Short Communications

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New ZnS polytypes of the families 10*L*, 22*L* and 26*L*.

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Nineteen hitherto unknown polytypes were found in seven specimens. All the polytypes found in each crystal belong to the same family. The Zhdanov symbols of the new polytypes are: 20*L* (13 7); 20*L* (7 3 3 7); 20*L* (5 3 2 2 3 5); 30*R* (7 3)$_3$; 60*R* (11 9)$_3$; 60*R* (12 8)$_3$; 60*R* (7 4 2 3 2 2)$_3$ of the family 10*L*; 22*L* (17 5); 22*L* (20 2); 22*L* (7 4 4 7); 66*R* (15 7)$_3$; 66*R* (7 7 5 3)$_3$; 66*R* (8 7 4 3)$_3$ and 66*R* (5 5 4 2 3 3)$_3$ of the family 22*L*, and 26*L* (7 3 3 3 3 7); 78*R* (13 5 5 3)$_3$; 78*R* (17 3 4 2)$_3$; 78*R* (7 7 3 3 4 2)$_3$ and 78*R* (9 3 3 3 5 3)$_3$ of the family 26*L*. X-ray oscillation photographs are shown; the calculated and observed intensities are compared.

Nineteen hitherto unknown ZnS polytypes of the families 10*L*, 22*L*, and 26*L* were found. A list of the new polytypes is given in Table 1. The concept of polytype families was introduced in a previous publication (Mardix, Alexander, Brafman & Steinberger, 1967).

Table 1. *List of the polytypes found*

Family	Specimen	New polytypes found	Known polytypes found
10*L*	232/62	20*L* (13 7)	
		60*R* (12 8)	
		60*R* (11 9)$_3$	
	154/70	20*L* (7 3 3 7)	20*L* (5 2 2 3 6 2)*
		20*L* (5 3 2 2 3 5)	
		30*R* (7 3)$_3$	
	175/15	60*R* (7 4 2 3 2 2)$_3$	20*L* (5 2 2 3 6 2)*
		60*R* (11 9)$_3$	
22*L*	206/56	22*L* (17 5)	
		22 *L*(7 4 4 7)	
		66*R* (15 7)$_3$	
		66*R* (7 7 5 3)$_3$	
		66*R* (8 7 4 3)$_3$	
	251/52	22*L* (20 2)	
		66*R* (5 5 4 2 3 3)$_3$	
26*L*	232/69	26*L* (7 3 3 3 3 7)	
		78*R* (13 5 5 3)$_3$	
		78*R* (17 3 4 2)$_3$	
		78*R* (7 7 3 3 4 2)$_3$	
	232/70	78*R* (9 3 3 3 5 3)$_3$	

* This polytype has already been reported (Mardix *et al.* 1967).

The crystals investigated were ZnS platelets grown by sublimation at 1200°C. They are fully described in a previous publication (Mardix, Kalman & Steinberger, 1968). The structure of the polytypes was determined by *c*-axis oscillation photographs, with the use of a Hilger microbeam X-ray generator (Cu *K* radiation) and a standard oscillation camera (r = 30 mm 15° oscillation), usually a fine collimator (diameter 0·1 or 0·2 mm) was used, except in two cases, Fig. 1(*b*) and (*c*), where a collimator of 0·4 mm was used. In most cases the width of the regions photographed was greater than 0·1 mm. The polytypes were identified by comparing the observed intensities of the reflexion spots on the X-ray photograph with those computed by a 7040 IBM computer. This procedure of identification was described in the above mentioned work (Mardix *et al.*, 1967). The observed and calculated intensities of the polytypes are compared in Table 2, and the (10.*l*) or the (21.*l*) row lines of the X-ray photographs are shown in Figs. 1 to 3.

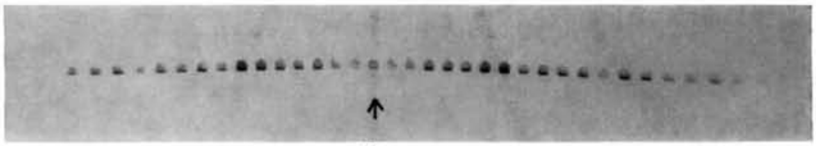
Seven polytypes of the family 10*L* have already been reported (Brafman, Alexander & Steinberger; Mardix *et al.*, 1967). The polytype 66*R*(7 3 2 4 3 3)$_3$ (Daniels, 1966) was the only polytype identified of the family 22*L*; also, from the family 26*L*, only one polytype was already reported (Brafman *et al.*, 1967). It is to be noted that all the polytypes found in the same specimen belong to the same family. Also, all the polytypes reported in this work have the two properties characteristic of ZnS polytypes: they are of even periodicity and do not have the number 1 in their Zhdanov sequence (Steinberger & Mardix, 1967).

References

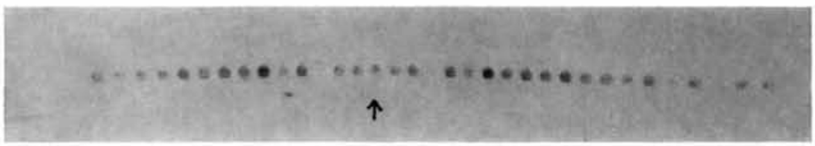
Brafman, O., Alexander, E. & Steinberger, I. T. (1967). *Acta Cryst.* **22**, 347.
Daniels, B. K. (1966). *Phil. Mag.* **14**, 487.
Mardix, S., Alexander, E., Brafman, O. & Steinberger, I. T. (1967). *Acta Cryst.* **22**, 808.
Mardix, S., Kalman, Z. H. & Steinberger, I. T. (1968). *Acta Cryst.* A**24**, 464.
Steinberger, I. T. & Mardix, S. (1967). Proceedings of the International Conference on II–VI Semiconducting Compounds. Brown Univ., Providence, Rhode Island, 1967. New York: Benjamin Press.

Figs. 1, 2 and 3. (10.l) or (21.l) row lines of oscillation photographs about the c axis of the various polytype regions. Cu K radiation, 60 mm diameter camera. Magnification × 3. The zero line is indicated by the arrow.

(*a*)

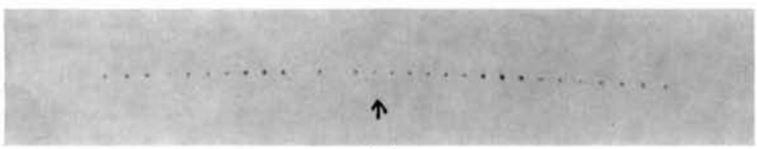


(*b*)

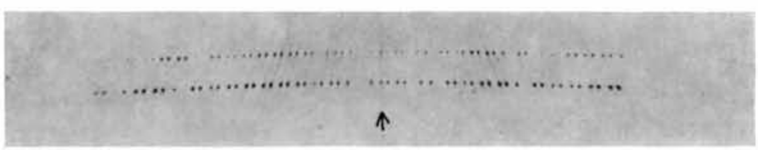


(*c*)

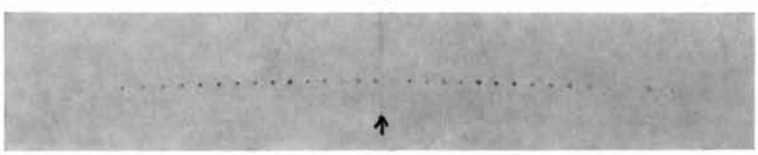
(*d*)



(*e*)



(*f*)



(*g*)

Fig. 1 (*a*) (10. l) row line of the polytype 20L (13 7); (*b*) (10. l) row line of the polytype 20L (7 3 3 7); *c* (10. l) row line of the polytype 20L (5 3 2 2 3 5); (*d*) (10. l) row line of the polytype 30R $(7\ 3)_3$; (*e*) (10. l) row line of the polytype 60R $(11\ 9)_3$; (*f*) (10. l) row line of tte polytypes 60R $(12\ 8)_3$ and 20L (13 7) photographed simultaneously; (*g*) (10. l) row line of the polytype 60R $(7\ 4\ 2\ 3\ 2\ 2)_3$.

Table 2. *Comparison of observed and calculated intensities of the new polytypes listed in Table* 1

Polytypes denoted by * have their observed intensities symmetrical with respect to the zero line (l=0).

Polytypes of the family 10*L*

20*L* (13 7)

l	I_{obs}		I_{cal}
0	*vvw*	(0 > −5)	1·36
1	*a*		0·01
2	*vw*		1·88
3	*vw*		1·83
4	*vvw*		0·21
5	*m*		10·53
6	*s*		29·26
7	*s*	(7 > 6)	32·43
8	*m*	(8 > 5)	15·88
9	*vvw*	(9 > 10)	1·70
10	*vvw*		0·87
−1	*vvw*	(−1 > −5)	1·34
−2	*a*		0·03
−3	*vw*		2·64
−4	*vw*		2·72
−5	*vvw*		0·76
−6	*vs*		62·52
−7	*vvs*		100·00
−8	*vw*		2·66
−9	*w*		5·73
−10	*vvw*		0·87

20*L* (7 3 3 7)*

l	I_{obs}		I_{cal}
0	*vw*	(0 > 2)	2·36
1	*vvw*		0·71
2	*vw*		1·95
3	*s*	(3 > 4)	16·20
4	*s*		11·22
5	*s*	(5 > 4)	14·70
6	*vs*		56·77
7	*vvs*		100·00
8	*w*		5·33
9	*s*	(9 > 3)	19·71
10	*m*		10·52

20*L* (5 3 2 2 3 5)*

l	I_{obs}		I_{cal}
0	*vw*		2·65
1	*w*	(1 > 5)	6·37
2	*m*		10·78
3	*vvw*		0·22
4	*vs*		38·61
5	*w*		5·49
6	*vvs*		100·00
7	*s*		17·92
8	*vs*		38·34
9	*s*		19·13
10	*vs*		31·97

30*R* (7 3)$_3$

l	I_{obs}		I_{cal}
1	*vvw*		0·52
4	*m*		7·14
7	*s*		15·53
10	*vvs*		100·00
13	*s*		14·38
−2	*vw*		2·01
−5	*m*	(−5 > 4)	10·17
−8	*s*		17·32
−11	*s*	(−11 > −14)	17·64
−14	*s*		12·27

60*R* (11 9)$_3$

l	I_{obs}		I_{cal}
1	*vw*		0·45
4	*w*		2·14
7	*vvw*		0·07
10	*w*		4·12
13	*vvw*	(13 > 7)	0·18
16	*m*		18·36
19	*vs*		62·86
22	*s*		48·79
25	*w*		6·22
28	*w*		1·90
−2	*w*		1·44
−5	*w*		1·25
−8	*w*		1·10
−11	*w*		3·84
−14	*w*		0·92
−17	*s*		34·32
−20	*vvs*		100·00
−23	*s*		32·62
−26	*vw*		0·85
−29	*w*		3·69

60*R* (12 8)$_3$

l	I_{obs}		I_{cal}
1	*vvw*		0·71
4	*vvw*		0·77
7	*w*		2·49
10	*a*		0·00
13	*m*		6·29
16	*m*	(16 > 28)	6·66
19	*vvs*		100·00
22	*vs*		64·23
25	*a*		0·00
28	*m*		4·71
−2	*vw*		1·89
−5	*a*		0·00
−8	*w*		2·74
−11	*vw*		1·59
−14	*w*		3·15
−17	*s*		30·20
−20	*vs*		50·20
−23	*s*		28·70
−26	*w*		2·92
−29	*vw*		1·52

60*R* (7 4 2 3 2 2)$_3$

l	I_{obs}		I_{cal}
1	*m*	(1 > 10)	11·42
4	*m*		6·16
7	*vw*		2·29
10	*m*	(10 > 13)	6·78
13	*m*		8·36
16	*vvs*		100·00
19	*m*	(19 > 22)	18·52
22	*m*	(22 > 25)	11·77
25	*m*	(25 > 13)	15·74
28	*vs*		62·83
−2	*vvw*		0·35
−5	*m*	(−5 > −11)	17·38
−8	*w*		5·18
−11	*m*	(−11 > 1)	13·47
−14	*m*		10·36
−17	*vs*	(−17 > 28)	90·64
−20	*vs*		50·38
−23	*vs*	(−23 > −20)	63·17
−26	*w*		9·59
−29	*w*		9·09

Polytypes of the family 22*L*

22*L* (17 5)

l	I_{obs}		I_{cal}
0	*w*		0·84
1	*w*	(1 > 0)	1·13
2	*vw*		0·51
3	*a*		0·004
4	*w*		1·17
5	*m*	(5 > 10)	4·44
6	*s*		8·36
7	*s*	(7 > 6)	10·61
8	*s*	(8 > 9)	9·84
9	*s*		6·65
10	*m*		2·96
11	*vw*		0·53
−1	*vvw*		0·12
−2	*vvw*		0·18
−3	*w*		1·33
−4	*w*	(−4 > −5)	2·33
−5	*w*	(−5 > 4)	1·51
−6	*vvw*		0·11
−7	*vvs*		100·00
−8	*vs*		46·77
−9	*m*		4·77
−10	*vvw*		0·12
−11	*w*		0·53

22*L* (20 2)

l	I_{obs}		I_{cal}
0	*vw*	(0 > −1)	0·66
1	*vw*	(1 > 0)	0·87
2	*w*		1·05
3	*w*	(3 > 2)	1·19
4	*w*		1·29
5	*w*		1·35
6	*w*		1·37
7	*w*		1·36
8	*w*		1·33
9	*w*		1·28
10	*w*		1·24
11	*w*		1·26
−1	*vw*	(−1 > −2)	0·44
−2	*vw*		0·22
−3	*vvw*	(−3 > −4)	0·05
−4	*vvw*		0·02
−5	*vw*	(−5 ∼ 0)	0·49
−6	*m*		3·80
−7	*vvs*		100·00
−8	*vs*		33·05
−9	*s*		6·08
−10	*m*		2·47
−11	*w*		1·26

22*L* (7 4 4 7)*

l	I_{obs}		I_{cal}
0	*m*		7·42
1	*vvw*		0·45
2	*w*		2·28
3	*w*	(3 > 2)	3·45
4	*w*	(4 > 3)	4·81
5	*m*		7·04
6	*vs*		71·28
7	*m*		8·58
8	*vvs*		100·00
9	*m*		7·62
10	*s*		14·86
11	*w*		1·82

66*R* (15 7)$_3$

l	I_{obs}		I_{cal}
1	*w*		0·60
4	*vw*		0·12
7	*w*	(7 > 1)	1·62
10	*w*		1·33
13	*vvw*		0·07
16	*m*		6·07

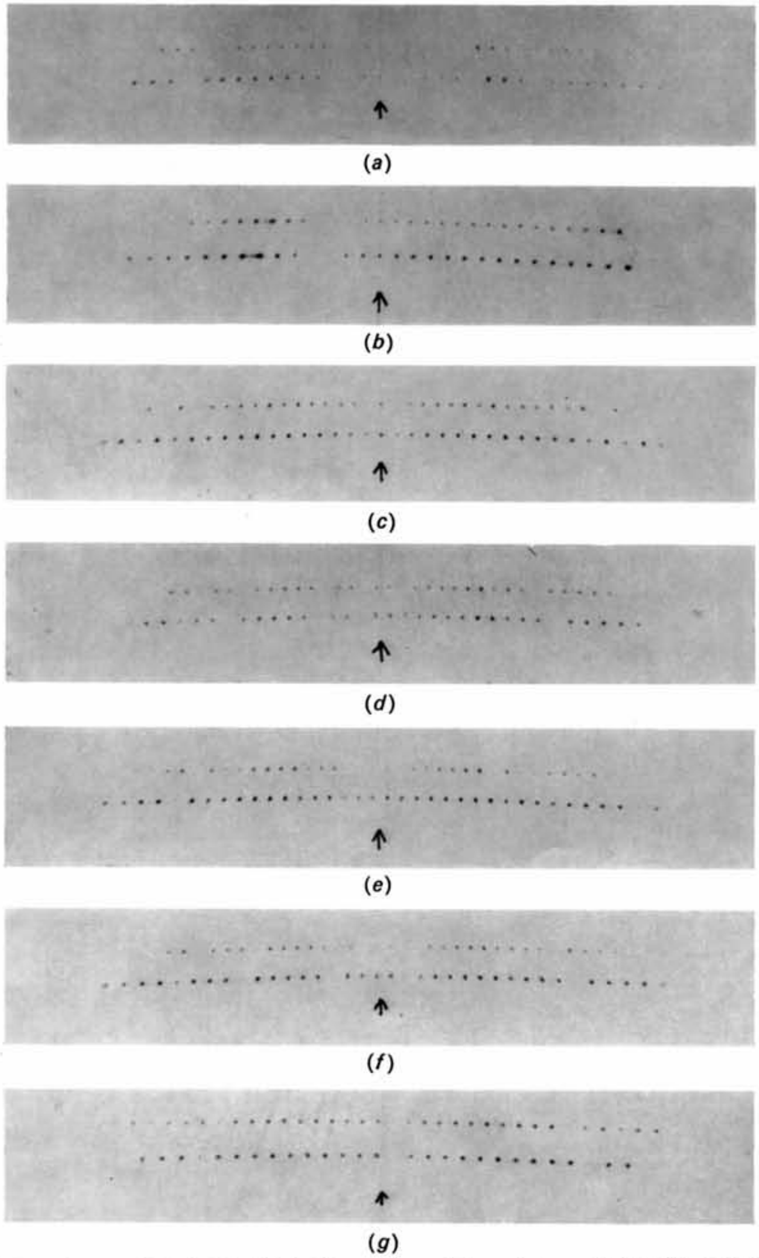


Fig. 2. (*a*) (10.*l*) row line of the polytype 22*L* (17 5); (*b*) (10.*l*) row line of the polytype 22*L* (20 2); (*c*) (10.*l*) row line of the polytype 22*L* (7 4 4 7); (*d*) (10.*l*) row line of the polytype 66*R* (15 7)$_3$; (*e*) (10.*l*) row line of the polytype 66*R* (7 7 5 3)$_3$; (*f*) (10.*l*) row line of the polytype 66*R* (8 7 4 3)$_3$; (*g*) (10.*l*) row line of the polytype 66*R* (5 5 4 2 3 3)$_3$.

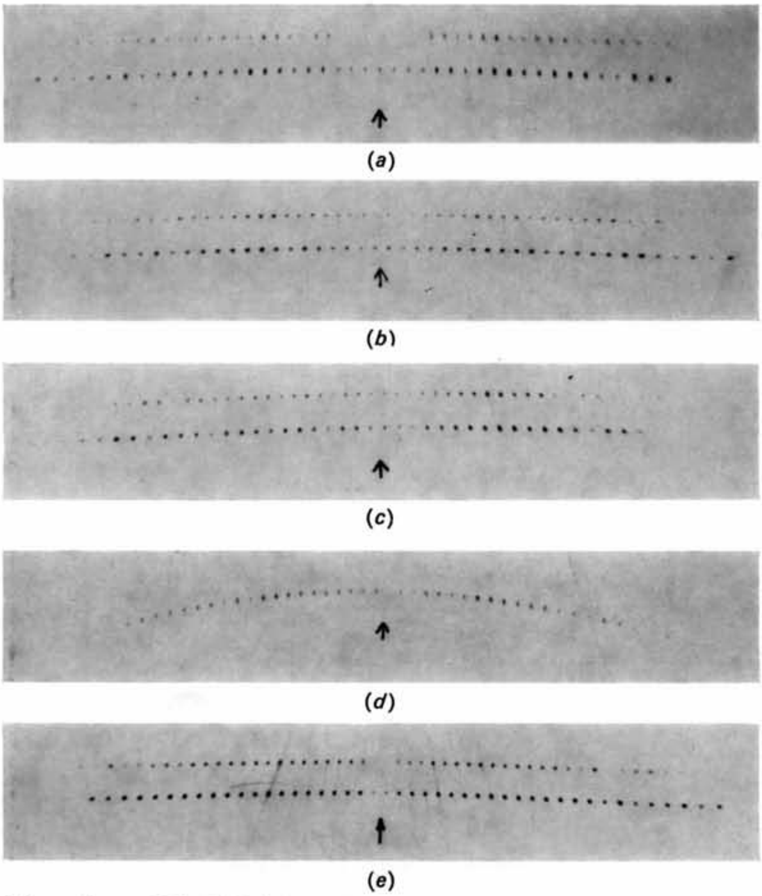


Fig. 3. (*a*) (10.*l*) row line of the polytype 26*L* (7 3 3 3 3 7); (*b*) (10.*l*) row line of the polytype 78*R* (13 5 5 3)$_3$; (*c*) (10.*l*) row line of the polytype 78*R* (17 3 4 2)$_3$; (*d*) (21.*l*) row line of the polytype 78*R* (7 7 3 3 4 2)$_3$; (*e*) (10.*l*) row line of the polytype 78*R* (9 3 3 3 5 3)$_3$.

Table 2 (*cont.*)

l	I_{obs}		I_{cal}
66*R* (15 7)$_3$			
19	*s*		19·26
22	*s*	(22 > 19)	26·05
25	*s*	(25 ~ 19)	18·37
28	*m*		5·63
31	*vvw*		0·07
−2	*w*	(−2 > −8)	1·38
−5	*vw*	(−5 > 4)	0·27
−8	*w*	(−8 ~ 1)	0·56
−11	*w*	(−11 > −17)	2·65
−14	*w*		1·29
−17	*w*	(−17 > −14)	1·77
−20	*vs*		58·91
−23	*vvs*		100·00
−26	*w*	(−26 ~ −14)	1·17
−29	*m*		4·75
−32	*w*	(−32 ~ −17)	1·69
66*R* (7 7 5 3)$_3$			
1	*vw*		1·26
4	*vw*		1·49
7	*vvw*		0·37
10	*m*	(10 > 13)	11·55
13	*m*	(13 > 31)	7·14
16	*w*		2·11
19	*vs*	(19 > 25)	61·38
22	*vs*		32·00
25	*vs*	(25 > 22)	44·16
28	*s*		16·21
31	*m*		4·73
−2	*w*		2·85
−5	*vw*		1·47
−8	*m*	(−8 ~ 31)	4·20
−11	*m*	(−11 ~ −8)	4·30
−14	*s*		13·16
−17	*s*	(−17 ~ 28)	18·13
−20	*vs*		50·04
−23	*vvs*		100·00
−26	*w*		2·13
−29	*s*	(−29 > −17)	24·31
−32	*w*	(−32 > −26)	3·28
66*R* (8 7 4 3)$_3$			
1	*vw*	(1 > 4)	1·14
4	*vw*	(4 ~ −8)	0·72
7	*m*	(7 > 31)	7·95
10	*vvw*	(10 > 28)	0·31
13	*w*		4·02
16	*s*		25·98
19	*s*	(19 > 22)	37·15
22	*s*	(22 > 16)	31·70
25	*vs*		76·18
28	*vvw*	(28 > −5)	0·18
31	*m*		6·36
−2	*w*		3·40
−5	*vvw*		0·15
−8	*vw*		0·76
−11	*m*	(−11 > −14)	12·81
−14	*m*		8·30
−17	*m*	(−17 > −11)	15·18
−20	*vs*		52·46
−23	*vvs*		100·00
−26	*w*	(−26 ~ −2)	3·59
−29	*m*	(−29 ~ −17)	16·70
−32	*m*	(−32 < −29)	9·70
66*R* (5 5 4 2 3 3)$_3$			
1	*w*	(1 > 4)	5·95
4	*w*	(4 > 7)	4·38
7	*w*		3·91
10	*s*		14·09
13	*s*	(13 > 10)	17·58
16	*m*		7·99
19	*vs*	(19 > −26)	48·97

l	I_{obs}		I_{cal}
66*R* (5 5 4 2 3 3)$_3$			
22	*s*	(22 > 13)	24·03
25	*vs*		48·04
28	*s*		15·66
31	*vvw*		1·41
−2	*a*		0·11
−5	*vw*		2·05
−8	*m*	(−8 ~ 1)	6·58
−11	*w*		4·79
−14	*s*		28·67
−17	*m*		10·05
−20	*vvs*		100·00
−23	*m*		12·40
−26	*vs*		32·56
−29	*s*		27·34
−32	*s*		25·26
Polytypes of the family 26*L*			
26*L* (7 3 3 3 3 7)*			
0	*w*		1·49
1	*vw*		0·67
2	*vw*		0·68
3	*w*		1·06
4	*s*		23·74
5	*s*		15·17
6	*w*	(6 > 3)	2·66
7	*s*		18·41
8	*vs*		44·78
9	*vvs*		100·00
10	*m*		6·36
11	*m*		5·46
12	*s*		15·08
13	*s*		19·81
78*R* (13 5 5 3)$_3$			
1	*vw*		0·64
4	*vw*		0·47
7	*w*		1·49
10	*w*		1·33
13	*w*	(13 > 10)	1·99
16	*s*		9·29
19	*w*		1·97
22	*m*		5·41
25	*vvs*		100·00
28	*vs*		40·40
31	*s*	(31 > 34)	10·56
34	*s*		6·31
37	*w*		2·86
−2	*w*		1·56
−5	*vvw*		0·29
−8	*vw*		1·20
−11	*vw*		1·25
−14	*s*		6·00
−17	*m*		4·50
−20	*m*		3·96
−23	*vs*		24·01
−26	*s*		7·57
−29	*s*	(−29 > −14)	7·48
−32	*vs*	(−32 > −23)	17·71
−35	*w*	(−35 > 10)	1·79
−38	*w*	(−38 > −35)	2·52
78*R* (17 3 4 2)$_3$			
1	*w*		0·70
4	*vw*		0·30
7	*vvw*		0·17
10	*w*	(10 > −23)	1·34
13	*w*		1·54
16	*m*		2·70
19	*s*	(19 > 22)	6·03
22	*s*		4·36
225	*vvs*		100·00
28	*vs*		33·48

l	I_{obs}		I_{cal}
78*R* (17 3 4 2)$_3$			
31	*m*		2·55
34	*s*		7·89
37	*s*		6·41
−2	*w*		0·58
−5	*m*		2·01
−8	*m*		2·50
−11	*vw*		0·31
−14	*m*		1·47
−17	*s*		6·27
−20	*s*		5·60
−23	*w*	(−23 > 1)	0·79
−26	*m*		2·17
−29	*s*		6·95
−32	*s*		5·22
−35	*vw*		0·54
−38	*w*		1·42
78*R* (7 7 3 3 4 2)$_3$			
1	*vw*		4·75
4	*vw*		4·02
7	*vw*		3·30
10	*w*		11·33
13	*vw*		4·09
16	*m*		18·10
19	*m*		16·92
22	*s*		26·05
25	*vs*		46·36
28	*vvs*		81·00
31	*vvw*		1·67
34	*m*		18·75
37	*vvw*		1·41
−22	*vvw*		0·02
−5	*vvw*	(−5 > −8)	1·89
−88	*vvw*	(−8 > −2)	0·92
−11	*w*		7·84
−14	*m*		15·61
−17	*w*		5·84
−20	*m*		15·79
−23	*vvs*	(−23 > 28)	100·00
−26	*vs*		40·25
−29	*vs*		42·93
−32	*m*		18·40
−35	*s*		23·45
−38	*s*		30·97
78*R* (9 3 3 3 5 3)$_3$			
1	*vvw*		0·08
4	*vw*		0·53
7	*vw*	(7 > 10)	0·80
10	*vw*		0·67
13	*vs*		15·51
16	*w*		1·35
19	*w*	(19 > 16)	3·65
22	*m*		7·77
25	*vs*	(25 > 13)	19·22
28	*w*		4·50
31	*m*		8·00
34	*m*		6·95
37	*w*		2·96
−2	*vvw*		0·08
−5	*vw*		0·91
−8	*w*		2·20
−11	*w*		1·97
−14	*s*		11·80
−17	*m*	(−17 > −20)	6·29
−20	*m*		3·81
−23	*w*		1·82
−26	*vvs*		100·00
−29	*w*		1·75
−32	*w*	(−32 > −29)	3·55
−35	*m*		5·84
−38	*s*		11·41