

The crystal structures of helvite group minerals, (Mn,Fe,Zn)₈(Be₆Si₆O₂₄)S₂

ISHMAEL HASSAN¹ 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(Be₆Si₆O₂₄)S₂ have been refined in the space group $P4_3n$ to R factors between 0.024 and 0.029 for observed reflections measured on an automated single-crystal 4-circle X-ray diffractometer using MoK α radiation. The 1:1 BeO₄ and SiO₄ 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 C₈(Be₆Si₆O₂₄)S₂, with C = Mn (helvite), Fe²⁺ (danalite) and Zn (genthelvite). The helvite group minerals are isotypic with cubic sodalite, Na₈(Al₆Si₆O₂₄)Cl₂ and their structures are characterized by four-membered rings of BeO₄ and SiO₄ 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, Fe²⁺ 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 $P4_3n$ 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⁺, Ca²⁺, Cl⁻, OH⁻, H₂O, SO₄²⁻, 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.

HELVITE (M30349)

<p>1,0,L 0 40* 0 0</p> <p>1,1,L 0 0* 29 500 1 0* 0 0</p> <p>2,0,L 0 326 309 500</p> <p>2,1,L 0 325 339 0 1 1320 1270 818</p> <p>2,2,L 0 364 368 0 1 38* 0 0 2 794 702 950</p> <p>3,0,L 0 0* 0 0</p> <p>3,1,L 0 609 620 500 1 19* 0 0</p> <p>3,2,L 0 273 285 500 1 642 626 951 2 19* 0 0</p> <p>3,3,L 0 1533 1535 0 1 20* 0 0 2 289 290 158 3 0* 0 0</p> <p>4,0,L 0 625 598 500</p> <p>4,1,L 0 20* 3 500 1 1200 1213 230</p> <p>4,2,L 0 575 590 0 1 252 258 998 2 831 813 772</p> <p>4,3,L 0 26* 0 0 1 147 150 169 2 237 242 999 3 574 557 959</p> <p>4,4,L 0 1283 1314 0 1 0* 0 0 2 895 874 803 3 22* 0 0 4 861 808 193</p> <p>5,0,L 0 0* 0 0</p> <p>5,1,L 0 474 493 0 1 0* 0 0</p> <p>5,2,L 0 223 237 500 1 506 489 218 2 2* 0 0</p> <p>5,3,L 0 767 781 500 1 0* 2 43</p>	<p>2 703 702 5 0 3 0* 0 0</p> <p>5,4,L 0 11* 3 500 1 796 795 194 2 216 208 3 3 325 313 57 4 0* 0 0</p> <p>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</p> <p>6,0,L 0 1311 1325 0</p> <p>6,1,L 0 208 220 0 1 279 297 14</p> <p>6,2,L 0 453 460 500 1 0* 3 506 2 416 406 208</p> <p>6,3,L 0 202 210 0 1 208 199 186 2 0* 0 762 3 946 945 24</p> <p>6,4,L 0 57* 36 500 1 134 196 3 2 0* 192 36 3 183 178 33 4 315 310 991</p> <p>6,5,L 0 181 185 0 1 580 581 20 2 0* 1 21 3 301 304 50 4 157 155 996 5 440 437 538</p> <p>6,6,L 0 546 543 0 1 576 560 98 2 0* 0 0 3 201 180 914 4 0* 0 0 5 207 193 3</p> <p>7,0,L 0 21* 0 0</p> <p>7,1,L 0 177 181 0 1 33* 0 0</p> <p>7,2,L 0 187 194 500 1 545 571 828 2 0* 0 0</p> <p>7,3,L 0 554 569 500 1 12* 2 217 2 360 357 41 3 29* 0 0</p> <p>7,4,L 0 0* 1 0 1 533 536 773</p>	<p>2 167 167 3 3 257 256 956 4 0* 0 0</p> <p>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</p> <p>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</p> <p>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</p> <p>8,0,L 0 145 156 0</p> <p>8,1,L 0 31* 0 0 1 650 661 178</p> <p>8,2,L 0 54 563 0 1 168 172 1 2 364 362 170</p> <p>8,3,L 0 25* 4 500 1 339 335 945 2 164 158 3 3 514 514 35</p> <p>8,4,L 0 565 577 0 1 469 45 915 2 0* 2 172 3 569 576 861</p> <p>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</p> <p>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</p> <p>8,7,L 0 0* 0 0 1 317 309 186 2 127 121 990 3 192 98 83 4 10* 3 73 5 226 218 767 6 101* 94 14</p>	<p>8,8,L 0 533 527 0 1 25* 0 0 2 300 304 792 3 35* 0 0 4 445 404 139 5 15* 0 0</p> <p>9,0,L 0 0* 0 0</p> <p>9,1,L 0 309 309 500 1 0* 0 0</p> <p>9,2,L 0 149 150 500 1 423 434 91 2 0* 0 0</p> <p>9,3,L 0 597 589 0 1 0* 3 929 2 103 108 31 3 20* 0 0</p> <p>9,4,L 0 0* 4 0 1 96* 103 921 2 147 131 999 3 253 247 949 4 37* 0 0</p> <p>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</p> <p>9,6,L 0 116 113 500 1 36* 46 25 2 0* 1 982 3 621 619 9 4 115 112 1 5 153 156 896 6 18* 0 0</p> <p>9,7,L 0 194 183 500 1 0* 3 832 2 261 262 74 3 0* 0 0 4 135 131 826 5 21* 4 809</p> <p>9,8,L 0 22* 6 500 1 134 131 34 2 93 97 2 3 295 295 38</p> <p>10,0,L 0 85 85 500</p> <p>10,1,L 0 133 135 0 1 429 423 132</p> <p>10,2,L 0 26* 20 0 1 0* 3 213 2 422 432 839</p> <p>10,3,L 0 126 127 0 1 196 199 886 2 0* 5 100 3 104* 117 890</p>	<p>10,4,L 0 302 295 0 1 121 119 998 2 301 306 247 3 120* 114 998 4 368 354 205</p> <p>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</p> <p>10,6,L 0 84 70 500 1 0* 4 890 2 175 180 913 3 0* 2 172 4 121 125 207</p> <p>10,7,L 0 92* 97 0 1 420 406 162 2 26* 5 247</p> <p>11,0,L 0 0* 0 0</p> <p>11,1,L 0 122 124 0 1 0* 0 0</p> <p>11,2,L 0 115 112 500 1 283 283 229 2 0* 0 0</p> <p>11,3,L 0 195 196 500 1 0* 2 145 2 361 360 10 3 0* 0 0</p> <p>11,4,L 0 32* 1 0 1 307 298 215 2 97 100 997 3 40* 19 922 4 0* 0 0</p> <p>11,5,L 0 157 164 0 1 12* 3 910 2 202 214 790 3 58* 5 86</p> <p>11,6,L 0 97* 89 500</p> <p>12,0,L 0 764 757 0</p> <p>12,1,L 0 0* 4 500 1 169 161 954</p> <p>12,2,L 0 107 112 500 1 94 86 1 2 254 254 831</p> <p>12,3,L 0 0* 1 0 1 287 288 953 2 95 93 996</p>
--	--	--	---	--

DANALITE (M37261)

1,0,L	2 0° 1 114	7,4,L	5 263 263 770	10,3,L
0 28 0 0	3 744 727 10	0 23 0 0	6 118 118 3	0 141 143 0
1,1,L	5,4,L	0 599 588 780	0 588 599 0	1 217 218 899
0 44 54 0	0 0° 0 500	1 187 186 3	0 406 395 787	2 14 2 860
1 22* 0 0	0 898 906 134	2 293 289 0	0 406 395 787	3 117 98 822
2,0,L	2 221 220 1000	3 21* 0 0	0 406 395 787	4 130 131 1000
0 406 415 500	3 355 359 957	4 21* 0 0	0 406 395 787	5 382 389 204
2,1,L	5,5,L	7,5,L	0 0° 0 0	10,4,L
0 359 343 0	0 215 203 0	0 216 212 0	0 0° 0 0	0 349 347 0
1 1371 1404 806	1 0° 0 0	1 434 44 211	0 0° 0 0	1 134 135 1
2,2,L	2 317 298 829	2 13 148	0 0° 0 0	2 361 355 237
0 411 409 0	3 588 599 768	3 456 466 196	0 0° 0 0	3 130 131 1000
1 16* 0 0	4 0° 0 0	4 0° 0 0	0 0° 0 0	4 382 389 204
2 685 694 977	0 6,0,L	5 7,6,L	0 408 408 500	10,5,L
3,0,L	0 1524 1500 0	0 168 167 500	1 0° 0 0	0 126 128 0
0 0° 0 0	0 237 227 0	1 284 283 927	0 0° 0 0	1 319 310 766
3,1,L	1 372 354 26	2 19 1 148	0 0° 0 0	2 0° 2 119
0 733 726 500	0 548 537 500	3 68 49 772	0 0° 0 0	3 376 378 43
1 0° 0 0	1 0° 2 181	4 146 150 998	0 0° 0 0	4 123 123 997
2,3,L	2 424 442 215	5 420 426 37	0 170 169 500	5 303 325 176
0 304 292 500	0 6,1,L	6 10* 0 0	1 464 459 75	10,6,L
1 685 693 950	0 237 227 0	7 7,7,L	2 23* 0 0	0 136 137 500
2 22* 0 0	1 372 354 26	0 415 409 0	0 0° 0 0	1 26* 2 114
3,3,L	0 548 537 500	1 525 517 802	0 0° 0 0	2 174 158 950
0 1634 1684 0	1 0° 2 181	2 583 561 840	0 0° 0 0	3 22* 1 208
1 25* 0 0	2 424 442 215	3 16* 0 0	0 0° 0 0	4 93 104 225
2 374 344 126	0 6,3,L	4 247 246 984	0 0° 0 0	10,7,L
0 830 779 500	0 227 219 0	5 33* 0 0	0 0° 0 0	0 113 115 0
4,0,L	1 154 178 249	6 8,0,L	0 139 136 986	1 443 462 184
0 830 779 500	2 17* 1 175	0 209 213 0	1 150 150 0	2 0° 1 870
4,1,L	3 195 195 12	1 8,1,L	2 337 341 963	11,0,L
0 9* 1 500	4 383 371 3	0 10* 3 0	0 0° 0 0	0 14* 0 0
1 1275 1298 237	0 6,4,L	1 764 769 186	0 0° 0 0	1 121 111 0
0 679 663 0	0 125 117 500	2 597 571 0	0 0° 0 0	2 31* 0 0
1 276 264 999	1 214 208 0	3 187 185 2	0 0° 0 0	11,2,L
2 989 938 76	2 126 123 1	4 466 472 184	0 0° 0 0	0 132 132 500
4,2,L	3 195 195 12	5 8,2,L	0 0° 0 0	1 329 342 228
0 679 663 0	4 383 371 3	0 597 571 0	0 0° 0 0	2 15* 0 0
1 276 264 999	0 6,5,L	1 187 185 2	0 0° 0 0	11,3,L
2 989 938 76	0 202 200 0	2 466 472 184	0 0° 0 0	0 212 208 500
4,3,L	1 620 619 13	3 563 550 36	0 0° 0 0	1 380 380 5
0 13* 1 0	2 0° 1 805	4 8,3,L	0 0° 0 0	2 5* 0 0
1 223 201 134	3 349 346 45	0 28* 1 500	0 0° 0 0	11,4,L
2 255 247 997	4 168 172 1	1 351 356 938	0 0° 0 0	0 0° 0 0
3 650 653 966	5 440 437 945	2 179 176 4	0 0° 0 0	1 360 362 217
4,4,L	6 252 272 971	3 563 550 36	0 0° 0 0	2 116 121 997
0 1439 1464 0	0 6,6,L	4 8,4,L	0 0° 0 0	3 35* 10 760
1 963 943 793	0 654 669 0	0 596 576 0	0 0° 0 0	4 0* 0 0
2 16* 0 0	1 20* 0 0	1 517 521 764	0 0° 0 0	11,5,L
3 814 842 211	2 656 664 968	2 159 158 500	0 0° 0 0	0 150 144 0
5,0,L	3 241 245 947	3 184 163 111	0 0° 0 0	1 13* 2 146
0 15* 0 0	4 0° 0 0	4 700 678 863	0 0° 0 0	2 286 274 795
5,1,L	5 252 272 971	5 8,5,L	0 0° 0 0	3 0* 3 832
0 557 535 0	0 7,0,L	0 17* 1 0	0 0° 0 0	12,0,L
1 0° 0 0	0 0° 0 0	1 517 521 764	0 0° 0 0	0 855 858 0
5,2,L	1 232 221 0	2 159 158 500	0 0° 0 0	12,1,L
0 255 244 500	2 0° 0 0	3 184 163 111	0 0° 0 0	0 0° 1 500
1 623 644 227	3 0° 0 0	4 700 678 863	0 0° 0 0	1 193 190 10
2 13* 0 0	4 0° 0 0	5 410 422 168	0 0° 0 0	12,2,L
5,3,L	5 252 272 971	6 8,6,L	0 0° 0 0	0 146 144 500
0 862 855 500	0 213 206 500	0 272 269 500	0 0° 0 0	1 109 115 898
	1 652 617 817	1 152 150 999	0 0° 0 0	2 225 224 840
	2 30* 0 0	2 233 224 993	0 0° 0 0	12,3,L
	3 0° 0 0	3 142 142 997	0 0° 0 0	0 0° 3 0
	4 0° 0 0	4 418 424 985	0 0° 0 0	1 349 356 952
	5 0° 0 0	5 128 133 998	0 0° 0 0	
	6 0° 0 0	6 437 439 24	0 0° 0 0	
	7 0° 0 0	7 8,7,L	0 0° 0 0	
	8 0° 0 0	0 359 366 185	0 0° 0 0	
	9 0° 0 0	1 130 136 996	0 0° 0 0	
	10 0° 0 0	2 121 117 79	0 0° 0 0	
	11 0° 0 0	3 0° 0 205	0 0° 0 0	
	12 0° 0 0	4 0° 0 205	0 0° 0 0	

DANALITE (M34769)

0 1,0,L 19* 0 0
0 1,1,L 38* 61 0
1 14* 0 0
0 2,0,L 397 406 500
0 2,1,L 357 343 0
1 1351 1403 805
0 2,2,L 404 402 0
2 28* 0 0
691 687 977
0 3,0,L 0* 0 0
0 3,1,L 729 724 500
1 0* 0 0
0 3,2,L 303 292 500
1 697 697 947
2 0* 0 0
0 3,3,L 1582 1665 0
1 5* 0 0
2 369 338 130
3 0* 0 0
0 4,0,L 848 805 500
0 4,1,L 1* 2 500
1 1293 1280 238
0 4,2,L 688 672 0
1 273 264 999
2 938 932 776
0 4,3,L 0* 0 0
1 239 215 131
2 259 247 967
3 685 660 967
0 4,4,L 1457 1491 0
1 0* 0 0
2 971 926 792
3 27* 0 0
4 797 817 214
0 5,0,L 0* 0 0
1 0* 0 0
0 5,1,L 546 531 0
1 27* 0 0
0 5,2,L 254 243 500
1 640 661 226
2 0* 0 0
0 5,3,L 842 840 500

1 12* 2 115
2 736 717 13
3 19* 0 0
0 5,4,L 17* 0 0
1 905 905 193
2 230 220 1000
3 366 363 954
4 0* 0 0
0 5,5,L 190 187 0
1 352 325 828
2 0* 0 0
3 620 607 766
4 28* 0 0
0 6,0,L 1484 1495 0
0 6,1,L 235 227 0
1 376 362 31
0 6,2,L 543 531 500
1 0* 0 0
2 418 439 213
0 6,3,L 227 219 0
1 154 175 249
2 0* 1 847
3 1086 1084 22
0 6,4,L 134 128 500
1 211 209 0
2 134 137 990
3 199 195 2
4 410 386 7
0 6,5,L 205 200 0
1 629 615 10
2 25* 1 148
3 346 334 45
4 177 172 1
5 431 423 948
0 6,6,L 678 672 0
1 0* 0 0
2 652 660 965
3 0* 0 0
4 256 253 952
5 0* 0 0
6 257 272 966
0 7,0,L 13* 0 0
0 7,1,L 241 232 0
1 12* 0 0
0 7,2,L 209 206 500
1 639 601 817
2 0* 0 0
0 7,3,L 681 672 500
1 0* 1 854
2 433 424 36
3 13* 0 0
0 7,4,L 0* 0 0
1 576 573 783
2 190 185 3
3 305 299 969
4 0* 0 0
0 7,5,L 233 218 0
1 0* 2 127
2 423 427 210
3 7* 2 851
4 457 461 194
5 23* 0 0
0 7,6,L 167 167 500
1 293 289 933
2 0* 1 814
3 78 52 244
4 433 430 35
5 0* 0 0
0 7,7,L 419 417 0
1 23* 0 0
2 517 506 802
3 575 551 843
4 0* 0 0
5 264 253 990
6 30* 0 0
0 8,0,L 255 244 0
0 8,1,L 15* 1 0
1 777 775 188
0 8,2,L 567 557 0
1 187 185 2
2 479 485 190
0 8,3,L 5* 3 500
1 345 350 933
2 174 177 4
3 538 528 38
0 8,4,L 581 563 0
1 0* 2 28
2 539 552 225
3 0* 1 897
4 722 684 865
0 8,5,L 0* 1 500
1 531 533 761
2 161 158 500
3 183 160 124
4 0* 0 915
5 436 440 175
0 8,6,L 250 244 500
1 151 151 399
2 220 214 1000
3 143 143 977
4 418 419 982
5 132 133 938
6 423 421 24
0 8,7,L 32* 0 0
1 357 361 187
2 133 136 996
3 121 115 77
4 0* 1 913

7,4,L 0* 0 0
1 576 573 783
2 190 185 3
3 305 299 969
4 0* 0 0
0 7,5,L 233 218 0
1 0* 2 127
2 423 427 210
3 7* 2 851
4 457 461 194
5 23* 0 0
0 7,6,L 167 167 500
1 293 289 933
2 0* 1 814
3 78 52 244
4 433 430 35
5 0* 0 0
0 7,7,L 419 417 0
1 23* 0 0
2 517 506 802
3 575 551 843
4 0* 0 0
5 264 253 990
6 30* 0 0
0 8,0,L 255 244 0
0 8,1,L 15* 1 0
1 777 775 188
0 8,2,L 567 557 0
1 187 185 2
2 479 485 190
0 8,3,L 5* 3 500
1 345 350 933
2 174 177 4
3 538 528 38
0 8,4,L 581 563 0
1 0* 2 28
2 539 552 225
3 0* 1 897
4 722 684 865
0 8,5,L 0* 1 500
1 531 533 761
2 161 158 500
3 183 160 124
4 0* 0 915
5 436 440 175
0 8,6,L 250 244 500
1 151 151 399
2 220 214 1000
3 143 143 977
4 418 419 982
5 132 133 938
6 423 421 24
0 8,7,L 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
0 8,8,L 591 594 0
1 0* 0 0
2 422 414 789
3 17* 0 0
4 456 472 160
5 38* 0 0
0 9,0,L 39* 0 0
0 9,1,L 407 416 500
1 0* 0 0
0 9,2,L 170 168 500
1 457 454 69
2 0* 0 0
0 9,3,L 722 726 0
1 0* 2 102
2 141 142 16
3 0* 0 0
0 9,4,L 13* 1 500
1 151 149 2
2 144 149 0
3 345 353 965
4 0* 0 0
0 9,5,L 374 369 500
1 0* 1 881
2 473 480 993
3 19* 93
4 118 117 26
5 14* 0 0
0 9,6,L 133 134 500
1 103 104 45
2 0* 0 503
3 737 747 7
4 123 128 998
5 155 173 878
6 0* 0 0
0 9,7,L 794 297 500
1 0* 3 107
2 305 303 57
3 0* 2 856
4 152 144 898
5 0* 2 73
0 9,8,L 33* 3 0
1 109 112 971
2 114 116 1000
3 307 300 46
0 10,0,L 144 141 500
0 10,1,L 155 154 0
1 413 452 140
0 10,2,L 75* 69 0
1 12* 3 167
2 549 549 836

10,3,L 143 144 0
1 216 222 904
2 5* 2 186
3 111 97 814
0 10,4,L 356 354 0
1 135 136 1
2 343 340 235
3 131 132 1000
4 366 375 204
0 10,5,L 128 128 0
1 310 309 765
2 0* 1 789
3 382 386 40
4 120 124 997
5 306 328 176
0 10,6,L 150 147 500
1 0* 1 229
2 156 145 970
3 90* 93 877
4 0* 0 242
0 10,7,L 112 116 0
1 427 455 183
2 12* 1 117
0 11,0,L 0* 0 0
0 11,1,L 108 100 0
1 0* 0 0
0 11,2,L 124 131 500
1 332 346 224
2 0* 0 0
0 11,3,L 185 186 500
1 0* 2 854
2 366 370 5
3 0* 0 0
0 11,4,L 0* 0 0
1 359 361 221
2 116 126 997
3 0* 13 168
4 15* 0 0
0 11,5,L 136 135 0
1 18* 2 14
2 297 283 799
3 0* 3 833
0 12,0,L 846 861 0
0 12,1,L 0* 4 500
1 199 198 28
0 12,2,L 137 140 500
1 110 117 998
2 205 202 850
0 12,3,L 21* 1 0
1 339 358 951

GENTHELVITE (M37267)

0 1 2 3 4 5 6	1,0,L 32 0 0 1,1,L 129 141 0 2,0,L 499 503 500 2,1,L 355 340 0 1 1440 1549 795 2,2,L 458 448 0 0 20 0 0 2 672 698 13 3,0,L 29 0 0 3,1,L 841 845 500 1 22 0 0 3,2,L 300 291 500 0 779 772 947 2 0 0 0 3,3,L 1847 1863 0 0 17 0 0 3 461 421 101 3 27 0 0 4,0,L 1042 1001 500 4,1,L 25 1 500 1 1442 1387 245 4,2,L 753 751 0 0 271 264 999 2 1078 1087 777 4,3,L 302 1 0 0 259 248 999 3 790 779 973 4,4,L 1652 1631 0 0 12 0 0 4 1056 1026 781 5 23 0 0 6 878 888 233 5,0,L 29 0 0 5,1,L 603 583 0 1 0 0 0 5,2,L 257 246 500 0 810 855 234 2 0 0 0	5,3,L 912 916 500 0 11 0 883 1 768 749 17 3 21 0 0 5,4,L 1027 1040 2 500 0 229 219 196 1 421 420 1 5 26 0 0 5,5,L 198 192 0 0 0 17 0 0 2 540 508 799 3 13 0 0 4 751 741 762 5 0 0 0 6,0,L 1711 1711 0 6,1,L 235 230 0 1 461 447 37 6,2,L 638 630 500 0 16 2 219 2 417 446 231 6,3,L 227 220 0 0 167 207 844 1 11 2 188 5 1297 1290 19 6,4,L 243 247 500 0 213 207 1 1 203 205 975 4 201 194 1 5 479 463 13 6,5,L 201 197 0 0 663 659 2 1 40 1 860 2 175 387 39 3 175 174 999 5 439 430 961 6,6,L 855 858 0 0 17 0 0 1 748 750 958 2 38 0 0 3 347 344 969 4 30 0 0 6 414 434 960 7,0,L 0 0 0 7,1,L 308 302 0 1 18 0 0 7,2,L 211 208 500 0 713 682 801 1 0 0 0 2 0 0 0 7,3,L 767 775 500	11 495 492 1 118 0 0 0 32 7,4,L 18 0 0 0 654 661 786 1 185 185 1 2 355 358 978 3 21 0 0 7,5,L 276 277 0 0 0 500 1 510 531 221 2 0 1 88 5 540 546 196 6 19 0 0 7,6,L 166 165 500 0 337 345 951 1 11 2 760 2 136 112 99 3 160 174 998 4 433 474 998 5 13 0 28 6 0 0 0 7,7,L 460 464 0 0 20 0 0 1 608 582 790 2 0 0 0 3 634 605 838 4 0 0 0 5 296 301 9 6 24 0 0 8,0,L 261 257 0 8,1,L 0 0 3 0 1 835 900 196 8,2,L 581 575 0 0 188 186 0 1 609 630 205 8,3,L 0 1 500 0 0 1 933 1 369 379 1 2 177 175 1 3 560 562 37 8,4,L 573 553 0 0 31 1 912 1 630 661 229 2 28 2 36 3 807 775 860 8,5,L 23 2 500 0 644 667 757 1 159 158 999 2 199 174 130 3 24 2 952 5 593 556 192 8,6,L 269 270 500 0 148 150 999 1 237 231 16 2 148 146 998 3 443 447 978 4 126 134 1 5 433 435 22 6 0 0 0	9,7,L 12 0 0 0 424 429 194 1 141 139 997 2 155 144 61 3 29 0 0 5 337 335 763 6 115 116 4 9,8,L 640 645 0 0 29 0 0 1 523 513 784 2 0 0 0 4 501 519 180 9,9,L 22 0 0 9,1,L 512 516 500 0 1 0 0 1 0 0 0 9,2,L 163 169 500 0 497 484 49 2 0 0 0 9,3,L 894 898 0 0 212 204 851 3 0 0 11 9,4,L 19 1 0 0 226 223 27 1 14 151 998 2 433 443 973 3 11 0 0 9,5,L 395 383 500 0 6 0 145 1 457 473 909 2 0 1 839 5 146 133 983 6 0 0 0 9,6,L 134 136 500 0 190 172 31 1 15 0 923 2 841 880 6 3 127 130 2 5 190 186 885 9,7,L 374 381 500 0 12 1 784 1 350 348 34 2 15 1 916 4 195 186 946 9,8,L 0 0 3 500 0 121 127 927 1 115 118 3 2 0 0 0 10,0,L 224 222 500 10,1,L 153 151 0 0 463 498 158 1 0 0 0 10,2,L	127 126 0 0 672 664 846 1 0 3 826 10,3,L 141 174 0 0 254 265 926 1 30 3 769 3 134 102 195 10,4,L 396 403 0 0 139 138 999 1 416 414 229 2 127 132 999 4 403 418 213 10,5,L 130 130 0 0 389 373 753 1 35 2 189 2 432 440 33 3 116 123 1 4 372 390 185 10,6,L 225 225 500 0 0 2 771 1 96 100 51 2 0 2 119 4 64 84 836 10,7,L 114 118 0 0 473 498 190 1 0 0 0 11,0,L 32 0 0 11,1,L 115 114 0 0 0 0 0 1 0 0 0 11,2,L 131 132 500 0 400 418 226 1 0 0 0 2 0 0 0 11,3,L 204 194 500 0 0 1 96 1 373 382 0 3 0 0 0 11,4,L 0 0 0 0 423 424 227 1 116 123 998 3 36 13 855 11,5,L 142 138 0 0 0 1 928 1 377 355 795 12,0,L 927 933 0 12,1,L 0 0 1 500 0 256 251 56 12,2,L 169 168 500 0 106 116 1 2 181 180 897
---------------------------------	--	---	---	---	---

GENTHELVITE (M32727)

0 1,0.L 36 0 0 1 1,1.L 140 146 0 23 0 0 2,0.L 497 492 500 2,1.L 344 340 0 1 1480 1544 794 2,2.L 456 452 0 42 0 0 2 792 693 15 3,0.L 53 0 0 3,1.L 872 847 500 30 0 0 3,2.L 294 288 500 814 775 947 0 0 0 3,3.L 1778 1834 0 406 418 102 0 0 0 4,0.L 1060 1019 500 4,1.L 0 2 500 1 1398 1367 246 4,2.L 770 756 0 275 261 499 2 1117 1039 777 4,3.L 28 2 0 294 297 98 255 244 109 3 822 733 974 4,4.L 1596 1633 0 25 0 0 1 1003 996 781 2 56 0 0 4 868 858 235 5,0.L 30 0 0 5,1.L 586 543 0 43 0 0 5,2.L 244 242 500 1 903 870 234 2 0 0 0 5,3.L 895 889 500 427 400 745 753 737 16 0 0 0 5,4.L 30 2 500 1045 1040 197 230 215 2 2 437 421 956 33 0 0 5,5.L 182 184 0 0 0 0 1 524 542 798 3 40 0 0 4 762 752 760 0 0 0 6,0.L 1646 1687 0 6,1.L 227 226 0 1 460 460 37 6,2.L 623 637 500 39 2 215 2 457 435 234 6,3.L 214 215 0 252 208 853 3 182 1281 192 0 20 20 6,4.L 264 260 500 205 202 1 4 221 22 973 193 188 1 4 480 467 12 6,5.L 184 192 0 554 653 1 4 46 1 853 367 377 455 5 159 167 945 426 415 961 6,6.L 454 471 0 1 43 0 0 2 76 74 958 3 367 36 375 4 35 0 0 6 482 45 567 7,0.L 39 0 0 7,1.L 314 315 0 1 0 0 0 7,2.L 207 203 500 543 669 735 3 35 0 0 7,3.L 767 761 500 7,4.L 46 1 83 439 490 31 54 0 0 7,5.L 29 0 0 468 640 798 191 174 2 3 372 362 478 0 0 0 7,6.L 290 274 0 500 0 500 5 500 537 224 500 0 48 5 50 530 198 0 0 0 7,7.L 160 158 500 359 348 953 3 4 2 770 115 120 106 4 154 147 998 468 472 25 18 0 0 8,0.L 275 270 0 8,1.L 47 5 0 1 892 899 196 8,2.L 552 559 0 1 176 180 1 2 641 641 211 8,3.L 0 1 500 1 380 362 432 2 164 169 1 3 521 529 37 8,4.L 541 542 0 1 34 0 29 4 674 653 227 0 0 26 5 722 752 359 8,5.L 0 2 500 1 675 679 753 4 155 51 998 5 161 165 136 0 0 361 4 577 580 196 8,6.L 244 250 500 1 129 143 999 2 229 222 16 3 132 134 378 4 462 430 480 5 124 127 1 6 396 394 19 9,7.L 425 2 0 1 137 132 996 2 135 137 66 3 1 0 759 4 345 335 763 5 133 104 5 9,8.L 614 607 0 1 47 0 0 2 499 516 786 3 0 0 0 4 542 515 177 9,9.L 63 0 0 9,1.L 504 515 500 1 71 0 0 9,2.L 153 163 500 1 455 480 43 2 37 0 0 9,3.L 895 901 0 1 0 1 816 2 203 214 0 3 50 0 0 9,4.L 0 1 0 1 235 242 33 2 142 144 998 3 457 444 975 4 22 0 0 9,5.L 373 381 500 1 43 1 169 2 459 446 915 3 1 1 823 4 153 146 567 5 0 0 0 9,6.L 122 128 500 1 157 191 35 2 0 0 0 3 97 88 5 4 113 123 2 5 206 193 881 9,7.L 397 369 500 1 0 1 750 2 347 347 24 3 27 1 317 4 134 188 953 9,8.L 7 4 500 1 155 124 909 2 107 110 3 10,0.L 236 228 500 10,1.L 145 144 0 1 52 491 161 10,2.L 149 136 0 1 43 4 863 2 627 658 825 10,3.L 125 137 0 1 279 272 931 2 0 3 784 3 44 105 201 10,4.L 401 388 0 1 132 130 999 2 410 414 226 3 136 124 999 4 439 413 218 10,5.L 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 241 239 500 1 0 2 250 2 103 75 61 3 31 3 125 10,7.L 103 110 0 1 503 493 190 11,0.L 0 0 0 11,1.L 104 112 0 1 29 0 0 11,2.L 122 125 500 1 428 415 226 2 0 0 0 11,3.L 184 181 500 1 0 1 76 2 365 365 0 3 75 0 0 11,4.L 0 0 0 1 404 406 231 2 113 116 998 3 31 16 989 11,5.L 137 142 0 1 0 1 966 2 333 367 794 12,0.L 899 914 0 12,1.L 0 2 500 1 257 257 83 12,2.L 178 164 500 1 97 106 2
