

## The crystal structure of braunite II and its relation to bixbyite and braunite

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## Abstract

The crystal structure of braunite II,  $\text{Ca}(\text{Mn,Fe})_3\text{SiO}_7$ , has been determined on a crystal from the Wessels Mine, near Hotazel, South Africa. It is tetragonal, space group  $I4_1/acd$ , with cell dimensions  $a = 9.431(2)$ ,  $c = 37.774(4)\text{\AA}$ . The structure was refined by use of anisotropic thermal parameters and an extinction correction to a conventional  $R = 0.058$ . The structure consists of an  $(A'ABA)_4$  stacking sequence of three non-equivalent edge- and corner-linked polyhedral sheets. The A- and A'-sheets consist of edge- and corner-linked  $(\text{Mn,Fe})$  octahedra, whereas the B-sheets consist of Ca in cubic coordination, Si in tetrahedral coordination, and  $(\text{Mn,Fe})$  in octahedral coordination. The A- and A'-sheets are present in bixbyite with stacking sequence  $(AA')_2$ , whereas the stacking sequence of braunite is  $(AB)_4$ . The A-, A', and B-sheets are virtually identical in the three structures. The structure determination confirms the validity of the braunite II structure as proposed previously. Comparative calculated X-ray diffraction data are presented so that distinctions can be made among these three minerals.

## Introduction

The crystal structure of bixbyite has been the subject of recent investigations by Norrestam (1967) and Geller (1971). De Villiers (1975) and Moore and Araki (1976) examined the braunite structure and independently pointed out the very close relation between these two structures. Moore and Araki (1976) derive a theory that not only describes the braunite-bixbyite relation but also classifies all fluorite-structure derivatives. They also propose a structure for the compound first described by De Villiers (1946) as ferrian braunite and later designated as braunite II by De Villiers and Herbstein (1967).

This investigation is the continuation of a study of the crystal chemistry of economically important minerals from the Kalahari manganese field, Cape Province, South Africa. It also presents an opportunity to test the validity of the structure of braunite II as proposed by Moore and Araki (1976).

## Experimental

A single crystal of braunite II was selected from specimens collected at the Wessels Manganese Mine, near Hotazel, Cape Province, South Africa. A part of

the type material has been deposited at the Royal Ontario Museum, Toronto, Canada, and is registered as M33733 and M34659. Braunite II occurs together with braunite and hausmannite as one of the predominant minerals in iron-rich portions of the mine. The composition given in Table 1 was determined by electron microprobe analysis using the Bence-Albee correction procedure, and was calculated on the basis of 24 oxygen atoms. Weight percentages of the constituent elements are 52.49 Mn, 10.63 Fe, 2.55 Si, and 3.03 Ca. Synthetic  $\text{Mn}_2\text{O}_3$  (Mn), magnetite (Fe), and wollastonite ( $\text{Ca,Si}$ ) were used as standards.

X-ray measurements with graphite-monochromated  $\text{MoK}\alpha$ -radiation were completed on a roughly spherical crystal (see Table 1 for dimensions) that had been ground and mounted on a Philips PW1100 computer-controlled four-circle diffractometer. The cell dimensions were obtained from least-squares analysis of angular measurements of 44 reflections collected with a Stoe precision Weissenberg camera, and refined by use of a program by Burnham (1962).

The cell data are given in Table 1. The intensities of a unique set of reflections up to  $\sin \theta/\lambda = 0.8$  were collected with the  $\omega/2\theta$  scan technique, and the back-

TABLE 6: Observed and Calculated structure factors of Brgunite II

M 13FD	ICFC	M 13FD	IOFC	M 10FD	IOFC	M 10FD	IOFC	M 10FD	IOFC	M 10FD	IOFC	M 10FD	IOFC	M 13FC							
2 1799	1764	M <sub>6,6,0</sub>	6 1030	950	5 965	971	M <sub>6,6,2</sub>	2 926	868	M <sub>5,5,2</sub>	5 702	701	13 463	170							
4 1231	1236	6 1920	1896	5 376	342	4 1086	5	4 1086	5	M <sub>3,3,1</sub>	7 593	288	11 816	676							
6 764	771	10 388	373	M <sub>3,3,1</sub>	2199	2064	6 2199	2064	8 449	330	M <sub>6,6,2</sub>	7 593	533	7 640	736						
8 1194	1193	12 3221	3214	4 779	778	6 1126	1098	8 449	330	6 1846	0	3 509	656	5 1186	0						
10 1261	1261	M <sub>7,7,0</sub>	6 2226	159	6 2226	159	10 1907	1979	6 891	678	M <sub>3,3,3</sub>	4 4306	4280	M <sub>6,6,4</sub>	6 803	614					
12 5924	5869	13 2096	0	10 313	690	12 2326	27	10 1297	1404	10 1297	1404	5 683	699	8 1403	1583						
14 1606	1533	11 1678	0	12 2326	27	14 974	964	12 1291	1323	12 1291	1323	10 541	615	10 1265	1262						
M <sub>1,1,0</sub>	6	7 2136	0	M <sub>1,1,2</sub>	15 3316	203	M <sub>7,7,2</sub>	13 06	154	M <sub>7,7,2</sub>	13 06	154	12 1414	1474	12 1961	2093					
15 3016	0	7 2256	0	13 661	603	13 1786	140	13 2096	109	13 2096	109	12 1414	1474	M <sub>7,7,4</sub>	3 2366	379					
11 374	0	M <sub>5,5,0</sub>	6 4820	4594	11 2336	420	9 516	459	7 421	248	M <sub>5,5,3</sub>	13 1697	1707	11 2966	166						
9 2136	0	6 4820	4594	10 1393	1454	7 2654	246	7 306	222	M <sub>5,5,2</sub>	6 520	2029	9 506	531	9 552	618					
7 1478	0	10 1393	1454	5 533	485	5 533	485	5 1346	1359	M <sub>5,5,2</sub>	12 06	57	7 996	162	7 1576	0					
5 1856	0	12 326	3302	M <sub>5,5,1</sub>	2 1896	0	2 1896	0	12 1925	2029	12 06	57	5 4616	4696	M <sub>5,5,4</sub>	8 1020	1195				
3 1856	0	11 1546	0	6 1478	407	6 1478	407	6 1700	1820	12 1925	2029	12 06	57	10 2142	2134	10 2142	2134				
1 696	0	9 2656	0	10 1996	186	10 1996	186	8 571	418	M <sub>7,7,2</sub>	11 2676	197	6 2296	182	12 1272	1223	12 1272	1223			
M <sub>2,2,0</sub>	2 583	449	4 590	602	12 06	41	14 1244	1198	10 2462	2512	M <sub>7,7,2</sub>	11 2676	197	6 2296	182	M <sub>5,5,6</sub>	11 665	635			
6 1427	1467	M <sub>10,10,0</sub>	10 965	853	14 1244	1198	M <sub>5,5,2</sub>	2 1896	0	11 2676	197	6 2296	182	4 1408	1424	9 66	0	9 66	0		
8 2995	3023	10 965	853	M <sub>6,6,1</sub>	13 2986	110	M <sub>5,5,2</sub>	2 1896	0	M <sub>10,10,2</sub>	10 1776	0	M <sub>6,6,3</sub>	13 796	208	M <sub>10,10,4</sub>	8 205	2119	M <sub>10,10,4</sub>	10 1326	1296
10 309	473	M <sub>10,10,1</sub>	15 2816	0	11 432	548	M <sub>3,3,2</sub>	13 3306	248	M <sub>10,10,2</sub>	10 1776	0	M <sub>6,6,3</sub>	13 796	208	M <sub>10,10,4</sub>	10 1326	1296	M <sub>10,10,4</sub>	10 1326	1296
12 3300	3317	11 300	0	7 2296	291	7 2296	291	11 2956	90	M <sub>10,10,2</sub>	10 1776	0	M <sub>6,6,3</sub>	13 796	208	M <sub>10,10,4</sub>	10 1326	1296	M <sub>10,10,4</sub>	10 1326	1296
14 598	446	M <sub>10,10,1</sub>	13 2986	110	11 432	548	M <sub>3,3,2</sub>	13 3306	248	M <sub>10,10,2</sub>	10 1776	0	M <sub>6,6,3</sub>	13 796	208	M <sub>10,10,4</sub>	10 1326	1296	M <sub>10,10,4</sub>	10 1326	1296
M <sub>3,3,0</sub>	13 430	0	11 300	0	7 2296	291	M <sub>3,3,2</sub>	13 3306	248	M <sub>10,10,2</sub>	10 1776	0	M <sub>6,6,3</sub>	13 796	208	M <sub>10,10,4</sub>	10 1326	1296	M <sub>10,10,4</sub>	10 1326	1296
11 2736	0	9 2216	0	M <sub>7,7,1</sub>	8 2016	358	M <sub>3,3,2</sub>	13 3306	248	M <sub>10,10,2</sub>	10 1776	0	M <sub>6,6,3</sub>	13 796	208	M <sub>10,10,4</sub>	10 1326	1296	M <sub>10,10,4</sub>	10 1326	1296
7 362	0	7 926	0	10 2326	19	12 2406	54	9 448	203	M <sub>7,7,1</sub>	13 3146	0	M <sub>6,6,3</sub>	13 796	208	M <sub>10,10,4</sub>	10 1326	1296	M <sub>10,10,4</sub>	10 1326	1296
5 06	0	2 2666	0	12 2406	54	12 2406	54	7 1036	1005	M <sub>7,7,1</sub>	13 3146	0	M <sub>6,6,3</sub>	13 796	208	M <sub>10,10,4</sub>	10 1326	1296	M <sub>10,10,4</sub>	10 1326	1296
3 06	0	M <sub>1,1,1</sub>	2 1069	1023	M <sub>8,8,1</sub>	11 1746	149	5 2256	713	M <sub>7,7,1</sub>	13 3146	0	M <sub>6,6,3</sub>	13 796	208	M <sub>10,10,4</sub>	10 1326	1296	M <sub>10,10,4</sub>	10 1326	1296
M <sub>4,4,0</sub>	4 298	411	4 298	411	11 1746	149	M <sub>4,4,2</sub>	4 379	0	M <sub>8,8,1</sub>	13 3146	0	M <sub>6,6,3</sub>	13 796	208	M <sub>10,10,4</sub>	10 1326	1296	M <sub>10,10,4</sub>	10 1326	1296
6 5128	6497	6 642	631	6 542	693	6 542	693	6 1066	1825	M <sub>1,1,1</sub>	2 342	317	M <sub>8,8,3</sub>	4 409	257	M <sub>1,1,1</sub>	2 342	317	M <sub>1,1,1</sub>	2 342	317
10 446	411	16 386	312	16 386	312	16 386	312	8 1506	21	M <sub>1,1,1</sub>	2 342	317	M <sub>8,8,3</sub>	4 409	257	M <sub>1,1,1</sub>	2 342	317	M <sub>1,1,1</sub>	2 342	317
12 3915	4003	12 06	51	14 1779	1667	14 1779	1667	10 2806	4709	M <sub>1,1,1</sub>	2 342	317	M <sub>8,8,3</sub>	4 409	257	M <sub>1,1,1</sub>	2 342	317	M <sub>1,1,1</sub>	2 342	317
14 530	476	M <sub>2,2,1</sub>	10 730	312	12 438	126	M <sub>5,5,2</sub>	13 3486	226	M <sub>1,1,1</sub>	2 342	317	M <sub>8,8,3</sub>	4 409	257	M <sub>1,1,1</sub>	2 342	317	M <sub>1,1,1</sub>	2 342	317
M <sub>5,5,0</sub>	13 2356	0	13 421	337	M <sub>10,10,1</sub>	11 2676	233	13 3486	226	M <sub>5,5,2</sub>	13 3486	226	M <sub>1,1,1</sub>	2 342	317	M <sub>1,1,1</sub>	2 342	317	M <sub>1,1,1</sub>	2 342	317
11 2626	0	11 516	324	9 406	64	7 839	646	11 629	373	M <sub>5,5,2</sub>	13 3486	226	M <sub>1,1,1</sub>	2 342	317	M <sub>1,1,1</sub>	2 342	317	M <sub>1,1,1</sub>	2 342	317
7 2336	0	9 406	64	11 2676	233	7 693	472	9 1301	1359	M <sub>5,5,2</sub>	13 3486	226	M <sub>1,1,1</sub>	2 342	317	M <sub>1,1,1</sub>	2 342	317	M <sub>1,1,1</sub>	2 342	317
5 976	0	7 839	646	7 693	472	7 693	472	7 693	472	M <sub>5,5,2</sub>	13 3486	226	M <sub>1,1,1</sub>	2 342	317	M <sub>1,1,1</sub>	2 342	317	M <sub>1,1,1</sub>	2 342	317

TABLE 6: Continued

H 10FO 14FC	H 10FO 10FC	H 10FO 10FC	H 10FO 14FC	H 10FO 10FC	H 10FO 10FC	H 10FO 14FC	H 10FO 10FC	H 10FO 10FC	H 10FO 14FC
M <sub>2,2,5</sub> 15 922 731 13 538 490 11 475 435 9 1167 1169 7 3110 3623 5 2110 2124 3 245 65	M <sub>2,3,6</sub> 12 319 336	M <sub>2,3,7</sub> 14 0 238	M <sub>2,3,8</sub> 13 565 596 11 617 672 9 447 441 7 482 374 5 242 278	M <sub>2,3,9</sub> 13 302 290 11 667 801 9 541 543 7 176 1799 5 416 345 3 950 877	M <sub>2,3,10</sub> 11 92 190	M <sub>2,3,11</sub> 10 146 44 12 469 508	M <sub>2,3,12</sub> 12 316 198 14 2877 2782	M <sub>2,3,13</sub> 8 249 188 10 525 397 12 862 822 14 511 379	M <sub>2,3,14</sub> 10 6 243 12 506 503
M <sub>2,3,15</sub> 4 356 394 6 424 4209 8 456 395 10 3068 3025 12 560 725 14 1017 685	M <sub>2,3,16</sub> 2 401 372 4 1107 1135 6 386 230 8 2698 2693 10 489 436 12 2909 2866 14 635 737	M <sub>2,3,17</sub> 4 1040 1073 6 156 124 8 725 746 10 3409 3385 12 43 326 14 3423 3204	M <sub>2,3,18</sub> 13 292 346 11 445 197 9 546 513 7 662 611 5 1852 1120	M <sub>2,3,19</sub> 13 302 290 11 667 801 9 541 543 7 176 1799 5 416 345 3 950 877	M <sub>2,3,20</sub> 0 169 0 2 401 372 4 1107 1135 6 386 230 8 2698 2693 10 489 436 12 2909 2866 14 635 737	M <sub>2,3,21</sub> 13 302 290 11 667 801 9 541 543 7 176 1799 5 416 345 3 950 877	M <sub>2,3,22</sub> 13 302 290 11 667 801 9 541 543 7 176 1799 5 416 345 3 950 877	M <sub>2,3,23</sub> 0 169 0 2 401 372 4 1107 1135 6 386 230 8 2698 2693 10 489 436 12 2909 2866 14 635 737	M <sub>2,3,24</sub> 13 302 290 11 667 801 9 541 543 7 176 1799 5 416 345 3 950 877
M <sub>2,3,25</sub> 13 247 2324 8 392 457 10 3119 3625 12 579 704 14 303 367	M <sub>2,3,26</sub> 2 199 0 4 1163 1114 6 296 100 8 2384 2428 10 262 16 12 247 2429 14 593 360	M <sub>2,3,27</sub> 13 292 346 11 445 197 9 546 513 7 662 611 5 1852 1120	M <sub>2,3,28</sub> 13 302 290 11 667 801 9 541 543 7 176 1799 5 416 345 3 950 877	M <sub>2,3,29</sub> 13 302 290 11 667 801 9 541 543 7 176 1799 5 416 345 3 950 877	M <sub>2,3,30</sub> 0 169 0 2 401 372 4 1107 1135 6 386 230 8 2698 2693 10 489 436 12 2909 2866 14 635 737	M <sub>2,3,31</sub> 13 292 346 11 445 197 9 546 513 7 662 611 5 1852 1120	M <sub>2,3,32</sub> 13 302 290 11 667 801 9 541 543 7 176 1799 5 416 345 3 950 877	M <sub>2,3,33</sub> 0 169 0 2 401 372 4 1107 1135 6 386 230 8 2698 2693 10 489 436 12 2909 2866 14 635 737	M <sub>2,3,34</sub> 13 302 290 11 667 801 9 541 543 7 176 1799 5 416 345 3 950 877
M <sub>2,3,35</sub> 13 1605 1926 11 2319 2381 9 2457 2557 7 2393 2481	M <sub>2,3,36</sub> 13 1176 1211 9 355 478 7 103 313 5 766 754 3 4076 4060	M <sub>2,3,37</sub> 13 292 346 11 445 197 9 546 513 7 662 611 5 1852 1120	M <sub>2,3,38</sub> 13 302 290 11 667 801 9 541 543 7 176 1799 5 416 345 3 950 877	M <sub>2,3,39</sub> 13 302 290 11 667 801 9 541 543 7 176 1799 5 416 345 3 950 877	M <sub>2,3,40</sub> 0 169 0 2 401 372 4 1107 1135 6 386 230 8 2698 2693 10 489 436 12 2909 2866 14 635 737	M <sub>2,3,41</sub> 13 292 346 11 445 197 9 546 513 7 662 611 5 1852 1120	M <sub>2,3,42</sub> 13 302 290 11 667 801 9 541 543 7 176 1799 5 416 345 3 950 877	M <sub>2,3,43</sub> 0 169 0 2 401 372 4 1107 1135 6 386 230 8 2698 2693 10 489 436 12 2909 2866 14 635 737	M <sub>2,3,44</sub> 13 302 290 11 667 801 9 541 543 7 176 1799 5 416 345 3 950 877
M <sub>2,3,45</sub> 11 55 267 6 957 1077	M <sub>2,3,46</sub> 6 80 0 8 549 477 8 159 1096 10 891 867 12 1817 1853 14 347 433	M <sub>2,3,47</sub> 13 292 346 11 445 197 9 546 513 7 662 611 5 1852 1120	M <sub>2,3,48</sub> 13 302 290 11 667 801 9 541 543 7 176 1799 5 416 345 3 950 877	M <sub>2,3,49</sub> 13 302 290 11 667 801 9 541 543 7 176 1799 5 416 345 3 950 877	M <sub>2,3,50</sub> 0 169 0 2 401 372 4 1107 1135 6 386 230 8 2698 2693 10 489 436 12 2909 2866 14 635 737	M <sub>2,3,51</sub> 13 292 346 11 445 197 9 546 513 7 662 611 5 1852 1120	M <sub>2,3,52</sub> 13 302 290 11 667 801 9 541 543 7 176 1799 5 416 345 3 950 877	M <sub>2,3,53</sub> 0 169 0 2 401 372 4 1107 1135 6 386 230 8 2698 2693 10 489 436 12 2909 2866 14 635 737	M <sub>2,3,54</sub> 13 302 290 11 667 801 9 541 543 7 176 1799 5 416 345 3 950 877
M <sub>2,3,55</sub> 10 1140 1213	M <sub>2,3,56</sub> 10 1140 1213	M <sub>2,3,57</sub> 13 292 346 11 445 197 9 546 513 7 662 611 5 1852 1120	M <sub>2,3,58</sub> 13 302 290 11 667 801 9 541 543 7 176 1799 5 416 345 3 950 877	M <sub>2,3,59</sub> 13 302 290 11 667 801 9 541 543 7 176 1799 5 416 345 3 950 877	M <sub>2,3,60</sub> 0 169 0 2 401 372 4 1107 1135 6 386 230 8 2698 2693 10 489 436 12 2909 2866 14 635 737	M <sub>2,3,61</sub> 13 292 346 11 445 197 9 546 513 7 662 611 5 1852 1120	M <sub>2,3,62</sub> 13 302 290 11 667 801 9 541 543 7 176 1799 5 416 345 3 950 877	M <sub>2,3,63</sub> 0 169 0 2 401 372 4 1107 1135 6 386 230 8 2698 2693 10 489 436 12 2909 2866 14 635 737	M <sub>2,3,64</sub> 13 302 290 11 667 801 9 541 543 7 176 1799 5 416 345 3 950 877

TABLE 6: Continued

M 10FO	10FC	M 10FO	10FC	M 10FO	10FC	M 10FO	10FC	M 10FO	10FC	M 10FO	10FC	M 10FO	10FC
M <sub>9,10</sub>	4 348 406	11 454 591	M <sub>9,13</sub>	10 1613 1747	M <sub>9,13</sub>	10 1290 1592	M <sub>9,13</sub>	6 1199 1101	M <sub>9,13</sub>	4 896 945	M <sub>9,13</sub>	13 1637 1592	M <sub>9,13</sub>
6 4210 4103	9 386 279	6 455 616	12 1289 1268	8 3009 2976	11 1290 1277	11 835 314	8 1780 68	6 596 339	8 1932 1464	10 2071 2098	11 465 669	13 422 369	
8 600 845	M <sub>9,11</sub>	10 886 691	14 876 748	10 886 691	1982 2019	7 1241 1237	10 2071 2098	8 288 182	7 1241 1237	12 206 200	9 242 249	11 465 669	
10 2400 2434	10 1956 1998	12 1611 1713	M <sub>9,12</sub>	10 886 691	M <sub>9,13</sub>	5 2159 2236	12 206 200	10 2071 2098	5 2159 2236	14 2556 2437	7 215 249	10 436 395	
14 888 839	M <sub>10,11</sub>	14 427 162	13 1290 222	12 1611 1713	10 716 779	M <sub>9,14</sub>	14 2556 2437	14 2556 2437	M <sub>9,14</sub>	14 1176 1159	2 256 100	12 373 152	
M <sub>9,10</sub>	11 1896 1759	M <sub>9,13</sub>	11 548 499	14 427 162	M <sub>9,13</sub>	10 716 779	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
13 584 512	M <sub>9,12</sub>	13 467 81	11 548 499	M <sub>9,13</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
11 443 439	11 1896 1759	11 602 481	9 266 244	M <sub>9,13</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
9 648 882	M <sub>9,12</sub>	11 211 349	7 426 576	13 467 81	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
7 648 677	3 641 554	7 709 678	5 C 0	11 602 481	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
M <sub>9,10</sub>	2 173 82	5 157 210	10 1956 1998	10 1956 1998	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
6 486 0	4 225 165	3 845 839	M <sub>10,11</sub>	M <sub>10,11</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
8 2296 2417	6 1857 1837	10 984 912	11 1896 1759	M <sub>10,11</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
10 268 38	8 982 1602	12 1038 936	11 1896 1759	11 1896 1759	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
12 1830 1770	10 984 912	14 691 734	M <sub>9,12</sub>	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
M <sub>9,10</sub>	4 407 407	M <sub>9,12</sub>	13 449 591	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
6 486 0	8 2602 2570	11 184 146	11 184 146	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
8 2296 2417	8 458 591	9 437 436	9 437 436	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
10 268 38	10 3028 2999	7 0 0	7 0 0	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
12 1830 1770	14 1222 1076	M <sub>9,12</sub>	11 744 674	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
M <sub>9,10</sub>	M <sub>9,11</sub>	M <sub>9,12</sub>	9 0 0	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
13 729 544	13 179 71	11 744 674	11 744 674	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
11 0 136	11 494 231	9 287 239	9 0 0	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
9 755 759	9 749 737	7 462 478	11 744 674	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
7 833 794	7 371 366	10 1038 936	11 744 674	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
M <sub>9,10</sub>	5 201 242	M <sub>9,12</sub>	8 1802 1677	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
10 432 1251	M <sub>9,11</sub>	M <sub>9,12</sub>	10 1211 1174	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
12 504 475	13 179 71	11 744 674	12 1109 1076	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
M <sub>9,10</sub>	11 494 231	9 287 239	M <sub>9,12</sub>	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
11 519 929	9 749 737	7 462 478	M <sub>9,12</sub>	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
9 583 638	7 371 366	10 1038 936	M <sub>9,12</sub>	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
M <sub>10,10</sub>	5 201 242	M <sub>9,12</sub>	10 1398 1474	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
10 2036 0	M <sub>9,11</sub>	M <sub>9,12</sub>	M <sub>9,13</sub>	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
M <sub>9,10</sub>	13 1317 1455	M <sub>9,12</sub>	13 256 0	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
13 321 0	11 2018 1967	13 266 430	11 120 0	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
11 193 0	9 1839 1715	11 304 196	9 181 0	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
9 213 0	7 375 3695	9 54 606	7 212 0	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
7 0 0	M <sub>9,11</sub>	5 0 109	5 109 0	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
5 239 0	8 320 259	3 375 461	3 179 0	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
3 0 0	10 2038 2171	3 219 0	1 84 0	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
1 233 0	12 776 720	M <sub>9,12</sub>	M <sub>9,13</sub>	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
M <sub>9,11</sub>	M <sub>9,11</sub>	M <sub>9,12</sub>	2 1052 965	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
2 640 650	M <sub>9,11</sub>	M <sub>9,12</sub>	4 698 778	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	
	M <sub>9,11</sub>	M <sub>9,12</sub>	4 1228 1089	M <sub>9,12</sub>	10 716 779	M <sub>9,14</sub>	14 1176 1159	M <sub>9,14</sub>	14 1176 1159	14 1176 1159	3 1460 1433	14 1176 1159	

TABLE 6: Continued

M 10FD 10FC	M 10FD 10FC	M 10FD 10FC	M 10FD 10FC	M 10FD 10FC	M 10FD 10FC	M 10FD 10FC	M 13FD
M <sub>8,2,15</sub> 8 206 <sup>0</sup> 360	M <sub>8,2,16</sub> 13 181 <sup>0</sup> 294 11 288 <sup>0</sup> 58 9 173 <sup>0</sup> 301 7 157 <sup>0</sup> 74 5 219 <sup>0</sup> 0	M <sub>8,2,17</sub> 13 283 <sup>0</sup> 20 17 205 <sup>0</sup> 74 9 617 <sup>0</sup> 650 7 552 <sup>0</sup> 504 5 187 <sup>0</sup> 194 3 500 526	M <sub>8,2,18</sub> 6 267 <sup>0</sup> 0 8 1393 1507 10 833 854 12 770 777	M <sub>8,2,19</sub> 4 1674 1698 6 362 535 8 3631 3677 10 799 873 17 1436 1460 14 87 <sup>0</sup> 318	M <sub>8,2,20</sub> 13 769 911 11 237 <sup>0</sup> 246 9 136 <sup>0</sup> 51 7 392 511 5 232 <sup>0</sup> 271 3 249 <sup>0</sup> 172 1 174 <sup>0</sup> C	M <sub>8,2,21</sub> 11 293 <sup>0</sup> 351 9 397 <sup>0</sup> 0	M 13FD 7 192 <sup>0</sup> 0 M <sub>8,2,20</sub> 8 1586 1627 10 1263 1217 M <sub>9,2,20</sub> 11 293 <sup>0</sup> 351 9 397 <sup>0</sup> 0 M <sub>10,2,20</sub> 2 836 819 4 231 <sup>0</sup> 69 6 1259 1275 8 609 552 10 1628 1568 12 763 609 14 1137 1068
013072 12174 2 1759 1882 419522 18998 6 2508 2476 3 8609 8227 10 1393 1414 12 4568 4462 14 1474 1438	M <sub>8,2,16</sub> 6 1732 1828 8 1597 1592 10 303 <sup>0</sup> 355 12 2072 2116	M <sub>8,2,17</sub> 4 126 <sup>0</sup> 30 6 632 630 8 428 450 10 363 352 12 104 <sup>0</sup> 99 14 1540 1487	M <sub>8,2,18</sub> 8 208 <sup>0</sup> 0 10 1740 1801 12 90 <sup>0</sup> 131	M <sub>8,2,19</sub> 11 423 534 9 1026 1075 7 1597 1601	M <sub>8,2,20</sub> 13 1216 1161 11 1247 1151 9 2617 2665 7 2685 2520 5 1422 1384	M <sub>8,2,21</sub> 8 612 793 6 3921 4079 10 398 91 12 1541 1424	M <sub>10,2,18</sub> 11 945 891 9 470 375
M <sub>8,2,15</sub> 13 327 <sup>0</sup> 437 11 0 <sup>0</sup> 22 9 531 463 5 216 <sup>0</sup> 14 3 148 <sup>0</sup> 137 1 154 <sup>0</sup> 0	M <sub>8,2,16</sub> 8 4762 4950 10 603 649 12 1324 1469	M <sub>8,2,17</sub> 13 244 <sup>0</sup> 248 11 403 109 9 287 <sup>0</sup> 155 5 364 304	M <sub>8,2,18</sub> 2 205 <sup>0</sup> 0 4 677 647 6 1433 1389 8 239 <sup>0</sup> 44 10 2474 2463 12 399 411 14 1896 1718	M <sub>8,2,19</sub> 11 487 471 11 492 407 9 229 <sup>0</sup> 41 7 695 717	M <sub>8,2,20</sub> 13 340 <sup>0</sup> 169 11 449 358 9 497 561 7 216 <sup>0</sup> 146 5 402 406 3 131 <sup>0</sup> C	M <sub>8,2,21</sub> 4 467 435 6 224 <sup>0</sup> 219 <sup>0</sup> 8 494 582 10 3344 3335 12 702 576 14 201 <sup>0</sup> 376	M <sub>10,2,18</sub> 10 223 <sup>0</sup> 0 M <sub>10,2,19</sub> 13 223 <sup>0</sup> 0 11 0 <sup>0</sup> C 9 266 <sup>0</sup> C 7 80 <sup>0</sup> 0 3 240 <sup>0</sup> C 3 300 C 1 160 <sup>0</sup> C
M <sub>8,2,15</sub> 2 2481 2418 4 800 712 6 961 714 8 1846 1871 10 821 786 12 3128 2938 14 47C 298	M <sub>8,2,16</sub> 11 388 <sup>0</sup> 66 5 27 <sup>0</sup> 0	M <sub>8,2,17</sub> 6 873 807 8 89 <sup>0</sup> 183 10 270 <sup>0</sup> 310 12 441 111	M <sub>8,2,18</sub> 13 707 594 11 1314 1371 9 1204 1184 7 1075 1072 5 1046 1058 3 2313 2342	M <sub>8,2,19</sub> 11 1730 1721 9 1713 18C2	M <sub>8,2,20</sub> 13 34 57 11 730 727 9 36 233 7 397 372 5 16 <sup>0</sup> 0	M <sub>8,2,21</sub> 14 1333 1169 11 138C 2475 9 592 56C 7 477 540 5 1269 1283 3 1961 1915	M <sub>10,2,18</sub> 13 707 594 11 1314 1371 9 1204 1184 7 1075 1072 5 1046 1058 3 2313 2342
M <sub>8,2,15</sub> 13 322 <sup>0</sup> 314 11 421 217 9 279 <sup>0</sup> 277 7 323 42 5 211 <sup>0</sup> 106 3 163 <sup>0</sup> 0	M <sub>8,2,16</sub> 2 277 609 4 732 737 6 544 580 8 293 <sup>0</sup> 69 10 620 515 12 0 <sup>0</sup> 106 14 1813 982	M <sub>8,2,17</sub> 11 246 <sup>0</sup> 343 9 309 <sup>0</sup> 351	M <sub>8,2,18</sub> 13 0 <sup>0</sup> 15 11 247 <sup>0</sup> 182 9 296 <sup>0</sup> 363 7 529 626 5 211 <sup>0</sup> 52 3 178 <sup>0</sup> 58	M <sub>8,2,19</sub> 0 459 459 2 184 <sup>0</sup> 96 4 1429 1462 6 240 <sup>0</sup> 143 8 1154 1102 10 1266 1304 12 1376 1372 14 1626 164	M <sub>8,2,20</sub> 6 1813 1898 8 1019 1100 10 1839 1783 12 352 633	M <sub>8,2,21</sub> 4 174 <sup>0</sup> 231 6 354C 3031 3 687 618 10 1435 1502 12 144 <sup>0</sup> 155	M <sub>10,2,18</sub> 13 267 <sup>0</sup> 175 11 1023 1119 9 1357 1317 7 1305 1379 5 463 493

TABLE 6 : Continued

M 10FU 10FC	M 10FU 10FC	M 10FC 10FC	M 10FD 10FC	M 10FC 10FC	M 10FC 10FC	M 10FD
M01051 4 00 C	M01052 1 2050 C	M01054 6 624 373	M02050 4 2774 2886	M02052 1 2180 0	M02054 1 3430 409	M02056 4 2376 2212
M02051 2 2100 146	M02052 3 1550 190	M02054 4 2750 552	M02050 0-2464 2330	M02052 3 1540 204	M02054 3 3040 38	M02056 2 2464 2330
M02051 7 524 168	M02052 7 1900 16	M02054 2 2920 117	M01056 4 00 623	M02052 5 10 131	M02054 5 10 213	M01056 2 00 0
M03051 6 1310 C	M02052 6 2017 2026	M02054 1 3430 409	M03050 3 1201 1169	M02052 3 2050 2026	M02054 2 2750 552	M03050 3 2910 0
M03051 1 0690 0	M02052 4 1378 1645	M02054 3 2330 9	M03050 5 00 59	M02052 2 2750 2026	M02054 5 700 0	M03050 3 2480 0
M03051 3 00 C	M02052 5 580 154	M02054 4 00 136	M03050 3 2910 0	M02052 7 459 227	M02054 2 700 C	M03050 3 2910 0
M03051 5 00 C	M02052 7 459 227	M02054 2 700 C	M03050 2 492 440	M02052 7 1950 16	M02054 2 700 C	M03050 2 492 440
M03051 7 2310 C	M02052 7 1950 16	M02054 2 700 C	M03050 3 3450 656	M04052 6 565 605	M02054 3 595 630	M03050 3 3450 656
M04051 8 1330 1424	M04052 6 565 605	M02054 3 595 630	M04050 4 1991 1837	M04052 6 1474 2411	M02054 5 3160 367	M04050 2 5456 5363
M04051 6 00 274	M04052 6 1474 2411	M02054 5 3160 367	M04050 3 1076 977	M04052 6 565 605	M02054 5 3160 367	M04050 3 1076 977
M04051 4 2055 2718	M04052 6 565 605	M02054 5 3160 367	M04050 M02059 2 492 440	M04052 6 1474 2411	M02054 5 3160 367	M04050 M02059 2 492 440
M04051 2 3180 125	M04052 6 1474 2411	M02054 5 3160 367	M04050 M02059 3 1076 977	M04052 6 1474 2411	M02054 5 3160 367	M04050 M02059 3 1076 977
M05051 3 2050 118	M04052 6 1474 2411	M02054 5 3160 367	M04050 M02059 M02060 2 1451 1434	M04052 6 1474 2411	M02054 5 3160 367	M04050 M02059 M02060 2 1451 1434
M05051 5 554 567	M04052 6 1474 2411	M02054 5 3160 367	M04050 M02059 M02060 0-2098 1947	M04052 6 1474 2411	M02054 5 3160 367	M04050 M02059 M02060 0-2098 1947
M05051 7 1940 94	M04052 6 1474 2411	M02054 5 3160 367		M04052 6 1474 2411	M02054 5 3160 367	
M05051 1 2100 C	M04052 6 1474 2411	M02054 5 3160 367		M04052 6 1474 2411	M02054 5 3160 367	
M05051 3 2520 C	M04052 6 1474 2411	M02054 5 3160 367		M04052 6 1474 2411	M02054 5 3160 367	
M05051 5 2740 J	M04052 6 1474 2411	M02054 5 3160 367		M04052 6 1474 2411	M02054 5 3160 367	
M05051 7 1950 0	M04052 6 1474 2411	M02054 5 3160 367		M04052 6 1474 2411	M02054 5 3160 367	
M06051 2 455 431	M04052 6 1474 2411	M02054 5 3160 367		M04052 6 1474 2411	M02054 5 3160 367	
M06051 4 497 1628	M04052 6 1474 2411	M02054 5 3160 367		M04052 6 1474 2411	M02054 5 3160 367	
M07051 1 1175 1114	M04052 6 1474 2411	M02054 5 3160 367		M04052 6 1474 2411	M02054 5 3160 367	
M07051 4 00 262	M04052 6 1474 2411	M02054 5 3160 367		M04052 6 1474 2411	M02054 5 3160 367	
M07051 2 1100 983	M04052 6 1474 2411	M02054 5 3160 367		M04052 6 1474 2411	M02054 5 3160 367	
M08051 3 1040 1049	M04052 6 1474 2411	M02054 5 3160 367		M04052 6 1474 2411	M02054 5 3160 367	
M08051 7 1446 1461	M04052 6 1474 2411	M02054 5 3160 367		M04052 6 1474 2411	M02054 5 3160 367	
M09051 3 2770 463	M04052 6 1474 2411	M02054 5 3160 367		M04052 6 1474 2411	M02054 5 3160 367	
M09051 5 1046 948	M04052 6 1474 2411	M02054 5 3160 367		M04052 6 1474 2411	M02054 5 3160 367	
M09051 7 3630 503	M04052 6 1474 2411	M02054 5 3160 367		M04052 6 1474 2411	M02054 5 3160 367	
M10051 4 1500 1503	M04052 6 1474 2411	M02054 5 3160 367		M04052 6 1474 2411	M02054 5 3160 367	
M10051 6 1737 1730	M04052 6 1474 2411	M02054 5 3160 367		M04052 6 1474 2411	M02054 5 3160 367	
M10051 2 1635 1376	M04052 6 1474 2411	M02054 5 3160 367		M04052 6 1474 2411	M02054 5 3160 367	
M10051 0 2111 2745	M04052 6 1474 2411	M02054 5 3160 367		M04052 6 1474 2411	M02054 5 3160 367	