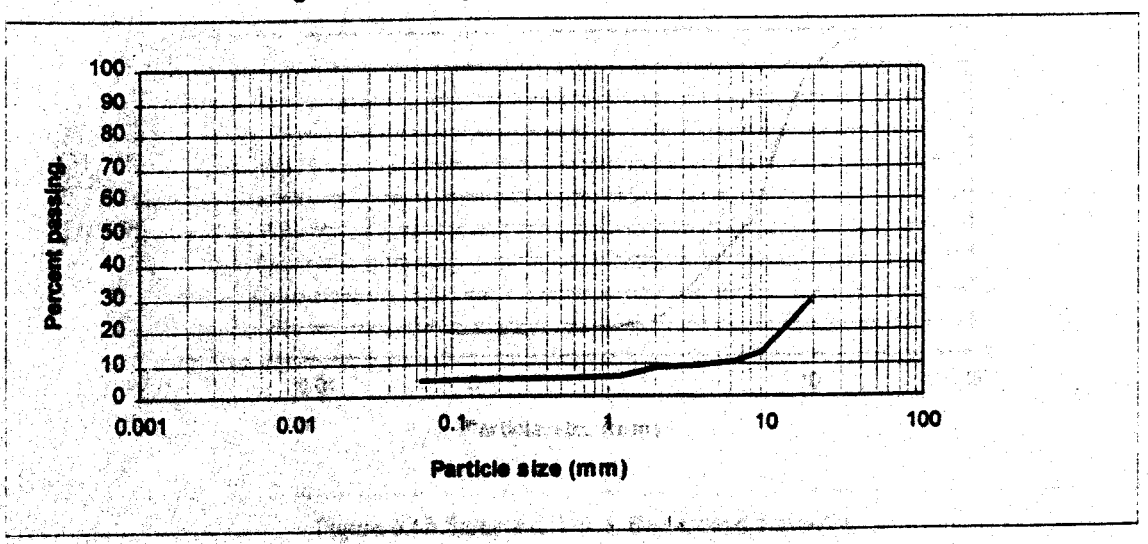


Figure 6.3b . Sample S.1.1. Blocky, almondy and platy.

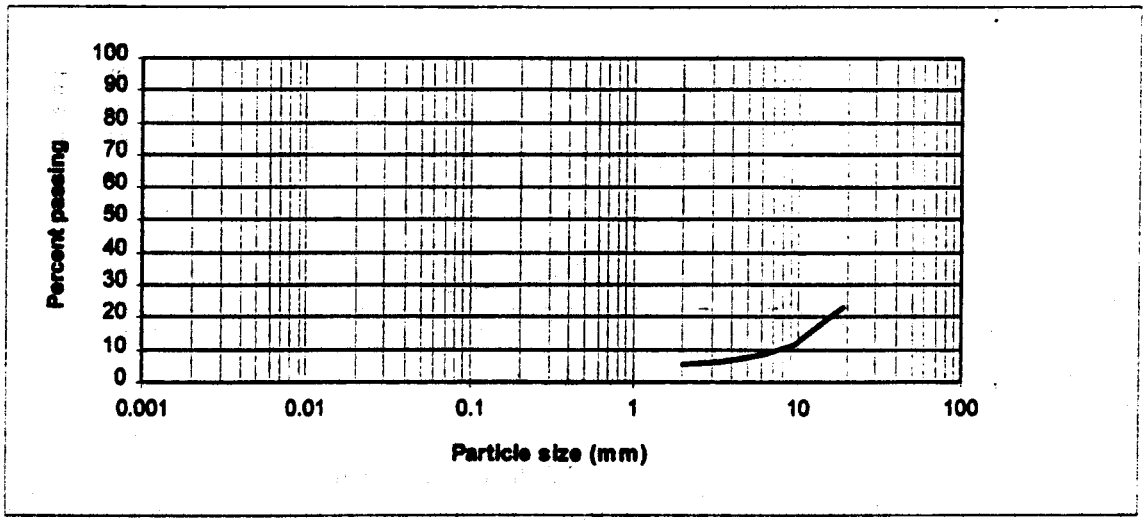


Figure 6.4b . Sample C.1.B.1. Platy.

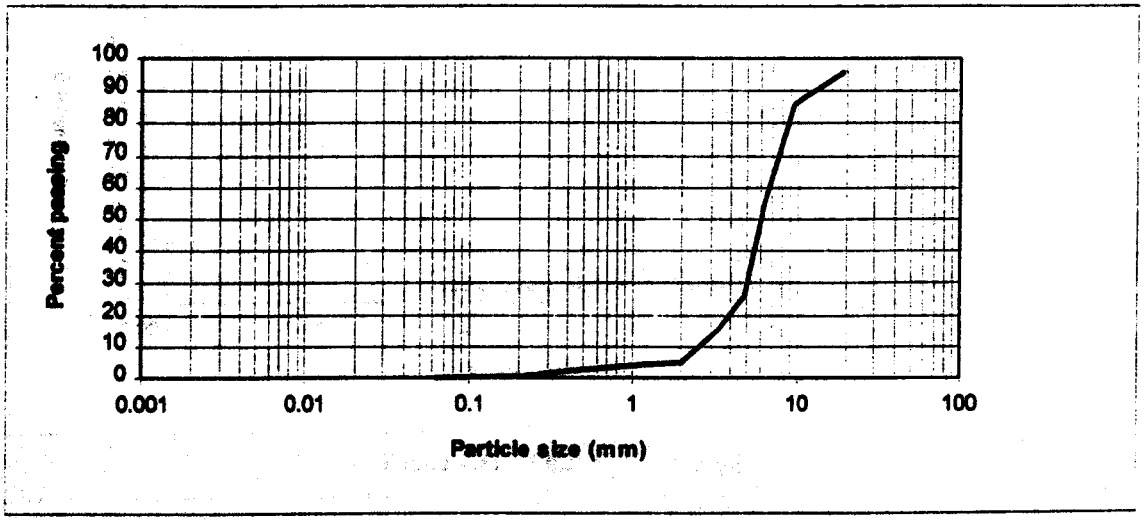


Figure 6.5b . Sample C.1.B.2. Platy, occasionally blocky.

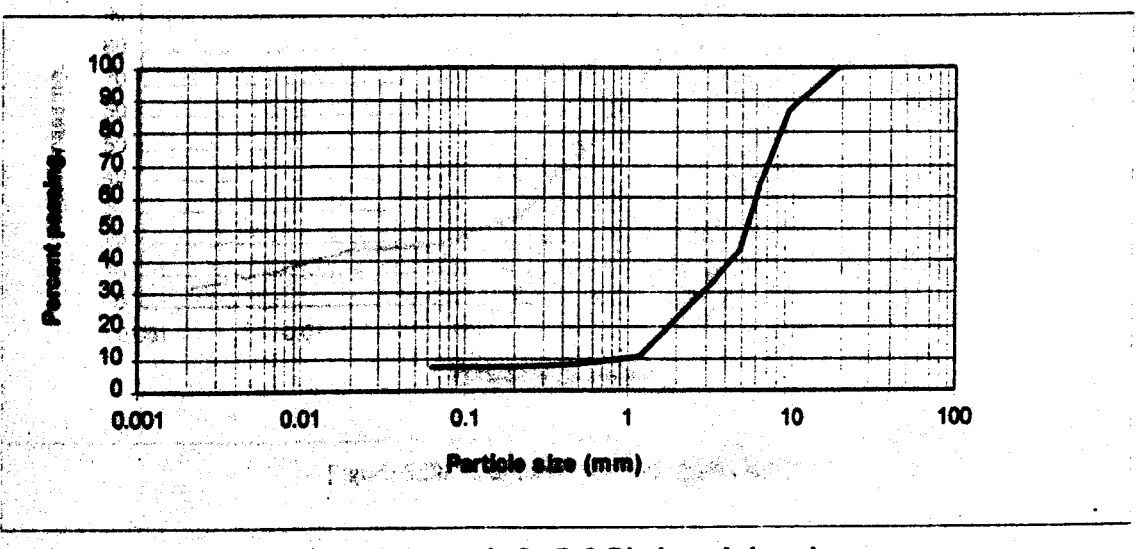


Figure 6.6b.Sample C.1.B.5. Blocky and almondy.

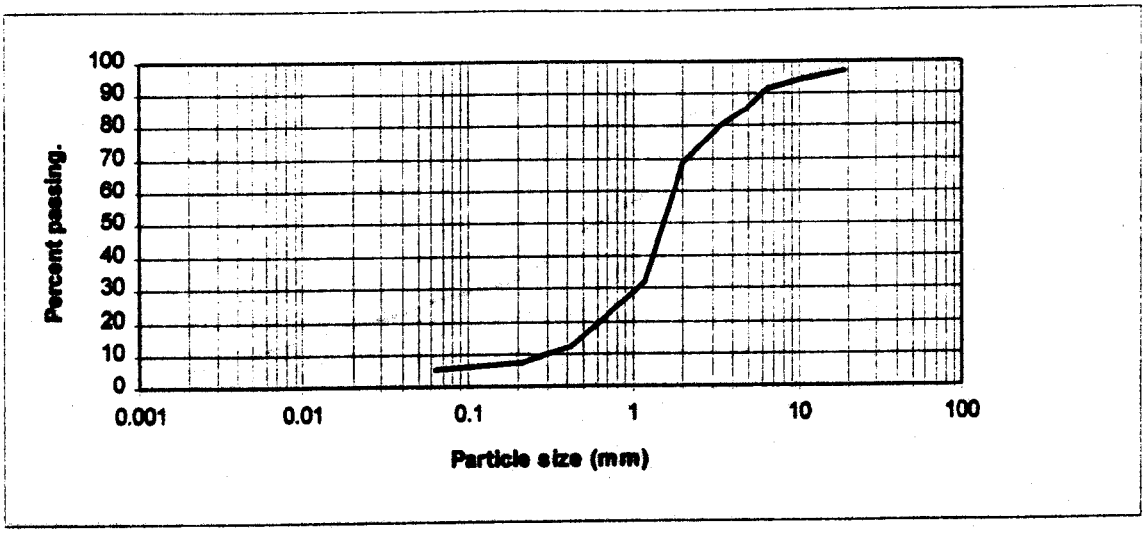


Figure 6.7b . Sample C.2.1. Platy and elongated.

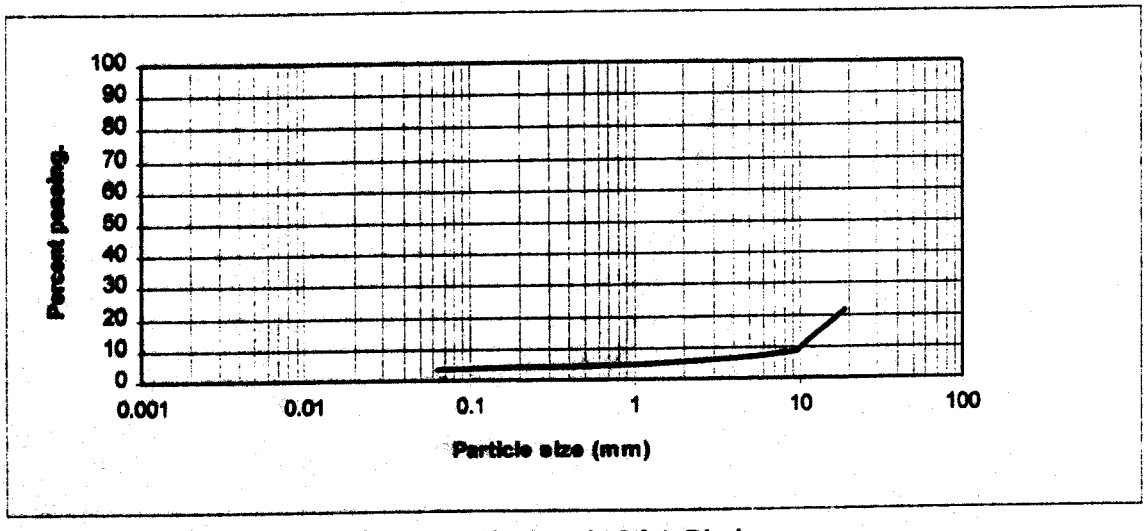


Figure 6.8b . Sample C.3.1. Blocky.

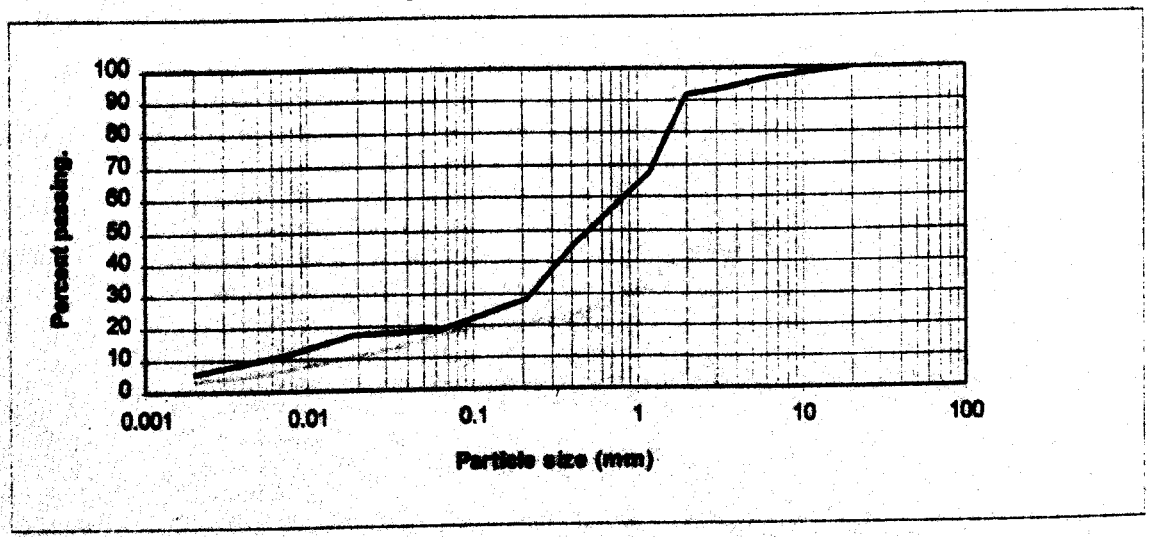


Figure 6.9b . Sample C.4.1. Elongated shards.

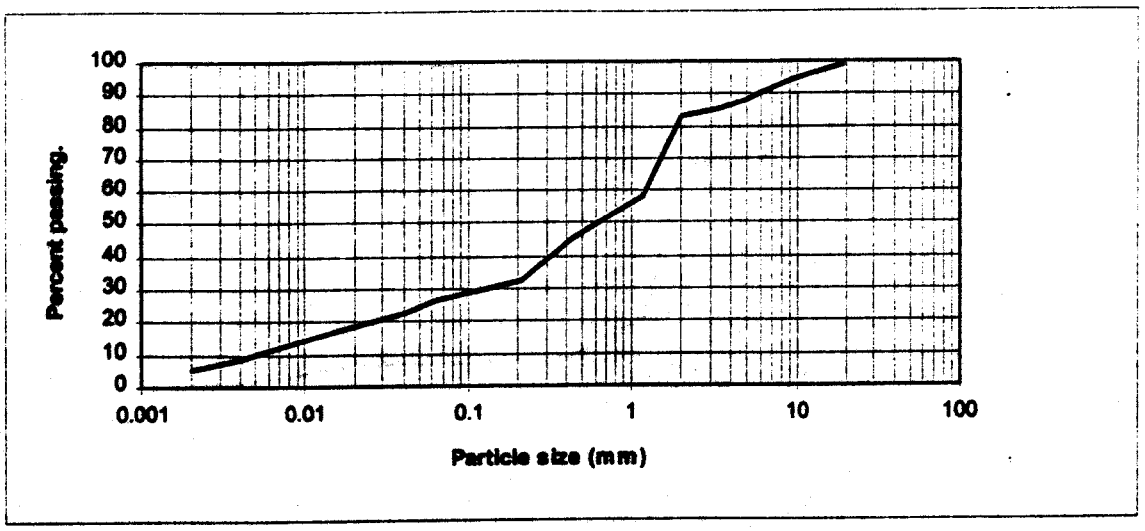


Figure 6.10b . Sample C.5.1. Platy.

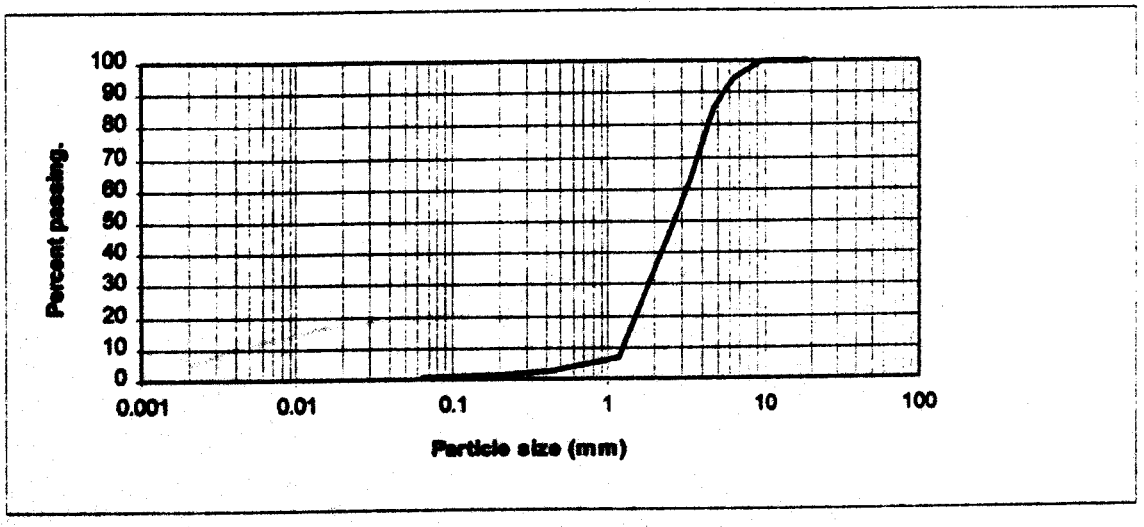


Figure 6.11b . Sample C.5.2. Platy.

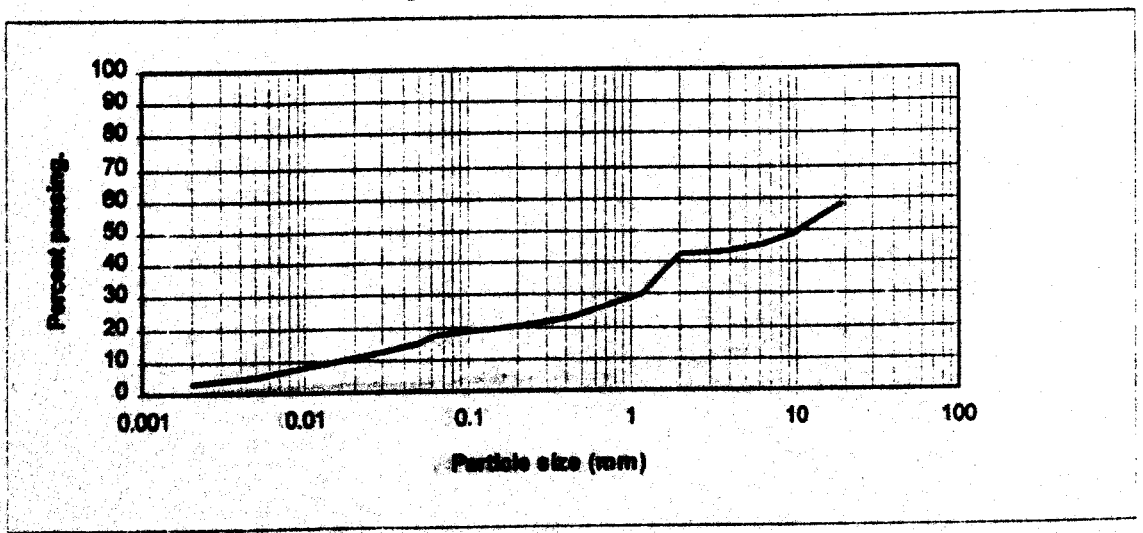


Figure 6.12b . Sample C.6.1. Platy, occasionally blocky.

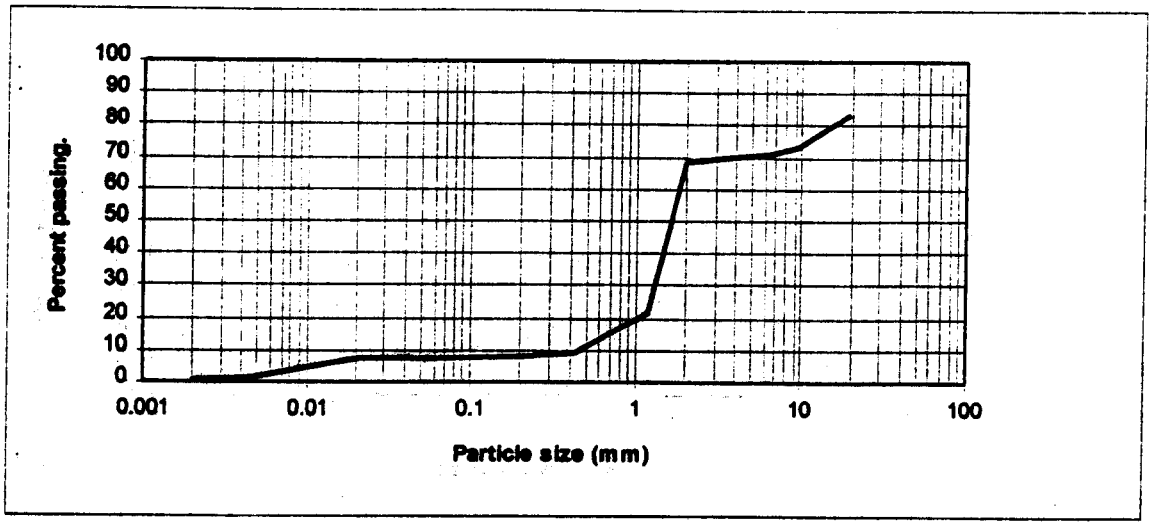


Figure 6.13b . Sample C.7.1. Platy and blocky.

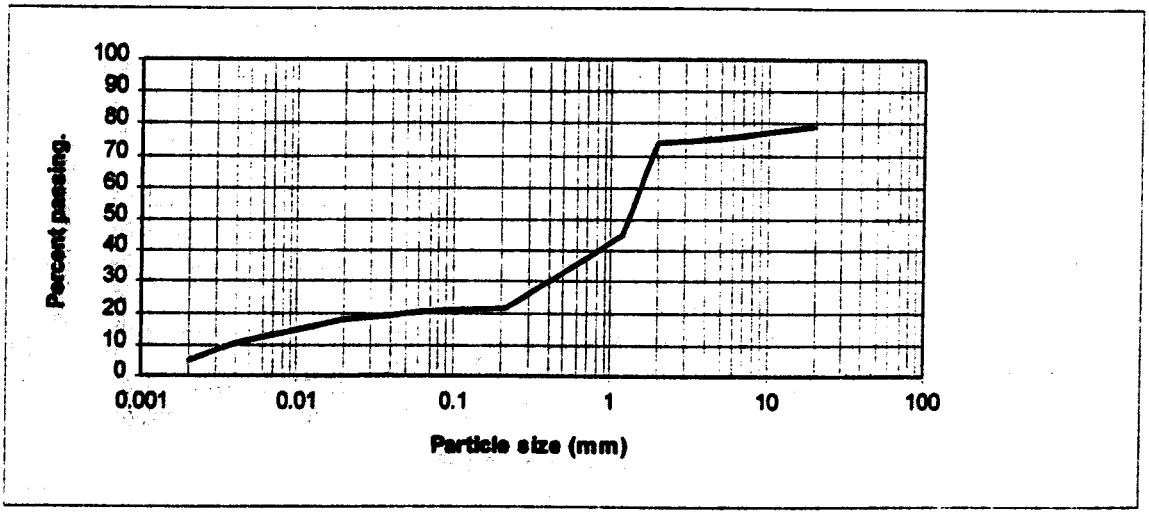


Figure 6.14b . Sample C.8.2. Platy.

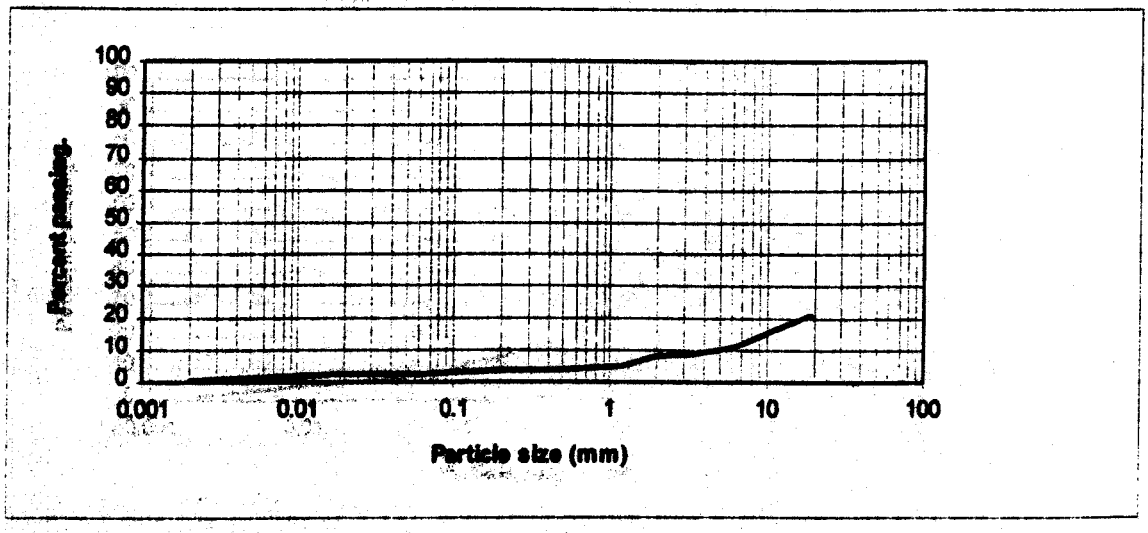


Figure 6.15b . Sample C.8.3. Blocky and platy.

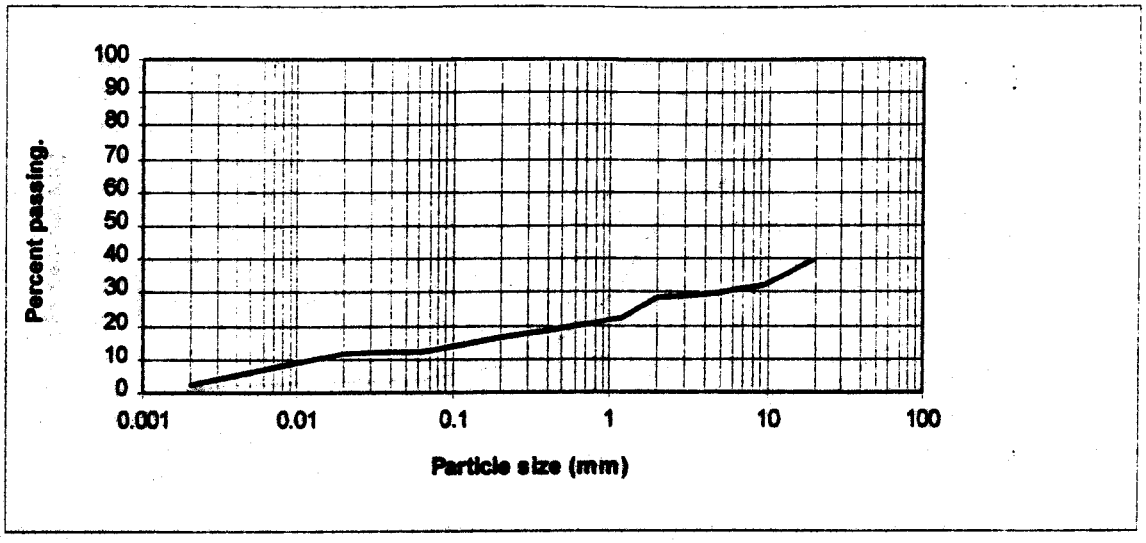


Figure 6.16b . Sample C.9.2. Platy, occasionally blocky.

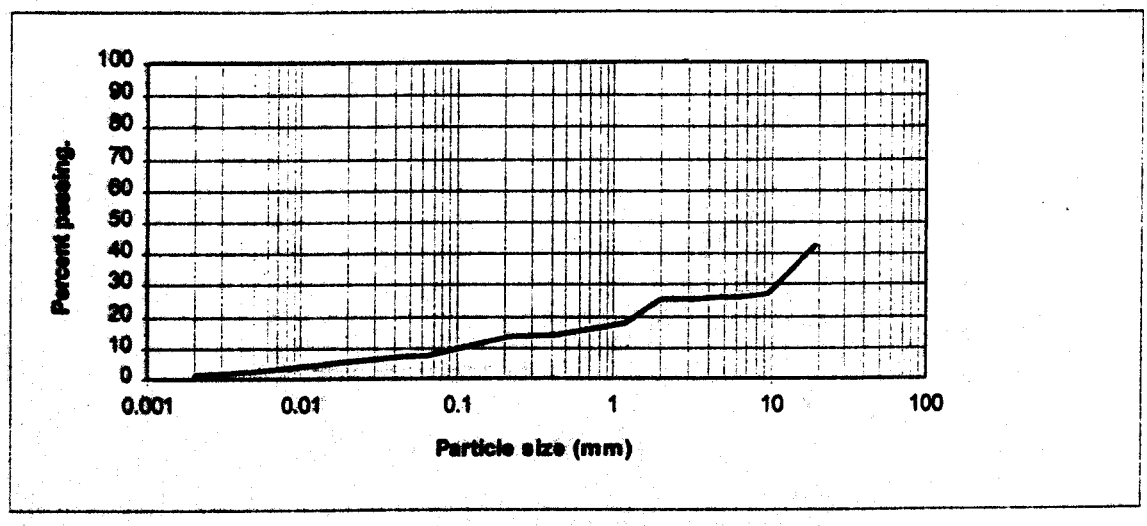


Figure 6.17b . Sample C.10.1. Blocky and platy.

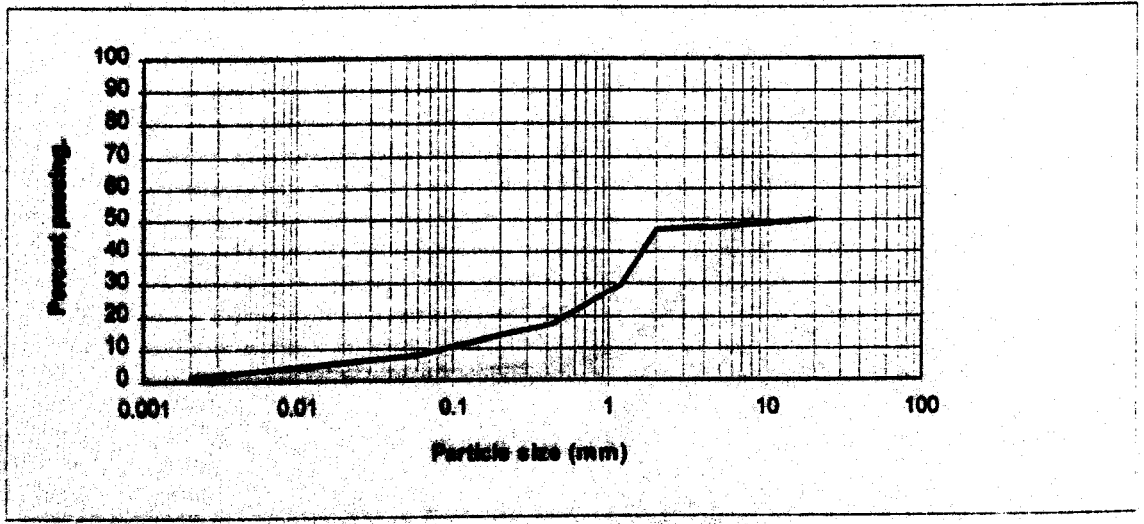


Figure 6.18b . Sample C.11.2. Blocky and platy.

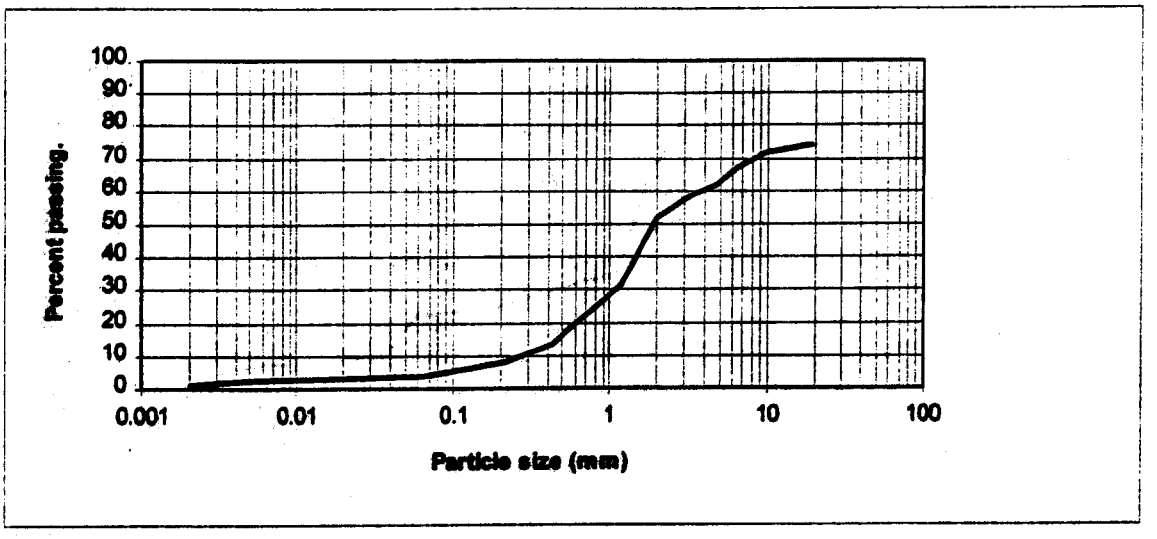


Figure 6.19b . Sample C.11.1. Platy and shards.Platy mudstone/almondy siltstone.

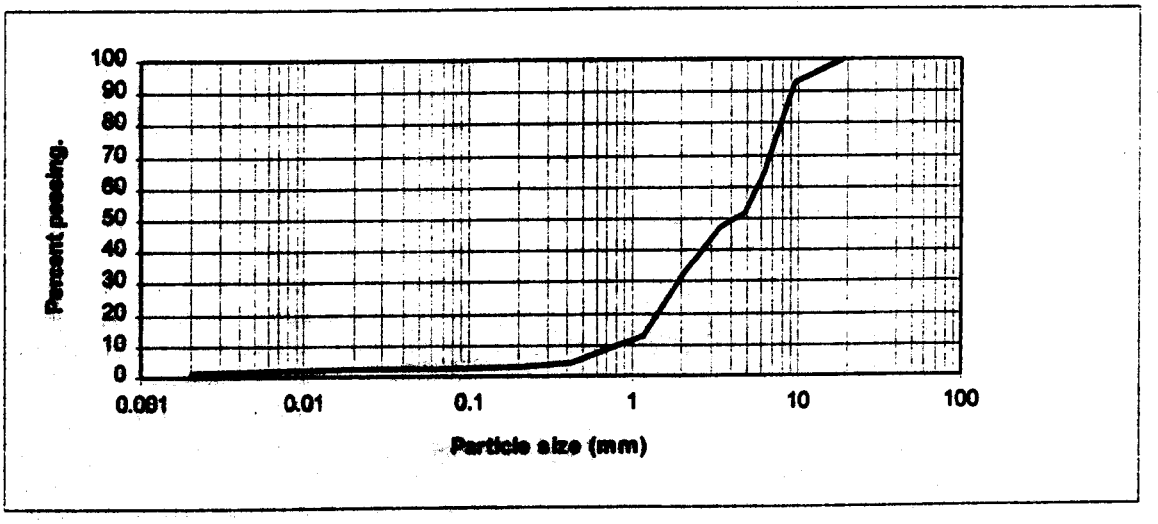


Figure 6.20b . Sample C.12.1.Platy and shards.

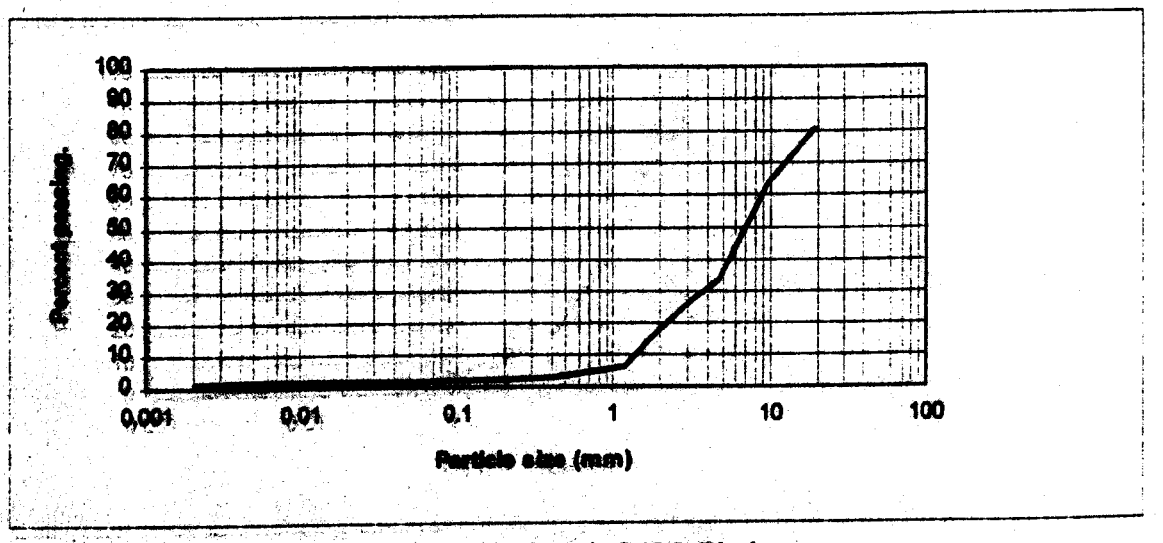


Figure 6.21b . Sample C.12.2. Blocky.

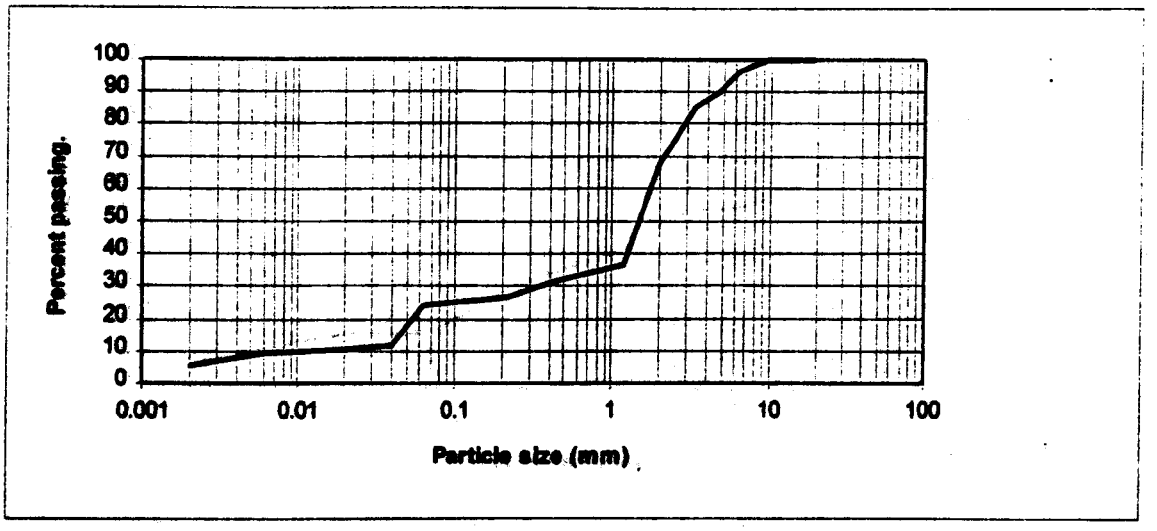


Figure 6.22b . Sample C.13.1. Platy and shards.

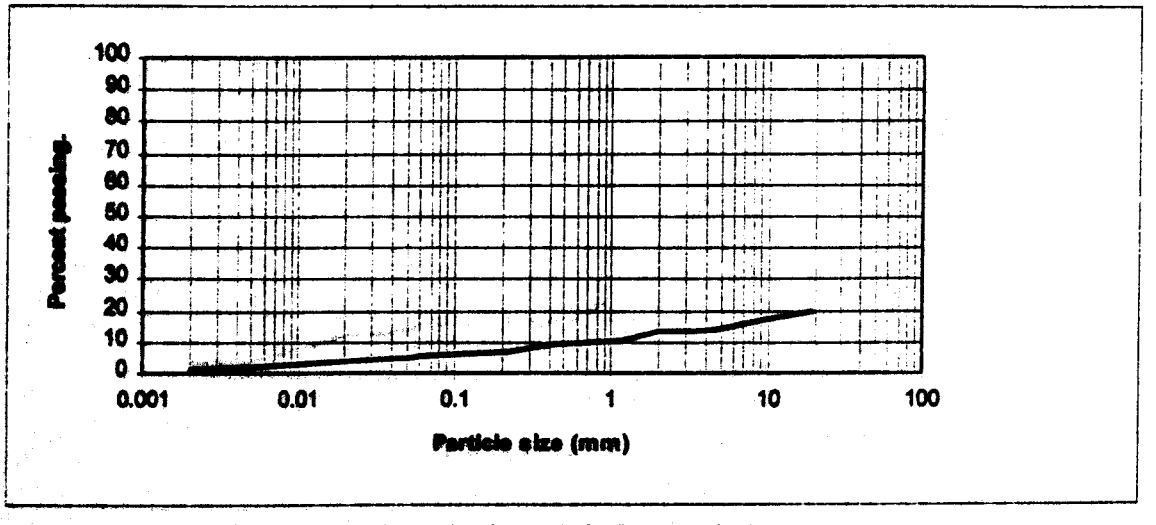


Figure 6.23b . Sample C.13.2. Blocky.

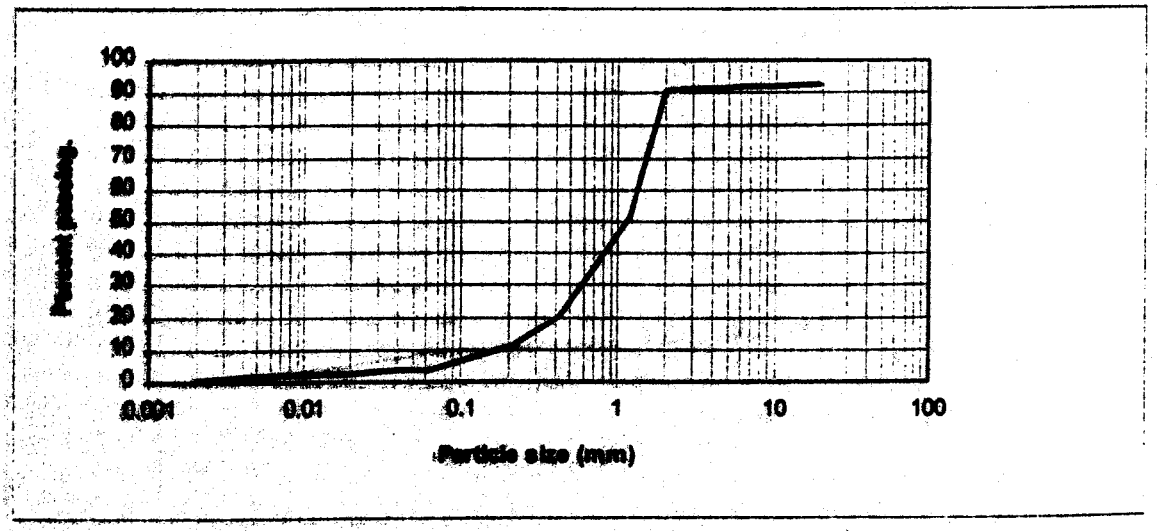


Figure 6.24b . Sample C.13.3. Almondy and shards.

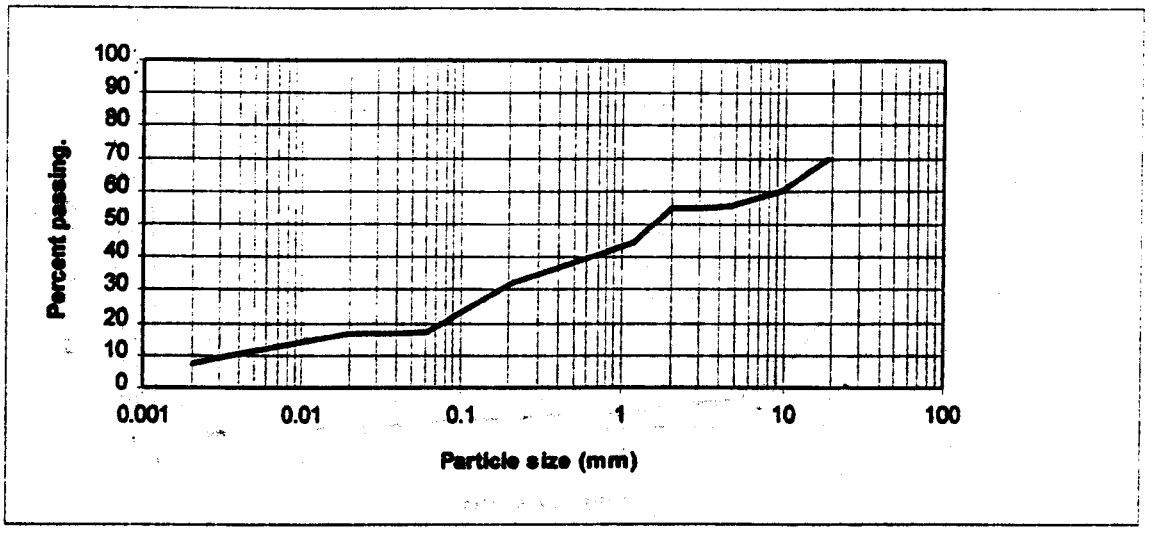


Figure 6.25b . Sample C.14.1. Blocky and platy.

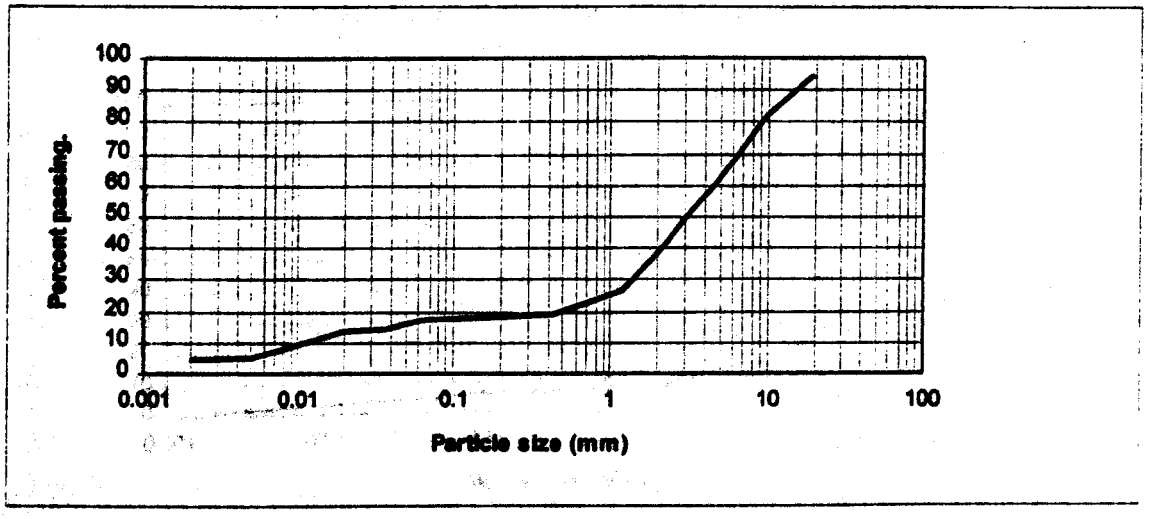


Figure 6.26b . Sample C.15.1. Almondy to blocky, occasionally platy.

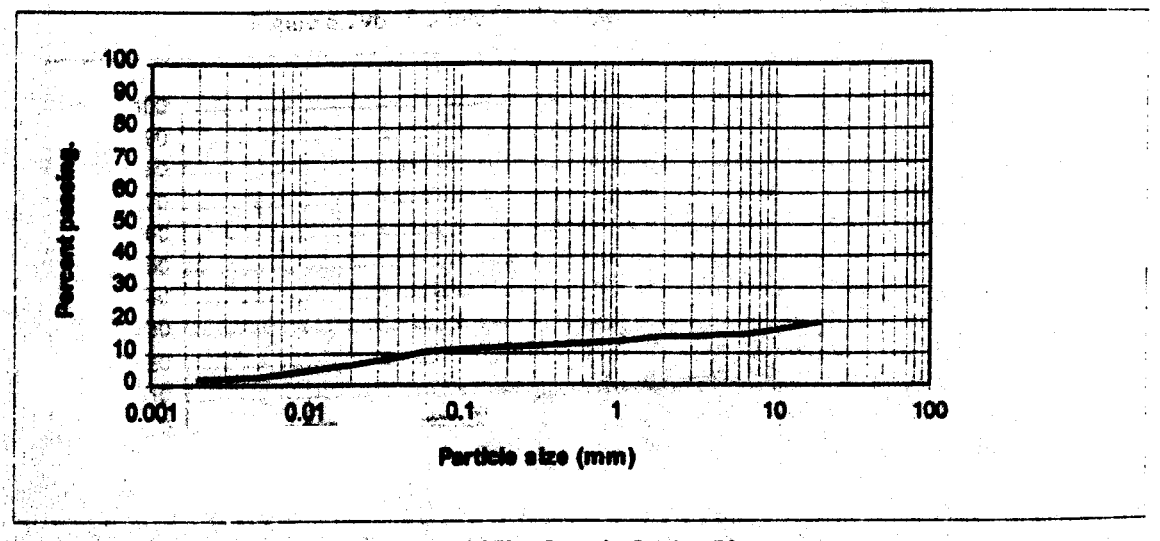


Figure 6.27b . Sample C.16.1. Platy.

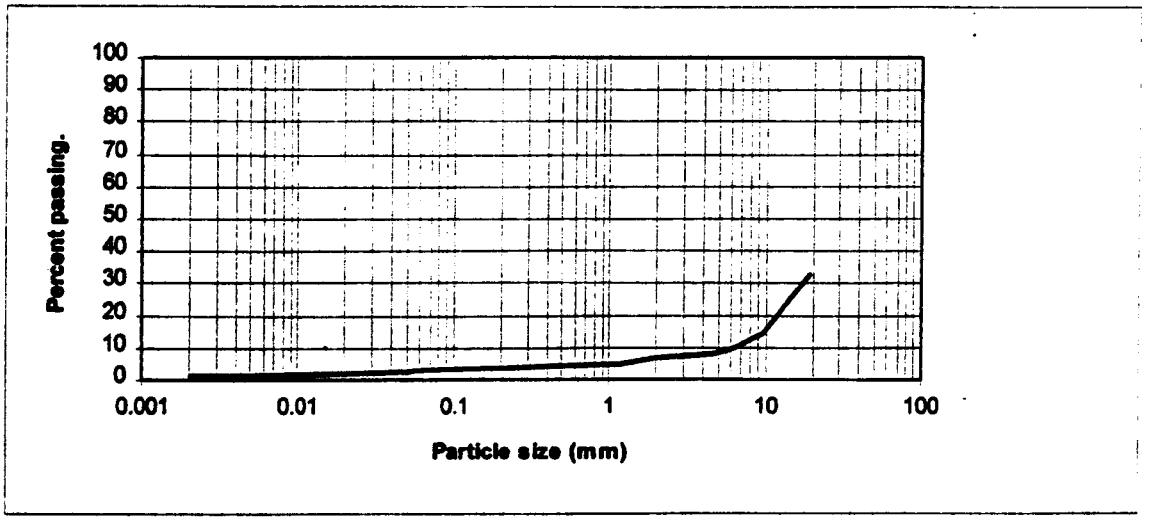


Figure 6.28b . Sample C.17.1. Platy, elongated occasionally blocky.

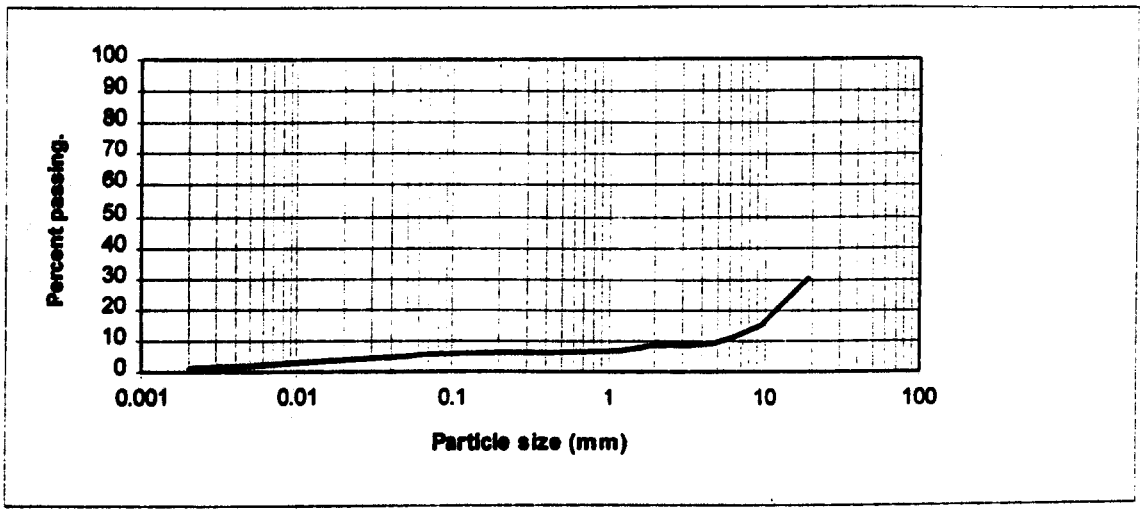


Figure 6.29b . Sample C.17.2. Blocky, almondy, occasionally platy.

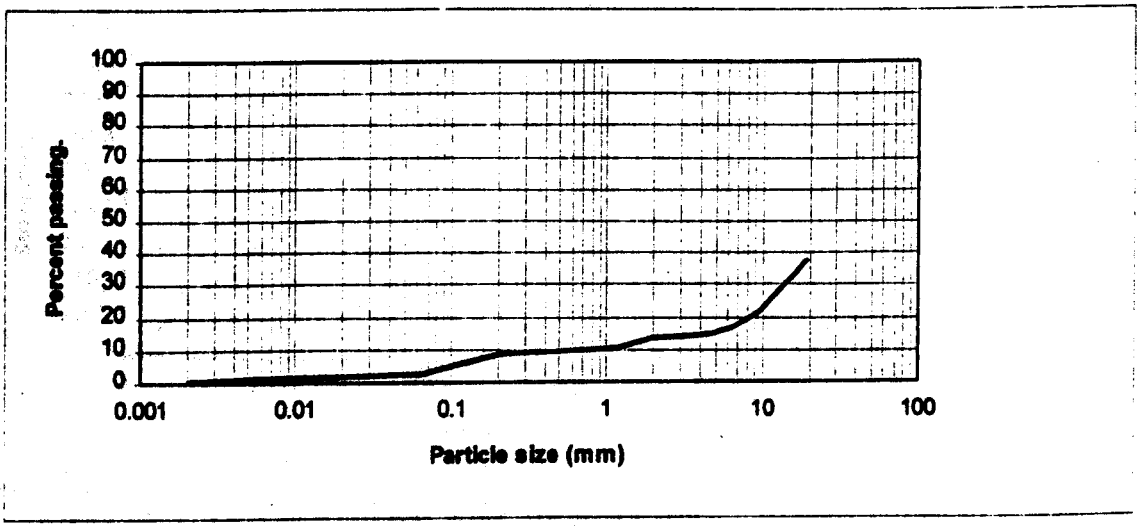


Figure 6.30b . Sample C.18.1. Almondy.

APPENDIX B4. TRIAXIAL SWELLING TEST PLOTS.

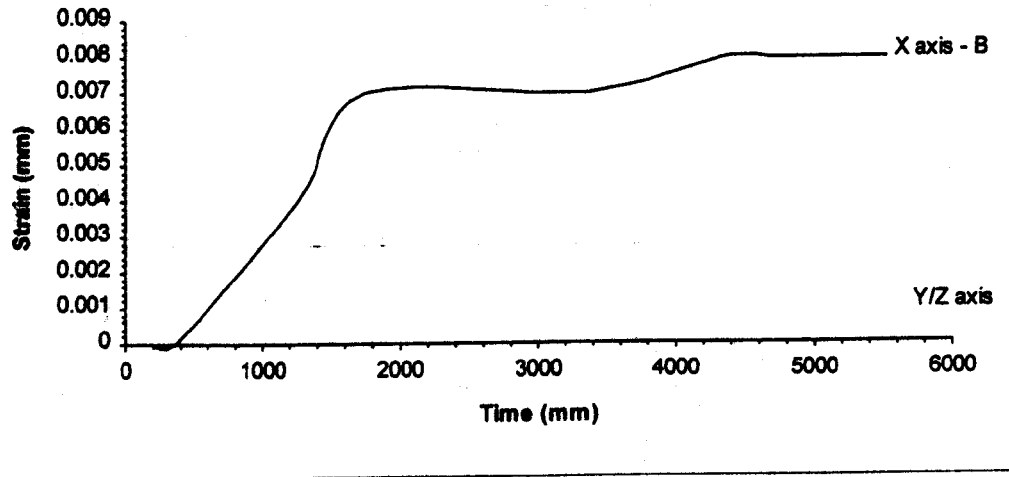


Figure 6.31b . Sample Ca.1.1.

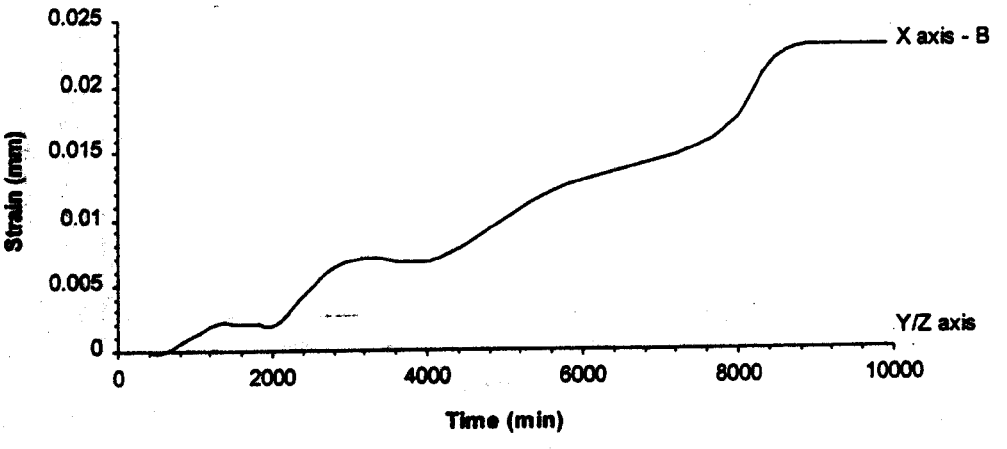


Figure 6.32b . Sample Ca.1.2.

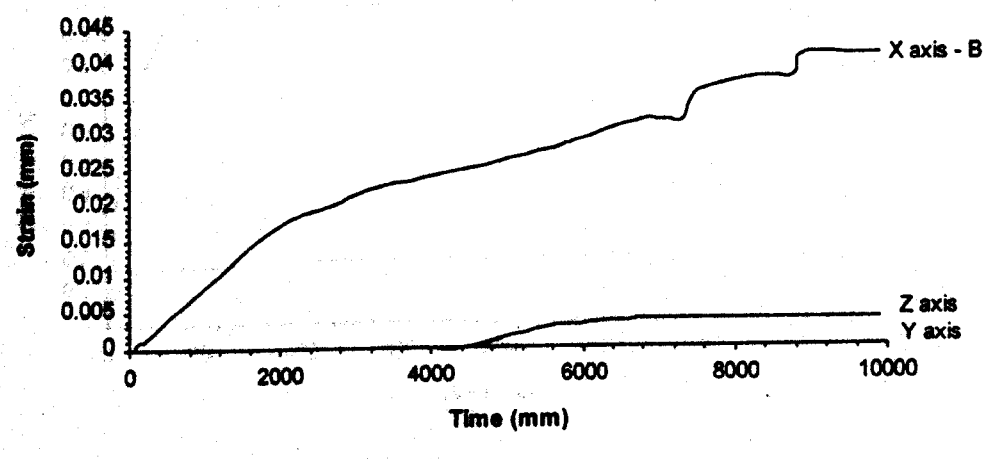


Figure 6.33b . Sample Ca.1.3.

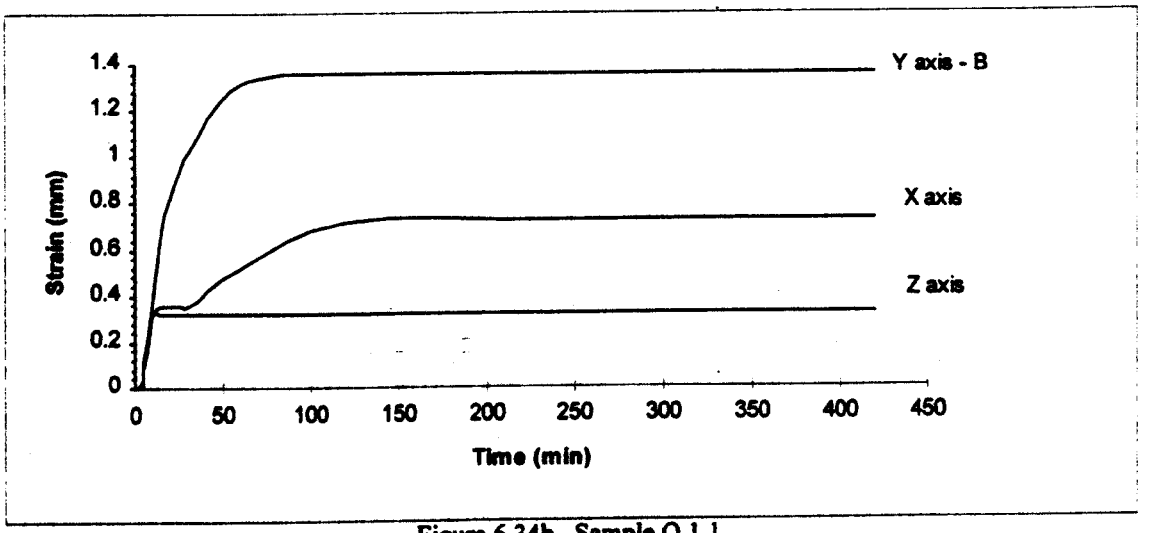


Figure 6.34b . Sample O.1.1.

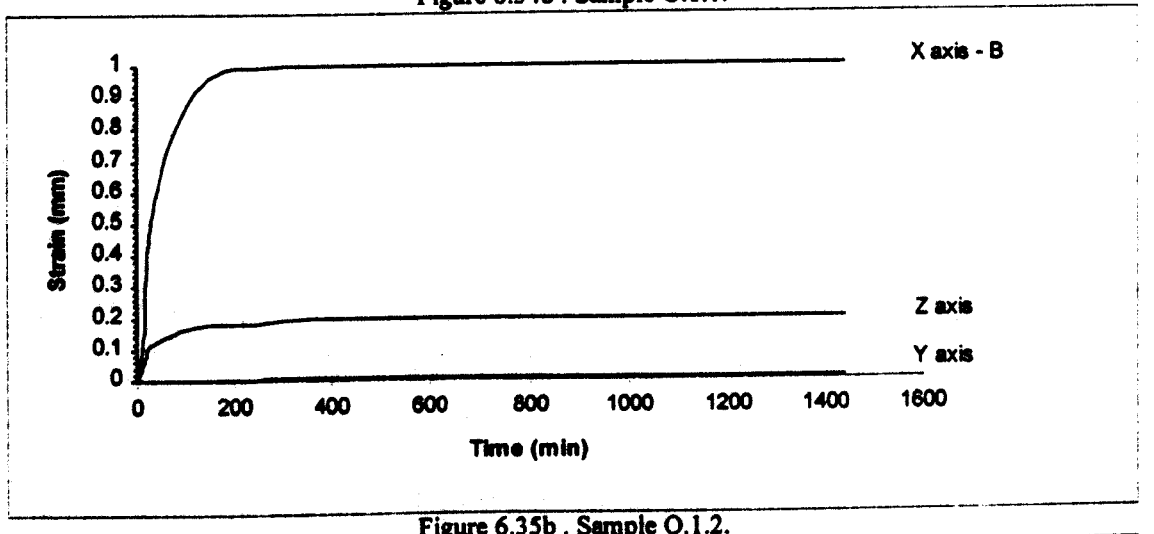


Figure 6.35b . Sample O.1.2.

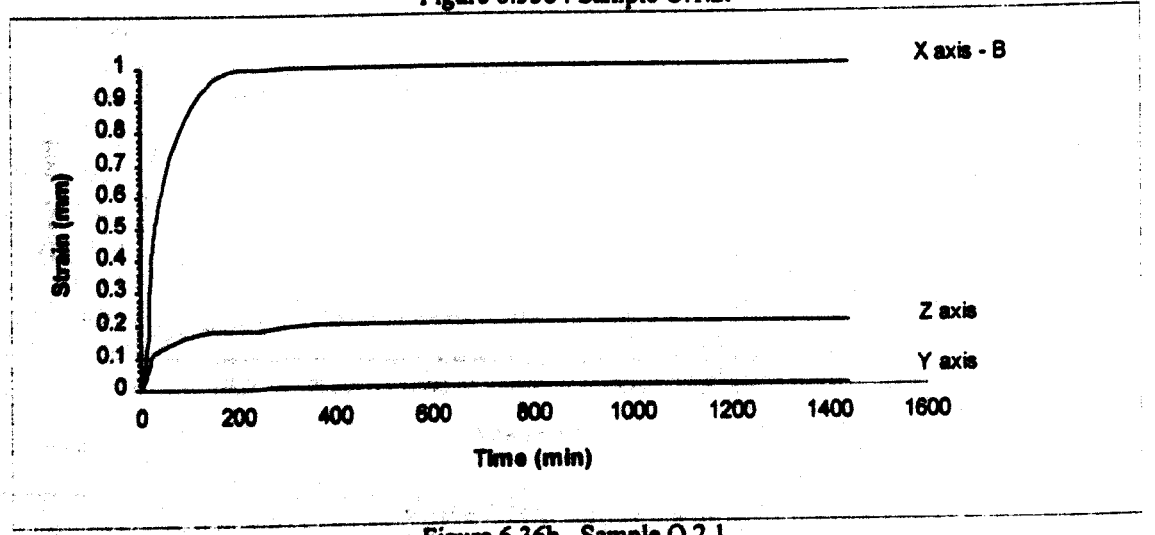


Figure 6.36b . Sample O.2.1.

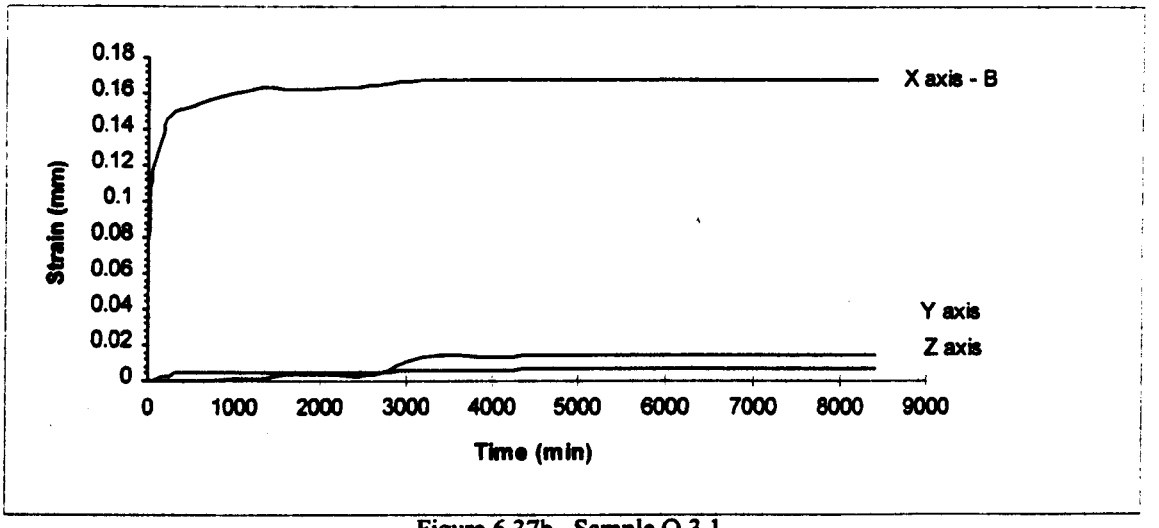


Figure 6.37b . Sample O.3.1.

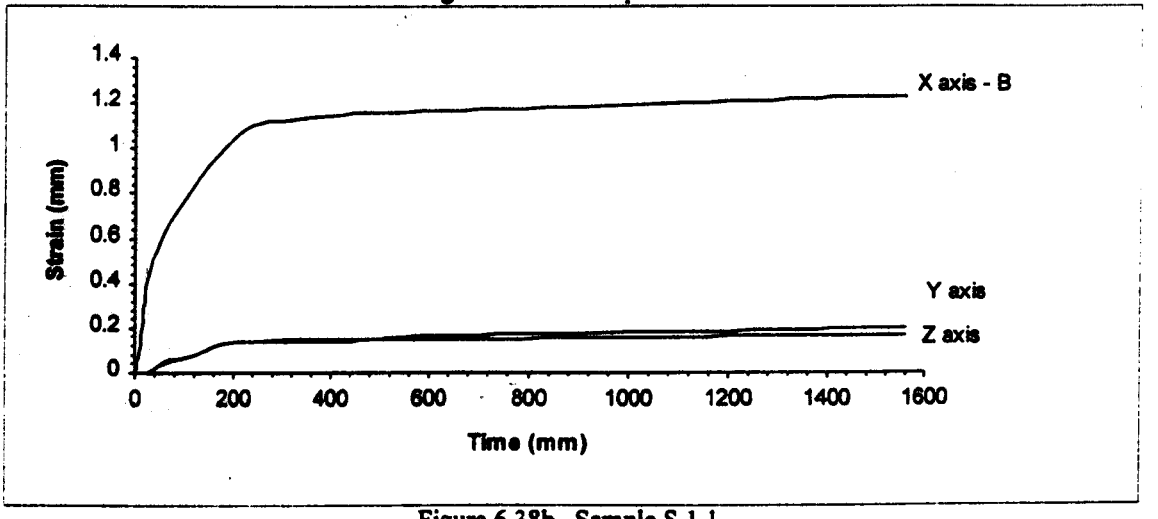


Figure 6.38b . Sample S.1.1.

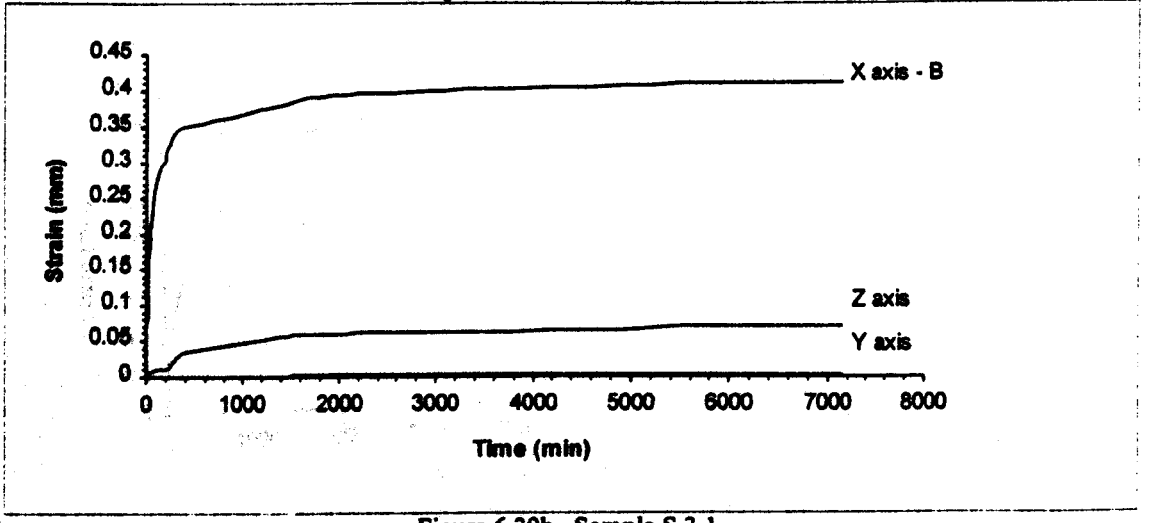


Figure 6.39b . Sample S.3.1.

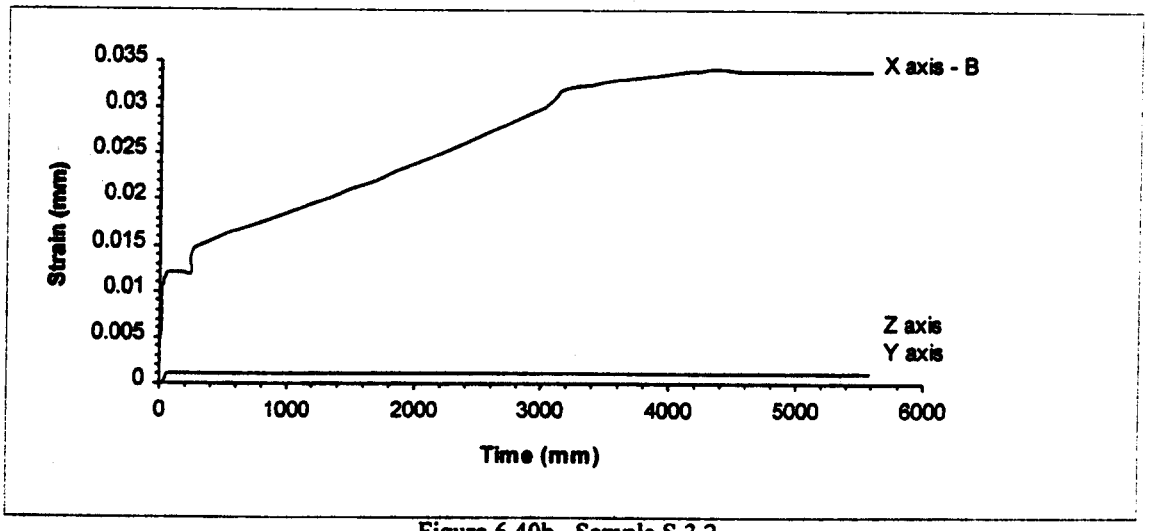


Figure 6.40b . Sample S.3.2.

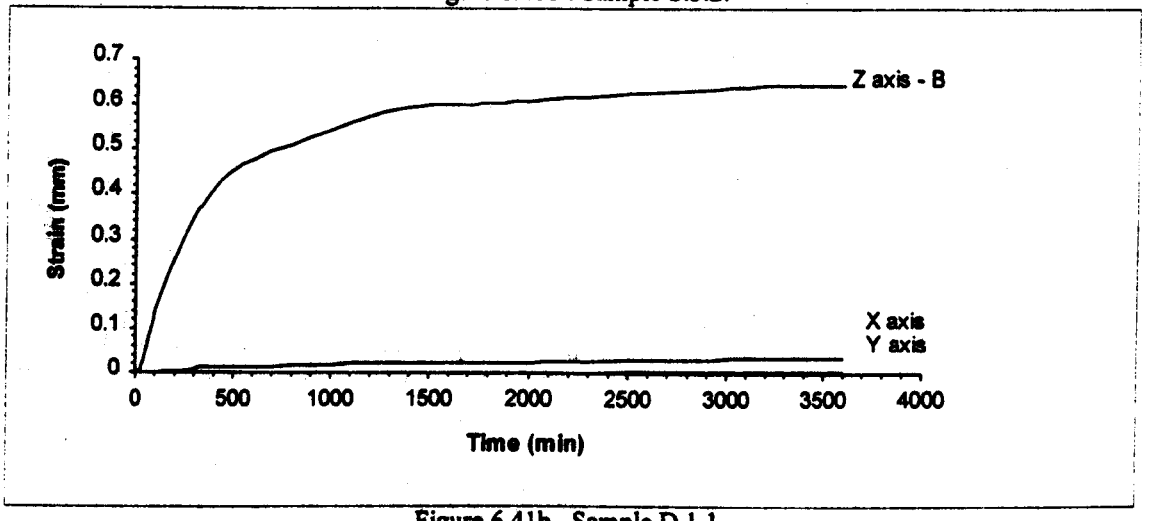


Figure 6.41b . Sample D.1.1.

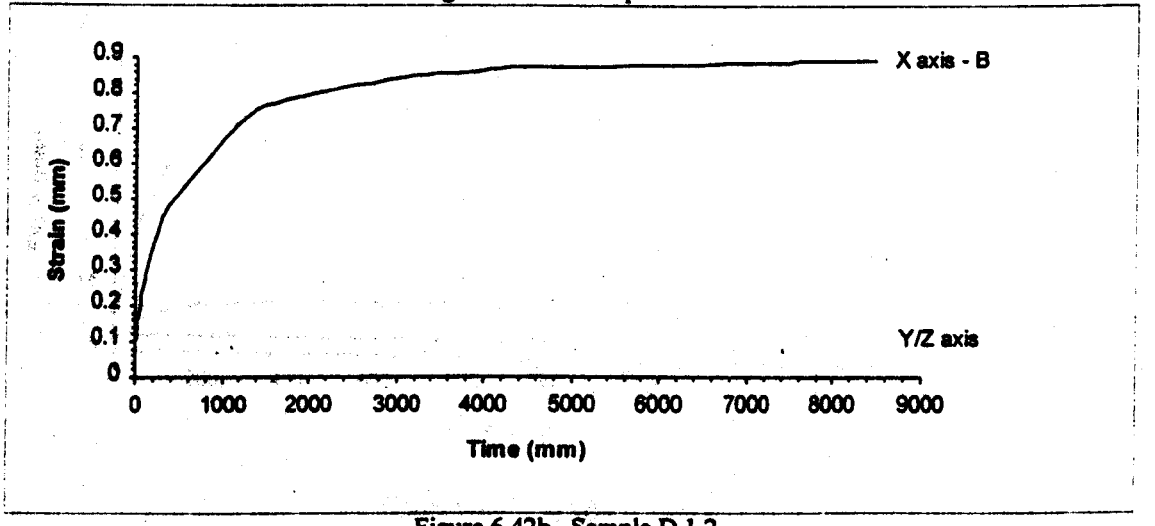


Figure 6.42b . Sample D.1.2.

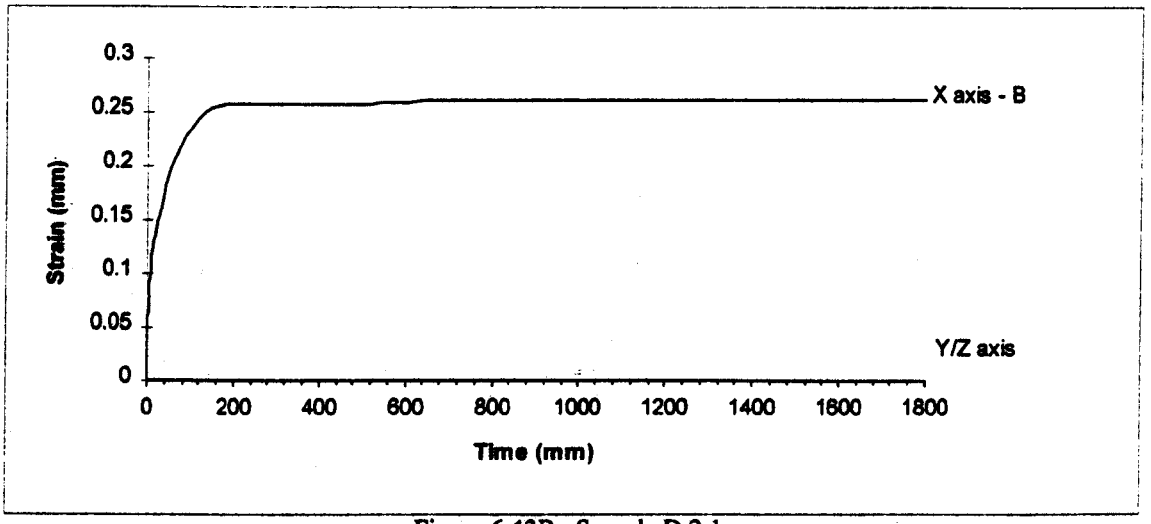


Figure 6.43B . Sample D.2.1.

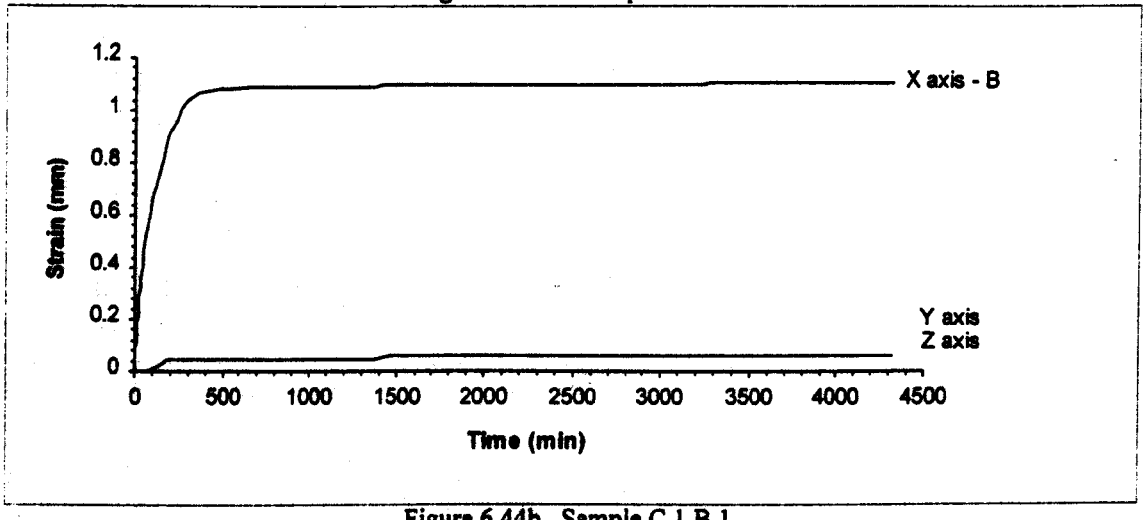


Figure 6.44b . Sample C.1.B.1.

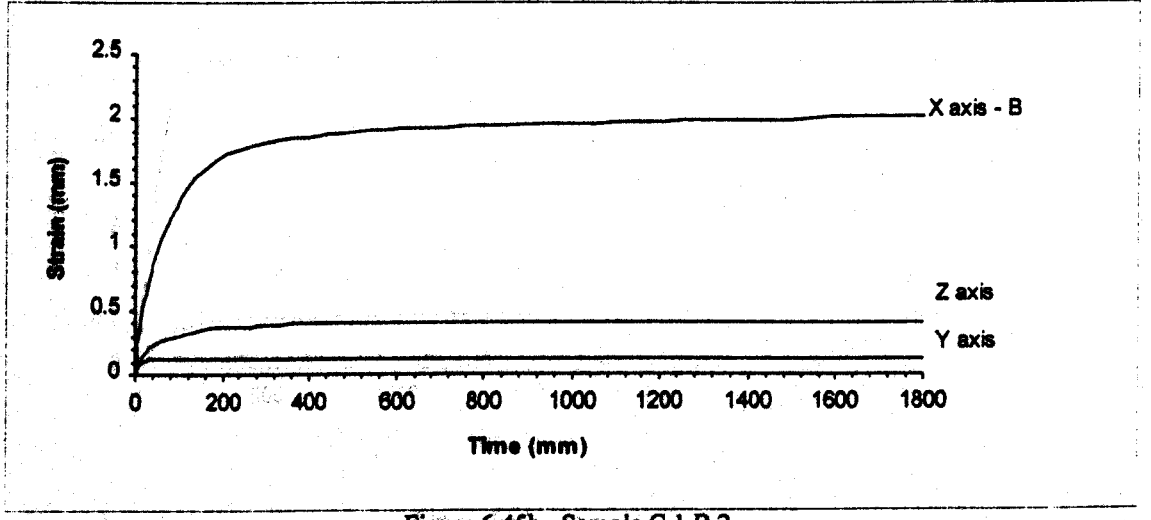


Figure 6.45b . Sample C.1.B.2.

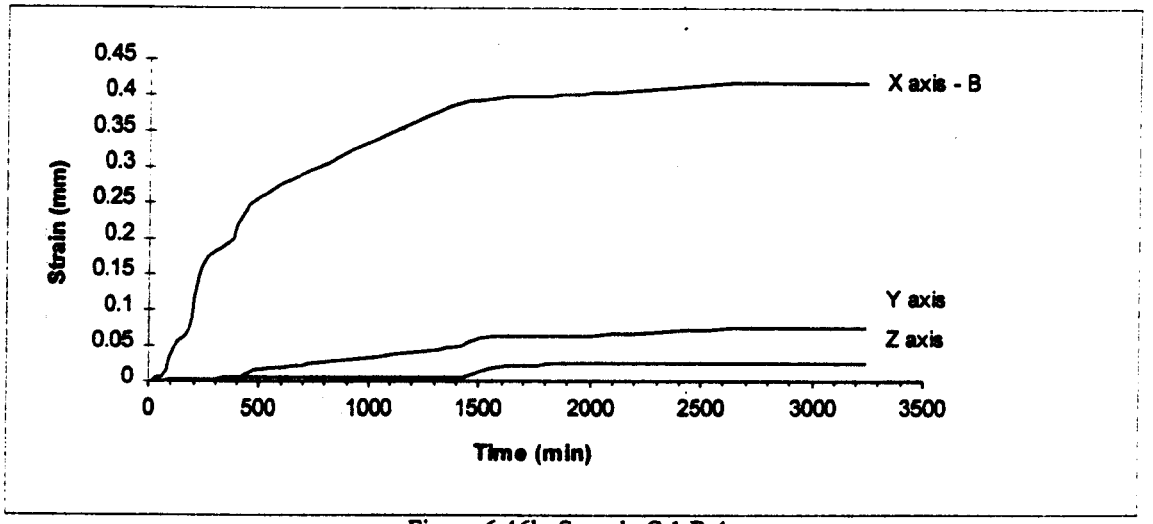


Figure 6.46b. Sample C.1.B.4.

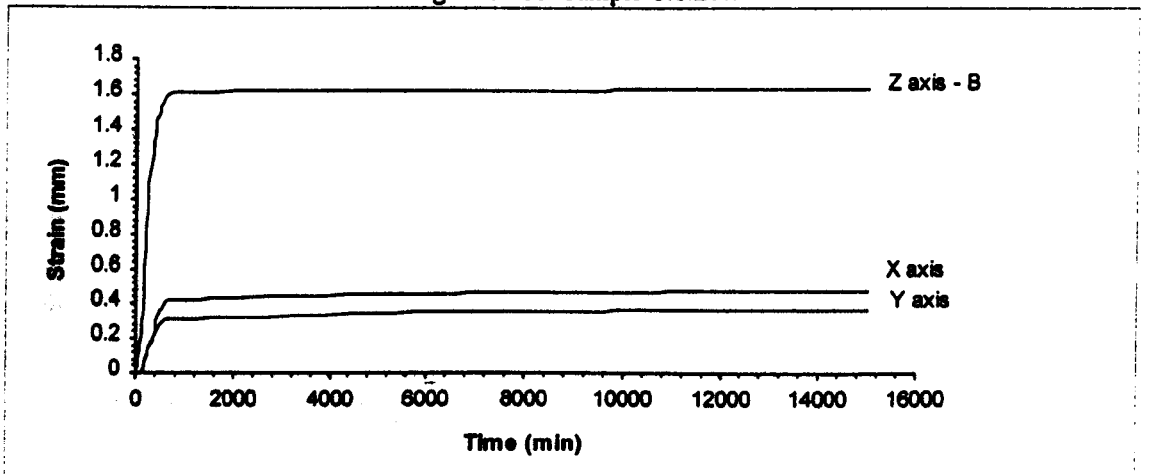


Figure 6.47b . Sample C.1.B.5.

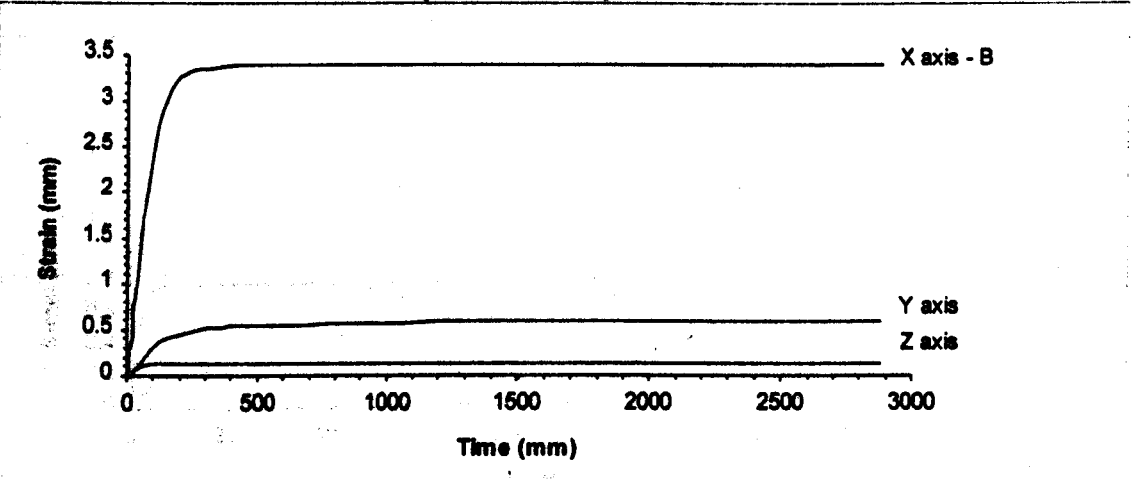


Figure 6.48b . Sample C.2.1.

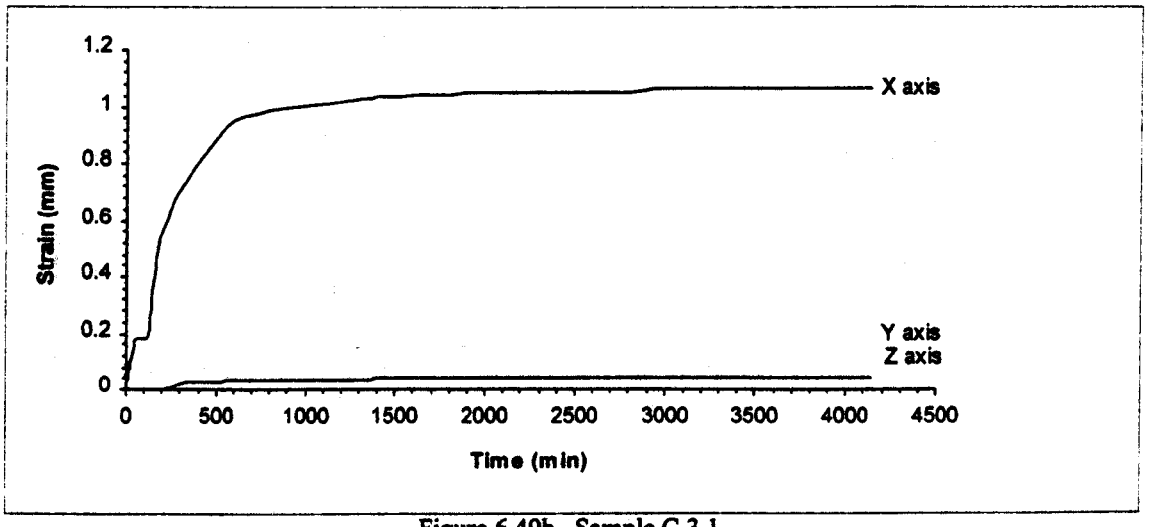


Figure 6.49b . Sample C.3.1.

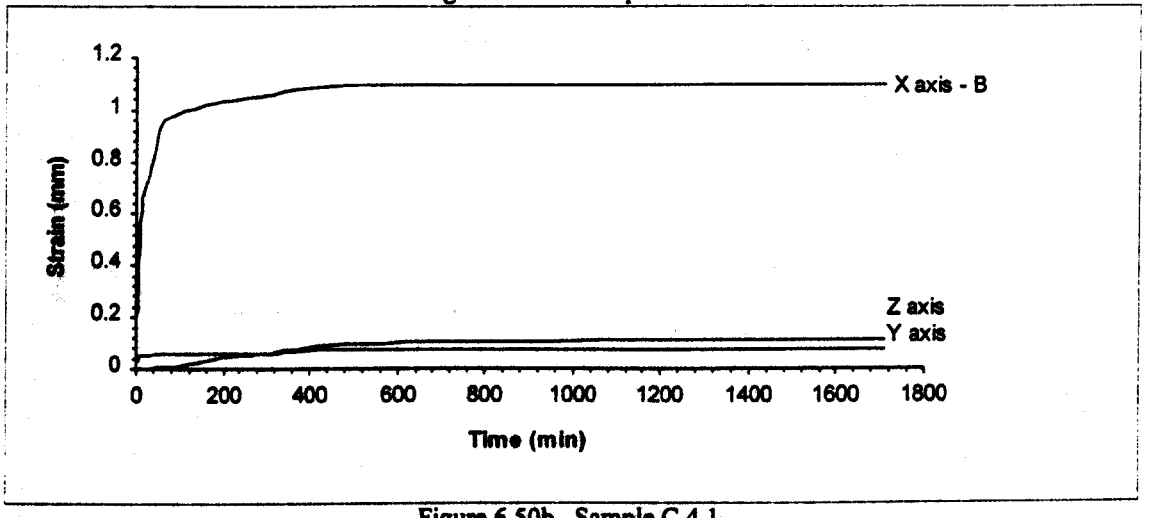


Figure 6.50b . Sample C.4.1.

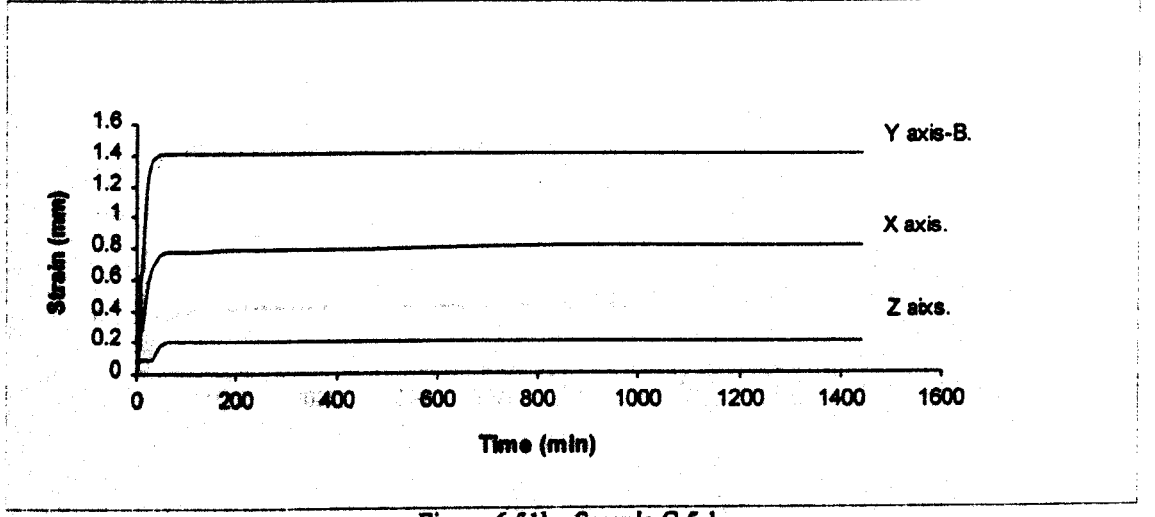


Figure 6.51b . Sample C.5.1.

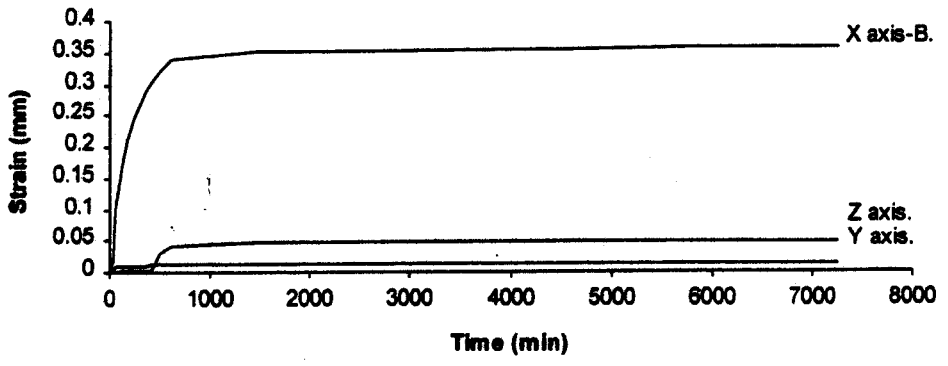


Figure 6.52b. Sample C.5.2.

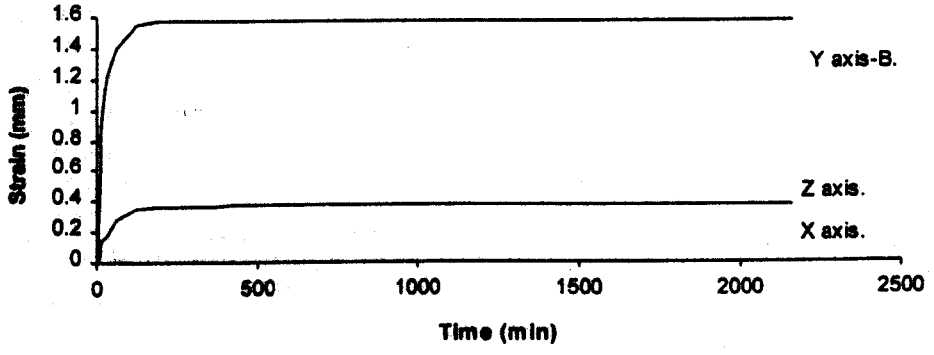


Figure 6.53b . Sample C.6.1.

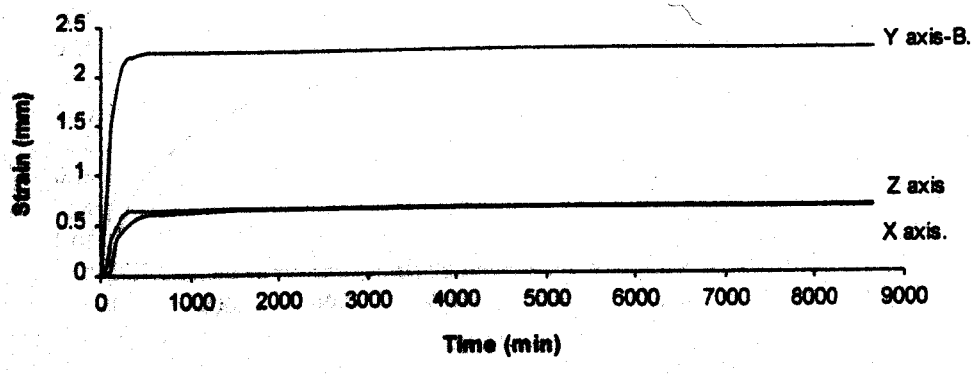


Figure 6.54b . Sample C.7.1.

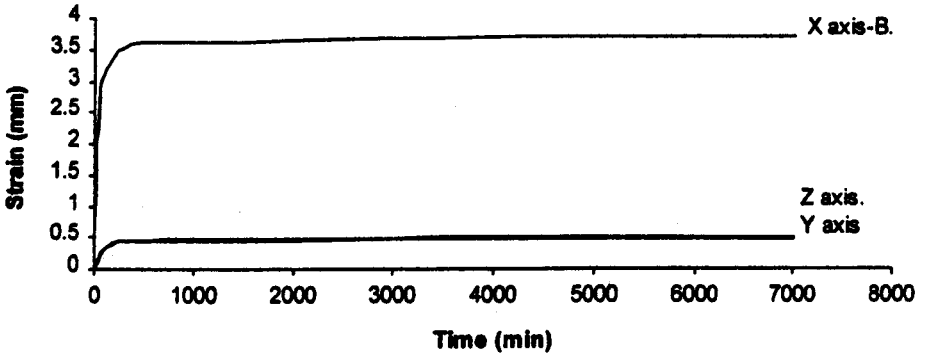


Figure 6.55b . Sample C.8.2.

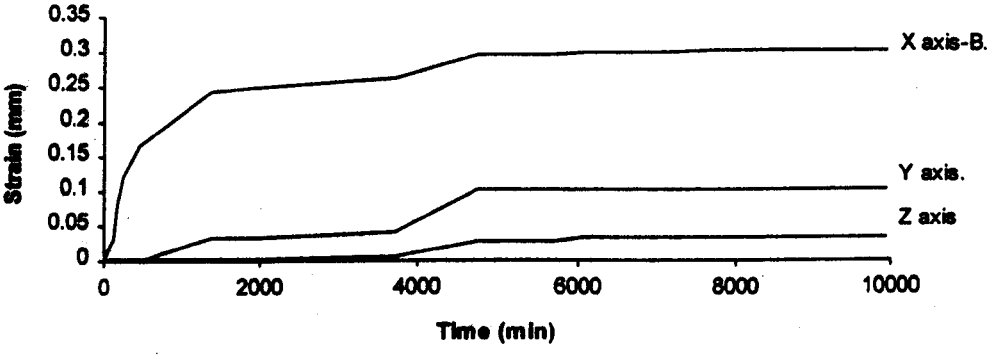


Figure 6.56b . Sample C.8.3.

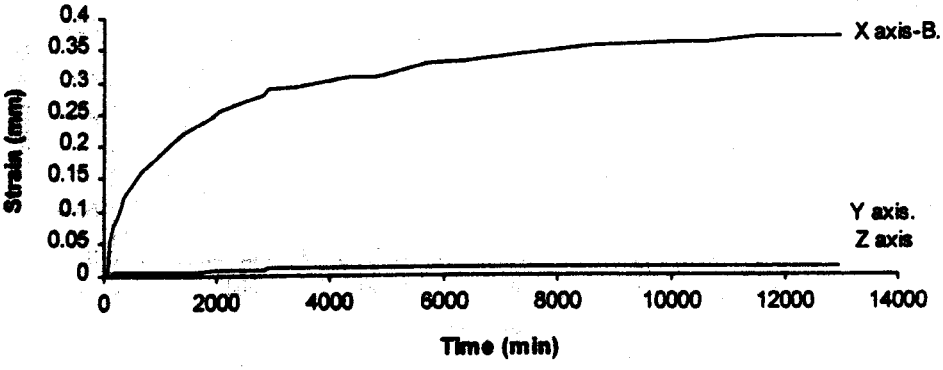


Figure 6.57b . Sample C.9.2.

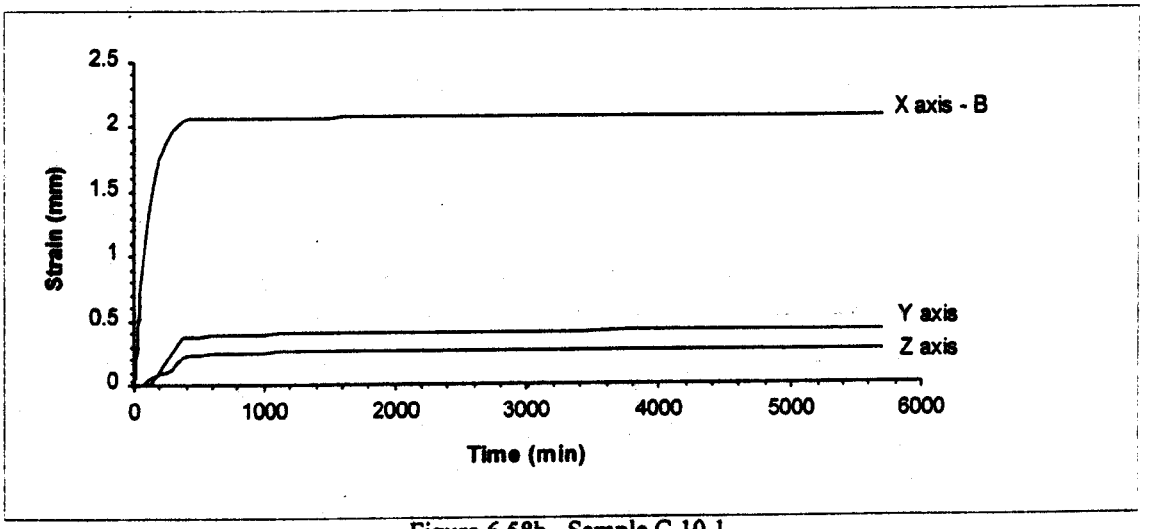


Figure 6.58b . Sample C.10.1.

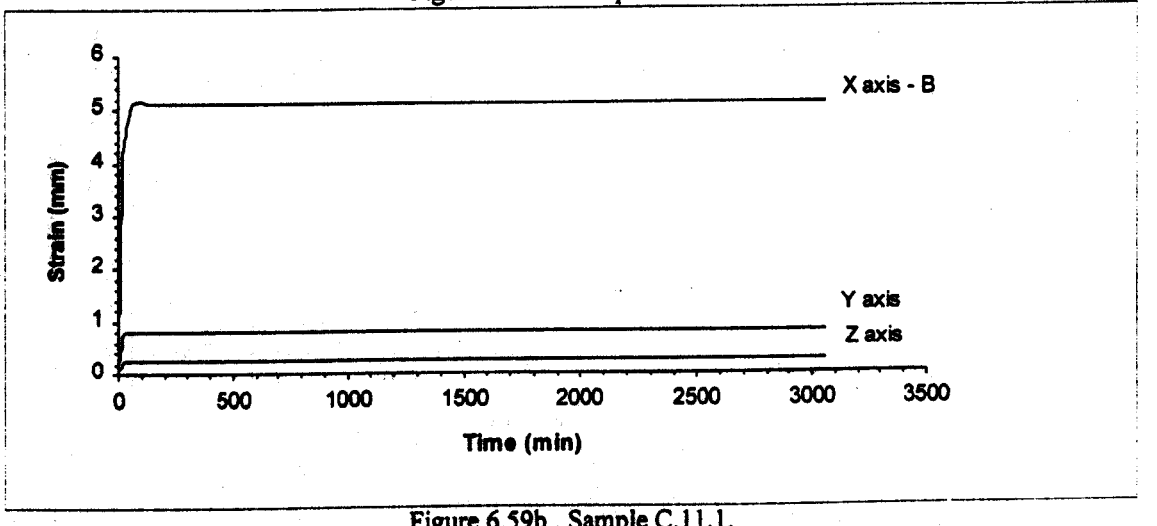


Figure 6.59b . Sample C.11.1.

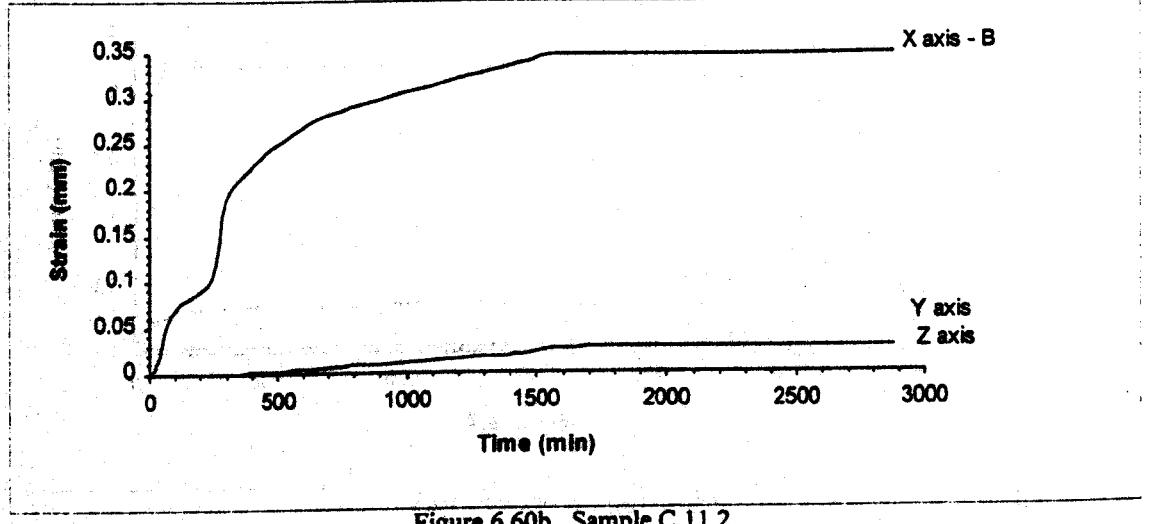


Figure 6.60b . Sample C.11.2.

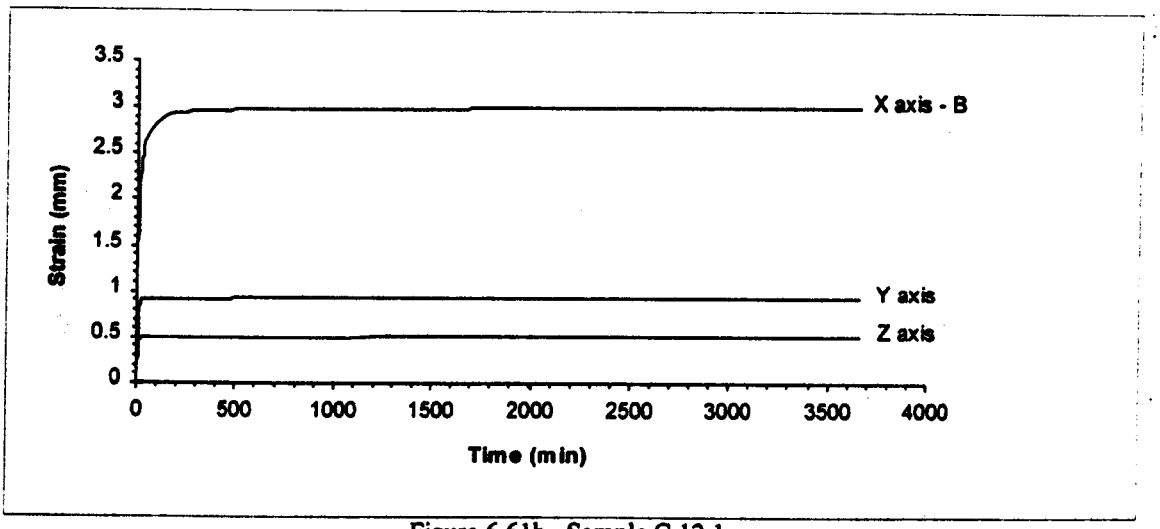


Figure 6.61b . Sample C.12.1.

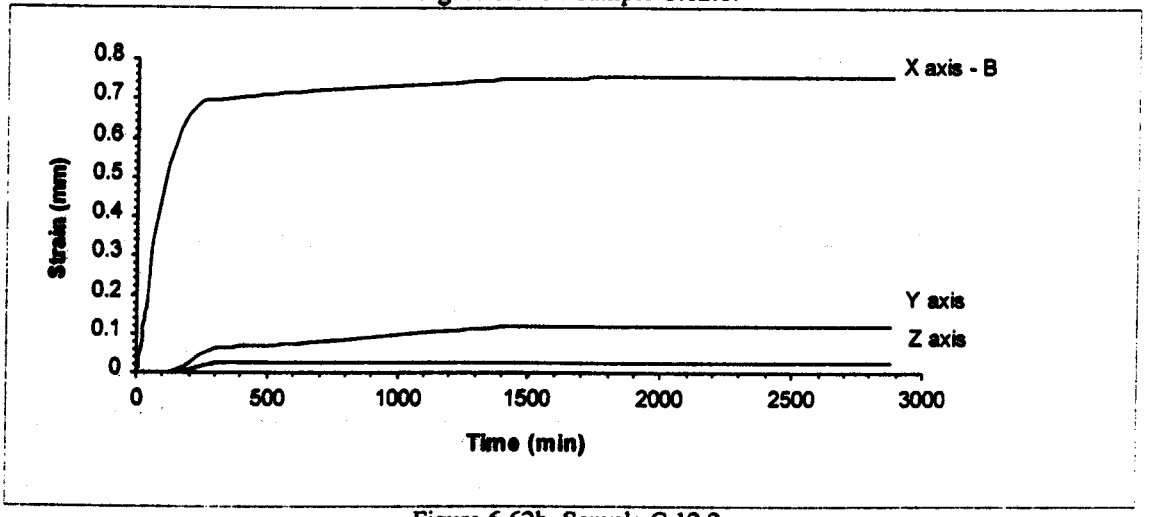


Figure 6.62b. Sample C.12.2.

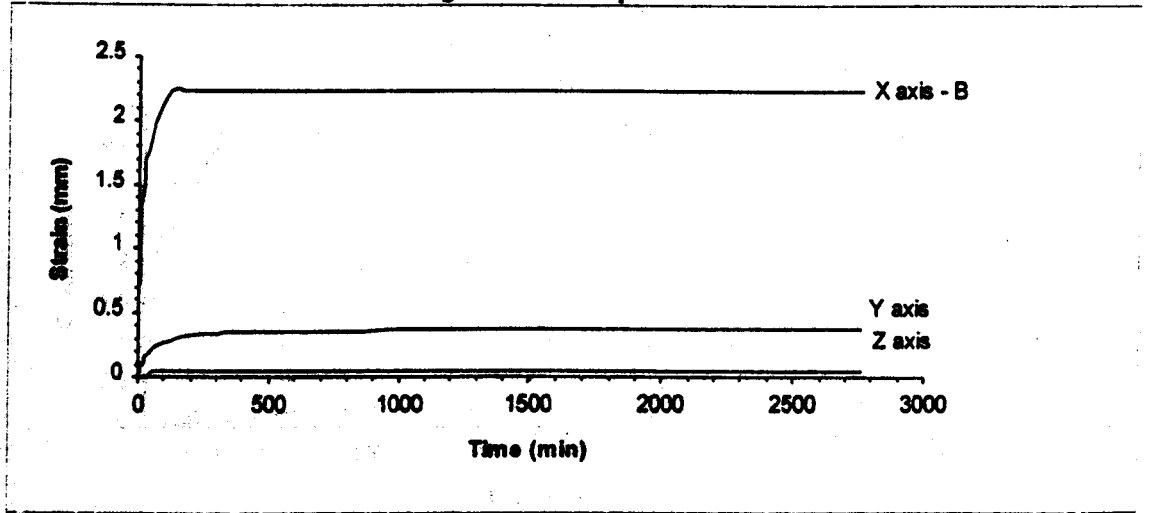


Figure 6.63b . Sample C.13.1.

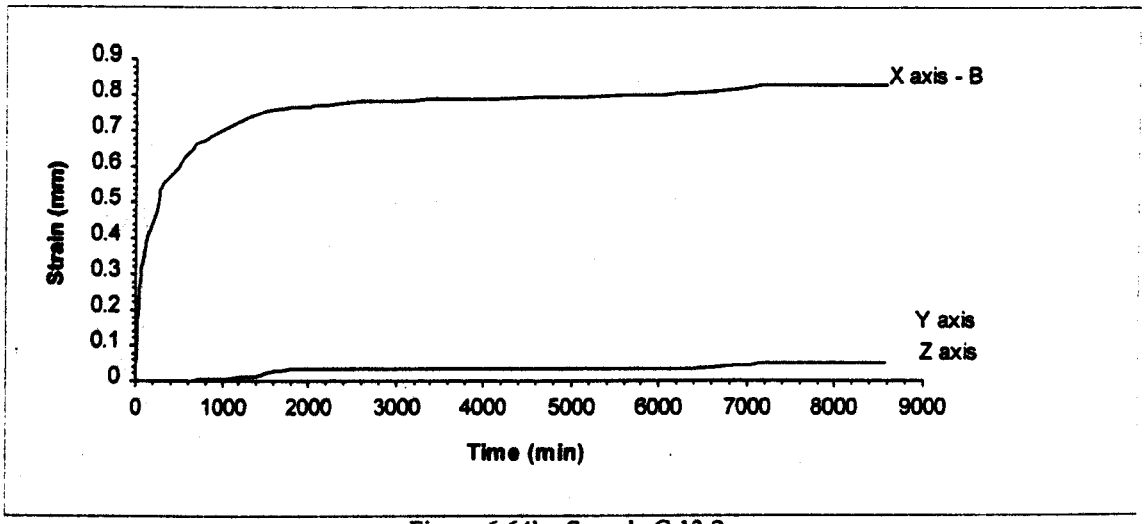


Figure 6.64b . Sample C.13.2.

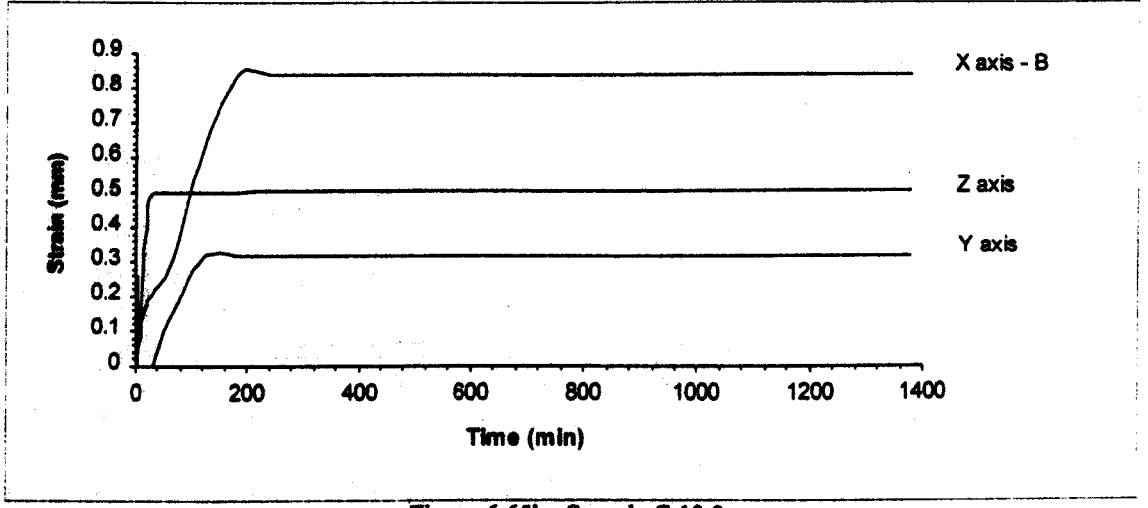


Figure 6.65b . Sample C.13.3.

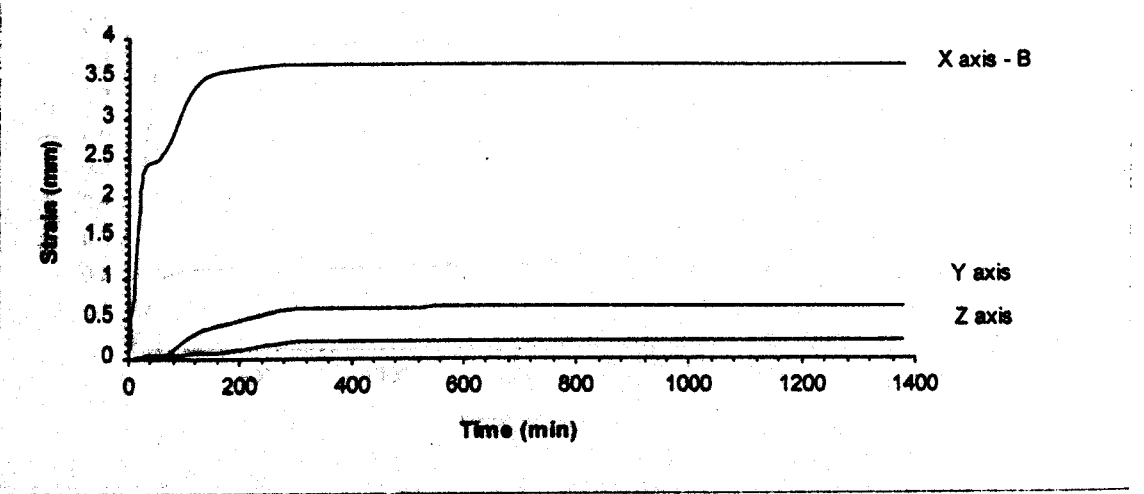


Figure 6.66b . Sample C.14.1.

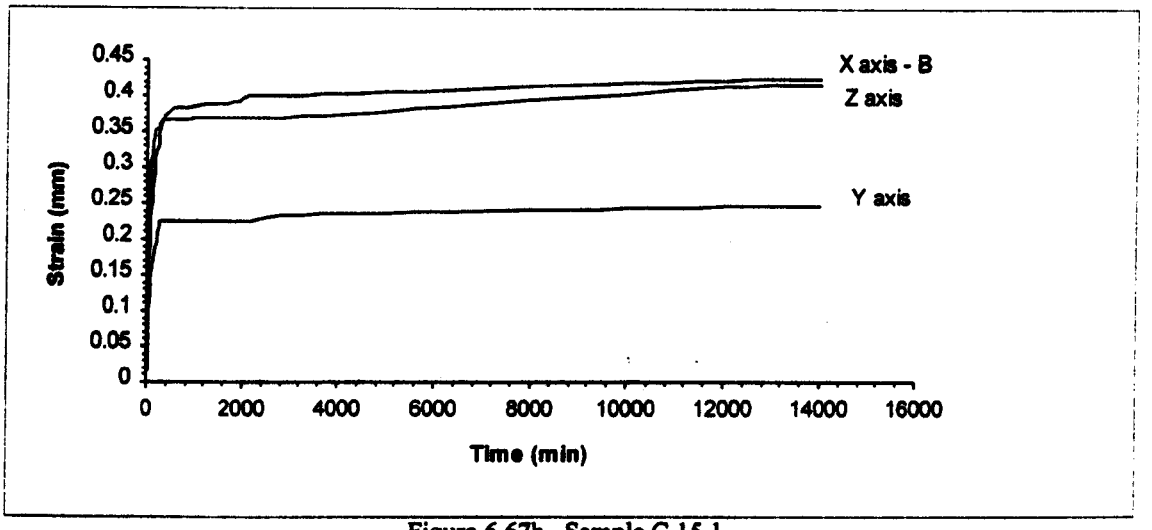


Figure 6.67b . Sample C.15.1.

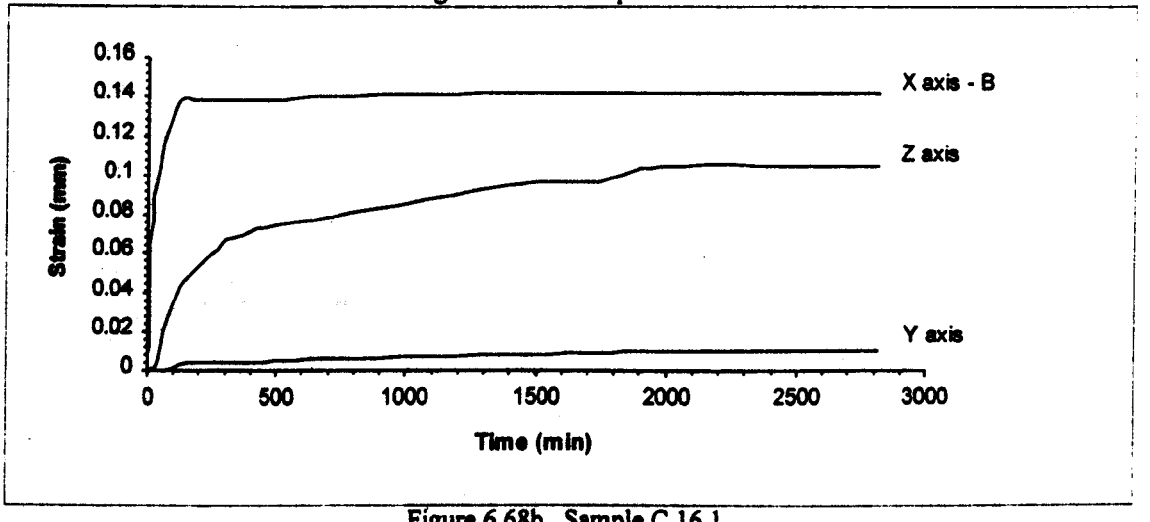


Figure 6.68b . Sample C.16.1.

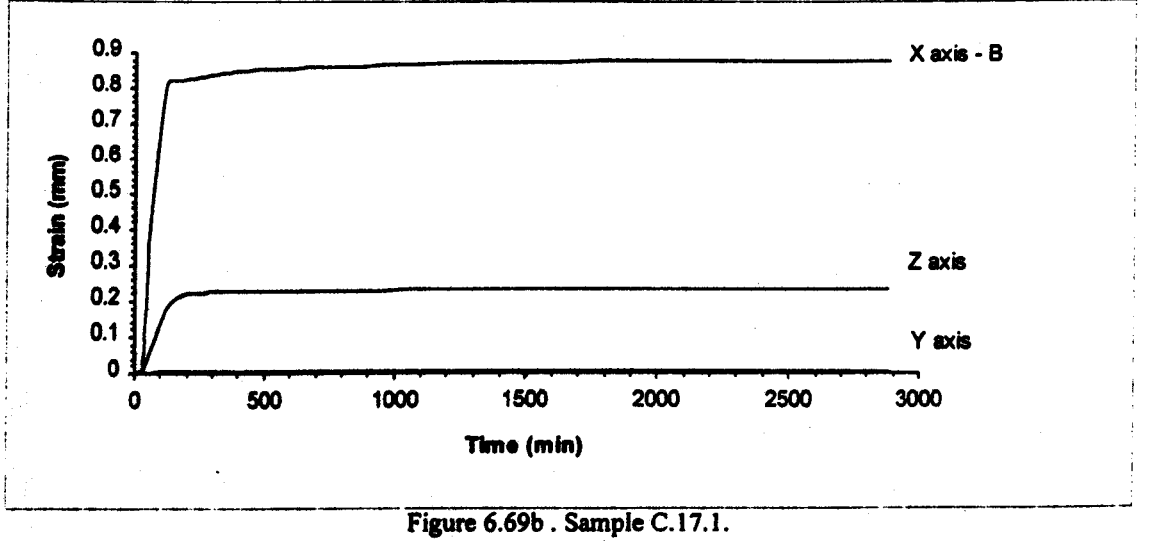


Figure 6.69b . Sample C.17.1.

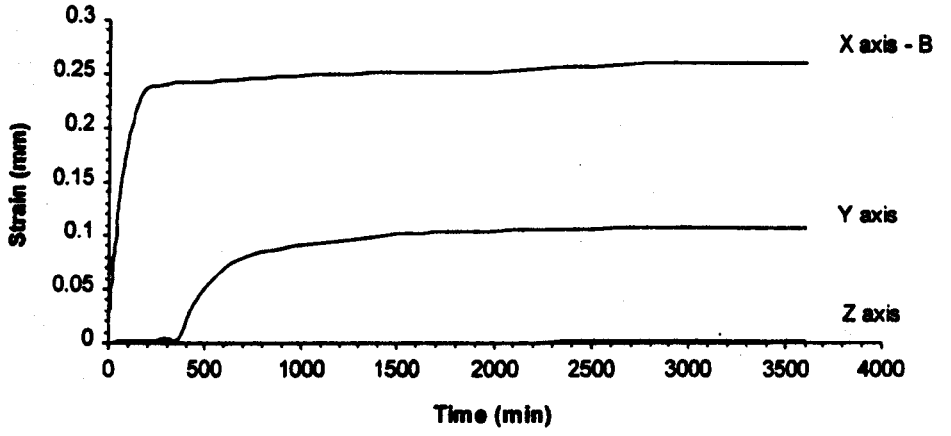


Figure 6.70b . Sample C.17.2.

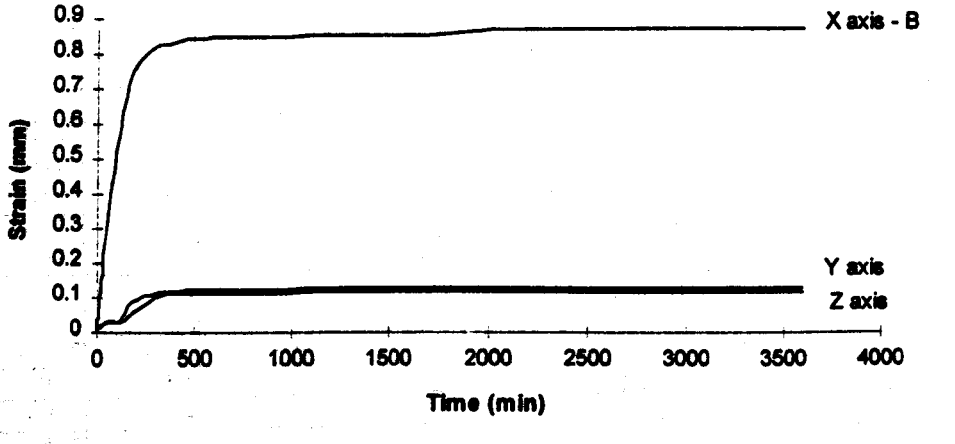


Figure 6.71b . Sample C.18.1.

APPENDIX C1 : Roof weathering experiment ICP-AES chemical data.

Natural Weathering.

C1B1-i (ppm)

	Al	Ca	Fe	Si
Sep-95	33.8	321.6	4857.7	15.5
Oct-95	13.6	161.5	1288.5	7.6
Nov-95	0.6	48.1	129.5	0.9
Dec-95	1.7	18.5	138.7	1.3
Jan-96	0.4	12.7	74.5	1.3
Mar-96	0.1	6.4	8.8	2.8
Jul-96	0.9	20.9	60.8	0.0

C1B1-ii (ppm)

	Al	Ca	Fe	Si
Sep-95	1.2	84.5	4.8	1.3
Oct-95	23.0	204.2	813.4	10.3
Nov-95	3.4	57.5	124.4	1.5
Dec-95	4.2	43.3	140.8	3.0
Jan-96	1.4	13.1	56.3	1.3
Mar-96	2.3	15.8	20.4	185.7
Jul-96	3.7	27.0	129.7	1.0

C1B1-iii (ppm)

	Al	Ca	Fe	Si
Sep-95	54.175	131.457	1360.28	14.56
Oct-95	28.33	96.5	1399	16.52
Nov-95	9.3	23.06	371.9	4.117
Dec-95	8.97	25.35	424.7	5.03
Jan-96	2.902	9.33	129.7	2.937
Mar-96	5.09	16.02	216.8	193.9
Jul-96	3.978	17.81	210.9	3.97

C1B1-iv (ppm)

	Al	Ca	Fe	Si
Sep-95	2.425	34.036	3.454	2.856
Oct-95	1.459	45.38	1.456	2.522
Nov-95	0.596	20.08	0.828	1.031
Dec-95	0.726	27.79	0.738	1.146
Jan-96	0.4325	6.03	1.016	0.76
Mar-96	0.501	8.51	0.471	31.97
Jul-96	0.0125	3.438	0.656	2.695

C1B1-v (ppm)

	Al	Ca	Fe	Si
Sep-95	5.03	95.58	46.54	2.716
Oct-95	1.327	41.54	57.6	2.009
Nov-95	1.167	35.98	35.92	0.983
Dec-95	0.3414	4.588	6.08	0.351
Jan-96	0.1571	2.431	2.524	0.3749
Mar-96	1.402	50.4	47.78	192.8
Jul-96	0.787	14.4	17.46	4.368

C1B1-Nat.(ppm)

	Al	Ca	Fe	Si
Sep-95	0.373	5.256	0.151	0.6548
Oct-95	0.0299	1.9203	0.014	0.5825
Nov-95	0.0447	4.087	0.0013	0.2749
Dec-95	0.1567	3.694	0.0027	0.4748
Jan-96	0.0593	2.176	0.0057	0.4535
Mar-96	0.097	4.025	0.0013	26.25
Jul-96	0.1192	5.56	0.2172	2.167

Assisted Weathering

C1B1-i (ppm)

	Al	Ca	Fe	Si
Aug-95	3.2	7.0	3.0	3.8
Sep-95	69.7	504.0	5957.0	35.5
Oct-95	19.7	137.0	1046.0	11.0
Nov-95	47.5	255.5	3194.0	22.4
Dec-95	10.9	519.0	71.5	5.1
Jan-96	2.4	11.6	67.0	2.0
Mar-96	10.2	43.6	119.3	9.4

C1B1-ii (ppm)

	Al	Ca	Fe	Si
Aug-95	1.08	13.04	3.75	1.06
Sep-95	59.66	269.99	2980.1	27.28
Oct-95	2.37	67.10	76.20	2.90
Nov-95	1.74	17.30	52.60	1.98
Dec-95	1.41	12.02	28.35	1.80
Jan-96	0.98	8.35	23.52	1.35
Mar-96	2.19	8.44	28.68	2.91

C1B1-iii (ppm)

	Al	Ca	Fe	Si
Aug-95	0.711	7.334	4.8997	0.834
Sep-95	9.9598	30.932	279.009	4.0758
Oct-95	3.656	27.41	318.8	4.915
Nov-95	4.284	20.63	261.5	2.168
Dec-95	2.179	6.1	107.9	2.216
Jan-96	2.981	26.73	208.8	3.938
Mar-96	0.699	6.85	18.58	1.684

C1B1-iv (ppm)

	Al	Ca	Fe	Si
Aug-95	3.106	22.04	2.3487	3.748
Sep-95	2.8328	20.1616	5.0573	3.7062
Oct-95	4.244	61.8	5.58	6.03
Nov-95	3.365	19.58	2.789	4.395
Dec-95	2.606	15.59	1.514	3.393
Jan-96	3.255	16.61	1.945	4.137
Mar-96	1.88	1.65	1.74	15.59

C1B1-v (ppm)

	Al	Ca	Fe	Si
Aug-95	1.9416	10.1326	48.6332	4.091
Sep-95	0.277	7.2118	11.3756	0.4204
Oct-95	0.813	43.48	18.12	1.023
Nov-95	19.77	50.95	64.3	32.9
Dec-95	0.957	5.965	8.395	1.6215
Jan-96	0.466	3.964	1.055	0.396
Mar-96	1.25	23.98	11.27	200.8

KEY

i = HCl treatment.

ii = HNO_3 treatment.

iii = Citric acid treatment.

iv = Calgon solution treatment.

v = EDTA treatment.

Nat.= Naturaly weathered sample.

Natural Weathering.

C21-i (ppm)

	Al	Ca	Fe	Si
Sep-95	77.25	888.09	803.24	79.37
Oct-95	60.60	810.00	3971.00	38.04
Nov-95	33.68	136.20	1098.00	14.20
Dec-95	36.99	80.70	946.00	31.93
Jan-96	16.60	22.38	271.20	29.25
Mar-96	2.68	5.96	45.19	3136.00
Jul-96	54.80	32.06	430.10	48.54

C21-ii (ppm)

	Al	Ca	Fe	Si
Sep-95	8.36	501.80	218.96	5.62
Oct-95	53.10	950.00	3439.00	35.46
Nov-95	16.93	105.30	851.00	9.43
Dec-95	23.34	709.00	54.20	19.74
Jan-96	12.93	20.60	359.70	28.23
Mar-96	29.31	21.94	453.90	144.80
Jul-96	42.21	15.39	378.70	63.50

C21-iii (ppm)

	Al	Ca	Fe	Si
Sep-95	641.34	761.63	5074.67	33.49
Oct-95	141.00	301.80	2208.00	37.67
Nov-95	154.80	195.80	1610.00	21.01
Dec-95	85.60	600.00	67.90	35.46
Jan-96	15.02	20.31	181.60	20.19
Mar-96	66.60	53.50	412.20	22.38
Jul-96	25.99	37.85	239.60	33.90

C21-iv (ppm)

	Al	Ca	Fe	Si
Sep-95	9.26	34.75	13.42	13.30
Oct-95	8.65	85.80	30.45	10.50
Nov-95	19.60	123.30	68.50	10.40
Dec-95	9.20	46.44	47.72	6.80
Jan-96	10.90	9.08	28.55	14.08
Mar-96	19.22	22.86	28.67	200.70
Jul-96	11.46	15.98	17.43	22.63

C21-Nat.(ppm)

	Al	Ca	Fe	Si
Sep-95	0.06	38.00	0.32	13.41
Oct-95	0.01	36.61	0.04	7.01
Nov-95	0.02	31.16	0.03	1.95
Dec-95	0.09	12.35	0.03	0.77
Jan-96	0.02	7.94	0.02	0.30
Mar-96	0.01	13.52	0.00	27.14
Jul-96	0.09	9.85	0.12	2.38

Assisted Weathering

C21-i (ppm)

	Al	Ca	Fe	Si
Aug-95	6.09	113.35	30.21	3.47
Sep-95	349.44	2325.57	10619.80	165.96
Oct-95	7.61	63.40	319.40	5.62
Nov-95	28.29	59.00	641.00	21.40
Dec-95	8.21	22.37	264.70	10.77
Jan-96	11.20	13.58	190.50	15.15
Mar-96	32.54	19.25	236.30	18.19

C21-ii (ppm)

	Al	Ca	Fe	Si
Aug-95	2.94	27.05	9.90	2.38
Sep-95	296.07	2620.46	9702.98	125.42
Oct-95	121.80	736.00	5060.00	54.80
Nov-95	177.40	326.80	4145.00	84.40
Dec-95	92.20	85.40	1874.00	37.67
Jan-96	89.50	55.70	1405.00	54.50
Mar-96	211.80	54.48	1482.00	60.51

C21-iii (ppm)

	Al	Ca	Fe	Si
Aug-95	344.05	1801.82	3666.81	164.70
Sep-95	92.93	242.03	1179.60	26.87
Oct-95	24.99	101.80	442.10	19.69
Nov-95	17.87	29.10	174.40	5.31
Dec-95	9.67	15.30	100.80	10.40
Jan-96	1.38	7.18	23.72	6.06
Mar-96	5.68	18.98	68.30	6.64

C21-iv (ppm)

	Al	Ca	Fe	Si
Aug-95	3.67	9.07	7.34	4.57
Sep-95	27.51	694.72	140.69	17.84
Oct-95	21.05	367.20	70.70	14.94
Nov-95	8.43	58.50	31.90	5.94
Dec-95	8.15	18.44	22.83	10.11
Jan-96	5.17	23.40	12.10	6.23
Mar-96	12.75	81.80	13.56	206.20

KEY

i = HCl treatment.

ii = HNO_3 treatment.

iii = Citric acid treatment.

iv = Calgon solution treatment.

v = EDTA treatment.

Nat.= Naturaly weathered sample.

Natural Weathering.

C31-i (ppm)

	Al	Ca	Fe	Si
Sep-95	0.50	60.74	62.20	0.66
Oct-95	3.37	120.40	613.00	10.10
Nov-95	0.60	51.00	308.90	1.34
Dec-95	1.63	38.51	487.60	4.16
Jan-96	0.08	1.99	18.24	2.68
Mar-96	0.13	5.47	34.59	174.00
Jul-96	0.77	8.44	84.30	1.35

C31-ii (ppm)

	Al	Ca	Fe	Si
Sep-95	5.19	762.96	154.28	0.60
Oct-95	24.96	724.00	3194.00	13.66
Nov-95	8.75	226.40	1435.00	3.82
Dec-95	6.86	77.40	1134.00	4.82
Jan-96	0.89	16.47	193.60	1.76
Mar-96	1.25	13.76	159.30	3266.00
Jul-96	3.20	39.62	412.10	3.47

C31-iii (ppm)

	Al	Ca	Fe	Si
Sep-95	38.41	188.30	2038.10	9.93
Oct-95	19.35	135.90	1835.00	11.25
Nov-95	7.49	76.00	1063.00	5.68
Dec-95	5.17	37.23	677.00	5.55
Jan-96	0.76	8.71	116.00	2.82
Mar-96	2.61	23.85	444.60	6.95
Jul-96	2.69	32.68	518.00	6.94

C31-iv (ppm)

	Al	Ca	Fe	Si
Sep-95	6.71	58.02	8.57	7.48
Oct-95	1.46	138.00	16.34	2.72
Nov-95	1.38	34.19	7.16	1.94
Dec-95	0.96	41.40	8.93	1.55
Jan-96	1.01	10.51	4.55	1.82
Mar-96	0.86	18.37	4.70	4.67
Jul-96	0.86	12.16	4.99	8.73

C31-v (ppm)

	Al	Ca	Fe	Si
Sep-95	2.11	1.54	1.05	3.60
Oct-95	1.86	139.10	518.00	5.10
Nov-95	0.72	58.00	167.30	1.47
Dec-95	0.71	38.53	154.60	1.51
Jan-96	0.40	6.33	68.80	1.07
Mar-96	2.02	82.40	282.00	186.10
Jul-96	0.94	20.79	127.50	3.99

C31-Nat.(ppm)

	Al	Ca	Fe	Si
Sep-95	1.84	5.46	0.36	5.55
Oct-95	0.07	9.16	0.06	2.36
Nov-95	0.01	8.59	0.02	2.00
Dec-95	0.05	1.88	0.01	1.53
Jan-96	0.17	17.60	0.07	1.38
Mar-96	0.03	6.73	0.04	46.56
Jul-96	0.39	2.47	1.70	0.61

Assisted Weathering

C31-i (ppm)

	Al	Ca	Fe	Si
Aug-95	0.90	15.31	7.98	1.90
Sep-95	58.22	938.94	5598.16	42.27
Oct-95	17.70	431.90	2957.00	18.92
Nov-95	42.55	536.00	6030.00	30.58
Dec-95	1.03	6.74	64.70	2.49
Jan-96	35.41	429.60	4435.00	28.89
Mar-96	3.15	23.06	173.60	5.44

C31-ii (ppm)

	Al	Ca	Fe	Si
Aug-95	1.96	8.76	9.85	2.05
Sep-95	0.25	197.64	55.12	1.56
Oct-95	4.03	82.50	819.00	3.90
Nov-95	14.16	137.30	2528.00	9.91
Dec-95	2.19	15.51	273.90	2.98
Jan-96	18.56	181.00	2705.00	13.59
Mar-96	9.60	73.40	870.00	4.88

C31-iii (ppm)

	Al	Ca	Fe	Si
Aug-95	0.88	10.56	8.62	1.42
Sep-95	4.18	29.42	278.20	3.40
Oct-95	2.32	75.30	564.00	8.70
Nov-95	1.45	19.21	219.50	2.21
Dec-95	0.36	5.34	61.80	1.45
Jan-96	0.11	3.53	26.80	1.20
Mar-96	6.44	8.11	89.70	37.34

C31-iv (ppm)

	Al	Ca	Fe	Si
Aug-95	3.11	6.08	2.37	3.76
Sep-95	5.28	29.16	13.06	7.42
Oct-95	4.06	123.50	9.35	5.08
Nov-95	3.31	17.03	7.61	4.27
Dec-95	2.28	10.33	5.78	2.99
Jan-96	2.64	6.02	5.58	3.72
Mar-96	1.77	6.69	3.34	17.45

C31-v (ppm)

	Al	Ca	Fe	Si
Aug-95	0.70	3.51	7.06	0.86
Sep-95	17.66	564.88	1171.92	18.89
Oct-95	0.59	49.51	48.96	1.03
Nov-95	0.72	32.99	66.80	1.31
Dec-95	0.18	9.84	41.89	0.60
Jan-96	0.09	8.09	17.66	0.58
Mar-96	0.13	2.82	20.81	158.50

KEY

i = HCl treatment.

ii = HNO_3 treatment.

iii = Citric acid treatment.

iv = Calgon solution treatment.

v = EDTA treatment.

Nat.= Naturaly weathered sample.

Natural Weathering.

C83-i (ppm)

	Al	Ca	Fe	Si
Sep-95	2.27	589.31	172.23	3.63
Oct-95	24.84	452.40	983.00	15.17
Nov-95	17.49	227.40	509.00	5.12
Dec-95	24.18	12.62	567.00	14.09
Jan-96	7.21	87.20	312.40	9.34
Mar-96	1.25	23.25	110.70	4128.00
Jul-96	21.22	329.10	1249.00	19.88

C83-ii (ppm)

	Al	Ca	Fe	Si
Sep-95	3.16	299.34	23.07	3.90
Oct-95	5.90	278.30	724.00	5.27
Nov-95	3.64	259.30	317.20	1.92
Dec-95	3.07	133.40	283.50	3.45
Jan-96	2.00	56.50	129.20	2.56
Mar-96	1.07	47.35	133.30	162.40
Jul-96	6.81	71.00	331.50	5.00

C83-iii (ppm)

	Al	Ca	Fe	Si
Sep-95	57.47	126.59	1195.14	16.89
Oct-95	75.10	208.40	2203.00	21.92
Nov-95	60.70	130.40	1393.00	11.98
Dec-95	37.68	104.20	1146.00	17.47
Jan-96	7.11	23.91	276.20	7.76
Mar-96	6.67	23.36	257.20	9.12
Jul-96	16.43	35.45	347.00	14.84

C83-iv (ppm)

	Al	Ca	Fe	Si
Sep-95	17.51	11.13	31.81	21.67
Oct-95	19.74	24.34	21.37	31.96
Nov-95	13.03	21.74	16.64	17.58
Dec-95	3.75	25.19	14.46	4.49
Jan-96	9.47	13.31	12.36	13.87
Mar-96	17.28	14.21	12.11	49.61
Jul-96	4.93	16.70	9.13	15.57

C83-Nat.(ppm)

	Al	Ca	Fe	Si
Sep-95	0.14	11.44	0.08	1.28
Oct-95	0.13	5.57	0.13	0.75
Nov-95	0.01	6.61	0.02	0.47
Dec-95	0.05	6.46	0.01	1.84
Jan-96	0.02	3.09	0.01	0.19
Mar-96	0.01	5.35	0.01	29.80
Jul-96	0.12	9.13	0.17	2.33

Assisted Weathering

C83-i (ppm)

	Al	Ca	Fe	Si
Aug-95	8.69	19.90	24.63	10.04
Sep-95	63.07	393.66	1018.48	31.08
Oct-95	14.24	112.50	307.30	12.42
Nov-95	6.23	99.90	205.00	8.08
Dec-95	5.83	46.04	177.90	7.47
Jan-96	8.92	19.02	76.80	7.89
Mar-96	4.96	22.03	102.40	6.33

C83-ii (ppm)

	Al	Ca	Fe	Si
Aug-95	15.14	37.15	46.73	17.53
Sep-95	187.66	1524.26	8869.09	107.83
Oct-95	14.11	117.60	460.60	14.66
Nov-95	2.51	43.70	56.70	2.54
Dec-95	2.70	33.62	70.70	3.54
Jan-96	2.67	15.94	42.67	3.56
Mar-96	18.33	50.90	134.70	18.98

C83-iii (ppm)

	Al	Ca	Fe	Si
Aug-95	4.59	10.04	17.93	5.48
Sep-95	61.76	213.88	1215.83	33.36
Oct-95	16.88	87.30	409.60	13.87
Nov-95	32.20	168.40	987.00	20.52
Dec-95	3.09	14.59	104.10	2.90
Jan-96	3.28	27.19	199.20	5.96
Mar-96	4.60	21.89	144.80	5.83

C83-iv (ppm)

	Al	Ca	Fe	Si
Aug-95	3.16	7.74	3.52	3.92
Sep-95	11.39	14.14	21.41	15.23
Oct-95	4.23	12.90	6.84	5.94
Nov-95	4.19	17.47	7.02	4.93
Dec-95	3.27	10.87	9.75	3.72
Jan-96	4.80	15.68	14.34	5.81
Mar-96	1.89	21.54	5.97	19.44

KEY

i = HCl treatment.
ii = HNO_3 treatment.
iii = Citric acid treatment.
iv = Calgon solution treatment.
v = EDTA treatment.
Nat.= Naturaly weathered sample.

Natural Weathering.

C92-I (ppm)

	Al	Ca	Fe	Si
Sep-95	1.73	183.48	843.85	0.79
Oct-95	3.91	202.40	1668.00	2.82
Nov-95	1.69	86.40	710.00	1.35
Dec-95	2.03	89.40	1093.00	2.28
Jan-96	0.89	32.52	355.90	1.13
Mar-96	0.88	46.38	510.00	155.10
Jul-96	2.84	53.10	631.00	1.44

C92-II (ppm)

	Al	Ca	Fe	Si
Sep-95	1.82	122.01	155.97	0.29
Oct-95	1.80	131.90	971.00	1.15
Nov-95	2.31	121.40	940.00	1.54
Dec-95	1.49	91.50	885.00	1.40
Jan-96	0.63	28.06	280.90	0.72
Mar-96	0.82	26.96	259.40	1.96
Jul-96	1.60	34.03	388.00	0.01

C92-III (ppm)

	Al	Ca	Fe	Si
Sep-95	0.31	10.11	11.88	0.86
Oct-95	6.76	67.40	681.00	3.06
Nov-95	3.89	41.66	421.20	1.93
Dec-95	7.21	89.30	1334.00	5.13
Jan-96	0.94	11.30	106.80	0.99
Mar-96	1.58	15.86	189.90	5.20
Jul-96	4.18	41.77	450.40	3.26

C92-Iv (ppm)

	Al	Ca	Fe	Si
Sep-95	2.98	15.67	6.41	3.38
Oct-95	1.31	37.60	5.22	2.25
Nov-95	0.91	16.02	2.58	1.37
Dec-95	0.73	14.95	2.03	1.19
Jan-96	0.50	6.27	2.57	0.85
Mar-96	0.66	16.41	2.26	29.06
Jul-96	0.52	12.29	3.48	8.07

C92-Nat.(ppm)

	Al	Ca	Fe	Si
Sep-95	0.23	7.14	0.11	0.39
Oct-95	0.13	5.29	0.01	0.50
Nov-95	0.13	7.41	0.00	0.53
Dec-95	0.20	6.02	0.00	0.56
Jan-96	0.17	3.69	0.01	0.35
Mar-96	0.15	7.08	0.00	25.02
Jul-96	0.08	7.07	0.32	2.26

Assisted Weathering

C92-I (ppm)

	Al	Ca	Fe	Si
Aug-95	73.32	1555.91	26210.30	53.80
Sep-95	35.25	881.68	11597.30	25.64
Oct-95	0.98	22.54	219.00	1.59
Nov-95	1.04	31.47	277.10	1.68
Dec-95	1.25	23.73	133.20	2.76
Jan-96	1.09	14.63	99.10	1.75
Mar-96	4.49	39.66	408.40	7.77

C92-II (ppm)

	Al	Ca	Fe	Si
Aug-95	35.94	924.48	14856.10	19.63
Sep-95	9.33	162.79	1957.12	4.29
Oct-95	0.82	114.90	239.30	2.30
Nov-95	1.26	65.90	486.70	1.53
Dec-95	1.04	53.60	404.00	1.40
Jan-96	0.99	23.11	206.80	1.41
Mar-96	4.08	35.72	368.70	4.23

C92-III (ppm)

	Al	Ca	Fe	Si
Aug-95	1.13	11.69	12.13	1.25
Sep-95	0.03	4.65	0.13	0.38
Oct-95	3.45	52.00	317.90	4.33
Nov-95	1.21	19.66	108.50	1.50
Dec-95	2.93	69.60	481.70	3.37
Jan-96	0.28	4.70	26.61	1.15
Mar-96	29.20	576.00	3381.00	34.86

C92-Iv (ppm)

	Al	Ca	Fe	Si
Aug-95	3.15	6.81	4.19	3.79
Sep-95	2.56	38.96	6.18	3.24
Oct-95	3.20	36.77	6.69	4.80
Nov-95	3.94	22.18	3.69	4.66
Dec-95	2.59	19.59	3.00	3.33
Jan-96	2.58	8.83	2.23	3.37
Mar-96	2.35	11.19	3.00	20.62

KEY

i = HCl treatment.

ii = HNO_3 treatment.

iii = Citric acid treatment.

iv = Calgon solution treatment.

v = EDTA treatment.

Nat.= Naturaly weathered sample.

Natural Weathering.

C133-i (ppm)

	Al	Ca	Fe	Si
Sep-95	148.52	232.22	119.13	13.20
Oct-95	28.70	64.30	40.43	34.99
Nov-95	36.12	13.96	22.50	5.67
Dec-95	3.50	2.02	2.58	8.37
Jan-96	10.54	3.61	6.05	21.67
Mar-96	9.03	4.04	6.12	51.40
Jul-96	4.81	2.69	6.95	31.62

C133-ii (ppm)

	Al	Ca	Fe	Si
Sep-95	247.27	310.24	177.98	18.89
Oct-95	238.60	1115.00	1717.00	82.60
Nov-95	22.99	18.00	32.15	14.90
Dec-95	4.41	3.21	5.53	24.19
Jan-96	5.55	2.80	6.74	14.24
Mar-96	2.98	3.02	3.22	10.51
Jul-96	2.65	1.75	3.15	19.56

C133-iii (ppm)

	Al	Ca	Fe	Si
Sep-95	176.94	162.70	282.95	22.65
Oct-95	20.30	61.70	37.70	42.02
Nov-95	3.06	12.11	30.03	11.00
Dec-95	1.53	8.34	13.98	10.18
Jan-96	0.43	2.60	2.70	6.57
Mar-96	0.13	4.46	5.77	133.00
Jul-96	1.05	7.64	8.04	7.04

C133-iv (ppm)

	Al	Ca	Fe	Si
Sep-95	69.35	52.18	41.18	39.76
Oct-95	43.38	96.70	57.60	19.64
Nov-95	164.60	67.00	55.70	176.70
Dec-95	145.90	18.80	32.21	165.40
Jan-96	595.00	6.72	64.90	718.00
Mar-96	919.00	10.04	89.20	766.00
Jul-96	125.70	20.66	19.81	212.40

C133-Nat.(ppm)

	Al	Ca	Fe	Si
Sep-95	1.08	53.92	1.43	3.38
Oct-95	0.16	17.63	0.05	2.15
Nov-95	0.28	13.93	0.12	1.72
Dec-95	0.03	7.73	0.03	1.63
Jan-96	0.25	4.62	0.09	0.81
Mar-96	0.25	7.36	0.11	23.96
Jul-96	0.06	3.77	1.03	4.11

Assisted Weathering

C133-i (ppm)

	Al	Ca	Fe	Si
Aug-95	2.44	9.11	3.65	2.11
Sep-95	141.92	247.24	127.20	14.38
Oct-95	476.60	163.90	270.40	42.44
Nov-95	217.60	77.10	122.20	32.64
Dec-95	61.80	19.05	32.75	17.09
Jan-96	86.50	27.02	52.70	23.84
Mar-96	111.40	45.49	75.60	23.17

C133-ii (ppm)

	Al	Ca	Fe	Si
Aug-95	11.39	54.58	8.52	2.70
Sep-95	251.59	281.59	290.09	37.39
Oct-95	206.00	94.30	246.30	18.22
Nov-95	118.80	40.93	143.00	21.05
Dec-95	73.40	21.54	84.60	14.82
Jan-96	35.94	17.10	42.47	15.89
Mar-96	77.70	34.21	81.10	15.74

C133-iii (ppm)

	Al	Ca	Fe	Si
Aug-95	0.80	4.63	1.67	0.89
Sep-95	64.04	94.68	87.75	32.86
Oct-95	12.69	48.46	42.75	30.15
Nov-95	2.56	18.60	10.66	4.73
Dec-95	3.79	30.89	21.63	6.95
Jan-96	3.10	20.21	7.58	5.77
Mar-96	0.89	13.65	2.71	1.74

C133-iv (ppm)

	Al	Ca	Fe	Si
Aug-95	3.26	8.89	2.80	3.68
Sep-95	81.05	423.47	133.16	32.21
Oct-95	42.89	296.20	55.00	4.62
Nov-95	45.50	25.16	12.16	52.00
Dec-95	8.79	9.30	7.08	9.29
Jan-96	5.34	14.81	4.82	4.36
Mar-96	58.80	147.70	15.73	251.80

KEY

i = HCl treatment.

ii = HNO_3 treatment.

iii = Citric acid treatment.

iv = Calgon solution treatment.

v = EDTA treatment.

Nat.= Naturaly weethered sample.

Natural Weathering.

C141-I (ppm)

	Al	Ca	Fe	Si
Sep-95	156.72	1906.01	527.92	13.93
Oct-95	180.50	114.80	2277.00	50.00
Nov-95	167.30	379.40	2215.00	26.56
Dec-95	86.60	98.50	1250.00	39.73
Jan-96	62.60	59.30	904.00	49.20
Mar-96	24.27	10.54	219.10	2679.00
Jul-96	112.80	35.33	631.00	76.70

C141-II (ppm)

	Al	Ca	Fe	Si
Sep-95	253.16	2124.31	210.78	16.34
Oct-95	140.70	184.80	246.10	42.32
Nov-95	68.40	192.20	887.00	27.91
Dec-95	164.20	80.70	868.00	59.20
Jan-96	42.08	12.98	340.90	51.60
Mar-96	42.02	17.90	9.97	334.20
Jul-96	139.70	11.44	455.00	106.30

C141-III (ppm)

	Al	Ca	Fe	Si
Sep-95	777.96	869.32	4669.05	47.31
Oct-95	454.20	424.40	2783.00	82.10
Nov-95	859.00	467.70	3799.00	74.50
Dec-95	335.00	1435.00	133.60	75.90
Jan-96	39.95	30.79	313.30	37.80
Mar-96	84.50	37.75	327.40	27.65
Jul-96	113.40	54.70	317.80	69.80

C141-Iv (ppm)

	Al	Ca	Fe	Si
Sep-95	395.63	38.75	103.93	546.75
Oct-95	214.80	53.40	53.50	368.40
Nov-95	43.45	31.37	12.66	64.00
Dec-95	14.67	45.86	15.13	18.02
Jan-96	2114.00	139.60	390.90	3253.00
Mar-96	**	**	**	**
Jul-96	**	**	**	**

C141-v (ppm)

	Al	Ca	Fe	Si
Sep-95	0.21	39.36	0.24	0.92
Oct-95	1.25	267.00	557.00	1.88
Nov-95	3.68	209.30	384.80	2.73
Dec-95	30.47	42.85	140.90	43.36
Jan-96	126.20	19.67	62.60	195.30
Mar-96	38.31	30.69	86.00	211.40
Jul-96	4.74	23.45	57.10	11.36

C141-Nat.(ppm)

	Al	Ca	Fe	Si
Sep-95	0.04	10.93	0.05	72.32
Oct-95	0.01	14.60	0.04	2.59
Nov-95	0.01	9.14	0.01	1.76
Dec-95	0.37	9.70	0.16	0.86
Jan-96	0.20	7.10	0.07	0.72
Mar-96	0.05	19.85	0.04	25.68
Jul-96	0.05	5.50	0.10	1.73

Assisted Weathering

C141-I (ppm)

	Al	Ca	Fe	Si
Aug-95	7.82	30.58	17.12	7.43
Sep-95	591.40	2718.10	5388.50	183.70
Oct-95	232.25	1155.50	2357.00	90.65
Nov-95	293.60	301.30	3835.00	97.80
Dec-95	255.80	211.60	3270.00	64.20
Jan-96	216.60	103.70	2564.00	66.20
Mar-96	500.00	154.20	3468.00	79.70

C141-II (ppm)

	Al	Ca	Fe	Si
Aug-95	*	*	*	*
Sep-95	116.02	491.92	319.51	22.50
Oct-95	543.00	1228.00	4414.00	143.10
Nov-95	564.00	266.20	3566.00	520.00
Dec-95	252.70	64.30	1860.00	50.10
Jan-96	217.50	18.39	1147.00	46.56
Mar-96	267.00	20.69	774.00	24.23

C141-III (ppm)

	Al	Ca	Fe	Si
Aug-95	27.78	15.72	44.52	36.51
Sep-95	326.90	504.45	1907.38	85.23
Oct-95	613.00	517.00	3203.00	105.10
Nov-95	84.50	55.80	390.00	15.43
Dec-95	30.60	22.19	177.00	13.30
Jan-96	5.51	7.63	25.93	12.77
Mar-96	26.16	21.27	76.60	23.45

C141-Iv (ppm)

	Al	Ca	Fe	Si
Aug-95	3.02	23.31	2.49	3.71
Sep-95	5.25	90.95	8.97	5.94
Oct-95	16.45	376.30	39.86	9.45
Nov-95	19.09	41.45	11.52	26.61
Dec-95	129.50	25.19	33.81	209.90
Jan-96	16.21	131.30	19.87	20.90
Mar-96	**	**	**	**

C141-v (ppm)

	Al	Ca	Fe	Si
Aug-95	10.68	9.90	18.76	14.81
Sep-95	33.84	676.87	1033.80	13.93
Oct-95	18.17	82.70	144.80	16.46
Nov-95	12.01	70.50	60.60	16.38
Dec-95	4.20	33.60	25.84	5.25
Jan-96	1.95	63.40	19.44	2.09
Mar-96	1853.00	56.50	462.80	2205.00

KEY

i = HCl treatment.

ii = HNO_3 treatment.

iii = Citric acid treatment.

iv = Calgon solution treatment.

v = EDTA treatment.

Nat.= Naturaly weathered sample.

* = No sample obtained for analysis.

** = Sample removed from testing.

APPENDIX C2: Roof weathering experiment ICP-AES data plots .

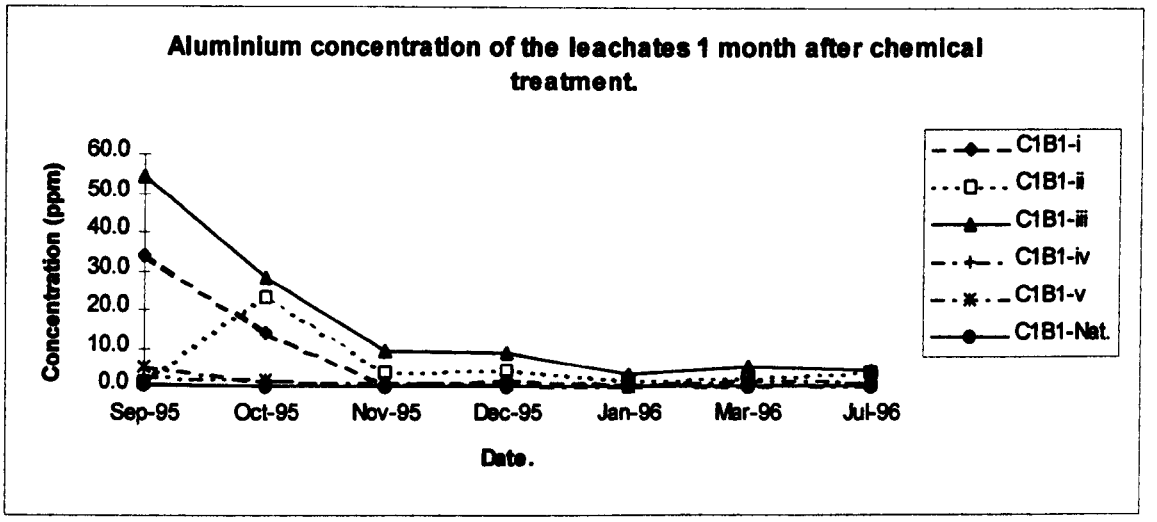


Figure C.1. Aluminium concentration of the leachate from sample C1B1. 1 month after reagent addition.

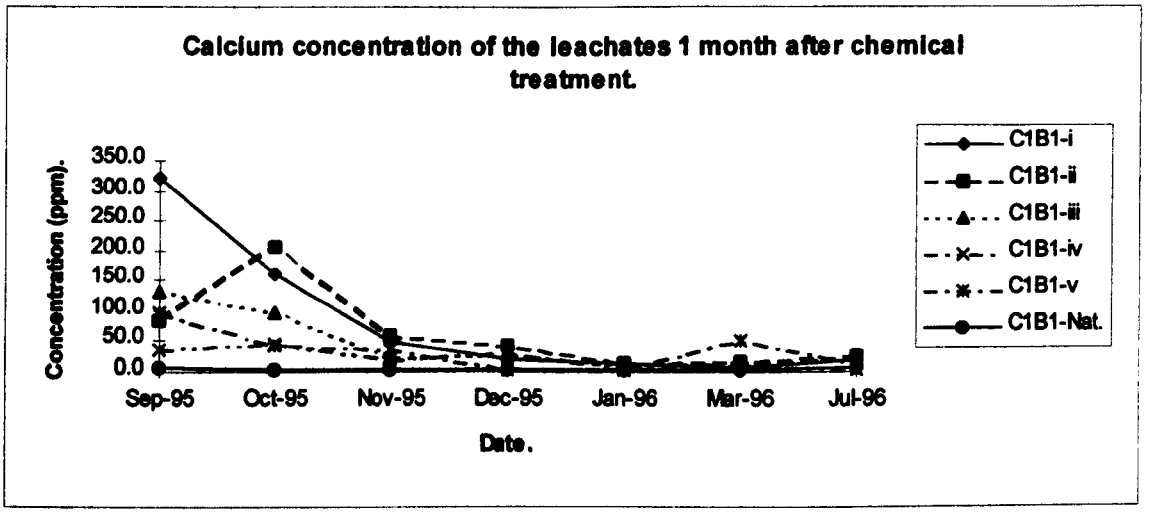


Figure C.2. Calcium concentration of the leachate from sample C1B1. 1 month after reagent addition.

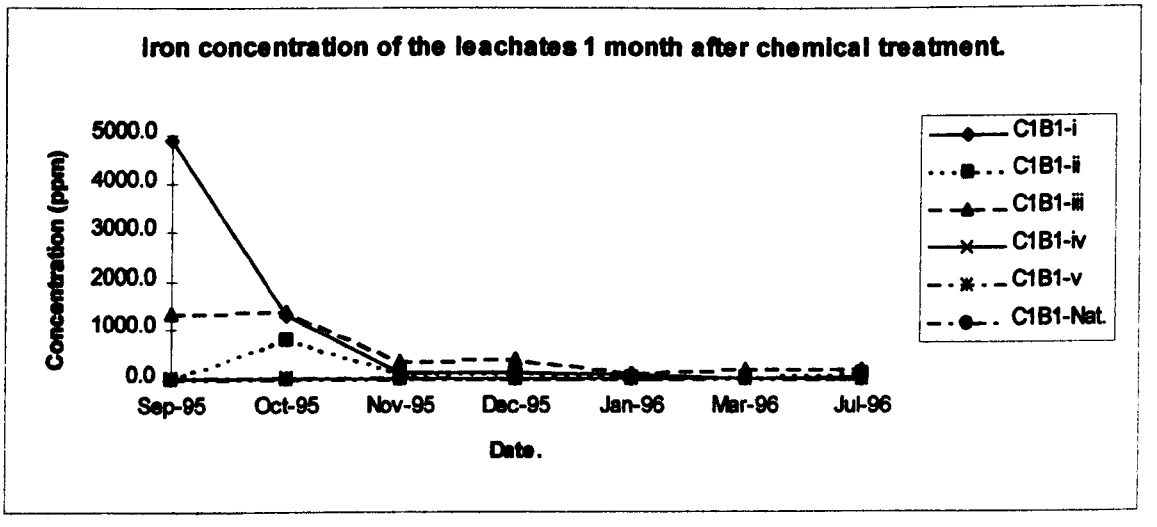


Figure C.3. Iron concentration of the leachate from sample C1B1. 1 month after reagent addition.

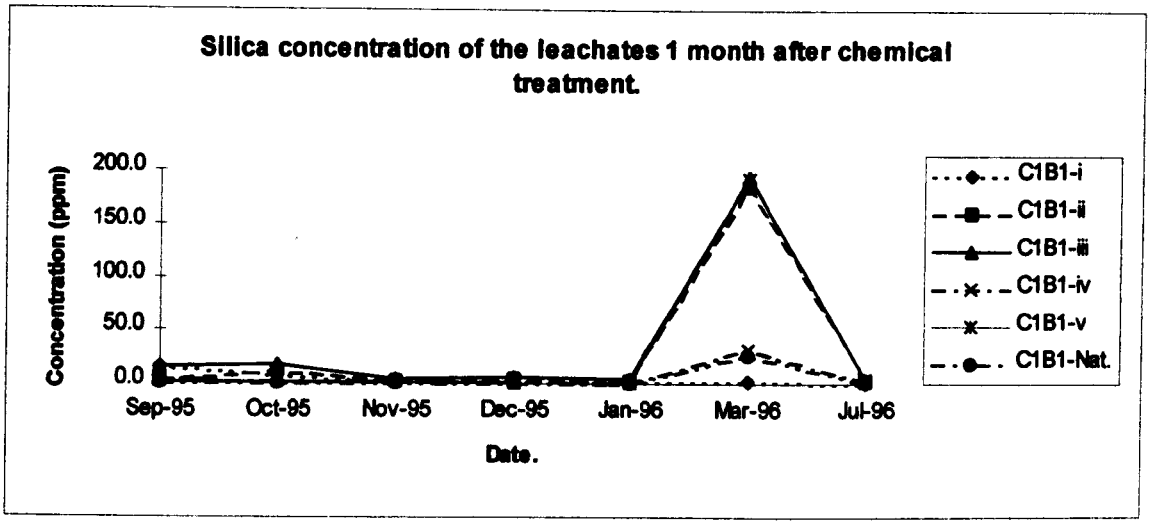


Figure C.4. Silica concentration of the leachate from sample C1B1. 1 month after reagent addition.

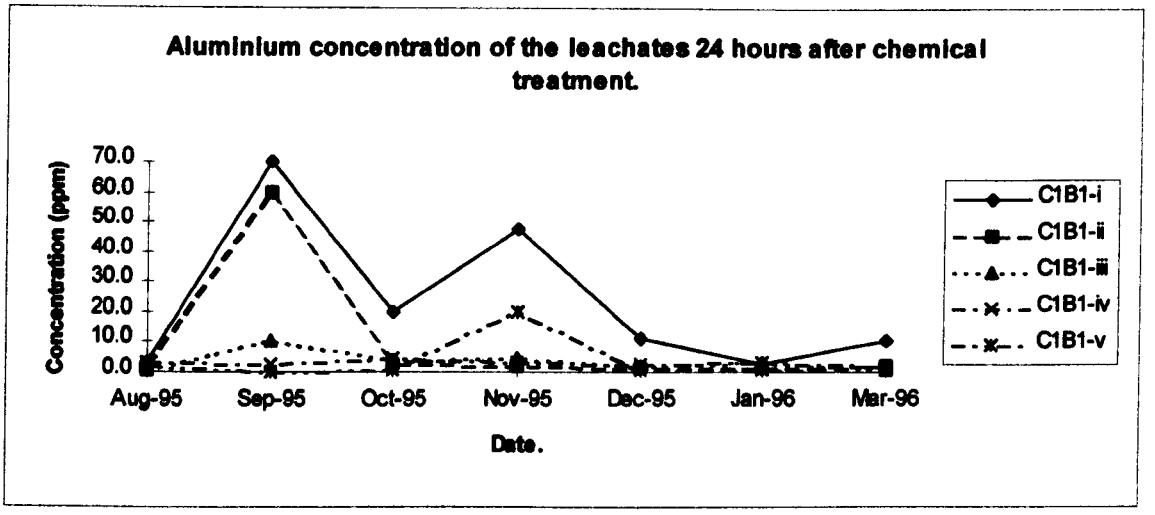


Figure C.5. Aluminium concentration of the leachate from sample C1B1. 24 hours after reagent addition.

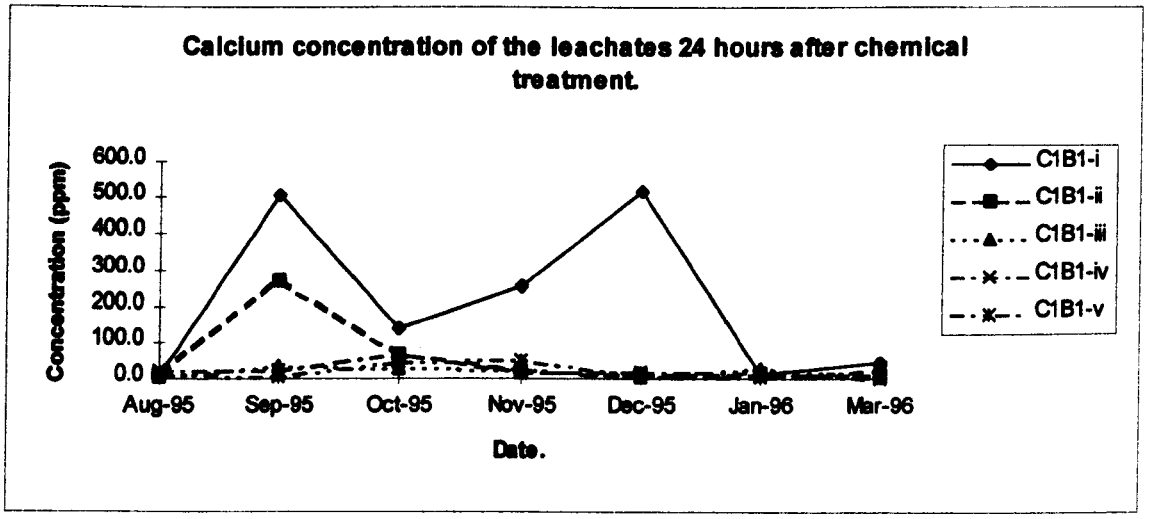


Figure C.6. Calcium concentration of the leachate from sample C1B1. 24 hours after reagent addition.

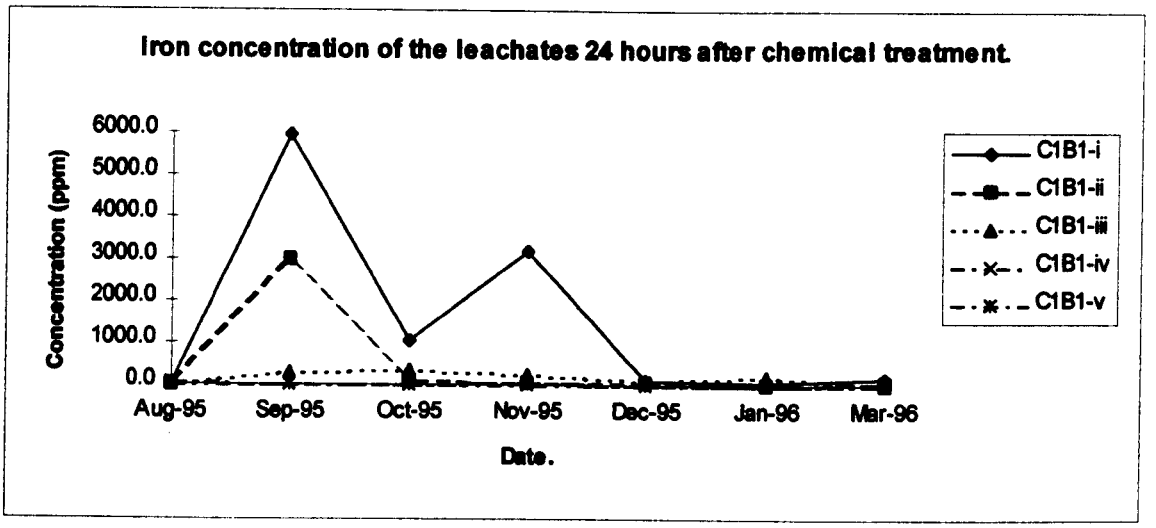


Figure C.7. Iron concentration of the leachate from sample C1B1. 24 hours after reagent addition.

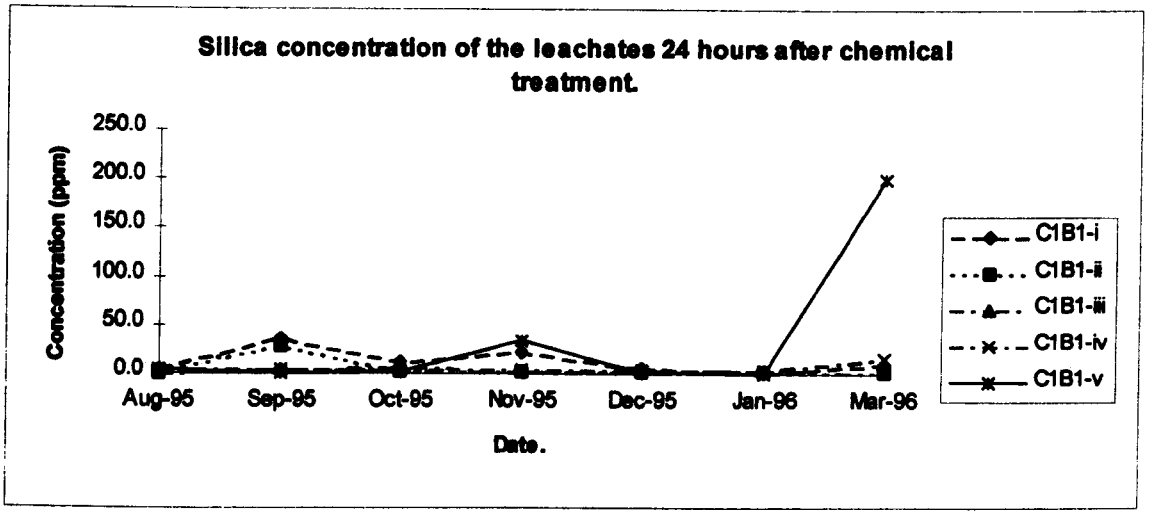


Figure C.8. Silica concentration of the leachate from sample C1B1. 24 hour after reagent addition.

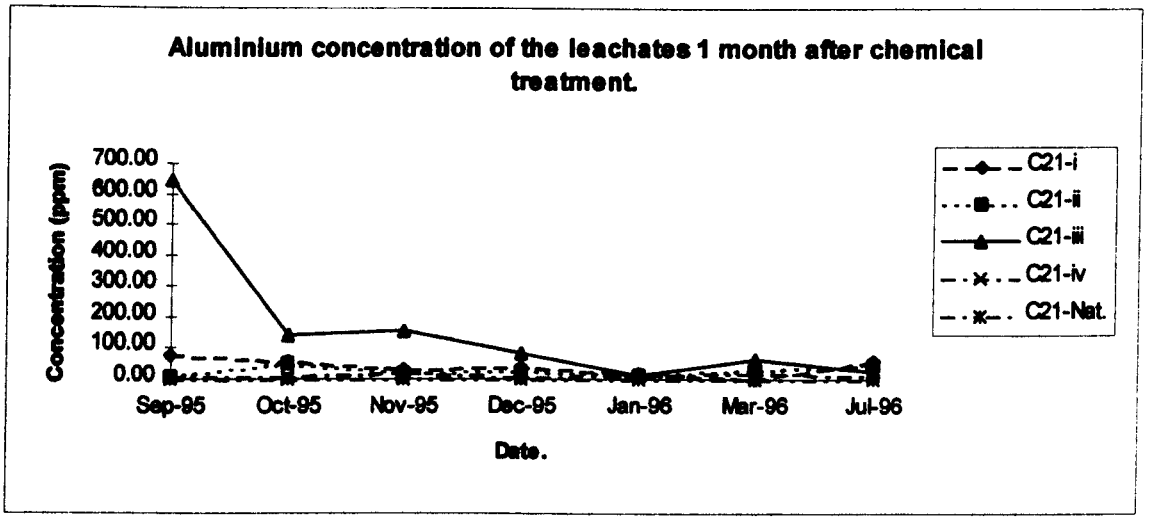


Figure C.9. Aluminium concentration of the leachate from sample C21. 1 month after reagent addition.

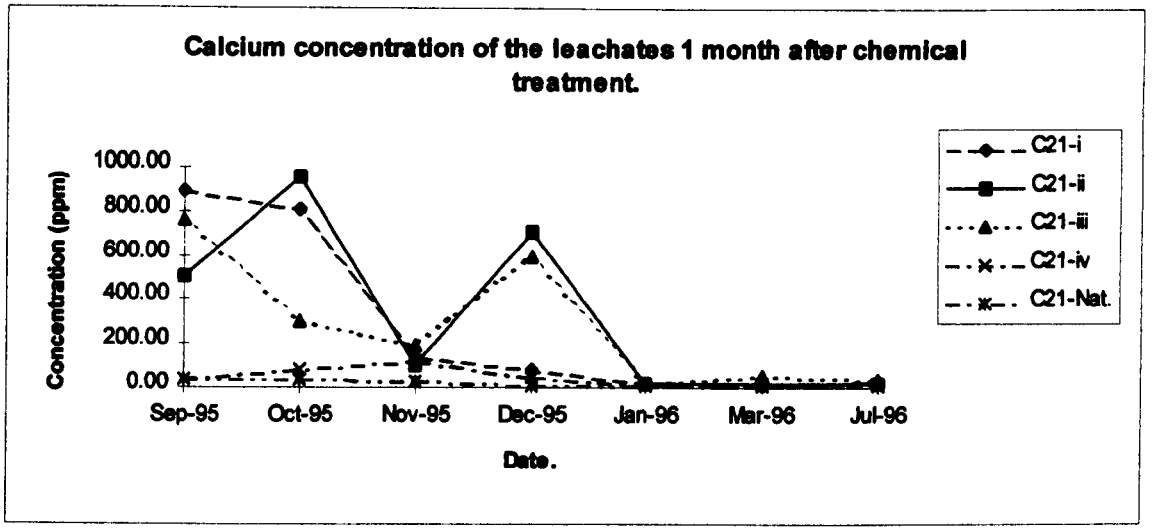


Figure C.10. Calcium concentration of the leachate from sample C21. 1 month after reagent addition.

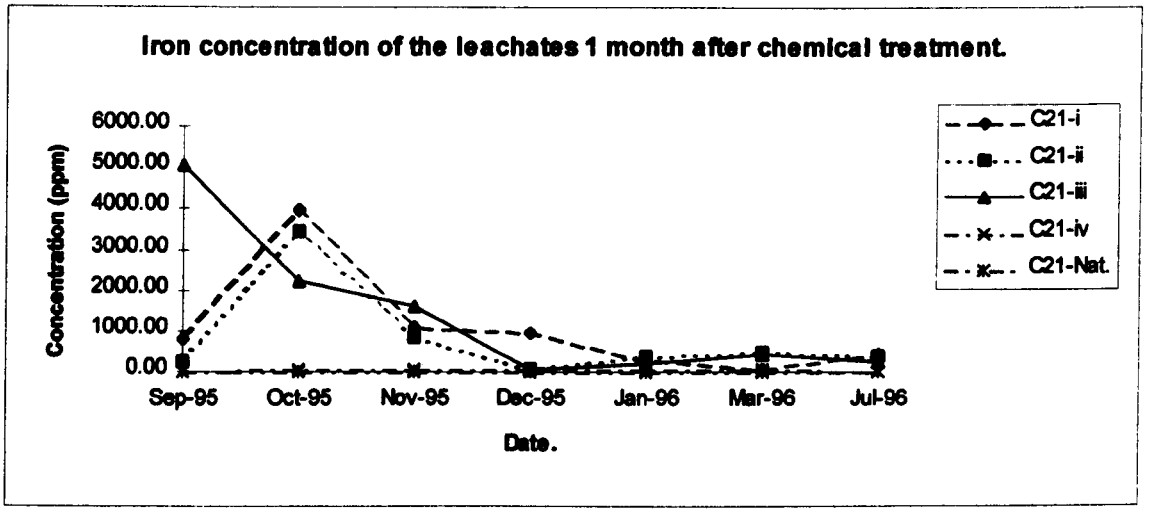


Figure C.11. Iron concentration of the leachate from sample C21. 1 month after reagent addition.

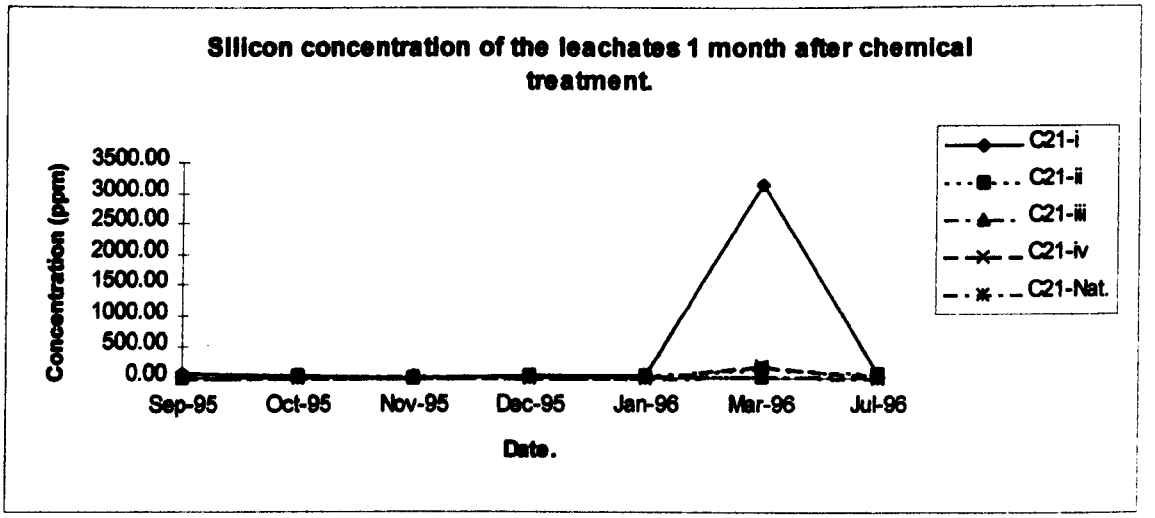


Figure C.12. Silicon concentration of the leachate from sample C21. 1 month after reagent addition.

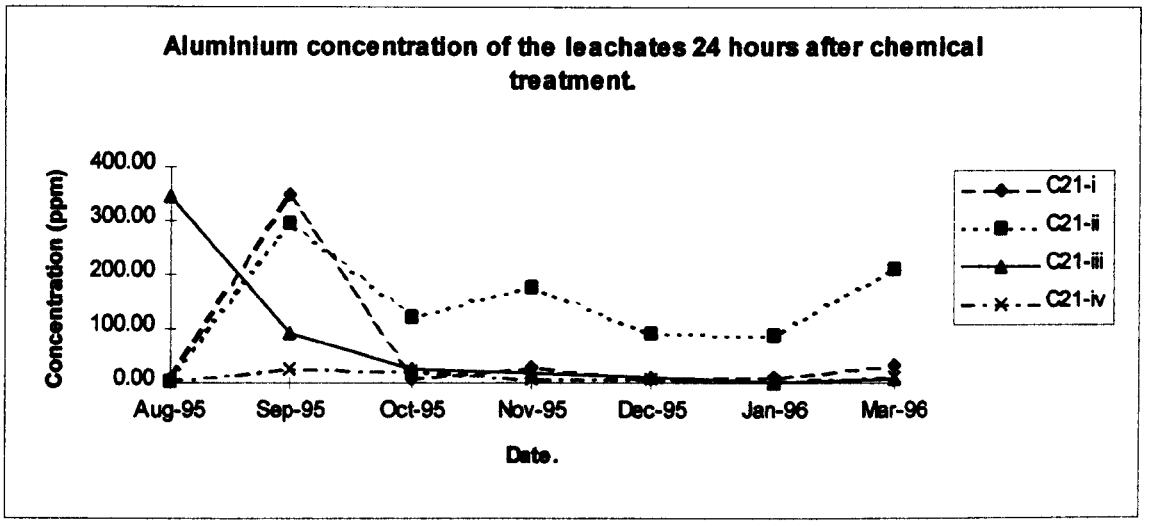


Figure C.13. Aluminium concentration of the leachate from sample C21. 24 hours after reagent addition.

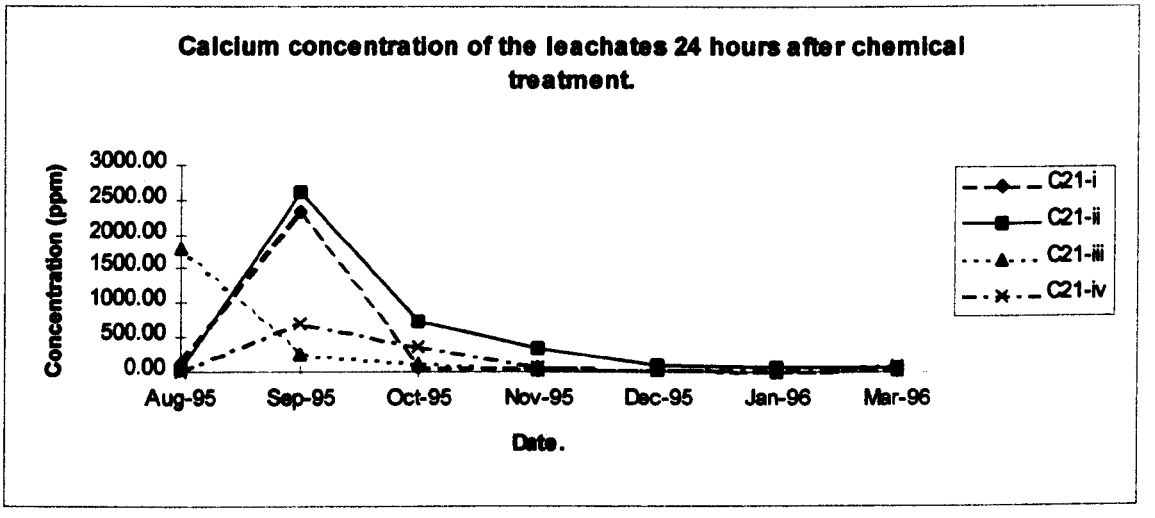


Figure C.14. Calcium concentration of the leachate from sample C21. 24 hours after reagent addition.

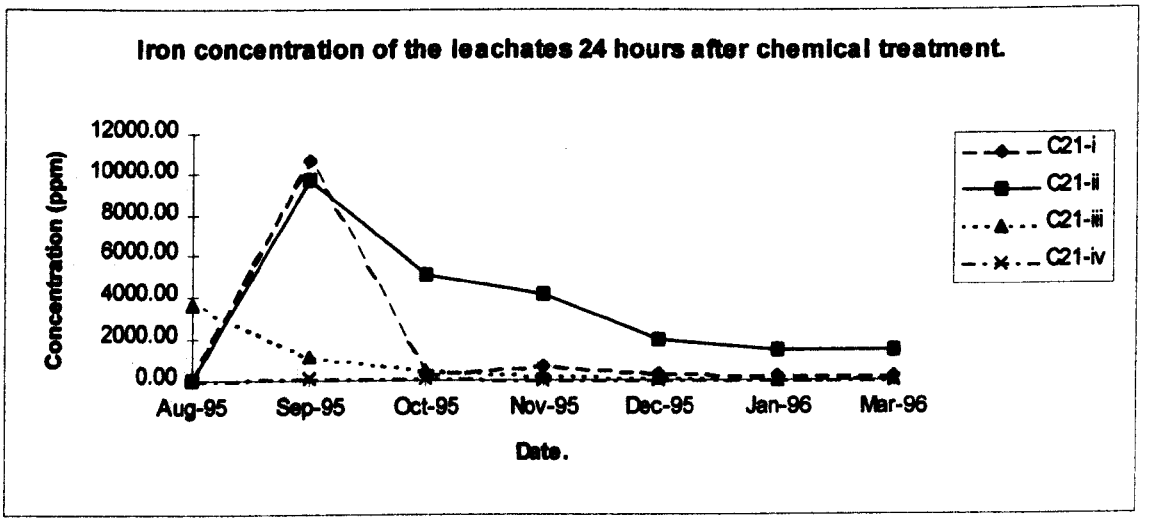


Figure C.15. Iron concentration of the leachate from sample C21. 24 hours after reagent addition.

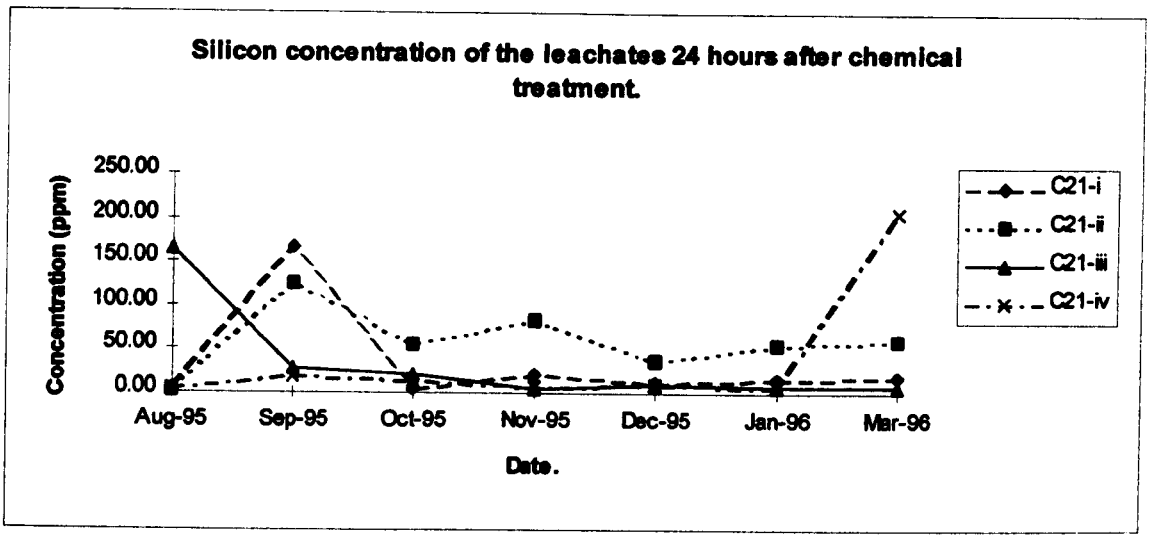


Figure C.16. Silicon concentration of the leachate from sample C21. 24 hours after reagent addition.

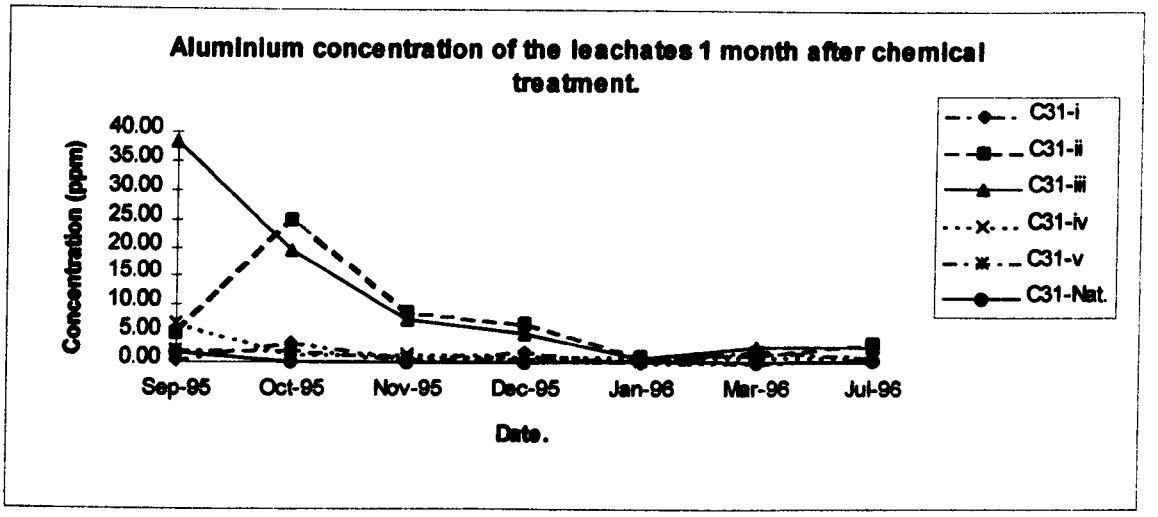


Figure C.17. Aluminium concentration of the leachate from sample C31. 1 month after reagent addition.

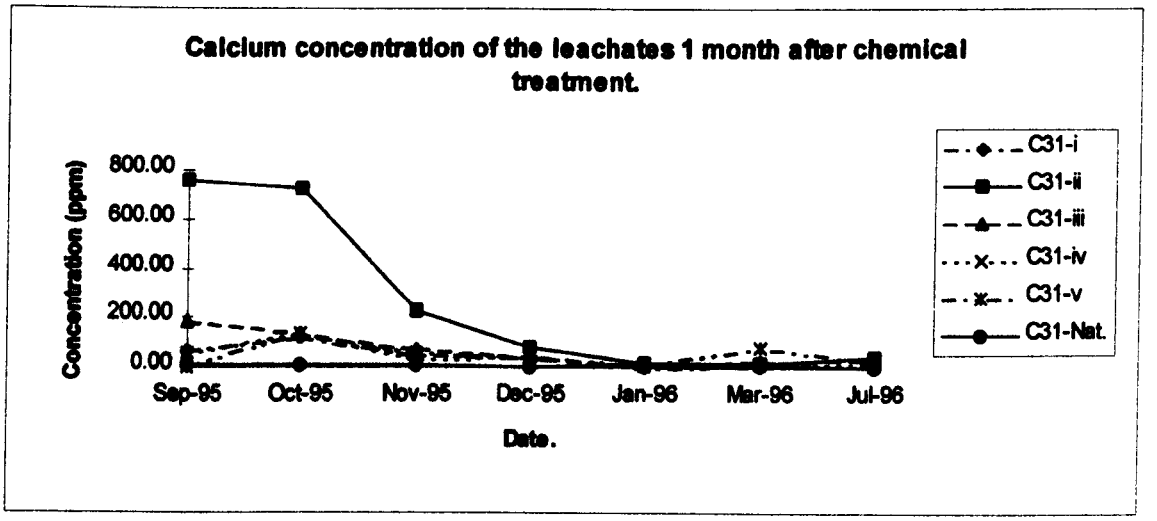


Figure C.18. Calcium concentration of the leachate from sample C31. 1 month after reagent addition.

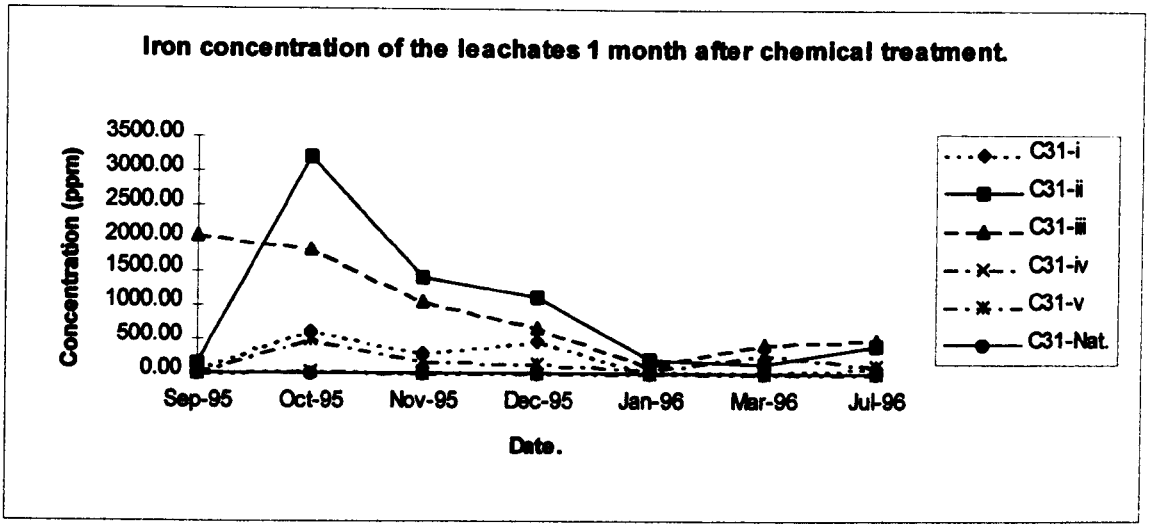


Figure C.19. Iron concentration of the leachate from sample C31. 1 month after reagent addition.

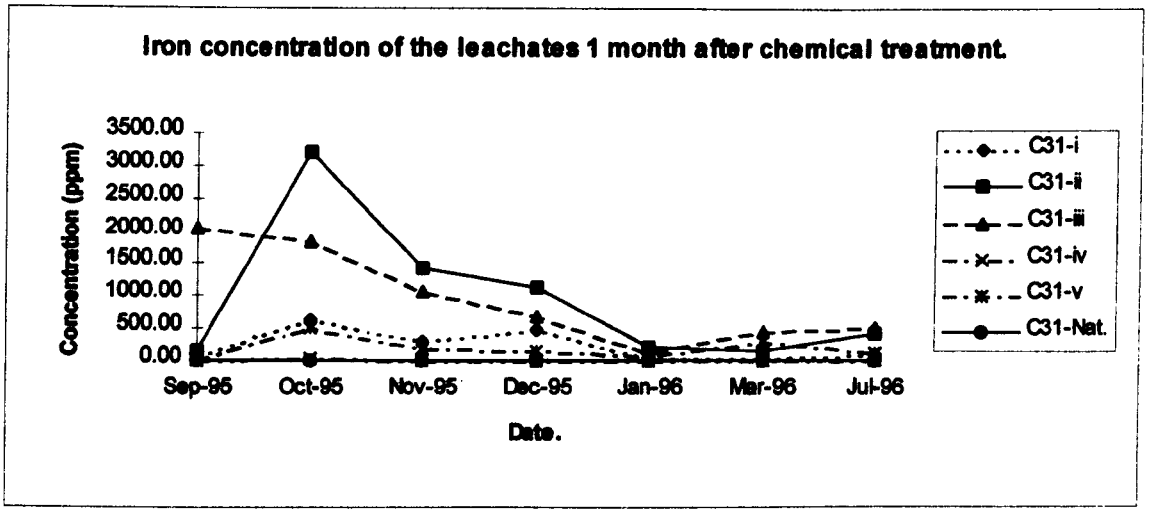


Figure C.20. Iron concentration of the leachate from sample C31. 1 month after reagent addition.

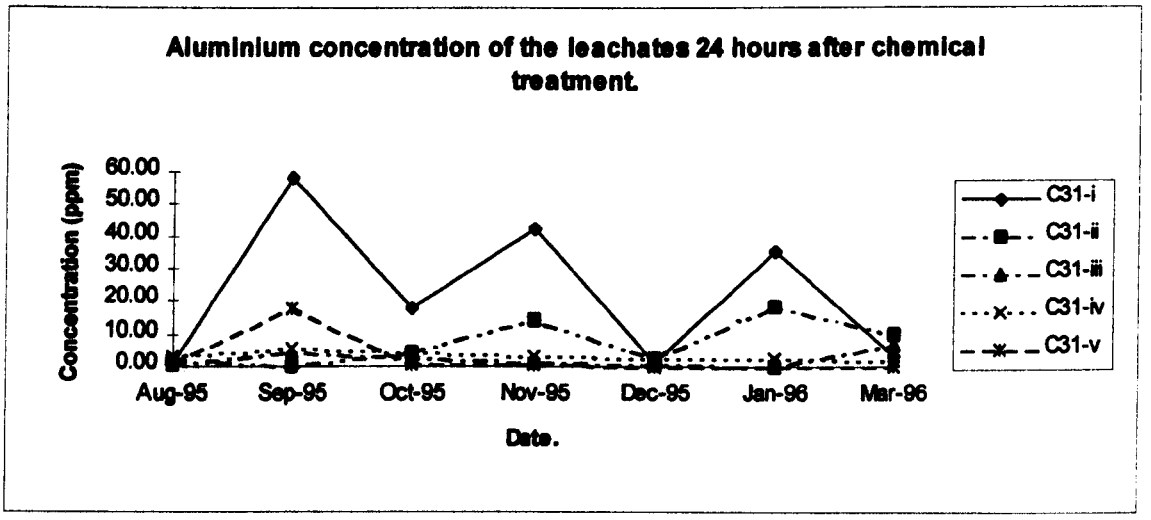


Figure C.21.Aluminium concentration of the leachate from sample C31.24 months after reagent addition.

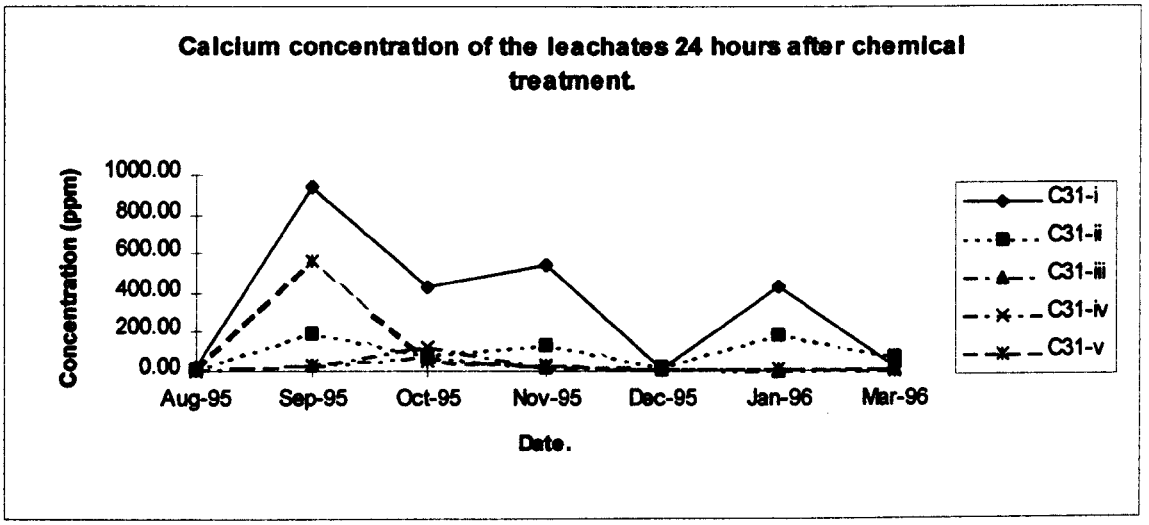


Figure C.22. Calcium concentration of the leachate from sample C31. 24 hours after reagent addition.

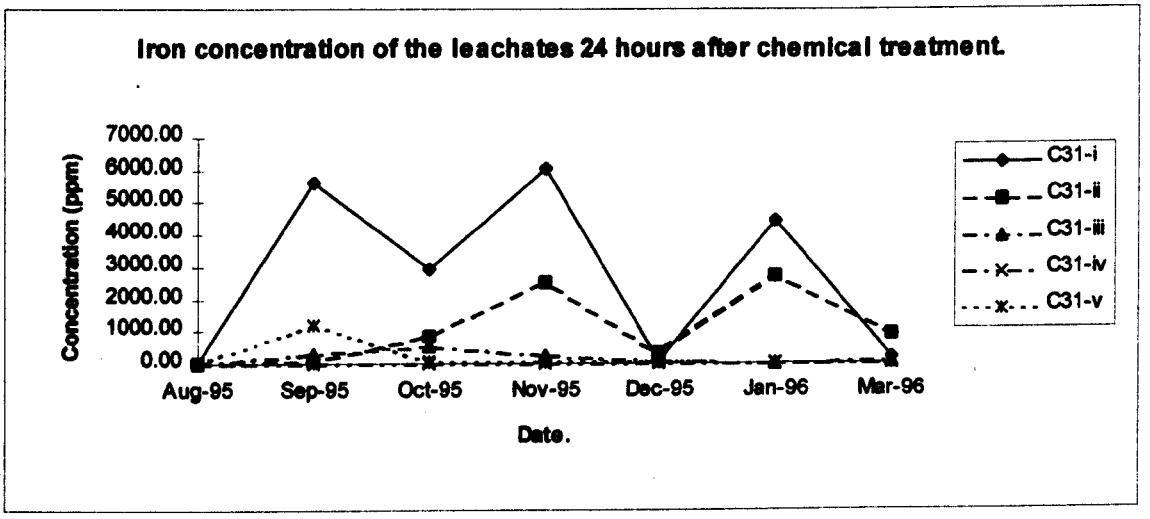


Figure C.23. Iron concentration of the leachate from sample C31. 24 hours after reagent addition.

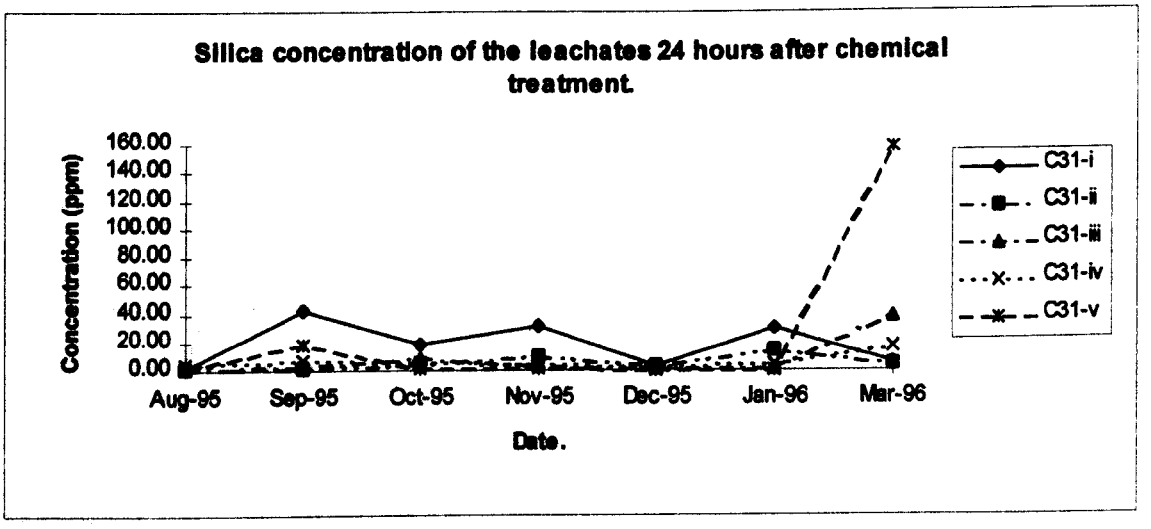


Figure C.24. Silica concentration of the leachate from sample C31. 24 hours after reagent addition.

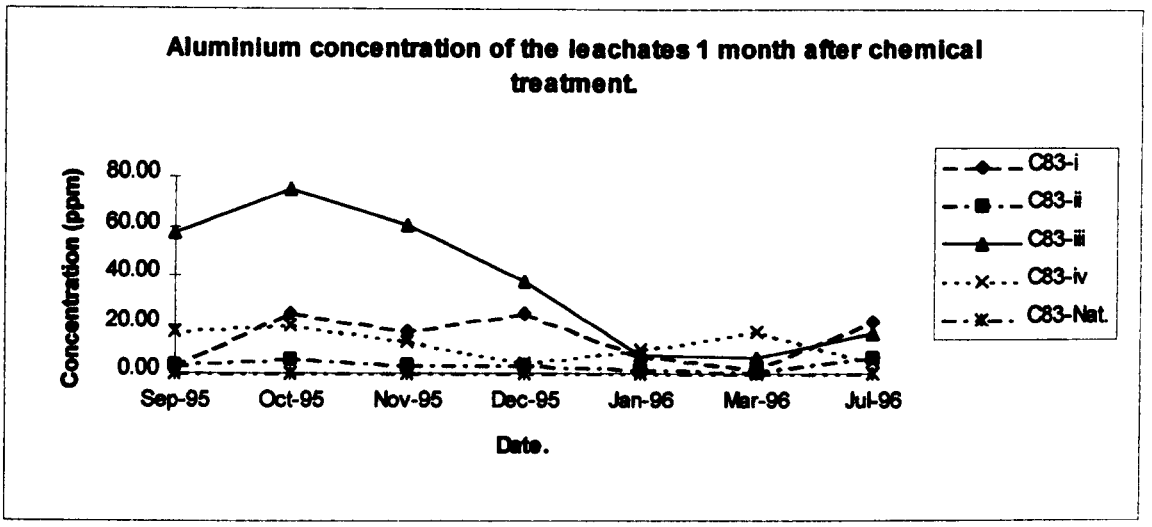


Figure C.25. Aluminium concentration of the leachate from sample C83. 1 month after reagent addition.

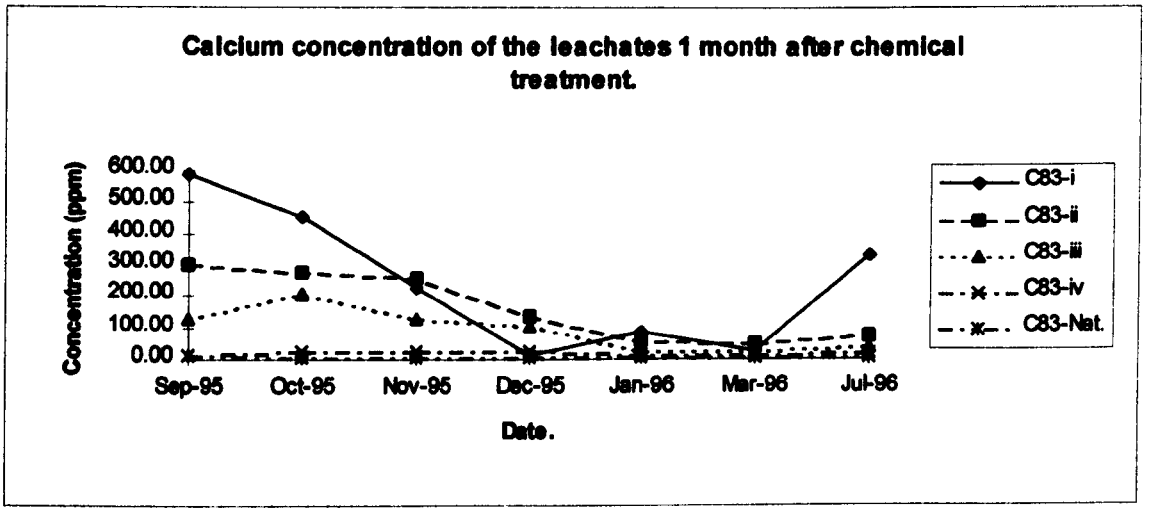


Figure C.26. Calcium concentration of the leachate from sample C83. 1 month after reagent addition.

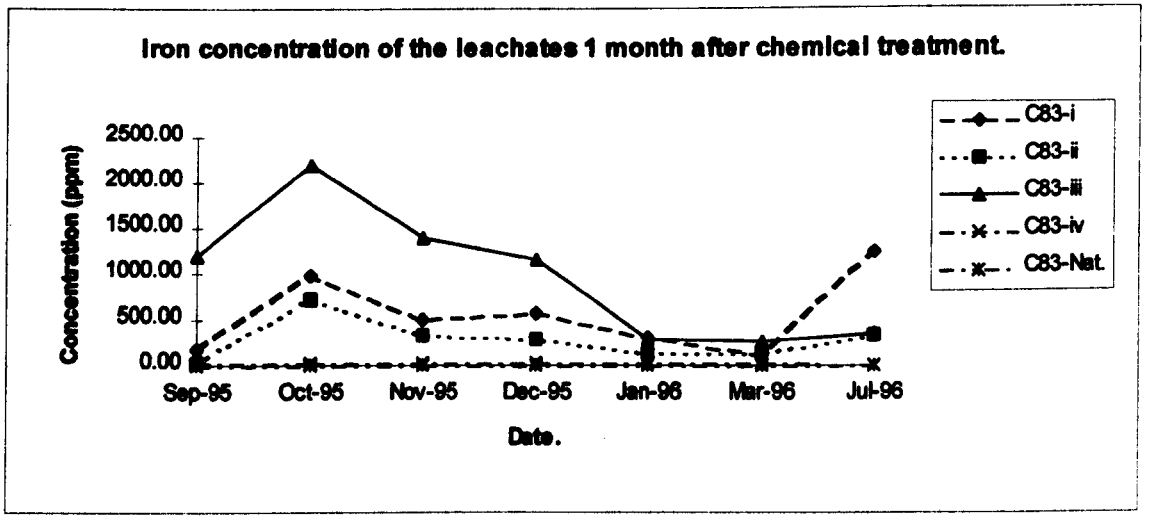


Figure C.27. Iron concentration of the leachate from sample C83. 1 month after reagent addition.

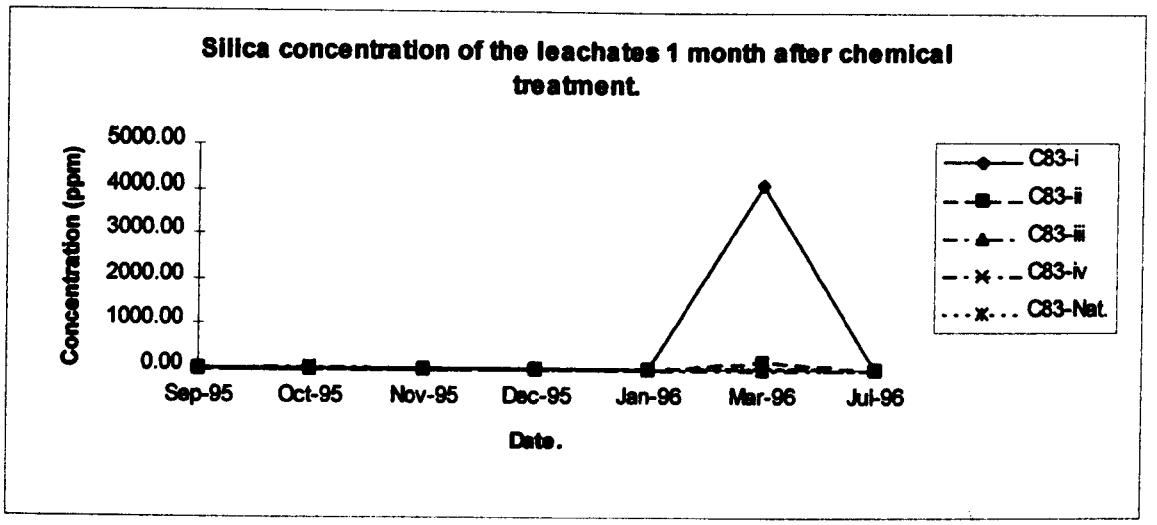


Figure C.28. Silica concentration of the leachate from sample C83. 1 month after reagent addition.

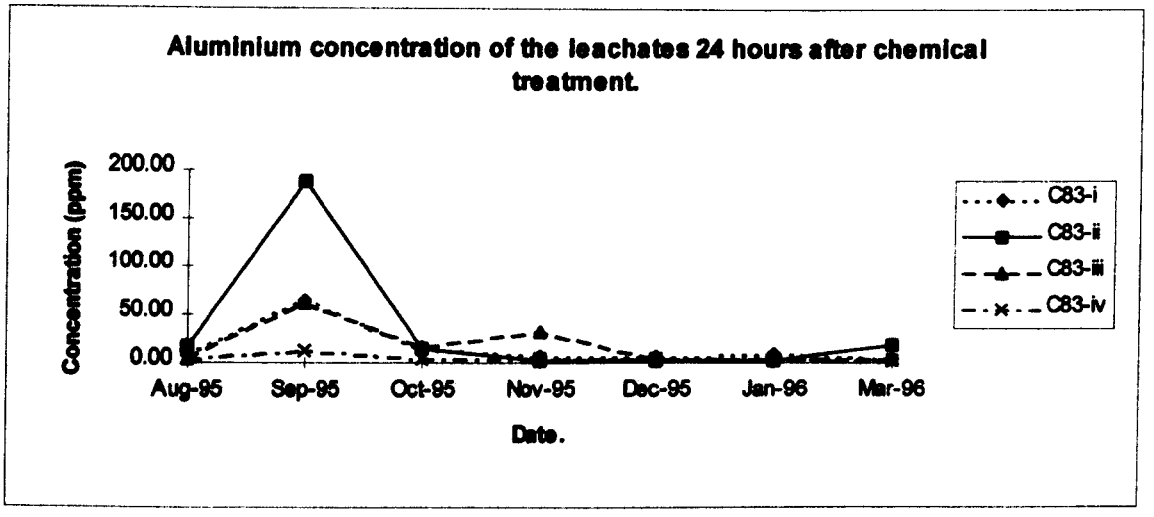


Figure C.29. Aluminium concentration of the leachate from sample C83. 24 hours after reagent addition.

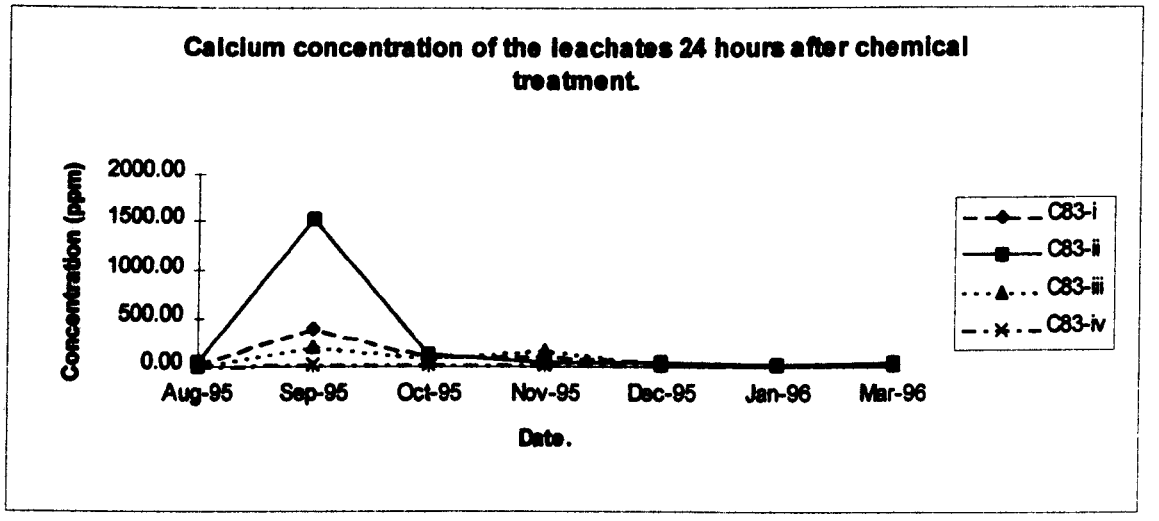


Figure C.30. Calcium concentration of the leachate from sample C83. 24 hours after reagent addition.

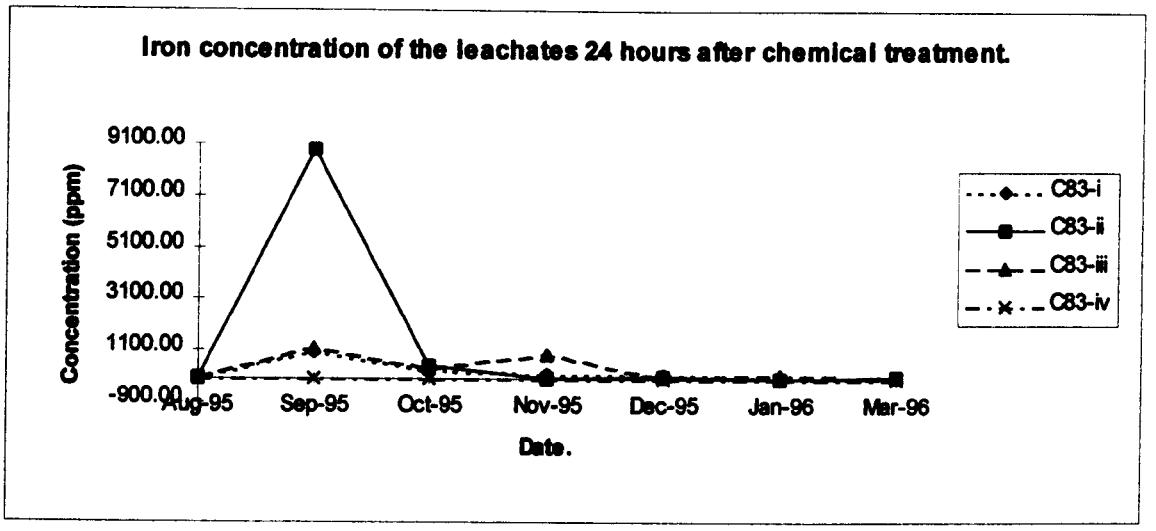


Figure C.31. Iron concentration of the leachate from sample C83. 24 hours after reagent addition.

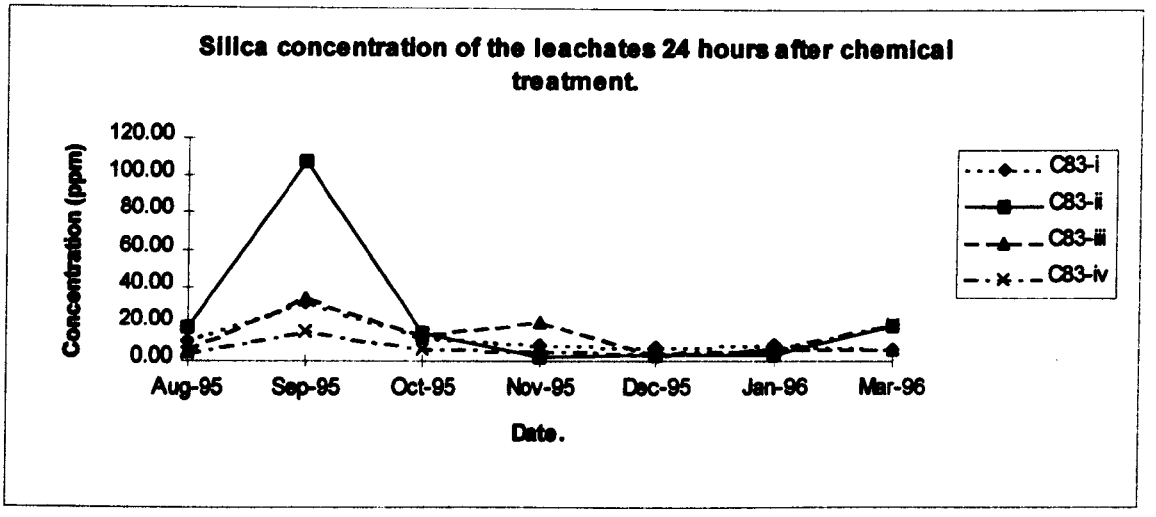


Figure C.32. Silica concentration of the leachate from sample C83. 24 hours after reagent addition.

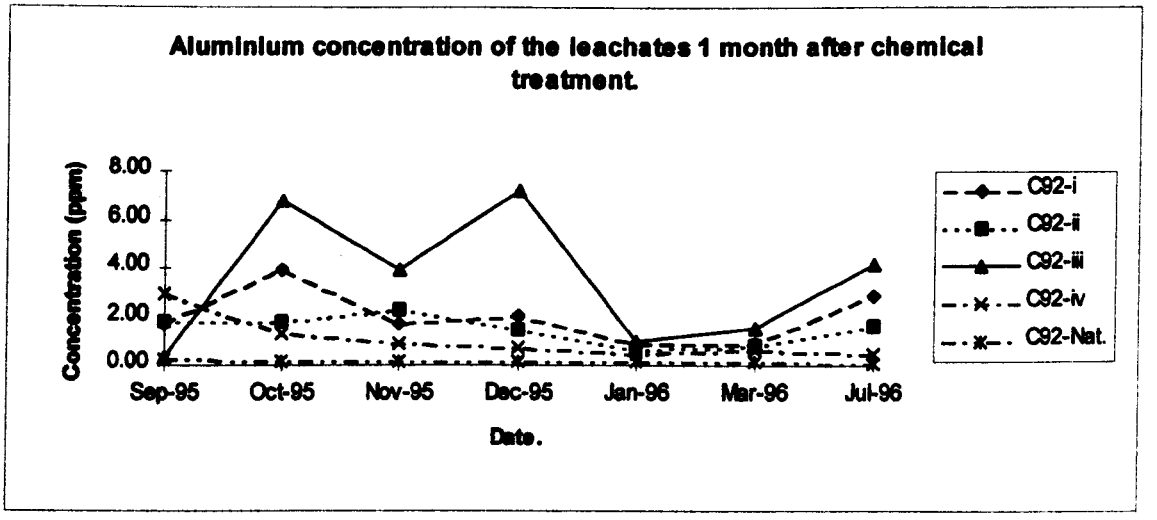


Figure C.33. Aluminium concentration of the leachate from sample C92. 1 month after reagent addition.

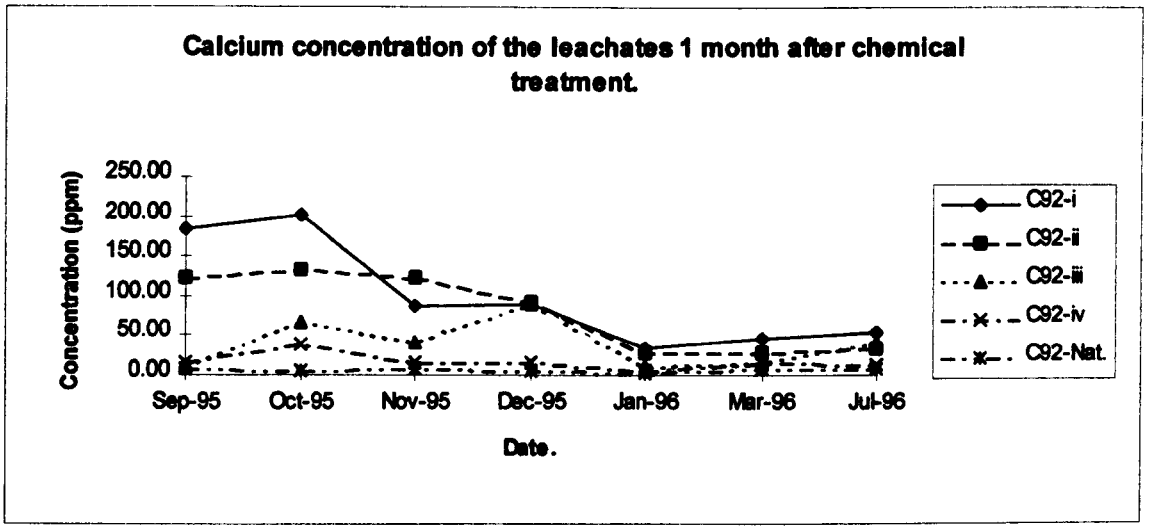


Figure C.34. Calcium concentration of the leachate from sample C92. 1 month after reagent addition.

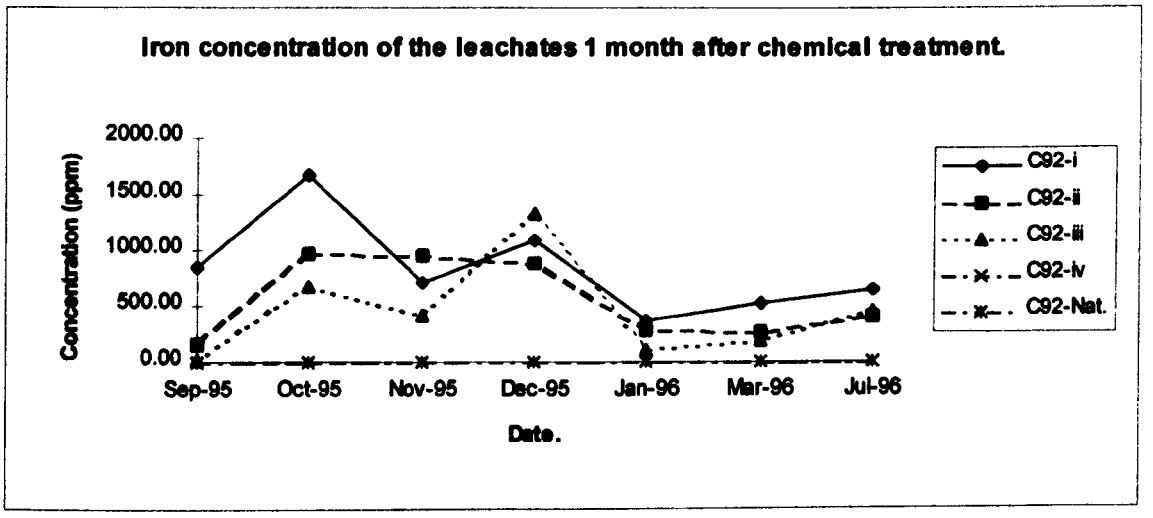


Figure C.35. Iron concentration of the leachate from sample C92. 1 month after reagent addition.

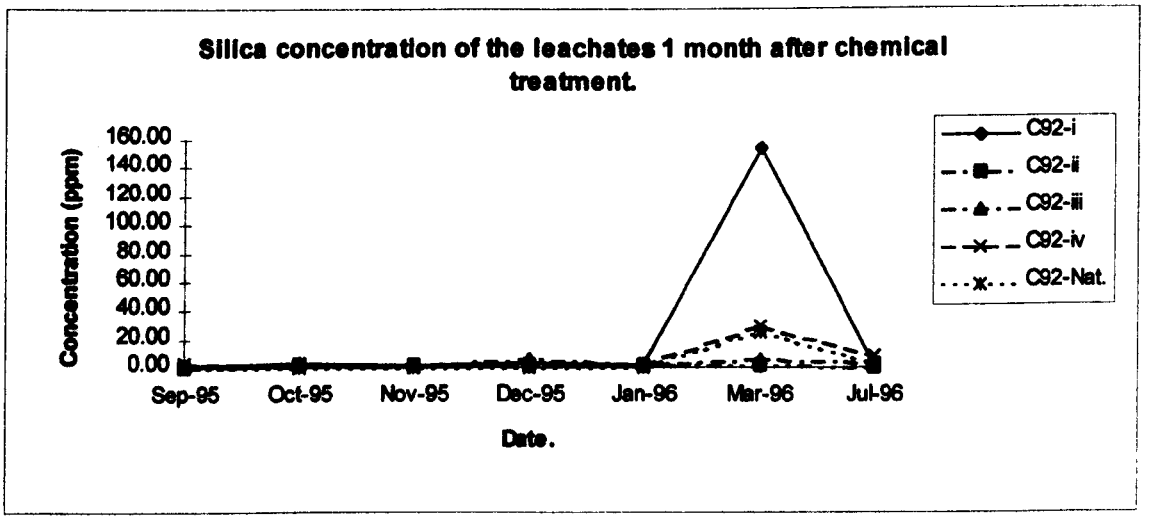


Figure C.36. Silica concentration of the leachate from sample C92. 1 month after reagent addition.

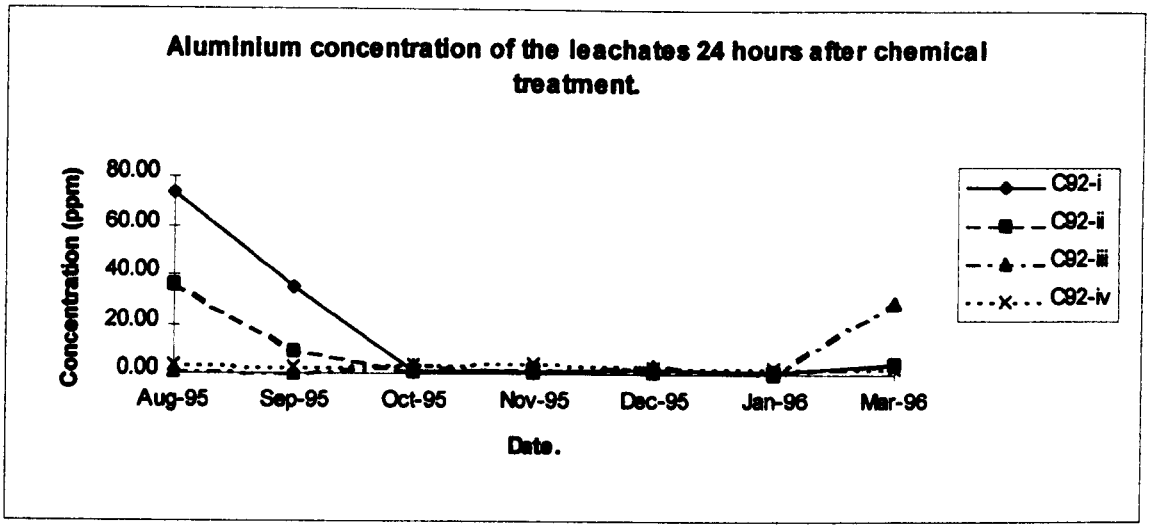


Figure C.37. Aluminium concentration of the leachate from sample C92. 24 hours after reagent addition.

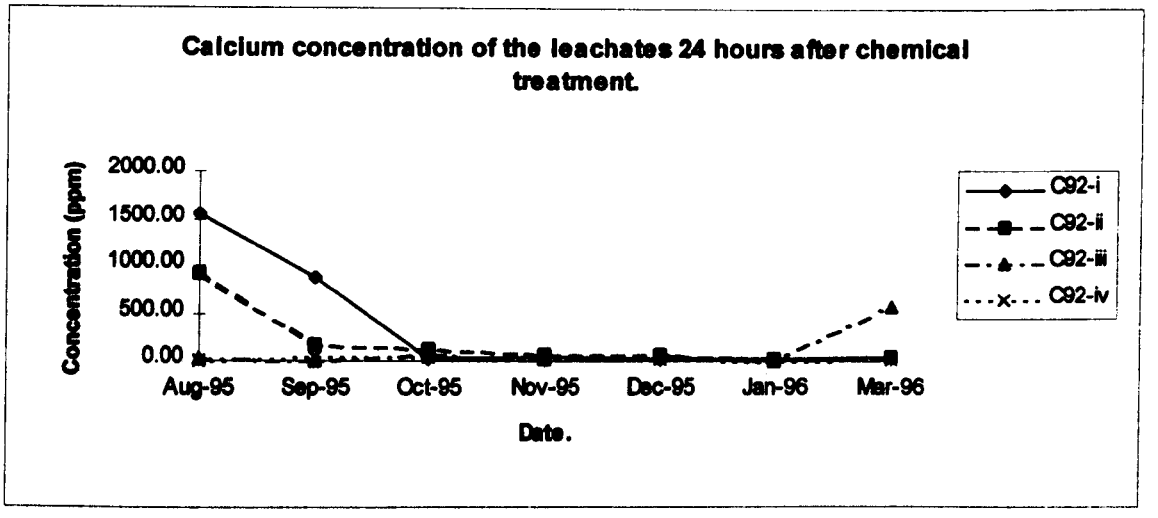


Figure C.38. Calcium concentration of the leachate from sample C92. 24 hours after reagent addition.

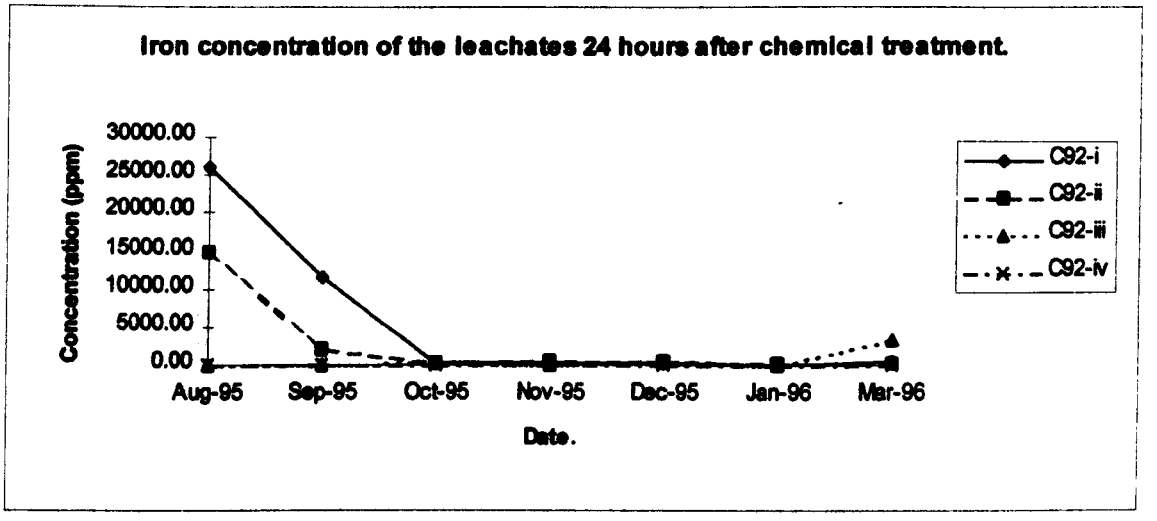


Figure C.39. Iron concentration of the leachate from sample C92. 24 hours after reagent addition.

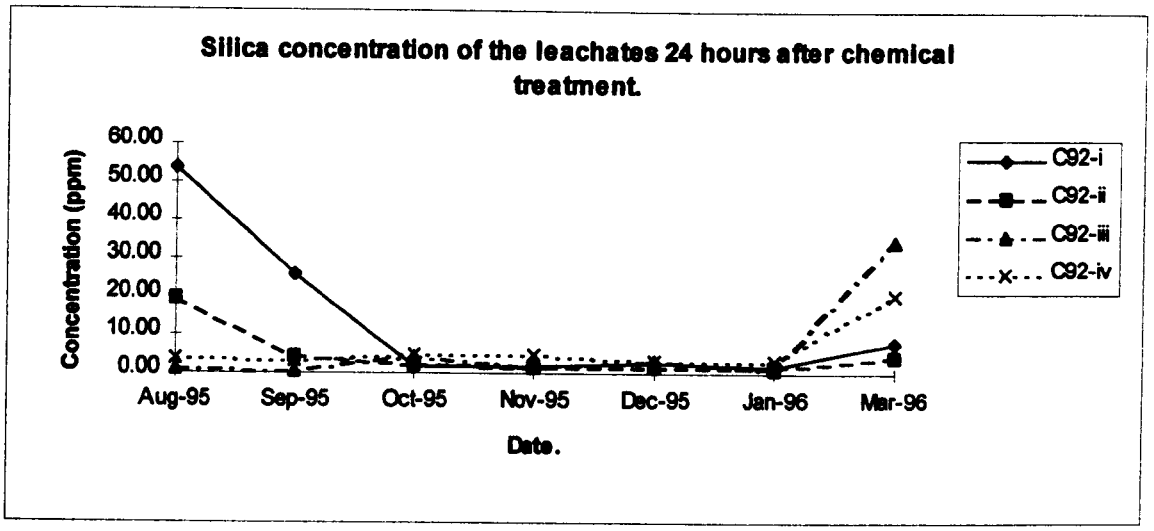


Figure C.40. Silica concentration of the leachate from sample C92. 24 hours after reagent addition.

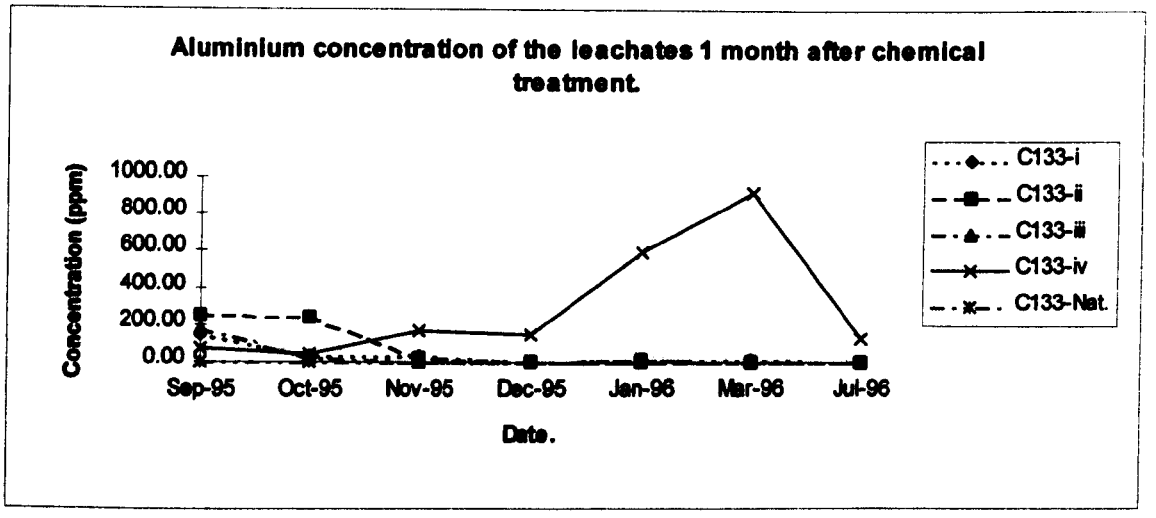


Figure C.41.Aluminium concentration of the leachate from sample C133.1 month after reagent addition.

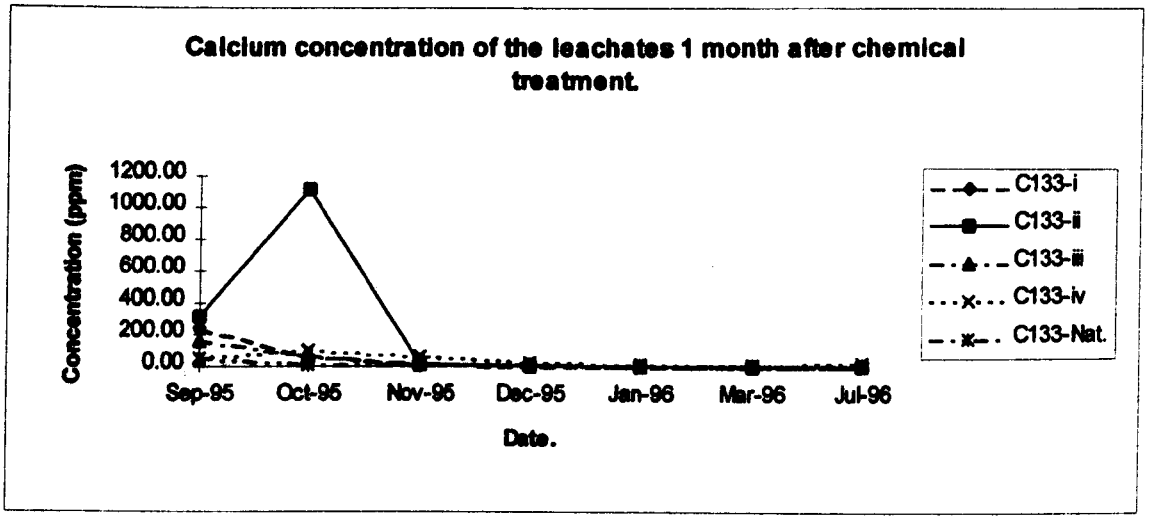


Figure C.42. Calcium concentration of the leachate from sample C133. 1 month after reagent addition.

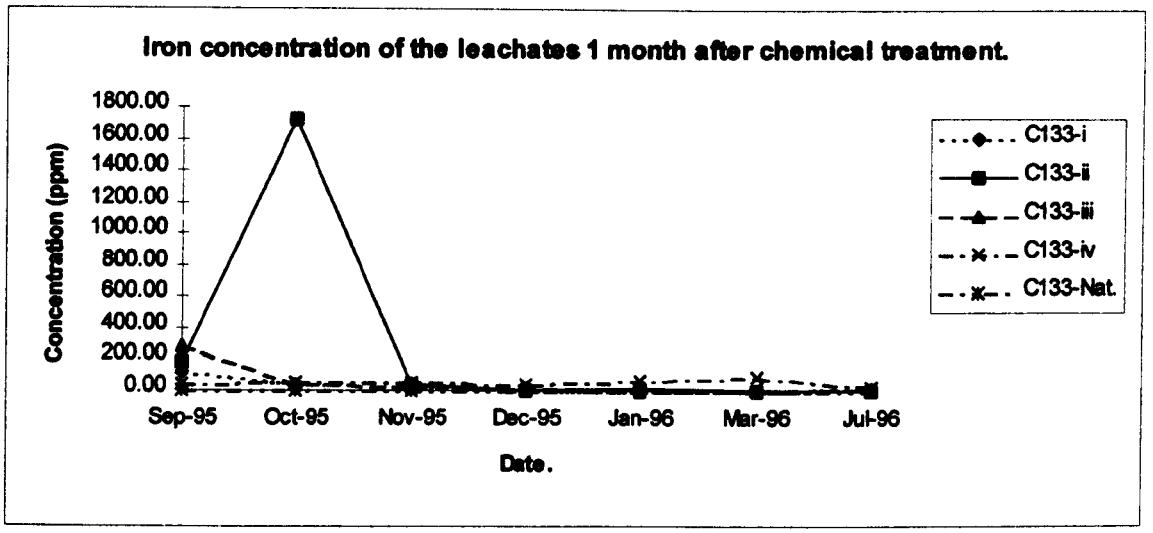


Figure C.43. Iron concentration of the leachate from sample C133. 1 month after reagent addition.

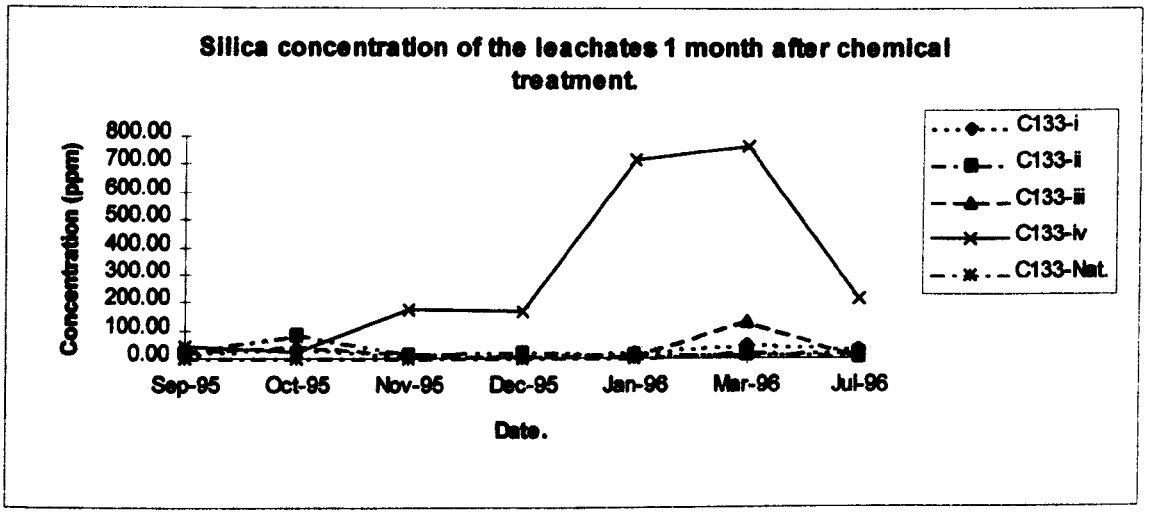


Figure C.44. Iron concentration of the leachate from sample C133. 1 month after reagent addition.

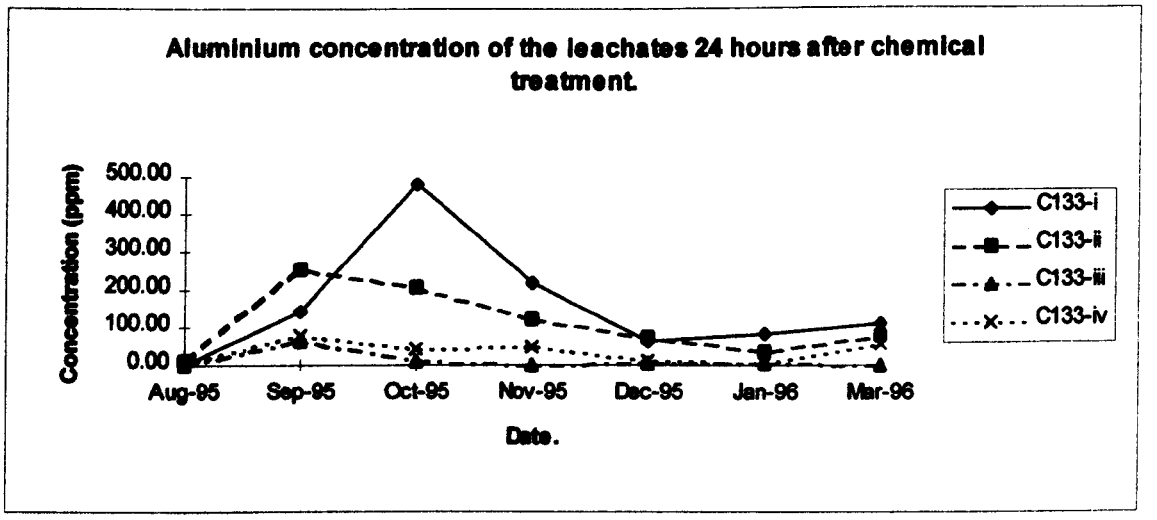


Figure C.45.Aluminium concentration of the leachate from sample C133.24 hours after reagent addition.

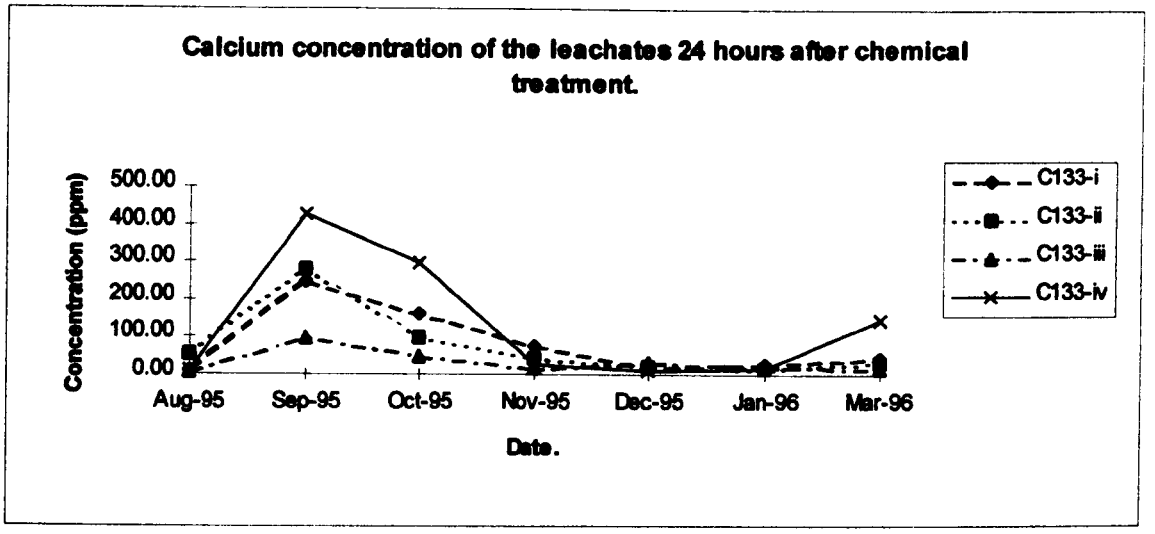


Figure C.46. Calcium concentration of the leachate from sample C133. 24 hours after reagent addition.

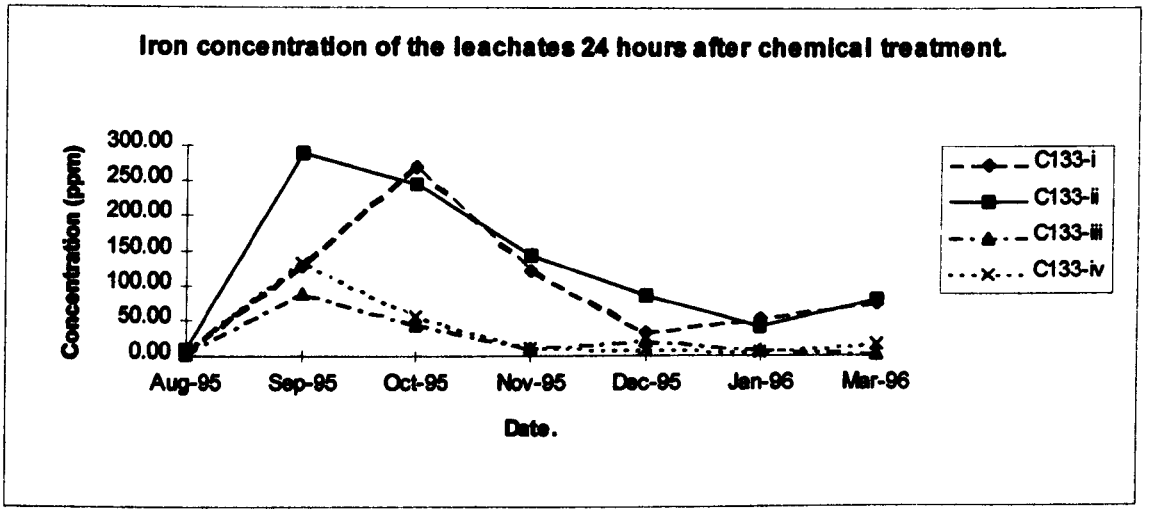


Figure C.47. Iron concentration of the leachate from sample C133. 24 hours after reagent addition.

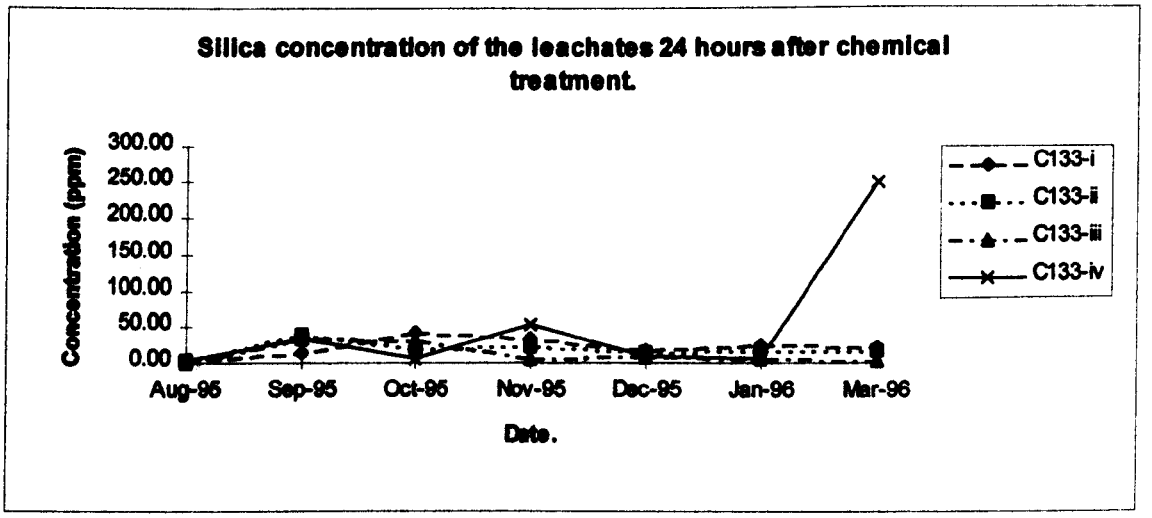


Figure C.48. Silica concentration of the leachate from sample C133. 24 hours after reagent addition.

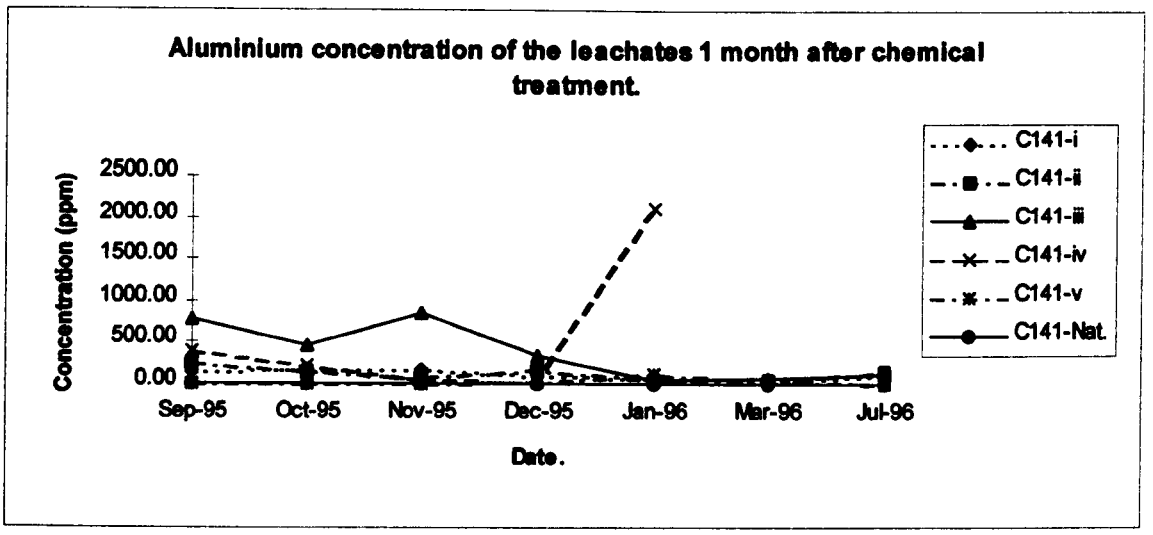


Figure C.49. Aluminium concentration of the leachate from sample C133.1 month after reagent addition.

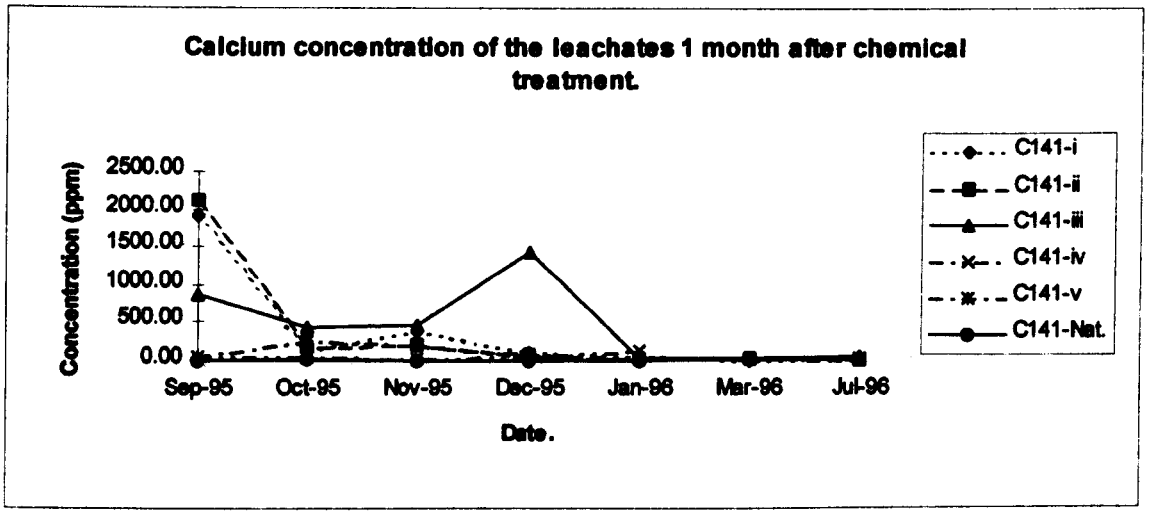


Figure C.50. Calcium concentration of the leachate from sample C133.1 month after reagent addition.

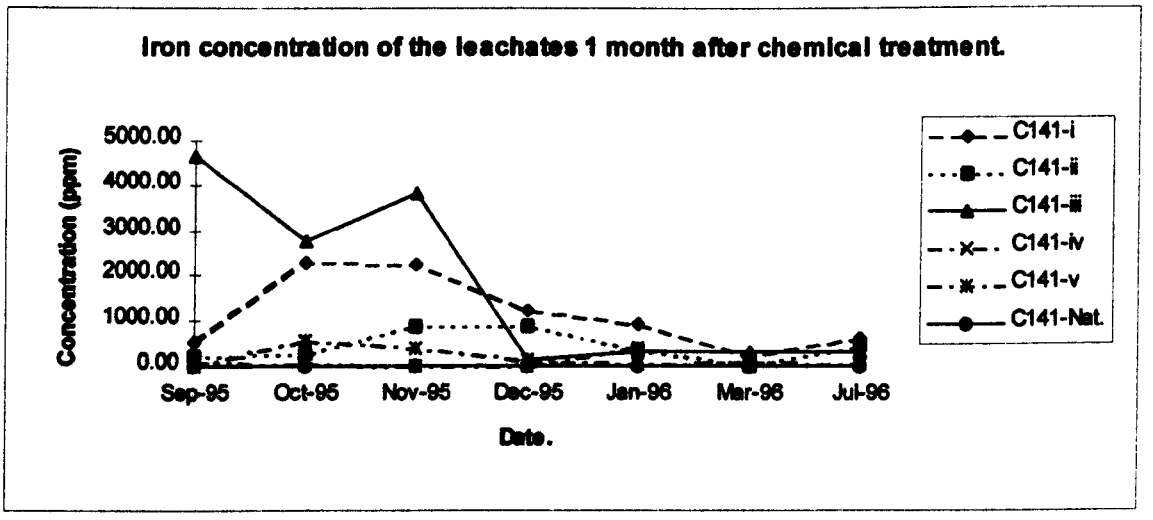


Figure C.51. Iron concentration of the leachate from sample C133.1 month after reagent addition.

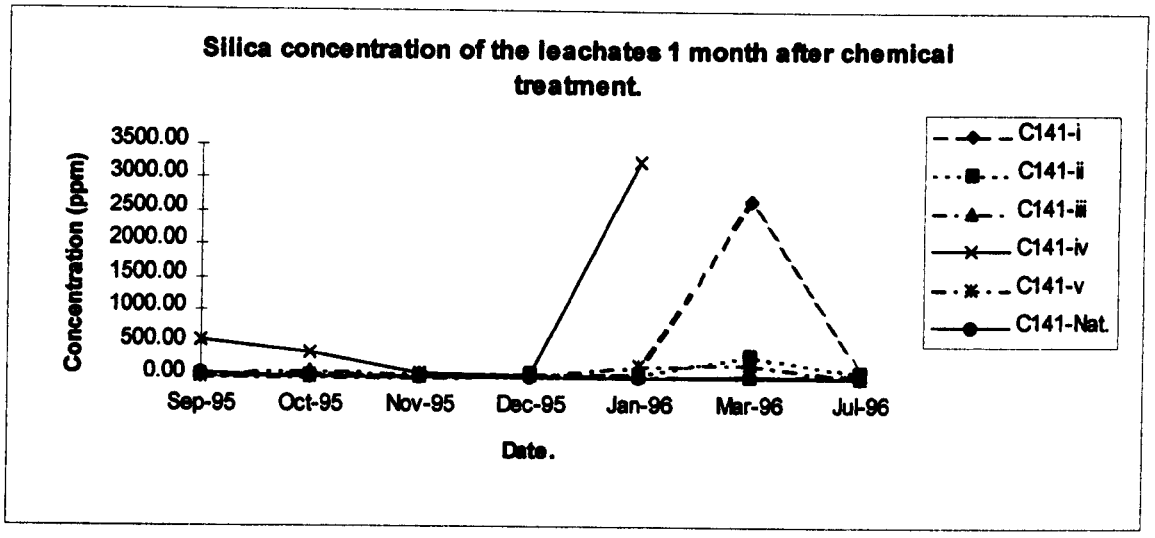


Figure C.52. Silica concentration of the leachate from sample C133.1 *month after reagent addition.*

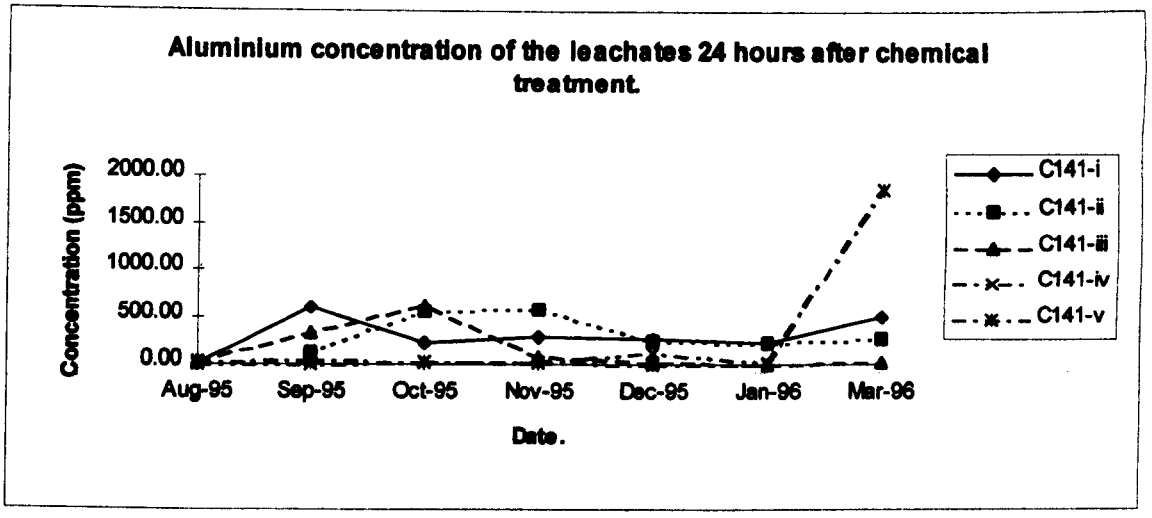


Figure C.53. Aluminium concentration of the leachate from sample C133.24 hours after reagent addition.

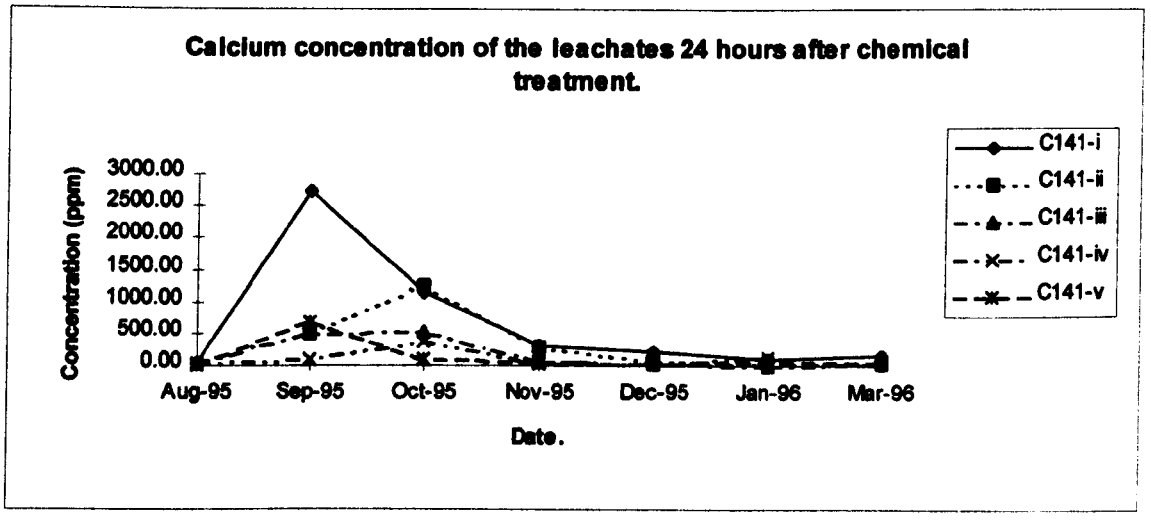


Figure C.54. Calcium concentration of the leachate from sample C133. 24 hours after reagent addition.

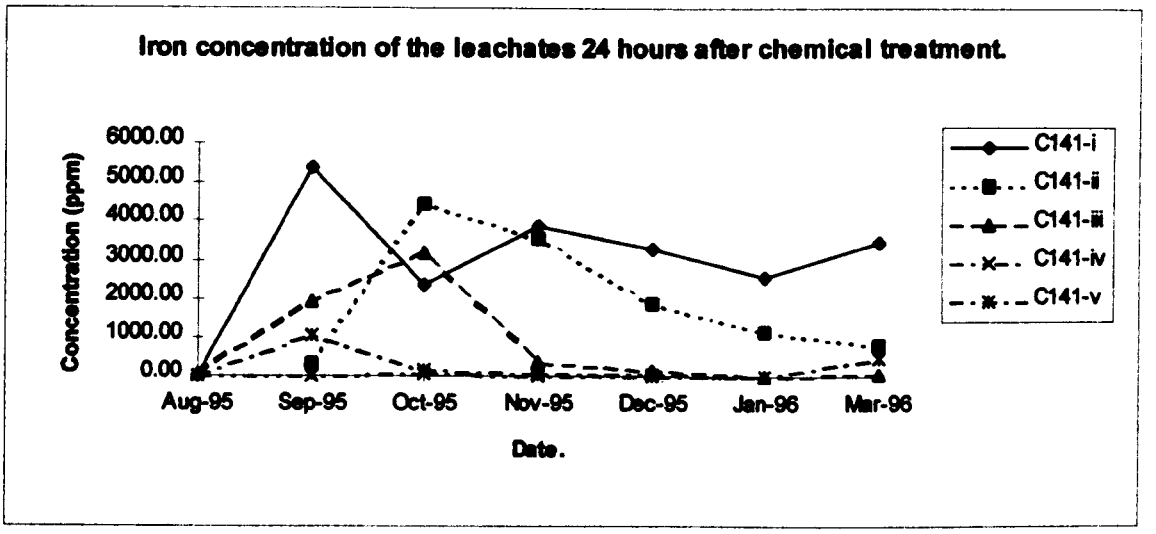


Figure C.55. Iron concentration of the leachate from sample C133. 24 hours after reagent addition.

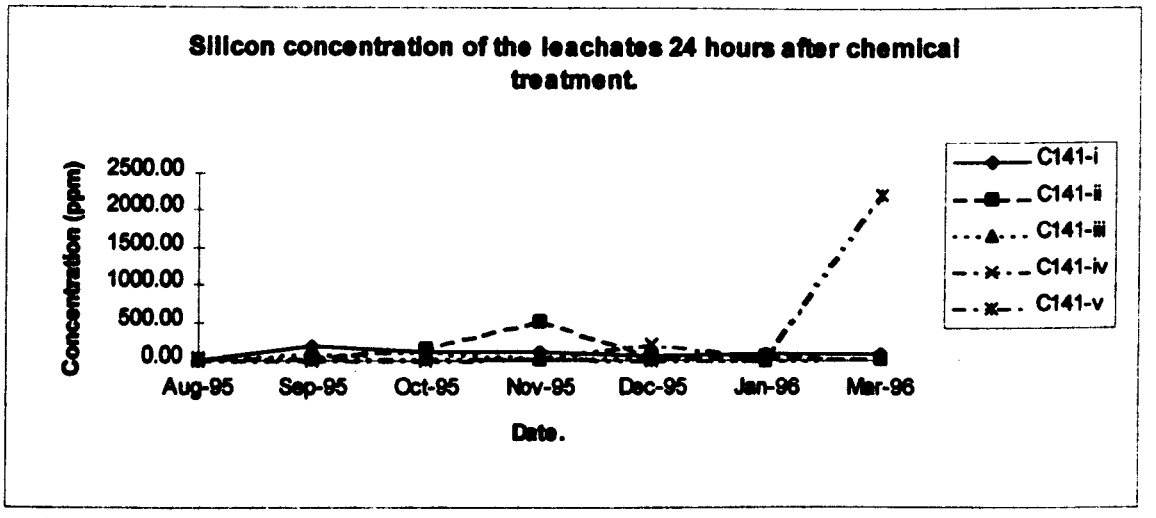


Figure C.56. Silica concentration of the leachate from sample C133. 24 hours after reagent addition.

APPENDIX C3: Roof weathering experiment XRF raw data.

Sample	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	TOT.	LOI
C1B1	51.06	0.68	24.25	15.29	0.72	1.98	0.42	0.45	4.14	0.17	0.01	99.37	21.64
C1B1-Na	48.29	0.67	23.24	18.32	0.82	2.21	0.55	0.49	3.99	0.18	0.02	98.76	24.06
C1B1-H	50.38	0.7	24.09	15.91	0.66	2.04	0.36	0.41	4.13	0.2	0.02	98.88	23.11
C1B1-N	54.28	0.72	26.62	9.28	0.32	1.76	0.2	0.46	4.42	0.15	0.12	97.97	26.51
C1B1-C	52.62	0.72	25.31	11.8	0.42	1.99	0.33	0.51	4.22	0.15	0.03	98.1	25.15
C1B1-Ca	54.28	0.75	26.38	9.57	0.35	1.81	0.26	0.63	4.51	0.17	0.02	98.71	26.27
C1B1-E	57.21	0.77	28.14	5.61	0.14	1.68	0.12	0.62	4.73	0.11	0.02	99.13	26.62
C21	63.81	1.17	23.4	4.88	0.05	1.3	0.32	0.24	3.42	0.1	0.11	98.86	15.74
C21-Nat.	63.33	1.18	22.41	6.12	0.1	1.47	0.32	0.19	3.26	0.13	0.03	98.54	16.92
C21-H	65.79	1.24	23.17	3.8	0.02	1.17	0.02	0.26	3.36	0.09	0.02	98.9	16.05
C21-N	64.32	1.22	24.03	3.66	0.03	1.15	0.02	0.24	3.37	0.07	0.02	98.09	16.81
C21-C	64.68	1.22	23.77	3.43	0.02	1.07	0.03	0.4	3.37	0.06	0.02	98.05	16.56
C21-Ca	63.13	1.19	22.74	4.91	0.07	1.34	0.2	0.51	3.31	0.23	0.11	97.74	15.41
C31	64.48	0.89	13.68	14.84	0.35	2.33	0.48	0.22	2.11	0.13	0.03	99.54	11.24
C31-Nat.	66.48	1.24	21.32	4.58	0.14	0.86	0.23	0.4	3.69	0.13	0.02	99.07	7.48
C31-H	67.65	1.24	21.08	3.94	0.11	0.76	0.07	0.33	3.57	0.11	0.02	98.86	5.96
C31-N	68.2	1.25	21.93	3.64	0.03	0.75	0.05	0.35	3.72	0.12	0.02	100	6.76
C31-C	68.33	1.24	21.33	3.43	0.11	0.8	0.12	0.42	3.63	0.11	0.02	99.52	6.85
C31-Ca	66.27	1.2	20.4	4.96	0.14	0.88	0.17	0.51	3.49	0.16	0.02	98.18	7.14
C31-E	66.07	1.26	21.35	4.49	0.12	0.88	0.14	0.45	3.7	0.13	0.02	98.59	7.57
C83	67.24	1.07	17.69	5.62	0.1	1.57	0.32	1.23	2.94	0.13	0.06	97.97	5.81
C83-Nat.	73.39	0.91	13.29	5.74	0.09	1.25	0.31	1.21	2.05	0.13	0.03	98.4	9.75
C83-H	75.61	0.95	13.44	4.71	0.01	1.02	0.08	1.26	2.08	0.1	0.02	99.25	4.16
C83-N	74.67	0.93	13.29	5.57	0.1	1.11	0.2	1.32	2.06	0.13	0.02	99.38	4.7
C83-C	75.24	0.96	13.59	4.64	0.06	1.2	0.22	1.28	2.11	0.11	0.02	99.41	4.81
C83-Ca	73.47	0.94	13.28	5.74	0.1	1.23	0.3	1.27	2.05	0.21	0.04	98.63	5.18
C92	42.85	0.69	18.52	26.62	0.94	1.6	2.22	0.39	2.81	1.16	0.12	97.12	64.35
C92-Nat.	29.44	0.48	10.79	50.59	1.29	1.54	1.87	0.1	1.73	0.63	0.16	98.52	38.22
C92-H	41.1	0.7	16.5	33.34	0.89	1.34	1.28	0.19	2.68	0.56	0.09	98.67	49.5
C92-N	25.62	0.34	8.85	56.4	1.59	2	2.18	0.1	1.28	0.78	0.04	99.08	32.17
C92-C	53.19	0.94	22.15	15.45	0.39	1.38	0.85	0.3	3.6	0.43	0.05	98.73	54.5
C92-Ca	43.02	0.74	17.08	30.93	0.73	1.45	1.57	0.41	2.71	0.77	0.02	99.41	51.11
C133	60.71	1.42	32.13	1.72	0.01	0.37	0.07	0.2	1.27	0.04	0.02	97.93	11.94
C133-Na	66.09	1.11	26.91	1.7	0.01	0.41	0.04	0.1	1.17	0.02	0.04	97.49	8.15
C133-H	67.35	1.15	27.34	1.64	0.01	0.31	0.02	0.17	1.18	0.03	0.02	99.18	8.83
C133-N	67.22	1.17	27.12	1.62	0.01	0.36	0.02	0.1	1.19	0.03	0.02	98.71	8.88
C133-C	65.36	1.13	27.21	1.89	0.01	0.35	0.02	0.1	1.13	0.02	0.06	97.17	8.39
C133-Ca	66.77	1.12	26.92	1.54	0.01	0.33	0.02	0.22	1.13	0.06	0.02	98.09	8.45
C141	59.85	1.04	20.82	9.95	0.26	1.98	0.58	0.25	3.5	0.25	0.04	98.52	8.72
C141-Na	59.22	1.01	20.76	9.51	0.22	1.99	0.54	0.22	3.45	0.23	0.08	97.23	8.33
C141-H	65.46	1.15	21.71	5.02	0.06	1.72	0.02	0.22	3.60	0.14	0.02	99.08	7.81
C141-N	64.54	1.12	21.84	4.13	0.02	1.65	0.02	0.1	3.69	0.11	0.02	97.12	6.94
C141-C	66.59	1.14	22.71	3.54	0.03	1.62	0.06	0.21	3.91	0.1	0.02	99.91	7.96
C141-Ca	62.36	1.08	21.67	5.75	0.11	1.95	0.35	0.57	3.59	0.59	0.02	98.02	8.62
C141-E	62.44	1.1	21.44	7.6	0.13	1.9	0.36	0.27	3.58	0.22	0.02	99.04	8.28