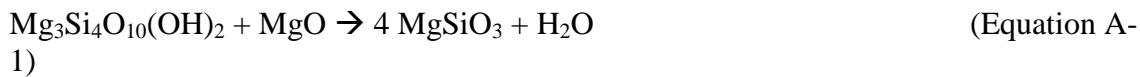


## **APPENDIX A-CHEMICAL CALCULATIONS**

Chemical equation for forming 50g forsterite powder

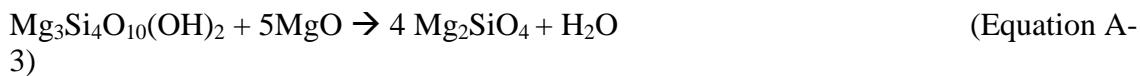


Talc



## Forsterite

From (Equation A-1) and (Equation A-2)



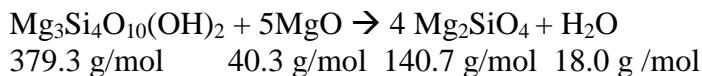
Talc

## Forsterite

Table A-1: Molecular Weight (g/mol) for each element:

Element	Molecular Weight (g/mol)
Mg	24.3
O	16.0
Si	28.1
H	1.0

From (Equation A-3)



To produce 50g forsterite powder, 4 mol of forsterite produce 1 mol of talc and 5 mol of MgO.

Therefore,

$$\text{Number of mol for forsterite} = \frac{50 \text{ g}}{140.7 \text{ g/mol}} = 0.3554 \text{ mol}$$

$$\text{Number of mol for talc} = \frac{0.3554 \text{ mol}}{4} = 0.0889 \text{ mol}$$

$$\text{Mass needed for talc} = 0.0889 \text{ mol} \times 379.3 \text{ g/mol} = 33.720 \text{ g}$$

$$\text{Number of mol for MgO} = 0.3554 \text{ mol} \times \frac{5}{4} = 0.4443 \text{ mol}$$

$$\text{Mass needed for MgO} = 0.4443 \text{ mol} \times 40.3 \text{ g/mol} = 17.9053 \text{ g}$$

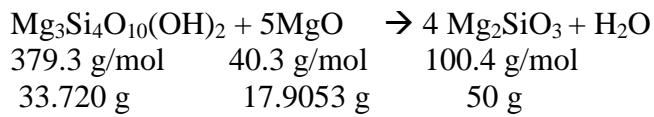
$$\text{Weight percentage of talc} = \frac{33.720}{33.720 + 17.9053} \times 100 \% = 65.3168 \%$$

$$\text{Weight percentage of MgO} = \frac{17.9053}{33.720+17.9053} \times 100 \% = 34.6832 \%$$

$$\text{Ratio of MgO/Talc} = \frac{34.6832 \%}{65.3168 \%} \times 100 \% = 0.5310$$

$$\text{Ratio of Talc/MgO} = \underline{\underline{1:1.8832}}$$

In conclusion:



## APPENDIX B – JCPDS FILES

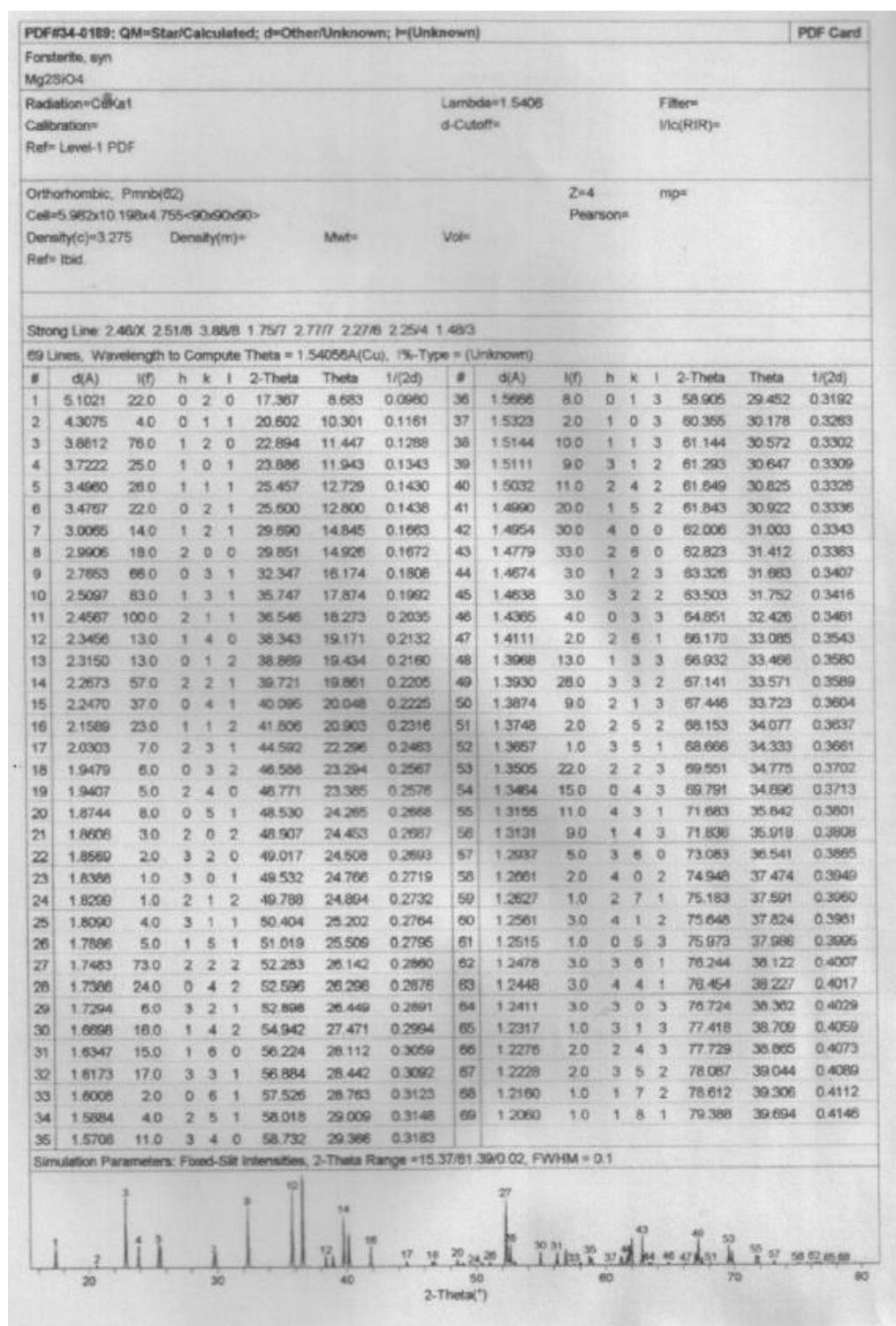


Figure B-1: JCPDS for forsterite

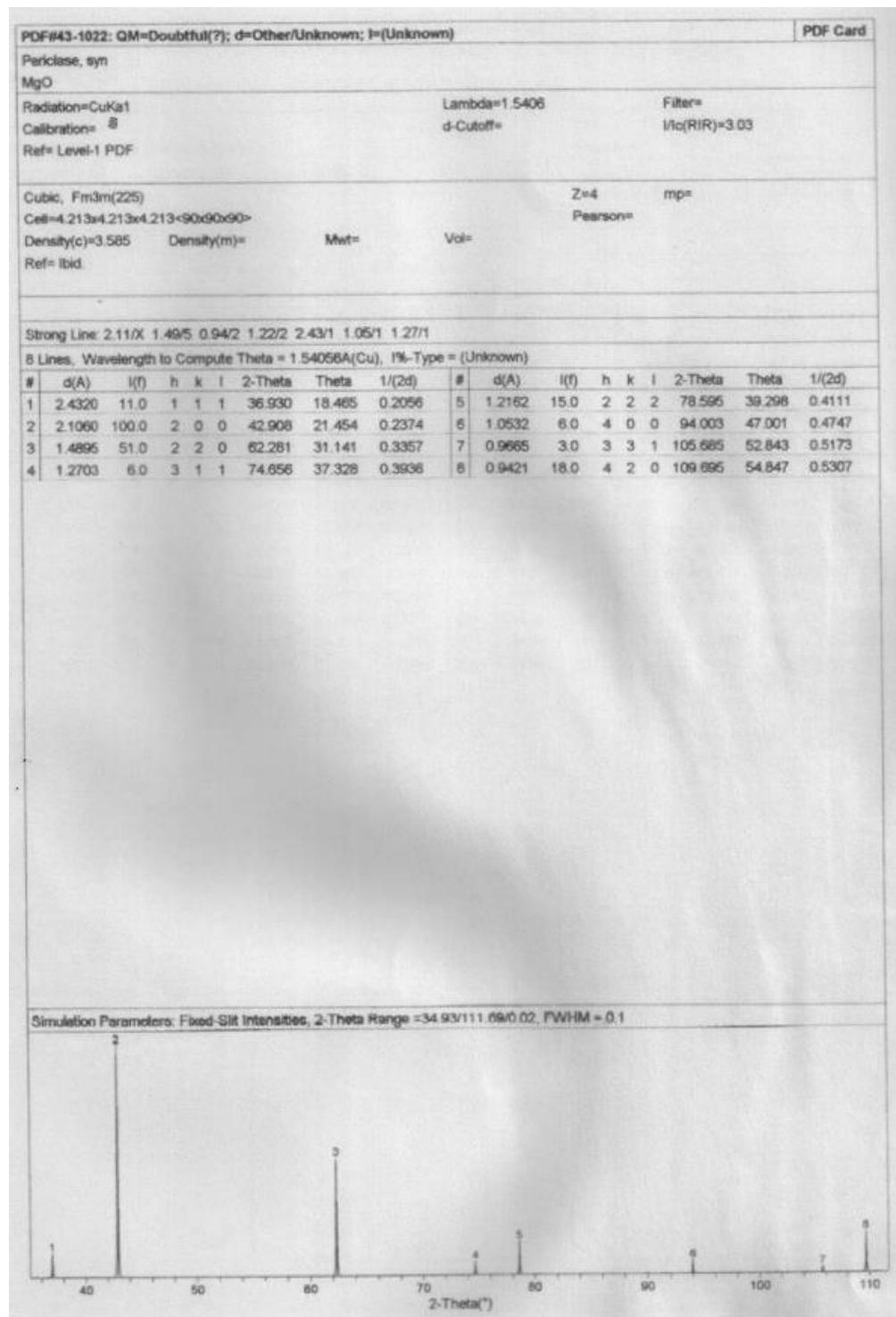


Figure B-2: JCPDS for magnesium oxide

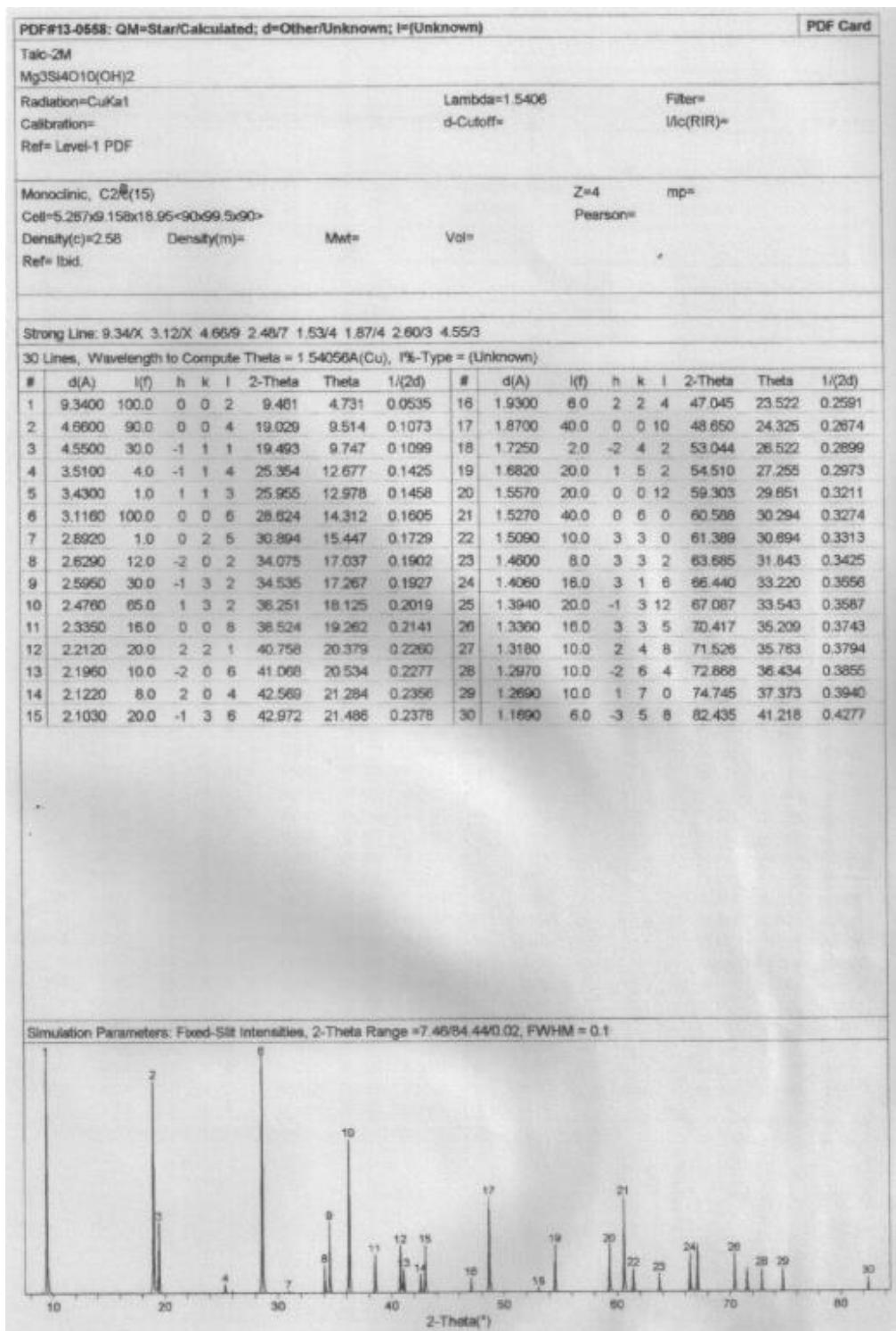


Figure B-3: JCPDS for talc,

PDF#11-0273: QM=Star/Calculated; d=Other/Unknown; I=(Unknown)												PDF Card														
Proto-enstatite MgSiO <sub>3</sub>																										
Radiation=CuKa1						Lambda=1.5406			Filter=																	
Calibration=						d-Cutoff=			I/c(RIR)=																	
Ref= Level-1 PDF																										
Orthorhombic, Pbcn(60) Cell=9.25x8.74x5.32<90x90x90>						Z=8	mp=			Pearson=																
Density(c)=3.101	Density(m)=	Mwt=	Vol=																							
Ref= Ibid.																										
Strong Line: 3.17/X 2.91/4 2.55/3 2.73/2 3.24/2 2.31/2 1.64/2 1.97/2																										
38 Lines, Wavelength to Compute Theta = 1.54056A(Cu), Pk-Type = (Unknown)																										
#	d(A)	I(f)	h	k	l	2-Theta	Theta	I/(2d)	#	d(A)	I(f)	h	k	l	2-Theta	Theta	I/(2d)									
1	6.3500	3.0	1	1	0	13.935	6.967	0.0787	20	1.8500	1.0	2	4	1	49.211	24.605	0.2703									
2	4.6200	1.0	2	0	0	19.195	9.598	0.1082	21	1.8290	1.0	3	2	2	49.814	24.907	0.2734									
3	4.3700	3.0	0	2	0	20.305	10.152	0.1144	22	1.8100	5.0	5	1	0	50.373	25.187	0.2762									
4	4.0900	1.0	1	1	1	21.711	10.855	0.1222	23	1.7450	1.0	4	0	2	52.389	26.195	0.2855									
5	3.2400	20.0	2	1	1	27.506	13.753	0.1543	24	1.7160	13.0	4	3	1	53.344	26.672	0.2914									
6	3.1700	100.0	1	2	1	28.126	14.063	0.1577	25	1.7110	3.0	4	1	2	53.512	26.756	0.2922									
7	2.9080	40.0	3	1	0	30.720	15.360	0.1719	26	1.6610	5.0	1	4	2	55.258	27.629	0.3010									
8	2.7790	3.0	1	3	0	32.184	16.092	0.1799	27	1.6420	20.0	0	2	3	55.953	27.977	0.3045									
9	2.7260	20.0	2	2	1	32.827	16.414	0.1834	28	1.6210	5.0	4	2	2	56.743	28.372	0.3085									
10	2.5510	30.0	3	1	1	35.150	17.575	0.1960	29	1.5880	1.0	4	4	0	58.033	29.017	0.3149									
11	2.4620	7.0	1	3	1	36.484	18.232	0.2031	30	1.5640	1.0	2	5	1	59.011	29.505	0.3197									
12	2.3050	20.0	2	0	2	39.045	19.523	0.2169	31	1.5430	1.0	6	0	0	59.895	29.948	0.3240									
13	2.2360	5.0	2	3	1	40.301	20.151	0.2236	32	1.5210	1.0	3	5	0	60.853	30.426	0.3287									
14	2.2290	3.0	2	1	2	40.433	20.217	0.2243	33	1.4990	15.0	5	3	1	61.843	30.921	0.3336									
15	2.1170	5.0	3	3	0	42.674	21.337	0.2362	34	1.4950	15.0	1	3	3	62.027	31.013	0.3344									
16	2.0610	3.0	4	1	1	43.893	21.947	0.2426	35	1.4570	7.0	0	6	0	63.832	31.918	0.3432									
17	1.9750	20.0	1	4	1	45.911	22.955	0.2532	36	1.4030	1.0	6	2	1	66.600	33.300	0.3564									
18	1.9680	20.0	3	3	1	46.084	23.042	0.2541	37	1.3760	7.0	0	4	3	68.083	34.042	0.3634									
19	1.9060	1.0	4	2	1	47.621	23.810	0.2621	38	1.3590	5.0	3	3	3	69.055	34.527	0.3679									
Simulation Parameters: Fixed-Slit Intensities, 2-Theta Range =11.93/71.05/0.02, FWHM = 0.1																										

Figure B-4: JCPDS for proto enstatite

PDF#19-0769: QM=Doubtful(?) d=Other/Unknown; I=(Unknown)												PDF Card							
Clinoenstatite, syn																			
MgSiO <sub>3</sub>																			
Radiation=CuKa1						Lambda=1.5406						Filter=							
Calibration=						d-Cutoff=						I/Ic(RIR)=							
Ref= Level-1 PDF																			
Monoclinic, P21/a(14)												Z=8	mp=						
Cell=9.606x8.815x6.169<90x108.3x90>												Pearson=							
Density(c)=3.21	Density(m)=	Mwt=	Vol=																
Ref= Ibid.																			
Strong Line: 2.67/X 2.98/8 2.45/3 2.12/3 3.17/3 3.28/3 2.43/2 2.52/2																			
61 Lines, Wavelength to Compute Theta = 1.54056A(Cu), I%-Type = (Unknown)																			
#	d(A)	I(f)	h	k	l	2-Theta	Theta	1/(2d)	#	d(A)	I(f)	h	k	l	2-Theta	Theta	1/(2d)		
1	6.3400	2.0	-1	1	0	13.957	6.978	0.0789	32	1.7618	8.0	1	3	2	51.852	25.926	0.2838		
2	4.4100	6.0	0	2	0	20.119	10.059	0.1134	33	1.7580	8.0	2	4	1	51.973	25.986	0.2844		
3	4.2900	2.0	0	1	1	20.687	10.344	0.1166	34	1.7305	4.0	1	5	0	52.862	26.431	0.2889		
4	3.5230	2.0	1	1	1	25.259	12.629	0.1419	35	1.7110	2.0	4	2	1	53.512	26.756	0.2922		
5	3.2610	25.0	0	2	1	27.156	13.578	0.1524	36	1.6567	2.0	-2	4	2	55.414	27.707	0.3018		
6	3.1700	30.0	-2	2	0	28.126	14.063	0.1577	37	1.6401	4.0	0	4	2	56.024	28.012	0.3049		
7	2.9760	75.0	-2	2	1	30.001	15.001	0.1680	38	1.6055	12.0	-5	3	1	57.342	28.671	0.3114		
8	2.8730	100.0	3	1	0	31.104	15.552	0.1740	39	1.5850	2.0	-4	4	0	58.154	29.077	0.3155		
9	2.7940	2.0	1	3	0	32.006	16.003	0.1790	40	1.5244	8.0	-6	0	2	60.703	30.351	0.3280		
10	2.7630	2.0	2	1	1	32.375	16.188	0.1810	41	1.5203	10.0	6	0	0	60.884	30.442	0.3289		
11	2.5380	14.0	-1	3	1	35.336	17.668	0.1970	42	1.4852	6.0	-2	3	3	62.482	31.241	0.3367		
12	2.5180	18.0	-2	0	2	35.626	17.813	0.1986	43	1.4752	2.0	-1	3	3	62.954	31.477	0.3389		
13	2.4520	30.0	0	0	2	36.618	18.309	0.2039	44	1.4691	4.0	0	6	0	63.245	31.623	0.3403		
14	2.4310	18.0	2	2	1	36.946	18.473	0.2057	45	1.4570	2.0	4	0	2	63.832	31.916	0.3432		
15	2.3740	8.0	-2	3	1	37.866	18.933	0.2106	46	1.3943	2.0	-4	5	0	67.070	33.535	0.3586		
16	2.2930	2.0	-4	1	1	39.258	19.629	0.2181	47	1.3563	2.0	1	3	3	69.212	34.606	0.3687		
17	2.2780	2.0	4	0	0	39.527	19.764	0.2195	48	1.3382	2.0	6	0	1	70.285	35.142	0.3736		
18	2.2066	6.0	4	1	0	40.862	20.431	0.2266	49	1.3230	2.0	6	1	1	71.214	35.607	0.3779		
19	2.2015	6.0	0	4	0	40.961	20.481	0.2271	50	1.3134	2.0	0	4	3	71.815	35.907	0.3807		
20	2.1362	2.0	1	1	2	42.272	21.136	0.2341	51	1.2873	2.0	-4	4	3	73.506	36.753	0.3884		
21	2.1152	30.0	-3	3	1	42.712	21.356	0.2364	52	1.2686	2.0	-2	6	2	74.773	37.387	0.3941		
22	2.0882	2.0	-4	2	1	43.292	21.646	0.2394	53	1.2604	2.0	0	6	2	75.344	37.672	0.3967		
23	2.0312	2.0	-3	2	2	44.571	22.286	0.2462	54	1.2423	2.0	-5	5	2	76.639	38.319	0.4025		
24	2.0157	4.0	-4	0	2	44.933	22.466	0.2481	55	1.2151	2.0	0	1	4	78.680	39.340	0.4115		
25	2.0106	4.0	0	4	1	45.053	22.526	0.2487	56	1.2123	2.0	3	5	2	78.897	39.449	0.4124		
26	1.9631	2.0	2	4	0	45.713	22.856	0.2521	57	1.1033	2.0	3	6	2	88.559	44.280	0.4532		
27	1.9648	2.0	-4	1	2	46.163	23.081	0.2545	58	1.0658	2.0	6	5	1	92.560	46.280	0.4691		
28	1.9326	2.0	-2	4	1	46.973	23.486	0.2587	59	1.0632	2.0	8	3	0	92.853	46.427	0.4703		
29	1.9220	2.0	2	0	2	47.253	23.626	0.2601	60	1.0478	2.0	7	5	0	94.638	47.319	0.4772		
30	1.8454	2.0	-4	3	1	49.342	24.571	0.2709	61	1.0307	2.0	2	8	1	96.720	48.360	0.4851		
31	1.7852	4.0	-3	4	1	51.123	25.562	0.2801											

Simulation Parameters: Fixed-Slit Intensities, 2-Theta Range =11.96/98.72/0.02, FWHM = 0.1

Figure B-5: JCPDS for clinoenstatite

## APPENDIX C: INSTRUMENTATIONS



(a)

(b)

Figure C-1: (a) Magnesium oxide powder, (b) talc powder

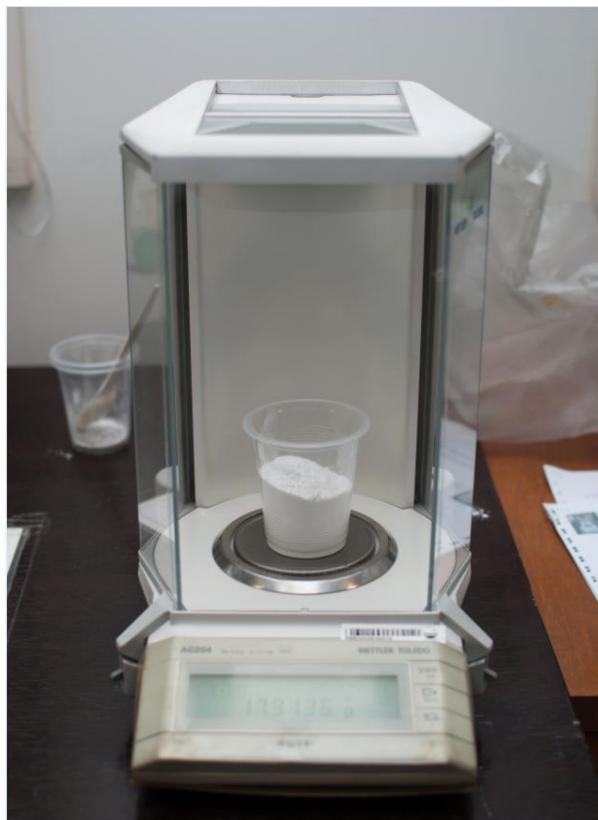


Figure C-2: AG204 Mettler Toledo Balance, Switzerland



Figure C3: Shimadzu AY220 Densi-Meter Balance

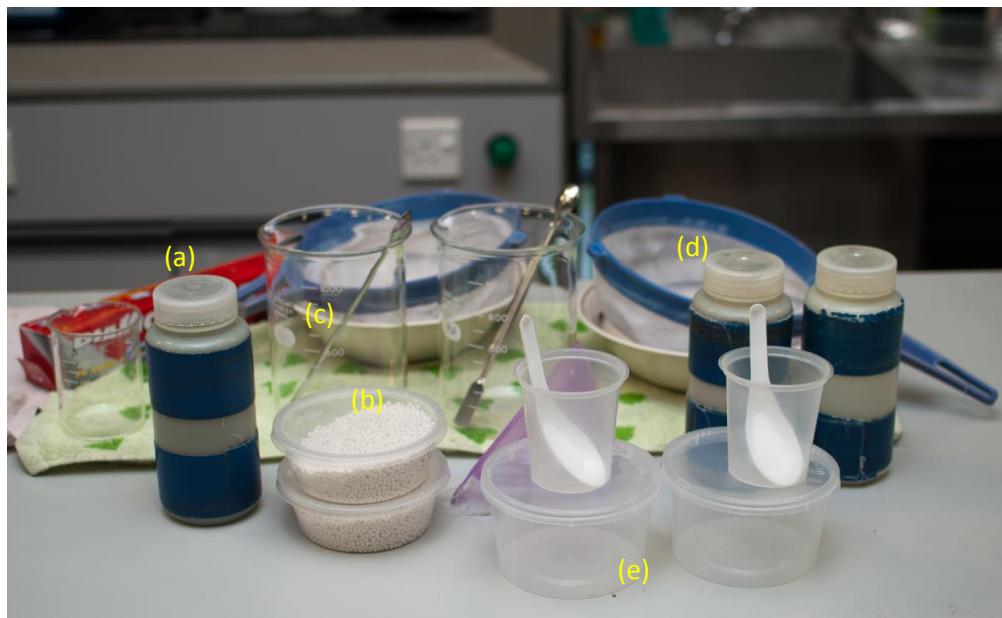


Figure C-4: (a) Ball milling bottle, (b) Ball milling media, (c) Beaker & spatula, (d) Plastic sieve, (e) Plastic container & spoon



Figure C-5: Liarre ultrasonic bath machine



Figure C-6: Cole-Palmer ultrasonic processor



Figure C-7: Ball milling machine and milling media



Figure C-8: Endecotts stainless steel test sieve



Figure C-9: Bench Press Machine



Figure C-10: Memmert oven used for drying samples



Figure C-11: 8.3kW Box Furnace (ModuTemp, Australia)



Figure C-12: Grinding machine (IMPTECH)

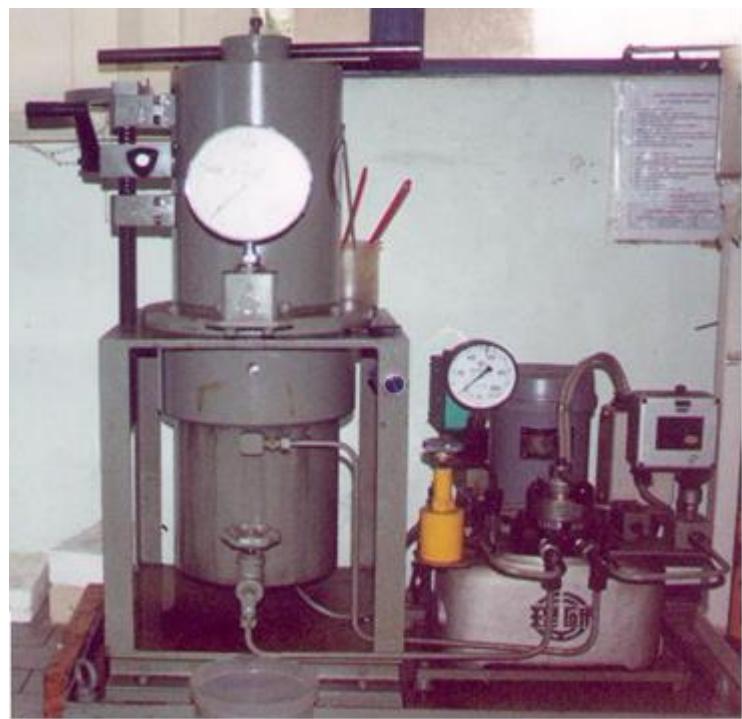


Figure C-13: Cold Isostatic Press Machine (Reiken Seiki Japan)



Figure C-14: X-ray Diffractometer (XRD) (Geiger-Flex, Rigaku, Japan)



Figure C-15: HMV Shimadzu Vickers micro hardness machine



Figure C-16: ZEISS AURIGA FESEM microscope



Figure C-17: Forsterite green disc samples



Figure C-18: Sintered forsterite disc samples



Figure C-19: Forsterite disc samples after quenching experiment