

## Structure variation in low cordierites

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## Abstract

Crystal structures of six metamorphic low cordierites with Fe/(Fe + Mg) ranging from 0.07 to 0.42 (atomic) were refined from X-ray data. No evidence of a superstructure was found, confirming that, in chemically intermediate cordierites, Fe and Mg are located on a single site. Although T-O distances remain nearly constant, increased Fe content causes (1) the M site to enlarge, (2) the channels to move apart, and (3) *a* and *b* to increase. In addition, channel rings rotate, change their shape, and move closer together within each channel, causing a decrease in *c*. Difference Fourier maps confirm that channel water is located in a split location near (0,0,¼). Its orientation is interpreted as being largely controlled by an excess negative charge on O(4) and O(5). The H-O-H plane is oriented nearly parallel to (100) and the H-H vector may either be close to [001] or [010]. Channel cations may be located at several locations at the channel walls in addition to the well-defined site at (0,0,0). Low framework cation-site occupancies are explained by 3-4 percent vacancies that balance for cation in the channel. Vacancies on T(2) and T(5) sites are inversely correlated, and on these sites an increasing number of vacancies produces an enlargement of tetrahedra. Minor differences in mean T-O distances, usually ascribed to Al-Si substitution, may be caused by tetrahedral distortions and vacancies.

## Introduction

Structural aspects of cordierite,  $(\text{Mg, Fe})_2\text{AlSi}_2\text{O}_{10}$ , have recently been the topic of lively discussions. Although the basic cordierite structure (Fig. 1) has been known for some time, intriguing questions have persisted. The present study is based on X-ray refinements made from six cordierites collected from the Bergell region in the Central Alps. These multiple refinements allowed us to observe trends in several structural parameters and to deduce how a number of them are related.

Although cordierite displays a wide range of Fe-Mg substitution, its effect on the cordierite structure has not been systematically examined. Our study fills this need because the six crystals display Fe/(Fe + Mg) values ranging from 0.07 to 0.42 (atomic). Over this compositional range it was found that the cordierite structure adjusts to Fe-Mg substitution in a regular fashion.

A considerable portion of the recent interest in cordierite relates to the channels formed by the stacking of six-membered tetrahedral rings parallel to (001). There is general agreement that the majority

of the minor constituents found in cordierite are located in these channels, although there is discussion about their precise location and orientation (Miyashiro, 1957; Smith and Schreyer, 1960; Schreyer and Yoder, 1964; Gibbs, 1966; Meagher, 1967; Farrell and Newnham, 1967; Tsang and Ghose, 1972; Cohen *et al.*, 1977; Goldman *et al.*, 1977). Our study presents new information concerning the location and orientation of water, possible locations for channel constituents at the channel walls, and evidence that the net positive charge of cations in the channel is balanced by cation site vacancies within the cordierite structural framework.

Cohen *et al.* (1977) presented a new interpretation of Al-Si distribution on cordierite tetrahedral sites. Adjustments in tetrahedral dimensions that we observed as Fe substitutes for Mg in the cordierite structure support their analysis.

After our paper was submitted the reviewers (G. E. Brown and M. Hochella) informed us that they had submitted a paper (Hochella *et al.*, 1979) on heating experiments, which arrived at similar conclusions but on the basis of different observations. Their work complements our study. We modified our manuscript

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16	2	24	23	*****	L =	5	*****	6	14	57	56
16	14	31	30					6	26	26	25
16	16	32	31	1	5	50	51	6	28	27	28
17	1	37	35	1	7	55	54	6	30	58	60
17	15	38	37	1	9	81	82	7	1	52	53
				1	15	60	60	7	3	53	55
*****	L =	4	*****	1	17	27	28	7	9	57	60
				1	19	21	19	7	13	72	71
0	0	327	322	1	21	33	33	7	15	45	45
0	2	20	14	1	27	36	36	7	17	47	48

0	4	77	73	1	31	34	33	7	19	85	86
0	6	170	168	2	4	56	55	7	21	33	32
0	8	46	47	2	8	59	58	8	0	167	168
0	10	70	68	2	12	69	68	8	2	36	37
0	12	37	39	2	14	27	26	8	4	34	34
0	16	42	41	2	16	40	40	8	6	46	49
0	20	81	81	2	18	25	25	8	8	49	52
0	22	35	35	2	20	23	23	8	10	31	31
0	24	64	65	2	24	34	33	8	12	80	83
0	26	35	35	3	1	48	51	8	14	48	51
0	28	47	48	3	5	45	46	8	16	35	34
1	1	24	24	3	7	26	25	8	18	60	62
1	3	45	44	3	11	65	65	8	20	40	39
1	5	15	14	3	13	49	50	8	22	40	39
1	7	98	96	3	17	77	76	8	24	35	37
1	11	17	16	3	19	50	50	9	1	52	53
1	13	103	102	3	21	35	35	9	3	31	31
1	15	72	71	3	23	36	37	9	5	19	20
1	19	71	70	4	2	52	54	9	7	65	65
1	23	33	33	4	6	93	97	9	13	51	53
1	25	50	51	4	8	22	21	10	0	22	22
2	0	41	42	4	10	24	24	10	2	31	30
2	2	68	66	4	14	78	78	10	4	63	64
2	4	60	61	4	20	47	46	10	6	97	99
2	6	291	285	4	22	43	43	10	10	33	35
2	8	125	124	4	24	28	28	10	14	56	58
2	10	157	158	5	1	34	35	10	16	56	58
2	12	157	155	5	3	72	78	10	18	24	24
2	16	92	91	5	5	23	23	10	26	33	31
2	18	97	97	5	5	86	88	11	3	41	42
2	20	38	39	5	13	48	48	11	5	56	57
2	22	32	32	5	21	26	26	11	7	32	33
2	26	62	65	5	25	38	39	11	11	68	69
2	28	27	27	6	2	40	40	11	13	24	25
2	30	42	44	6	4	29	28	11	15	33	34
3	1	73	77	6	8	42	43	11	25	57	59
3	3	164	168	6	12	37	36	12	4	31	31
3	5	53	53	6	14	23	22	12	8	47	46
3	7	150	147	6	24	34	34	12	10	31	32
3	11	83	82	7	1	60	61	12	12	67	70
3	13	74	73	7	3	66	68	12	18	31	33
3	15	31	31	7	9	72	76	12	24	49	51
3	17	30	28	7	13	45	46	13	1	69	69
3	21	60	61	7	15	38	37	13	3	63	63
3	23	28	28	7	25	45	44	13	5	54	54
3	25	33	33	8	2	27	27	13	7	40	40
3	29	28	29	8	4	26	27	13	9	48	48
3	31	37	40	8	6	40	41	14	0	25	26
4	0	288	303	8	8	31	32	14	2	30	29
4	2	38	41	8	10	29	30	14	4	22	22
4	4	56	58	8	12	45	46	14	6	32	32
4	8	129	129	9	1	70	72	14	18	42	43
4	10	172	174	9	3	43	44	15	5	31	31
4	12	93	91	9	7	49	51	15	11	44	45
4	16	51	51	9	11	28	30	16	0	27	27
4	20	57	56	9	13	53	54	16	12	56	55

4	24	76	77	9	15	58	59	17	1	39	39
4	26	41	40	9	17	25	26	17	7	32	32
5	1	112	118	9	19	31	31	18	0	59	57
5	5	78	82	9	23	38	38				
5	7	33	34	10	2	40	41	*****	L =	7	*****
5	9	121	123	10	4	39	41				
5	11	32	33	10	10	24	23	1	5	134	136
5	13	20	21	10	12	22	23	1	9	34	33
5	17	24	24	10	14	44	44	1	15	58	57
5	19	102	104	10	16	37	39	1	21	66	66

K	H	FO	FC	K	H	FO	FC	K	H	FO	FC
1	27	34	34	9	13	24	24	6	6	157	159
1	31	47	48	9	19	44	45	6	8	29	30
2	4	120	121	9	25	36	37	6	10	51	51
2	8	36	37	10	0	59	60	6	14	25	25
2	12	84	83	10	6	61	60	6	16	37	37
2	18	33	34	10	8	47	47	6	22	40	37
2	20	41	43	10	12	37	37	6	26	36	35
2	24	29	30	10	18	64	67	7	3	44	45
3	1	126	133	11	1	54	54	7	7	32	31
3	13	22	21	11	7	43	43	7	13	43	44
3	15	52	51	11	9	37	37	7	15	45	43
3	17	91	91	11	13	38	38	7	19	54	55
3	19	37	36	11	19	29	32	7	25	37	38
3	23	23	24	11	23	34	34	8	0	85	85
3	27	28	28	12	0	107	106	8	2	32	32
4	6	51	52	12	2	41	40	8	4	50	49
4	10	36	37	12	6	42	39	8	12	49	50
4	14	62	61	12	12	40	41	8	14	35	35
4	16	21	21	12	20	25	24	8	20	54	54
4	18	26	25	13	3	26	24	8	22	34	35
4	20	65	65	13	7	24	23	8	24	32	34
4	22	52	52	13	13	50	49	9	1	39	39
4	28	31	31	13	19	32	31	9	7	51	50
5	3	44	45	14	6	67	68	9	13	32	32
5	7	31	31	14	8	42	42	9	19	27	27
5	9	87	88	14	10	35	34	10	0	51	50
5	13	35	35	14	14	27	24	10	4	30	30
5	21	24	24	14	18	33	33	10	6	59	58
5	25	33	36	15	1	44	43	10	12	40	40
6	4	51	53	15	7	30	30	10	18	28	28
6	10	36	38	16	0	68	65	11	1	28	28
6	12	48	50	16	10	31	30	11	3	35	33
6	14	24	24	17	5	33	30	11	5	43	41
6	22	24	24					11	9	30	29
7	3	84	85	*****	L =	9	*****	11	11	60	58
7	9	47	48					11	17	28	27
7	11	37	36	1	5	38	39	11	19	26	28
7	13	76	79	1	7	37	36	12	4	29	28
7	17	23	23	1	9	49	50	12	10	42	40
7	21	27	26	1	15	39	39	12	12	46	45
7	27	27	26	1	17	22	23	12	18	35	36
8	2	30	29	1	21	23	23	13	1	63	61

8	4	50	53	1	27	32	32	13	9	32	33
8	6	26	27	2	4	28	28	14	2	51	47
8	8	29	29	2	8	33	33	14	4	35	33
8	12	51	52	2	10	18	16	14	6	33	33
8	20	25	23	2	12	40	38	14	14	34	34
8	24	27	27	2	14	30	30	15	3	28	25
9	1	57	57	2	16	28	27	15	5	38	36
9	3	48	48	2	18	25	24	16	2	30	27
9	5	58	57	3	1	39	41				
9	13	76	78	3	5	55	57	*****	L = 11	*****	
9	15	54	55	3	11	56	55				
9	17	42	41	3	17	57	58	1	7	58	57
9	19	40	40	3	19	49	49	1	9	58	56
9	23	35	37	3	21	36	35	1	15	34	33
10	2	35	34	4	2	53	53	1	17	31	30
10	4	64	64	4	6	71	71	2	8	32	31
10	6	22	24	4	10	23	22	2	12	29	29
10	12	41	42	4	14	65	66	2	14	27	29
10	14	26	27	4	20	23	24	2	16	35	35
10	16	27	29	4	22	38	39	3	5	55	56
10	20	44	45	5	1	22	21	3	11	62	61
11	5	24	25	5	3	54	55	3	13	36	36
11	7	27	29	5	9	62	62	3	17	37	38
11	9	67	66	5	13	41	40	3	19	35	35
11	19	24	22	5	25	29	30	3	21	35	34
12	2	29	28	6	2	30	31	3	23	29	27
12	4	34	34	6	4	26	25	4	2	56	57
12	6	48	47	6	8	31	31	4	6	59	59
12	18	29	30	6	12	30	30	4	8	24	24
12	22	26	26	7	1	40	40	4	10	35	34
13	5	22	21	7	3	58	59	4	14	49	50
14	2	27	27	7	9	49	50	4	24	29	29
14	6	36	35	7	13	45	47	5	1	20	19
15	7	27	26	7	15	25	27	5	3	46	47
15	9	28	27	7	25	32	32	5	9	44	45
16	4	37	36	8	6	38	39	5	13	33	33
				8	8	22	22	5	25	26	25
*****	L = 8	*****		8	10	30	30	6	2	31	32
				8	12	23	24	6	8	31	33
0	0	386	391	9	1	48	47	6	24	31	32
0	2	76	78	9	3	20	19	7	1	58	56
0	6	75	73	9	7	31	30	7	3	27	27
0	10	122	120	9	11	31	30	7	9	50	50
0	12	51	51	9	13	28	31	7	11	30	29
0	14	57	56	9	15	37	39	7	15	40	38
0	16	95	94	9	19	33	33	8	6	29	28
0	20	61	60	10	2	39	38	8	10	24	23
0	24	67	66	10	4	26	26	8	12	24	23
1	1	46	49	10	14	37	38	9	1	46	45
1	3	28	29	10	16	28	28	9	7	44	43
1	7	52	51	10	18	25	25	9	11	23	23
1	9	45	46	10	20	27	27	9	15	35	35
1	13	75	73	11	3	38	37	9	21	25	25
1	15	34	32	11	9	38	36	10	2	26	27
1	17	28	27	12	6	46	45	10	14	34	34
1	19	69	70	12	10	22	22	10	16	30	29

1	21	30	30	14	6	46	46	11	3	44	42
1	23	32	31	14	10	26	26	11	13	26	25
2	0	36	37					11	17	27	26
2	6	116	113	*****	L = 10	*****		12	6	47	45
2	8	52	62					12	10	30	28
2	10	95	94	0	0	29	28	12	16	32	31
2	12	90	89	0	2	54	53	14	6	42	39
2	14	31	31	0	4	80	81	14	10	31	29
2	16	51	50	0	6	24	24				
2	18	60	58	0	8	47	47	*****	L = 12	*****	
2	22	42	44	0	10	46	45				
2	26	57	59	0	12	179	175	0	0	192	188
2	29	27	28	0	14	27	27	0	6	45	45
2	30	32	34	0	18	50	49	0	10	58	56
3	1	22	24	0	22	83	82	0	16	48	47
3	3	51	50	0	24	40	40	0	20	44	44
3	7	89	88	0	26	33	30	0	24	30	31
3	9	35	35	0	28	35	33	1	1	30	29
3	11	25	24	1	1	79	80	1	3	27	28
3	13	61	61	1	3	78	76	1	7	30	30
3	21	30	29	1	5	63	62	1	13	53	51
3	25	41	41	1	7	32	32	1	19	50	49
4	0	135	137	1	9	51	51	2	6	86	86
4	6	52	53	1	11	60	59	2	8	55	54
4	8	67	68	1	13	23	22	2	10	65	64
4	10	70	77	1	17	28	28	2	12	62	62
4	12	39	40	1	19	28	29	2	16	34	35
4	24	55	56	2	0	86	86	2	18	51	51
5	1	80	82	2	2	93	92	3	3	46	45
5	3	47	49	2	4	58	58	3	5	21	19
5	5	104	107	2	6	49	48	3	7	60	60
5	9	87	89	2	10	55	54	3	11	33	31
5	11	56	55	2	12	39	40	3	13	39	38
5	15	41	42	2	14	65	65	4	0	97	95
5	17	40	41	2	16	59	57	4	8	65	64
5	19	54	55	2	22	30	30	4	10	61	60
5	25	38	40	3	1	46	48	4	12	41	40
6	0	45	48	3	3	21	22	4	20	26	23
6	2	86	85	3	5	37	39	4	24	51	51
6	4	30	31	3	9	37	37	5	1	40	41
6	6	71	72	3	13	35	35	5	5	57	56
6	8	29	28	3	19	58	59	5	9	39	41
6	10	23	24	3	25	35	35	5	11	29	29
6	12	34	32	4	0	36	35	5	19	43	45
6	14	28	28	4	2	43	45	6	0	32	30
6	16	66	67	4	4	33	32	6	2	48	47
6	18	118	119	4	5	54	55	6	6	25	25
6	20	24	22	4	10	26	25	6	12	27	27
7	1	48	49	4	12	92	92	6	16	43	41
7	3	95	94	4	14	30	30	6	18	71	70
7	5	58	59	4	18	34	34	7	1	36	36
7	7	65	66	4	22	40	41	7	3	68	67
7	11	39	40	4	24	30	32	7	5	44	43
7	13	23	24	4	26	27	27	7	7	40	40
7	25	38	38	5	3	55	54	7	11	34	34
8	0	43	41	5	7	102	103	8	0	38	37

8	2	32	32	5	9	32	32	8	6	25	24
8	8	107	109	5	11	26	26	8	8	53	53
8	10	49	49	5	13	64	64	8	10	29	28
8	12	69	70	5	15	44	43	8	12	51	52
8	24	48	48	5	21	38	37	9	5	33	31
9	1	20	21	5	23	34	33	9	11	36	35
9	5	41	42	5	25	35	35	9	19	32	31
9	7	21	22	6	0	57	55	10	2	33	33
9	9	20	20	6	4	74	75	10	6	42	41
9	11	49	51								

K	H	FO	FC	K	H	FO	FC	K	H	FO	FC
10	8	42	42								
10	18	56	57								
11	1	38	37								
11	7	28	26								
11	11	25	25								
11	13	32	31								
12	0	83	77								
12	2	32	29								
12	6	31	30								
12	12	32	32								
13	11	26	24								
14	6	48	46								

\*\*\*\*\* L = 13 \*\*\*\*\*

1	5	57	57
1	9	28	26
1	15	32	32
1	21	34	34
2	4	55	54
2	12	43	43
3	1	57	56
3	15	23	22
3	17	49	48
4	6	25	26
4	14	32	31
4	20	40	39
4	22	28	27
5	3	24	23
5	9	45	44
6	4	22	21
7	3	34	35
7	9	30	29
7	13	34	34
8	4	32	30
8	12	32	32
9	1	36	34
9	3	28	28
9	5	29	27
9	13	45	45
9	15	35	34
9	17	25	23

10	4	37	35
11	9	37	35
12	6	33	30

\*\*\*\*\* L = 14 \*\*\*\*\*

0	0	76	75
0	4	28	28
0	8	48	48
0	10	22	22
0	12	65	62
0	16	48	48
0	22	37	37
1	3	45	45
1	5	43	43
1	7	33	33
1	11	31	32
2	0	52	51
2	2	39	38
2	4	51	51
2	6	70	68
2	16	23	22
2	18	48	48
3	1	41	41
3	5	39	39
3	9	48	47
3	11	25	23
3	15	24	23
3	17	25	25
3	19	40	40
4	0	58	56
4	2	40	39
4	4	48	47
4	12	75	75
4	14	30	28
4	20	30	31
5	7	44	44
5	13	41	40
6	0	67	65
6	4	22	22
6	6	50	50
6	14	27	27
7	1	26	26
7	9	33	32
7	13	34	35
7	17	29	28
8	0	82	78
8	6	32	30
8	8	36	35
8	12	45	42
8	14	24	26
9	1	29	28
9	7	29	29
9	13	29	29
10	2	27	23
10	4	36	35

10	6	51	48
11	5	26	27

\*\*\*\*\* L = 15 \*\*\*\*\*

1	5	41	40
2	4	31	30
2	12	25	25
3	1	42	41
3	17	40	40
3	19	26	24
4	6	27	27
4	14	33	33
5	9	35	34
7	3	41	39
7	13	42	40
10	4	26	23

\*\*\*\*\* L = 16 \*\*\*\*\*

0	0	98	97
0	2	24	23
0	6	35	37
0	10	24	24
1	7	29	29
1	13	30	30
2	6	56	54
2	8	26	24
2	10	41	42
2	12	40	39
3	3	25	24
3	7	36	36
3	13	26	26
4	0	66	64
4	8	29	29
4	10	42	41
5	1	42	39
5	5	29	30
5	9	41	40
6	2	40	39
7	1	34	32
7	3	40	38
8	0	29	27
8	6	36	35

\*\*\*\*\* L = 17 \*\*\*\*\*

1	7	29	28
1	9	27	26
3	5	33	33
3	11	36	34
4	2	33	31
4	6	31	30
5	3	25	23
7	1	32	29

\*\*\*\*\* L = 18 \*\*\*\*\*

0	2	29	26
0	4	32	29
1	1	25	23
1	3	29	29
1	5	28	25
2	0	29	27
2	2	31	29

BEST COPY AVAILABLE

GIN CLDR2.3B 9 APR

LOCK	ORIGIN	LENGTH	DATE			
/	000100	004554				
RD /	004654	000004				
ARM /	004660	000001				
ISTER	004661	012260	30 JAN 76	16:30:21	RUN2.3C0	INPUT
RFILL	017141	000050	30 JAN 76	16:30:21	RUN2.3C0	INPUT
QUNT	017211	000352	30 JAN 76	16:30:21	RUN2.3C0	INPUT
EEP	017563	000074	30 JAN 76	16:30:21	RUN2.3C0	INPUT
RINT1	017657	000212	30 JAN 76	16:30:21	RUN2.3C0	INPUT
RINT2	020071	000523	30 JAN 76	16:30:21	RUN2.3C0	INPUT
EJL	020614	000013	30 JAN 76	16:30:21	RUN2.3C0	INPUT
OF	020627	000020	30 JAN 76	16:30:21	RUN2.3C0	INPUT
KBLOK\$	020647	000023	12 NOV 70	12:32:16	CMP1.1A4	SUBRLIB
FENDF	020672	000025	12 NOV 70	12:32:16	CMP1.1A4	SUBRLIB
NPUTB	020717	000237	08 JAN 76	16:45:15	CMP2.5B2	SUBRLIB
NPUTC	021156	001025	20 APR 73	19:59:46	CMP1.1A4	SUBRLIB
NPUTS	022203	000103	12 NOV 70	12:32:16	CMP1.1A4	SUBRLIB
OMSG\$	022306	000226	12 NOV 70	12:32:16	CMP1.1A4	SUBRLIB
O.SUP	022534	001323	01 DEC 76	17:15:17	CMP2.5B2	SUBRLIB
CT\$	024057	000011	12 NOV 70	12:32:16	CMP1.1A4	SUBRLIB
UTPTC	024070	001242	04 APR 74	23:24:20	CMP1.1A4	SUBRLIB
UTPTS	025332	000075	12 NOV 70	12:32:16	CMP1.1A4	SUBRLIB
EWINM	025427	000046	12 NOV 70	12:32:16	CMP1.1A4	SUBRLIB
YS.MEM/	025475	000005				
YSTEM	025502	001024	20 APR 73	19:59:46	CMP1.1A4	SUBRLIB
YS.MAP	026526	000034	DIAGNOSTIC STORAGE MAP			

QUIRES 046337B WORDS TO LOAD, 026562B WORDS TO EXECUTE

CORDIERITE

Sci 1104

FASTEST VARYING INDEX IS 1

SLOWEST VARYING INDEX IS 3

SCALE = 1.0000

CARDS WILL NOT BE PUNCHED

DATA HAS ALREADY BEEN SORTED

NUMBER OF REFLECTIONS IS 1324

NUMBER OF INDICES IS 35

NUMBER OF PRINTED LINES IS 1429

NUMBER OF JOURNAL PAGES IS 1

COLUMN	1	2	3	4	5	6	7	8	9	10		
PAGE	1	143	143	143	143	143	143	143	143	143	142	
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0	8	48	47		-2	10	127	124	12	4	41	42
0	10	289	283		-2	26	75	75	12	8	37	38
0	12	118	115		-2	30	44	42	12	-24	42	40
0	14	100	101		-1	3	76	74	13	1	91	90
0	16	170	168		-1	5	15	15	13	9	51	53
0	18	22	25		-1	7	27	26	13	19	32	26
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12	24	43	42								
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CORDIERITE

Sci 1018

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CARDS WILL NOT BE PUNCHED  
 DATA HAS ALREADY BEEN SORTED  
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NUMBER OF INDICES IS 36  
 NUMBER OF PRINTED LINES IS 2378  
 NUMBER OF JOURNAL PAGES IS 2

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K	H	FO	FC	K	H	FO	FC	K	H	FO	FC
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-5	9	34	37
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-4	6	26	29
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-3	19	29	27
-2	12	27	26
-2	18	17	18
-1	9	15	14
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\*\*\*\*\* L = 16 \*\*\*\*\*

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-7	7	19	19
-7	9	16	13
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-4	12	21	21
-3	1	13	12
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-2	10	47	47
-2	12	38	39
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\*\*\*\*\* L = 17 \*\*\*\*\*

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-3	11	34	37
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\*\*\*\*\* L = 18 \*\*\*\*\*

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\*\*\*\*\* L = -18 \*\*\*\*\*

0	2	27	29
1	1	25	23

\*\*\*\*\* L = -16 \*\*\*\*\*

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0	16	26	25
1	7	31	30
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2	8	25	24
3	7	36	37
3	11	17	18
3	13	27	26
6	8	19	18

\*\*\*\*\* L = -15 \*\*\*\*\*

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5	13	21	21
6	14	14	13
8	6	21	20

\*\*\*\*\* L = -14 \*\*\*\*\*

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3	17	27	26
3	19	37	38
5	15	16	17
5	19	19	19
7	17	32	29
8	2	14	12
10	6	45	49

\*\*\*\*\* L = -13 \*\*\*\*\*

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3	19	17	17
6	12	25	25
8	12	33	33
10	10	15	14
11	7	14	13
12	2	14	13

\*\*\*\*\* L = -12 \*\*\*\*\*

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2	6	85	86

K	H	FO	FC	K	H	FC	FC	K	H	FC	FC
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2	14	15	14	1	5	62	62	4	24	52	52
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3	13	36	36	3	9	33	34	7	1	48	47
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6	6	23	23	4	0	33	32	9	21	19	19
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11	9	18	18	11	1	29	26				
12	12	30	30	14	14	38	36	*****	L = -7	*****	

\*\*\*\*\* L = -11 \*\*\*\*\*

\*\*\*\*\* L = -9 \*\*\*\*\*

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2	24	24	24
3	21	33	33
4	2	59	59
4	6	62	62
4	8	24	24
4	22	23	22
4	24	26	27
5	21	18	17
9	11	25	24
9	13	21	22
9	21	25	25
10	10	17	16
11	9	17	19
13	9	23	21

\*\*\*\*\* L = -8 \*\*\*\*\*

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4	26	17	16
6	6	10	9
7	9	47	48
7	25	16	17
8	20	24	23
10	4	67	66
10	14	25	26
11	13	20	18
13	5	23	24
17	7	16	17

\*\*\*\*\* L = -6 \*\*\*\*\*

\*\*\*\*\* L = -10 \*\*\*\*\*

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0	4	88	88
0	18	32	30
1	3	140	138
1	7	97	94
1	11	82	81
2	20	18	18
2	16	55	55

K	H	FO	FC	K	H	FO	FC	K	H	FO	FC
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2	24	49	49	7	11	16	16	8	24	46	48
3	17	41	42	7	25	44	44	9	19	40	39
3	19	77	77	8	22	21	19	10	28	51	49
5	13	84	84	9	13	57	57	11	13	46	47
7	7	14	11	9	21	17	15	12	6	70	71
7	25	14	15	11	7	10	9	12	8	28	27
8	6	42	43	11	21	15	14	12	12	54	55
8	22	38	37	12	12	13	11	12	14	31	30
9	3	28	27	12	22	24	23	12	16	16	15
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-2	2	115	113					-5	3	20	20
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2	24	34	34	2	8	121	117	-1	3	55	54
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*Sci 1542 filter*

ORDIERITE

ASTEST VARYING INDEX IS 1  
 LOWEST VARYING INDEX IS 3  
 SCALE = 1.0000

ARDS WILL NOT BE PUNCHED  
 DATA HAS ALREADY BEEN SORTED  
 NUMBER OF REFLECTIONS IS 1452

NUMBER OF INDICES IS 31  
 NUMBER OF PRINTED LINES IS 1545  
 NUMBER OF JOURNAL PAGES IS 1

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