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The crystal structures of helvite group minerals, $(Mn,Fe,Zn)_8(Be_6Si_6O_{24})S_2$

ISHMAEL HASSAN[1] AND H. DOUGLAS GRUNDY

Department of Geology, McMaster University
Hamilton, Ontario, Canada L8S 4L8

Abstract

The structures of six members of the helvite–genthelvite series $(Mn,Fe,Zn)_8(Be_6Si_6O_{24})S_2$ have been refined in the space group $P\bar{4}3n$ to R factors between 0.024 and 0.029 for observed reflections measured on an automated single-crystal 4-circle X-ray diffractometer using Mo$K\alpha$ radiation. The 1:1 BeO_4 and SiO_4 tetrahedra are completely ordered. The Be–O, Si–O and O–O distances of the two distinct tetrahedra are constant throughout the compositional series, indicating that the interframework cations have no effect on the dimensions of the framework tetrahedra. Thus the geometrical sodalite model of Hassan and Grundy (1984) is applicable to the helvite group minerals and is used for a thorough analysis of the variations in crystal parameters. The results also indicate that pure danalite is probably stable and that complete miscibility should exist between the Mn, Fe and Zn end-members.

Introduction

The chemical composition of the helvite group minerals can be expressed as $C_8(Be_6Si_6O_{24})S_2$, with C = Mn (helvite), Fe^{2+} (danalite) and Zn (genthelvite). The helvite group minerals are isotypic with cubic sodalite, $Na_8(Al_6Si_6O_{24})Cl_2$ and their structures are characterized by four-membered rings of BeO_4 and SiO_4 tetrahedra in each of the faces of the unit cell; these rings are linked together, forming six-membered rings about each of the cell corners. The Al atoms in sodalite correspond to Be atoms in the helvite group minerals, the Na atoms to Mn, Fe^{2+} or Zn atoms and the Cl atoms to S atoms (see Fig. 1 of Hassan and Grundy, 1984).

Barth (1926) and Gottfried (1927) reported that helvite has space group $P\bar{4}3n$ and Pauling (1930) determined the structure of a helvite from Schwarzenberg, Saxony by making full use of the isotypic relationship with sodalite. A sample of helvite from the same locality was refined to an R-factor of 0.04 by Holloway et al. (1972).

Dunn (1976) analyzed seventy-five members of the helvite group from world-wide localities and also used fifty-seven analyses from the literature, and concluded that the chemical analyses indicate complete miscibility between the Fe- and Mn-members and between the Fe- and Zn-members but not between the Mn- and Zn-members. Essentially pure helvite and genthelvite occur naturally but the nearest approach to pure danalite is a sample with 86% of the Fe end-member. Danalite was the only end-member of the helvite group that could not be synthesized by Mel'nikov, Latvia and Fedosova (1968). This would suggest that pure danalite is unstable. Structural analyses and the sodalite model of Hassan and Grundy (1984) may be useful in considering the existence of pure danalite and the absence of miscibility between the Mn- and Zn-members of the Helvite group.

Hassan and Grundy (1984) have developed a geometrical model for structures based on the sodalite framework topology. In this model, they assumed that the interframework ions (Na^+, K^+, Ca^{2+}, Cl^-, OH^-, H_2O, SO_4^{2-}, etc.) have no effect on the Si–O and Al–O distances. The helvite group minerals provide an ideal opportunity to examine the isolated effect of the interframework cations on analogous Be–O and Si–O distances, together with the application of the sodalite model to variations of crystal parameters and thermal expansion behavior.

The sodalite structure has also been modelled by Taylor (1968, 1972), Taylor and Henderson (1978), Dempsey and Taylor (1980) and Beagley, Henderson and Taylor (1982). These models, including that of Hassan and Grundy (1984) have been used to analyze the thermal expansion behavior of aluminosilicate-sodalites; using thermal expansion data of Taylor (1968, 1972) and Henderson and Taylor (1978). The sodalite-type framework topology is usually in a partially collapsed state due to the relatively small interframework ions (Pauling, 1930). Heating (or substitution) causes the framework tetrahedra to rotate. This rotational mechanism is described in terms of ψ_{Si} and ψ_{Al}, the angles through which the distinct framework tetrahedra are rotated relative to their position

[1] Present address: Earth and Planetary Sciences, Erindale Campus, University of Toronto, Mississauga, Ontario, Canada L5L 1C6.

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HELVITE (M30349)

1,0,L			
0	40*	0	0
1,1,L			
0	0*	29	500
1	0*	0	0
2,0,L			
0	326	309	500
2,1,L			
0	325	339	0
1	1320	1270	818
2,2,L			
0	364	368	0
1	38*	0	0
2	794	702	950
3,0,L			
0	0*	0	0
3,1,L			
0	609	620	500
1	19*	0	0
3,2,L			
0	273	285	500
1	642	626	951
2	19*	0	0
3,3,L			
0	1533	1535	0
1	0*	0	0
2	289	290	158
3	0*	0	0
4,0,L			
0	625	598	500
4,1,L			
0	20*	3	500
1	1200	1213	230
4,2,L			
0	575	590	0
1	252	258	998
2	831	818	772
4,3,L			
0	26*	0	0
1	147	155	169
2	237	242	999
3	574	557	959
4,4,L			
0	1283	1314	0
1	0*	0	0
2	895	874	803
3	22*	0	0
4	861	808	193
5,0,L			
0	0*	0	0
5,1,L			
0	474	493	0
1	0*	0	0
5,2,L			
0	223	237	500
1	506	489	218
2	2*	0	0
5,3,L			
0	767	781	500
1	0*	2	43
2	703	702	5
3	0*	0	0
5,4,L			
0	11*	3	500
1	796	795	194
2	216	208	3
3	325	313	957
4	0*	0	0
5,5,L			
0	220	230	0
1	0*	0	0
2	165	172	881
3	0*	0	0
4	507	495	771
5	0*	0	0
6,0,L			
0	1311	1325	0
6,1,L			
0	208	220	0
1	279	297	14
6,2,L			
0	453	460	500
1	0*	3	906
2	416	406	208
6,3,L			
0	202	210	0
1	208	199	186
2	0*	3	762
3	946	945	24
6,4,L			
0	57*	36	500
1	194	196	3
2	98	92	36
3	183	178	3
4	315	310	991
6,5,L			
0	181	185	0
1	580	581	20
2	0*	1	215
3	301	304	50
4	157	155	996
5	440	437	938
6,6,L			
0	546	543	0
1	0*	0	0
2	576	569	983
3	0*	0	0
4	201	180	914
5	0*	0	0
6	207	193	3
7,0,L			
0	21*	0	0
7,1,L			
0	177	181	0
1	33*	0	0
7,2,L			
0	187	194	500
1	545	571	828
2	0*	0	0
7,3,L			
0	554	569	500
1	12*	2	217
2	360	357	41
3	29*	0	0
7,4,L			
0	0*	1	0
1	533	530	773
2	167	167	3
3	257	256	956
4	0*	0	0
7,5,L			
0	174	169	0
1	37*	1	177
2	404	384	201
3	0*	3	182
4	416	399	203
5	0*	0	0
7,6,L			
0	146	147	500
1	249	248	910
2	24*	5	201
3	58*	70	935
4	138	136	995
5	377	371	43
6	0*	0	0
7,7,L			
0	374	375	0
1	0*	0	0
2	448	450	812
3	27*	0	0
4	497	502	836
5	0*	0	0
6	230	215	954
7	20*	0	0
8,0,L			
0	145	156	0
8,1,L			
0	31*	0	0
1	650	661	178
8,2,L			
0	545	563	0
1	168	172	1
2	364	362	170
8,3,L			
0	25*	4	500
1	339	335	945
2	164	158	3
3	514	514	35
8,4,L			
0	565	577	0
1	0*	4	915
2	469	458	222
3	0*	2	172
4	569	576	861
8,5,L			
0	0*	7	500
1	414	412	770
2	143	140	998
3	151	167	83
4	0*	3	886
5	320	325	148
8,6,L			
0	251	255	500
1	136	132	998
2	224	231	981
3	136	129	996
4	410	388	991
5	119	117	3
6	394	396	26
8,7,L			
0	0*	0	0
1	317	309	186
2	127	121	990
3	102	98	83
4	10*	3	73
5	226	218	767
6	101*	94	14
8,8,L			
0	533	527	0
1	25*	0	0
2	300	304	792
3	35*	0	0
4	445	409	139
5	15*	0	0
9,0,L			
0	0*	0	0
9,1,L			
0	309	309	500
1	0*	0	0
9,2,L			
0	149	150	500
1	420	434	91
2	0*	0	0
9,3,L			
0	597	589	0
1	0*	3	928
2	103	108	31
3	20*	0	0
9,4,L			
0	0*	4	0
1	96*	103	921
2	140	131	999
3	253	247	949
4	37*	0	0
9,5,L			
0	345	354	500
1	0*	1	53
2	490	484	882
3	0*	3	885
4	137	135	76
5	0*	0	0
9,6,L			
0	116	113	500
1	36*	46	25
2	0*	1	982
3	621	619	9
4	115	112	3
5	160	156	896
6	18*	0	0
9,7,L			
0	194	183	500
1	0*	3	832
2	268	262	74
3	0*	1	0
4	135	131	826
5	20*	4	809
9,8,L			
0	22*	6	500
1	138	131	34
2	93	97	2
3	295	296	38
10,0,L			
0	85	85	500
10,1,L			
0	133	135	0
1	429	423	132
10,2,L			
0	26*	20	0
1	0*	3	213
2	422	432	839
10,3,L			
0	125	127	0
1	195	199	886
2	0*	5	100
3	104*	117	890
10,4,L			
0	302	295	0
1	121	119	998
2	301	306	247
3	120*	114	998
4	368	354	205
10,5,L			
0	109	107	0
1	258	266	787
2	0*	5	877
3	324	313	51
4	109	108	4
5	284	270	167
10,6,L			
0	84	70	500
1	0*	4	890
2	175	180	913
3	0*	2	172
4	121	125	207
10,7,L			
0	92*	97	0
1	420	409	182
2	26*	5	247
11,0,L			
0	0*	0	0
11,1,L			
0	122	124	0
1	0*	0	0
11,2,L			
0	115	112	500
1	283	283	229
2	0*	0	0
11,3,L			
0	195	199	500
1	0*	2	145
2	361	360	10
3	0*	0	0
11,4,L			
0	32*	1	0
1	307	298	215
2	97	100	997
3	40*	19	922
4	0*	0	0
11,5,L			
0	157	164	0
1	12*	3	910
2	202	214	790
3	58*	5	86
11,6,L			
0	97*	89	500
12,0,L			
0	764	757	0
12,1,L			
0	0*	4	500
1	169	161	954
12,2,L			
0	107	112	500
1	94	96	1
2	254	254	831
12,3,L			
0	0*	1	0
1	287	288	953
2	95	93	996

HELVITE (M36390)

1,0,L

0	18*	0	0

1,1,L

0	53*	24	0
1	9*	0	0

2,0,L

0	344	326	500

2,1,L

0	343	342	0
1	1250	1324	811

2,2,L

0	354	365	0
1	11*	0	0
2	707	685	963

3,0,L

0	22*	0	0

3,1,L

0	710	671	500
1	0*	0	0

3,2,L

0	289	289	500
1	645	659	943
2	10*	0	0

3,3,L

0	1504	1563	0
1	0*	0	0
2	349	307	153
3	0*	0	0

4,0,L

0	813	734	500

4,1,L

0	16*	2	500
1	1225	1203	236

4,2,L

0	624	622	0
1	262	261	998
2	889	861	775

4,3,L

0	16*	2	0
1	222	194	147
2	251	245	997
3	666	622	963

4,4,L

0	1405	1439	0
1	14*	0	0
2	902	861	798
3	0*	0	0
4	756	762	209

5,0,L

0	0*	0	0

5,1,L

0	472	485	0
1	0*	0	0

5,2,L

0	239	241	500
1	579	583	221
2	0*	0	0

5,3,L

0	762	772	500
1	21*	1	169
2	701	682	14
3	11*	0	0

5,4,L

0	15*	1	500
1	829	832	192
2	221	216	1
3	316	320	946
4	0*	0	0

5,5,L

0	187	172	0
1	0*	0	0
2	302	267	840
3	19*	0	0
4	572	547	765
5	0*	0	0

6,0,L

0	1381	1379	0

6,1,L

0	223	224	0
1	340	333	37

6,2,L

0	498	480	500
1	22*	2	234
2	391	411	200

6,3,L

0	216	216	0
1	163	193	221
2	18*	2	208
3	1005	989	24

6,4,L

0	108	93	500
1	204	204	1
2	104	106	971
3	194	189	2
4	372	356	5

6,5,L

0	192	195	0
1	578	571	7
2	4*	1	796
3	312	297	55
4	170	165	0
5	409	393	951

6,6,L

0	585	586	0
1	0*	0	0
2	609	608	972
3	17*	0	0
4	235	239	933
5	6*	0	0
6	194	211	969

7,0,L

0	0*	0	0

7,1,L

0	227	213	0
1	21*	0	0

7,2,L

0	202	203	500
1	589	555	824
2	13*	0	0

7,3,L

0	654	646	500
1	14*	1	969
2	390	384	37
3	0*	0	0

7,4,L

0	11*	0	0
1	538	523	787
2	178	179	3
3	295	290	967
4	0*	0	0

7,5,L

0	170	170	0
1	0*	2	106
2	387	397	204
3	17*	2	932
4	410	411	191
5	0*	0	0

7,6,L

0	157	159	500
1	264	266	928
2	21*	1	750
3	63	41	776
4	144	145	997
5	394	382	34
6	0*	0	0

7,7,L

0	412	416	0
1	0*	0	0
2	461	451	804
3	0*	0	0
4	553	524	853
5	6*	0	0
6	255	246	983
7	13*	0	0

8,0,L

0	259	'259	0

8,1,L

0	19*	4	0
1	704	711	183

8,2,L

0	537	530	0
1	181	180	1
2	432	436	183

8,3,L

0	23*	2	500
1	314	322	927
2	170	170	3
3	498	490	40

8,4,L

0	534	526	0
1	0*	2	965
2	492	498	222
3	9*	2	500
4	665	627	869

8,5,L

0	0*	2	500
1	475	483	762
2	151	151	999
3	175	151	136
4	3*	2	948
5	394	407	164

8,6,L

0	226	225	500
1	141	143	999
2	198	191	12
3	137	137	997
4	385	382	977
5	128	127	1000
6	399	390	29

8,7,L

0	15*	1	0
1	310	322	182
2	128	130	994
3	92	79	94
4	6*	0	914
5	233	238	766
6	113	110	6

8,8,L

0	556	550	0
1	0*	0	0
2	373	373	786
3	0*	0	0
4	418	441	153
5	0*	0	0

9,0,L

0	21*	0	0

9,1,L

0	361	371	500
1	4*	0	0

9,2,L

0	163	163	500
1	420	414	71
2	0*	0	0

9,3,L

0	623	629	0
1	19*	2	208
2	123	118	35
3	0*	0	0

9,4,L

0	0*	0	0
1	115	119	0
2	146	143	999
3	304	320	956
4	10*	0	0

9,5,L

0	351	342	500
1	7*	1	775
2	437	440	891
3	14*	2	213
4	107	93	19
5	26*	0	0

9,6,L

0	128	127	500
1	73	80	4
2	20*	0	847
3	653	662	8
4	125	123	1000
5	132	146	883
6	13*	0	0

9,7,L

0	251	265	500
1	13*	3	162
2	274	271	51
3	3*	2	870
4	124	130	876
5	15*	2	175

9,8,L

0	12*	1	500
1	99	94	949
2	105	110	2
3	283	282	49

10,0,L

0	151	143	500

10,1,L

0	147	146	0
1	389	403	134

10,2,L

0	57*	41	0
1	14*	4	791
2	433	492	841

10,3,L

0	136	137	0
1	203	213	898
2	4*	3	758
3	107	92	802

10,4,L

0	340	345	0
1	133	129	0
2	302	303	229
3	126	124	999
4	330	336	212

10,5,L

0	119	121	0
1	268	266	771
2	0*	2	196
3	336	334	44
4	116	117	998
5	263	294	168

10,6,L

0	130	144	500
1	17*	2	238
2	174	161	962
3	19*	2	154
4	94	102	245

10,7,L

0	107	109	0
1	387	404	188
2	0*	2	141

11,0,L

0	19*	0	0

11,1,L

0	87	81	0
1	23*	0	0

11,2,L

0	126	124	500
1	305	317	226
2	0*	0	0

11,3,L

0	162	166	500
1	0*	2	977
2	346	342	12
3	34*	0	0

11,4,L

0	0*	0	0
1	318	323	216
2	115	114	997
3	40*	32	99
4	0*	0	0

11,5,L

0	132	124	0
1	0*	2	50
2	266	264	792
3	10*	3	956

12,0,L

0	768	771	0

12,1,L

0	18*	3	500
1	167	171	20

12,2,L

0	119	124	500
1	104	108	0
2	186	188	837

12,3,L

0	4*	4	0
1	315	333	947

DANALITE (M37261)

1,0,L

0	28	0	0

1,1,L

0	44	54	0
1	22*	0	0

2,0,L

0	406	415	500

2,1,L

0	359	343	0
1	1371	1404	806

2,2,L

0	411	409	0
1	16*	0	0
2	685	694	977

3,0,L

0	0*	0	0

3,1,L

0	733	726	500
1	0*	0	0

3,2,L

0	304	292	500
1	685	693	950
2	22*	0	0

3,3,L

0	1634	1684	0
1	25*	0	0
2	374	344	126
3	0*	0	0

4,0,L

0	830	779	500

4,1,L

0	9*	1	500
1	1275	1298	237

4,2,L

0	679	663	0
1	276	264	999
2	969	938	976

4,3,L

0	13*	1	0
1	223	201	134
2	255	247	997
3	650	653	966

4,4,L

0	1439	1464	0
1	0*	0	0
2	963	943	793
3	16*	0	0
4	814	842	211

5,0,L

0	15*	0	0

5,1,L

0	557	535	0
1	0*	0	0

5,2,L

0	255	244	500
1	623	644	227
2	13*	0	0

5,3,L

0	862	855	500
1	0*	1	114
2	744	727	10
3	22*	0	0

5,4,L

0	0*	0	500
1	898	906	194
2	228	220	1000
3	355	359	957
4	0*	0	0

5,5,L

0	215	203	0
1	0*	0	0
2	317	298	829
3	0*	0	0
4	588	599	768
5	0*	0	0

6,0,L

0	1524	1500	0

6,1,L

0	237	227	0
1	372	354	26

6,2,L

0	548	537	500
1	0*	2	181
2	424	442	215

6,3,L

0	227	219	0
1	159	178	249
2	17*	1	175
3	1090	1089	22

6,4,L

0	125	117	500
1	214	208	0
2	126	120	1
3	195	195	2
4	383	371	3

6,5,L

0	202	200	0
1	620	619	13
2	0*	1	805
3	349	346	45
4	168	172	1
5	440	437	945

6,6,L

0	654	669	0
1	20*	0	0
2	656	664	968
3	6*	0	0
4	241	245	947
5	0*	0	0
6	252	272	971

7,0,L

0	0*	0	0

7,1,L

0	232	221	0
1	0*	0	0

7,2,L

0	213	206	500
1	652	617	817
2	30*	0	0

7,3,L

0	672	665	500
1	0*	1	851
2	423	417	38
3	0*	0	0

7,4,L

0	23*	0	0
1	599	588	780
2	187	186	3
3	293	289	966
4	21*	0	0

7,5,L

0	216	212	0
1	14*	2	127
2	434	442	211
3	13*	2	850
4	456	466	196
5	8*	0	0

7,6,L

0	168	167	500
1	284	283	927
2	19*	1	148
3	68	49	772
4	146	150	998
5	420	426	37
6	10*	0	0

7,7,L

0	415	409	0
1	0*	0	0
2	525	517	802
3	0*	0	0
4	583	561	840
5	16*	0	0
6	247	246	984
7	33*	0	0

8,0,L

0	209	213	0

8,1,L

0	10*	3	0
1	764	769	186

8,2,L

0	587	571	0
1	187	185	2
2	466	472	184

8,3,L

0	28*	1	500
1	351	356	938
2	179	176	4
3	563	550	36

8,4,L

0	596	576	0
1	0*	1	75
2	536	547	227
3	0*	2	960
4	700	678	863

8,5,L

0	17*	1	0
1	517	521	764
2	159	158	500
3	184	163	111
4	15*	1	44
5	410	422	168

8,6,L

0	272	269	500
1	152	150	999
2	233	224	993
3	142	142	997
4	418	424	985
5	128	133	998
6	437	439	24

8,7,L

0	0*	1	0
1	359	366	185
2	130	136	996
3	121	117	79
4	0*	0	205
5	265	269	770
6	113	119	3

8,8,L

0	588	599	0
1	0*	0	0
2	404	395	787
3	17*	0	0
4	448	464	158
5	39*	0	0

9,0,L

0	0*	0	0

9,1,L

0	409	408	500
1	0*	0	0

9,2,L

0	170	169	500
1	464	459	75
2	20*	0	0

9,3,L

0	719	716	0
1	22*	2	99
2	147	145	18
3	0*	0	0

9,4,L

0	0*	1	500
1	139	136	986
2	150	150	0
3	337	341	963
4	0*	0	0

9,5,L

0	391	381	500
1	11*	1	886
2	495	495	890
3	0*	2	90
4	123	120	44
5	19*	0	0

9,6,L

0	132	134	500
1	104	99	40
2	17*	0	0
3	725	739	8
4	126	129	998
5	165	178	885
6	0*	0	0

9,7,L

0	294	282	500
1	7*	3	106
2	299	303	56
3	0*	2	858
4	140	138	878
5	0*	2	74

9,8,L

0	0*	1	0
1	115	118	992
2	111	116	1000
3	323	317	43

10,0,L

0	145	135	500

10,1,L

0	150	153	0
1	445	460	141

10,2,L

0	64	58	0
1	0*	2	797
2	554	547	836

10,3,L

0	141	143	0
1	217	219	899
2	14*	2	860
3	117	98	822

10,4,L

0	349	347	0
1	134	135	1
2	361	355	237
3	130	131	1000
4	302	309	204

10,5,L

0	126	128	0
1	319	310	766
2	0*	2	119
3	376	379	43
4	123	123	997
5	303	325	176

10,6,L

0	136	137	500
1	26*	2	114
2	174	158	950
3	22*	1	208
4	93	104	225

10,7,L

0	113	115	0
1	443	462	184
2	0*	1	870

11,0,L

0	14*	0	0

11,1,L

0	121	111	0
1	31*	0	0

11,2,L

0	132	132	500
1	329	342	228
2	15*	0	0

11,3,L

0	212	208	500
1	0*	1	850
2	380	380	5
3	5*	0	0

11,4,L

0	0*	0	0
1	360	362	217
2	116	121	997
3	35*	10	760
4	0*	0	0

11,5,L

0	150	144	0
1	13*	2	146
2	286	274	795
3	0*	3	832

12,0,L

0	855	858	0

12,1,L

0	0*	1	500
1	193	190	10

12,2,L

0	146	144	500
1	109	115	998
2	225	224	840

12,3,L

0	0*	3	0
1	349	356	952

DANALITE (M34769)

1,0,L

0	19*	0	0

1,1,L

0	38*	61	0
1	14*	0	0

2,0,L

0	397	406	500

2,1,L

0	357	343	0
1	1351	1403	805

2,2,L

0	404	402	0
1	28*	0	0
2	691	687	977

3,0,L

0	0*	0	0

3,1,L

0	729	724	500
1	0*	0	0

3,2,L

0	303	292	500
1	697	697	947
2	0*	0	0

3,3,L

0	1582	1665	0
1	5*	0	0
2	369	338	130
3	0*	0	0

4,0,L

0	848	805	500

4,1,L

0	1*	2	500
1	1293	1280	238

4,2,L

0	688	672	0
1	273	264	999
2	938	932	776

4,3,L

0	0*	1	0
1	239	215	131
2	259	247	997
3	685	660	967

4,4,L

0	1457	1491	0
1	0*	0	0
2	971	926	792
3	27*	0	0
4	797	817	214

5,0,L

0	0*	0	0

5,1,L

0	546	531	0
1	27*	0	0

5,2,L

0	254	243	500
1	640	661	226
2	0*	0	0

5,3,L

0	842	840	500
1	12*	2	115
2	736	717	13
3	19*	0	0

5,4,L

0	17*	0	0
1	905	905	193
2	230	220	1000
3	366	363	954
4	0*	0	0

5,5,L

0	190	187	0
1	0*	0	0
2	352	325	828
3	0*	0	0
4	620	607	766
5	28*	0	0

6,0,L

0	1484	1495	0

6,1,L

0	235	227	0
1	376	362	31

6,2,L

0	543	531	500
1	0*	2	778
2	418	439	213

6,3,L

0	227	219	0
1	154	175	249
2	0*	1	847
3	1086	1084	22

6,4,L

0	134	128	500
1	211	209	0
2	134	137	990
3	199	195	2
4	410	386	7

6,5,L

0	205	200	0
1	629	615	10
2	25*	1	148
3	346	334	45
4	177	172	1
5	431	423	948

6,6,L

0	678	672	0
1	0*	0	0
2	652	660	965
3	0*	0	0
4	256	253	952
5	0*	0	0
6	257	278	966

7,0,L

0	13*	0	0

7,1,L

0	241	232	0
1	12*	0	0

7,2,L

0	209	206	500
1	639	601	817
2	0*	0	0

7,3,L

0	681	672	500
1	0*	1	854
2	433	424	36
3	13*	0	0

7,4,L

0	0*	0	0
1	576	573	783
2	190	185	3
3	305	299	969
4	0*	0	0

7,5,L

0	233	218	0
1	0*	2	127
2	423	437	210
3	7*	2	851
4	457	461	194
5	23*	0	0

7,6,L

0	167	167	500
1	293	289	933
2	0*	1	814
3	78	52	244
4	148	150	998
5	433	430	35
6	0*	0	0

7,7,L

0	419	417	0
1	23*	0	0
2	517	506	802
3	27*	0	0
4	575	551	843
5	0*	0	0
6	264	253	990
7	30*	0	0

8,0,L

0	255	244	0

8,1,L

0	15*	1	0
1	777	775	188

8,2,L

0	567	557	0
1	187	185	2
2	479	485	190

8,3,L

0	5*	3	500
1	345	350	933
2	174	177	4
3	538	528	38

8,4,L

0	581	563	0
1	0*	2	28
2	539	552	225
3	0*	1	897
4	722	684	865

8,5,L

0	0*	1	500
1	531	538	761
2	161	158	500
3	183	160	124
4	0*	0	915
5	436	440	175

8,6,L

0	250	248	500
1	151	151	399
2	220	214	1000
3	143	143	997
4	418	419	982
5	132	133	998
6	423	421	24

8,7,L

0	32*	0	0
1	357	361	187
2	133	136	996
3	121	115	77
4	0*	1	913
5	265	270	768
6	115	119	3

8,8,L

0	591	594	0
1	0*	0	0
2	422	414	789
3	17*	0	0
4	456	472	160
5	38*	0	0

9,0,L

0	39*	0	0

9,1,L

0	407	416	500
1	0*	0	0

9,2,L

0	170	168	500
1	457	454	69
2	0*	0	0

9,3,L

0	722	726	0
1	0*	2	102
2	141	142	16
3	0*	0	0

9,4,L

0	13*	1	500
1	151	149	2
2	144	149	0
3	345	353	965
4	0*	0	0

9,5,L

0	374	369	500
1	0*	1	881
2	473	480	893
3	17*	2	93
4	118	117	26
5	14*	0	0

9,6,L

0	133	134	500
1	103	104	45
2	0*	0	500
3	737	747	7
4	123	128	998
5	155	173	878
6	0*	0	0

9,7,L

0	294	297	500
1	0*	3	107
2	305	308	50
3	0*	2	856
4	152	144	898
5	0*	2	73

9,8,L

0	33*	3	0
1	109	112	971
2	114	116	1000
3	307	300	46

10,0,L

0	144	141	500

10,1,L

0	155	154	0
1	413	452	140

10,2,L

0	75*	68	0
1	12*	3	167
2	549	549	836

10,3,L

0	143	144	0
1	216	222	904
2	5*	2	186
3	111	97	814

10,4,L

0	356	354	0
1	135	136	1
2	343	349	235
3	131	132	1000
4	366	379	204

10,5,L

0	128	128	0
1	310	309	765
2	0*	1	789
3	382	386	40
4	120	124	997
5	306	328	176

10,6,L

0	150	147	500
1	0*	1	229
2	150	145	970
3	0*	1	877
4	90*	93	242

10,7,L

0	112	116	0
1	427	455	183
2	12*	1	117

11,0,L

0	0*	0	0

11,1,L

0	108	100	0
1	0*	0	0

11,2,L

0	124	131	500
1	332	346	224
2	0*	0	0

11,3,L

0	185	186	500
1	0*	2	854
2	366	370	5
3	0*	0	0

11,4,L

0	0*	0	0
1	359	361	221
2	116	120	997
3	0*	13	168
4	15*	0	0

11,5,L

0	136	135	0
1	18*	2	147
2	297	283	792
3	0*	3	833

12,0,L

0	846	861	0

12,1,L

0	0*	4	500
1	199	198	28

12,2,L

0	137	140	500
1	110	117	998
2	205	202	850

12,3,L

0	21*	1	0
1	339	358	951

GENTHELVITE (M37267)

1,0,L

0	32	0	0

1,1,L

0	129	141	0
1	0*	0	0

2,0,L

0	499	503	500

2,1,L

0	355	340	0
1	1440	1549	795

2,2,L

0	458	448	0
1	20*	0	0
2	672	698	13

3,0,L

0	29*	0	0

3,1,L

0	841	845	500
1	22*	0	0

3,2,L

0	300	291	500
1	779	772	947
2	0*	0	0

3,3,L

0	1847	1863	0
1	17*	0	0
2	461	421	101
3	27*	0	0

4,0,L

0	1042	1001	500

4,1,L

0	25*	1	500
1	1442	1387	245

4,2,L

0	763	751	0
1	271	264	999
2	1078	1087	777

4,3,L

0	0*	1	0
1	302	284	101
2	259	248	999
3	790	779	973

4,4,L

0	1652	1631	0
1	12*	0	0
2	1056	1026	781
3	23*	0	0
4	878	888	233

5,0,L

0	29*	0	0

5,1,L

0	603	583	0
1	0*	0	0

5,2,L

0	257	246	500
1	810	855	234
2	[illegible]	0	0

5,3,L

0	912	916	500
1	11*	0	883
2	768	749	17
3	21*	0	0

5,4,L

0	0*	2	500
1	1027	1040	196
2	229	219	1
3	421	420	957
4	26*	0	0

5,5,L

0	198	192	0
1	17*	0	0
2	540	508	799
3	13*	0	0
4	751	741	762
5	0*	0	0

6,0,L

0	1711	1711	0

6,1,L

0	235	230	0
1	461	447	37

6,2,L

0	638	630	500
1	16*	2	219
2	417	446	231

6,3,L

0	227	220	0
1	167	207	844
2	11*	2	188
3	1297	1290	19

6,4,L

0	243	247	500
1	213	207	1
2	203	205	975
3	201	194	1
4	479	463	13

6,5,L

0	201	197	0
1	663	659	2
2	12*	1	860
3	404	387	39
4	175	174	999
5	439	430	961

6,6,L

0	855	858	0
1	17*	0	0
2	748	750	958
3	38*	0	0
4	347	344	969
5	30*	0	0
6	414	434	960

7,0,L

0	0*	0	0

7,1,L

0	308	302	0
1	18*	0	0

7,2,L

0	211	208	500
1	713	682	801
2	0*	0	0

7,3,L

0	767	775	500
1	11*	1	118
2	495	492	32
3	0*	0	0

7,4,L

0	18*	0	0
1	654	661	786
2	185	185	1
3	355	358	978
4	21*	0	0

7,5,L

0	276	277	0
1	0*	0	500
2	510	531	221
3	0*	1	88
4	540	546	196
5	19*	0	0

7,6,L

0	166	165	500
1	337	345	951
2	11*	2	760
3	136	112	99
4	160	154	998
5	483	475	28
6	13*	0	0

7,7,L

0	460	464	0
1	20*	0	0
2	608	582	790
3	0*	0	0
4	634	605	838
5	0*	0	0
6	296	301	9
7	24*	0	0

8,0,L

0	261	257	0

8,1,L

0	0*	3	0
1	835	900	196

8,2,L

0	581	575	0
1	188	186	0
2	609	630	205

8,3,L

0	0*	1	500
1	369	379	933
2	177	175	1
3	560	562	37

8,4,L

0	573	553	0
1	31*	1	912
2	630	661	229
3	28*	2	36
4	807	775	860

8,5,L

0	23*	2	500
1	644	667	757
2	159	158	999
3	199	174	130
4	24*	2	952
5	553	556	192

8,6,L

0	269	270	500
1	148	150	999
2	237	231	16
3	148	146	998
4	443	447	978
5	126	134	1
6	433	435	22

8,7,L

0	12*	[illegible]	0
1	424	429	194
2	141	139	997
3	156	144	63
4	25*	0	75
5	337	335	763
6	115	116	4

8,8,L

0	640	645	0
1	29*	0	0
2	529	513	784
3	0*	0	0
4	501	519	180

9,0,L

0	22*	0	0

9,1,L

0	512	516	500
1	5*	0	0

9,2,L

0	169	169	500
1	497	484	49
2	0*	0	0

9,3,L

0	894	898	0
1	0*	1	851
2	212	204	11
3	0*	0	0

9,4,L

0	19*	1	0
1	226	223	27
2	148	151	998
3	433	443	973
4	11*	0	0

9,5,L

0	395	383	500
1	6*	0	148
2	457	473	909
3	0*	1	839
4	144	133	983
5	0*	0	0

9,6,L

0	134	136	500
1	190	172	31
2	15*	0	923
3	851	880	6
4	127	130	2
5	180	186	885

9,7,L

0	374	381	500
1	12*	1	784
2	350	348	34
3	15*	1	916
4	185	186	946

9,8,L

0	0*	3	500
1	121	127	927
2	115	118	3

10,0,L

0	224	222	500

10,1,L

0	153	151	0
1	463	498	158

10,2,L

0	127	126	0
1	0*	3	846
2	672	664	826

10,3,L

0	141	144	0
1	254	265	926
2	30*	3	769
3	134	102	195

10,4,L

0	396	403	0
1	139	138	999
2	416	414	229
3	127	132	999
4	403	418	213

10,5,L

0	130	130	0
1	389	373	753
2	35*	2	189
3	432	440	33
4	116	123	1
5	372	390	185

10,6,L

0	225	225	500
1	0*	2	771
2	96	100	51
3	0*	2	119
4	64	84	836

10,7,L

0	114	118	0
1	473	498	190

11,0,L

0	32*	0	0

11,1,L

0	115	114	0
1	0*	0	0

11,2,L

0	131	132	500
1	400	419	226
2	0*	0	0

11,3,L

0	204	194	500
1	0*	1	96
2	373	382	0
3	0*	0	0

11,4,L

0	0*	0	0
1	423	424	227
2	116	123	998
3	36*	13	855

11,5,L

0	142	138	0
1	0*	1	928
2	377	355	795

12,0,L

0	927	933	0

12,1,L

0	0*	1	500
1	256	251	56

12,2,L

0	169	169	500
1	106	116	1
2	181	180	897

GENTHELVITE (M32727)

1,0,L			
0	36*	0	0
1,1,L			
0	140	146	0
1	23*	0	0
2,0,L			
0	497	492	500
2,1,L			
0	344	340	0
1	1480	1548	794
2,2,L			
0	456	452	0
1	42*	0	0
2	792	693	15
3,0,L			
0	53*	0	0
3,1,L			
0	872	847	500
1	30*	0	0
3,2,L			
0	294	288	500
1	814	775	947
2	0*	0	0
3,3,L			
0	1778	1839	0
1	5*	0	0
2	406	418	102
3	0*	0	0
4,0,L			
0	1060	1019	500
4,1,L			
0	0*	2	500
1	1398	1367	246
4,2,L			
0	770	756	0
1	275	261	999
2	1117	1089	778
4,3,L			
0	28*	2	0
1	294	297	98
2	255	244	999
3	822	783	974
4,4,L			
0	1596	1633	0
1	25*	0	0
2	1003	996	781
3	56*	0	0
4	868	858	235
5,0,L			
0	30*	0	0
5,1,L			
0	586	583	0
1	43*	0	0
5,2,L			
0	244	242	500
1	903	870	234
2	0*	0	0
5,3,L			
0	896	889	500
1	42*	0	795
2	756	737	16
3	0*	0	0
5,4,L			
0	30*	2	500
1	1045	1040	196
2	230	215	2
3	437	421	956
4	33*	0	0
5,5,L			
0	182	184	0
1	0*	0	0
2	526	542	798
3	40*	0	0
4	762	752	760
5	0*	0	0
6,0,L			
0	1646	1687	0
6,1,L			
0	227	226	0
1	460	460	37
6,2,L			
0	623	637	500
1	39*	2	215
2	457	435	234
6,3,L			
0	214	215	0
1	252	208	850
2	0*	3	192
3	1282	1281	20
6,4,L			
0	269	260	500
1	205	202	1
2	221	226	973
3	193	188	1
4	480	467	12
6,5,L			
0	189	192	0
1	654	653	1
2	46*	1	850
3	363	377	35
4	159	167	999
5	426	415	961
6,6,L			
0	854	871	0
1	43*	0	0
2	765	743	358
3	0*	0	0
4	367	364	976
5	35*	0	0
6	482	458	567
7,0,L			
0	39*	0	0
7,1,L			
0	319	315	0
1	0*	0	0
7,2,L			
0	203	203	500
1	643	669	799
2	35*	0	0
7,3,L			
0	763	761	500
1	46*	1	83
2	499	490	31
3	54*	0	0
7,4,L			
0	29*	0	0
1	648	640	798
2	191	179	2
3	372	362	478
4	0*	0	0
7,5,L			
0	290	274	0
1	27*	0	58
2	559	537	224
3	56*	1	48
4	558	530	198
5	0*	0	0
7,6,L			
0	160	158	500
1	359	348	953
2	34*	2	770
3	115	120	106
4	154	147	998
5	468	472	25
6	18*	0	0
7,7,L			
0	454	450	0
1	0*	0	0
2	536	560	790
3	24*	0	0
4	562	584	836
5	0*	0	0
6	304	287	11
7	0*	0	0
8,0,L			
0	275	270	0
8,1,L			
0	47*	5	0
1	892	893	196
8,2,L			
0	552	559	0
1	176	180	1
2	641	641	211
8,3,L			
0	0*	1	500
1	380	362	932
2	164	169	1
3	521	529	37
8,4,L			
0	541	542	0
1	34*	1	929
2	674	653	227
3	0*	2	26
4	722	752	859
8,5,L			
0	0*	2	500
1	675	679	753
2	155	151	998
3	161	165	136
4	0*	3	361
5	577	580	196
8,6,L			
0	248	250	500
1	129	143	999
2	229	222	16
3	132	139	398
4	442	430	980
5	124	127	1
6	396	396	19
8,7,L			
0	0*	2	0
1	425	420	199
2	137	132	996
3	135	137	65
4	0*	0	750
5	345	335	763
6	103*	108	5
8,8,L			
0	616	607	0
1	47*	0	0
2	499	516	786
3	0*	0	0
4	542	515	177
9,0,L			
0	60*	0	0
9,1,L			
0	509	515	500
1	71*	0	0
9,2,L			
0	153	163	500
1	455	480	43
2	37*	0	0
9,3,L			
0	895	901	0
1	0*	1	816
2	209	214	4
3	50*	0	0
9,4,L			
0	0*	1	0
1	235	242	33
2	142	144	998
3	457	444	975
4	22*	0	0
9,5,L			
0	370	381	500
1	42*	1	169
2	459	446	915
3	0*	1	820
4	153	146	967
5	0*	0	0
9,6,L			
0	122	128	500
1	167	191	35
2	0*	0	0
3	871	883	5
4	113*	123	2
5	206	193	881
9,7,L			
0	392	369	500
1	0*	1	750
2	347	347	24
3	27*	1	917
4	134	188	953
9,8,L			
0	0*	4	500
1	155	124	909
2	103*	110	3
10,0,L			
0	235	228	500
10,1,L			
0	145	144	0
1	522	491	161
10,2,L			
0	149	136	0
1	9*	4	843
2	627	658	825
10,3,L			
0	125*	137	0
1	279	272	931
2	0*	3	784
3	44*	109	201
10,4,L			
0	401	388	0
1	132	130	999
2	410	414	226
3	136	124	999
4	439	413	218
10,5,L			
0	109*	122	0
1	366	386	755
2	69*	2	174
3	435	435	29
4	104	116	1
5	421	406	191
10,6,L			
0	241	239	500
1	0*	2	250
2	103	75	61
3	31*	3	125
10,7,L			
0	103*	110	0
1	503	493	190
11,0,L			
0	0*	0	0
11,1,L			
0	104*	112	0
1	29*	0	0
11,2,L			
0	122	125	500
1	428	419	226
2	0*	0	0
11,3,L			
0	184	181	500
1	0*	1	76
2	365	365	0
3	75*	0	0
11,4,L			
0	0*	0	0
1	404	406	231
2	113	116	998
3	31*	16	989
11,5,L			
0	137	142	0
1	0*	1	966
2	333	367	794
12,0,L			
0	899	914	0
12,1,L			
0	0*	2	500
1	257	257	63
12,2,L			
0	178	164	500
1	97*	108	2