

REVISÃO

Cristalografia Morfológica

Elementos de Simetria

Plano de simetria – m – *reflexão*

Eixos de simetria

próprios: 1, 2, 3, 4, 6 – *rotação*

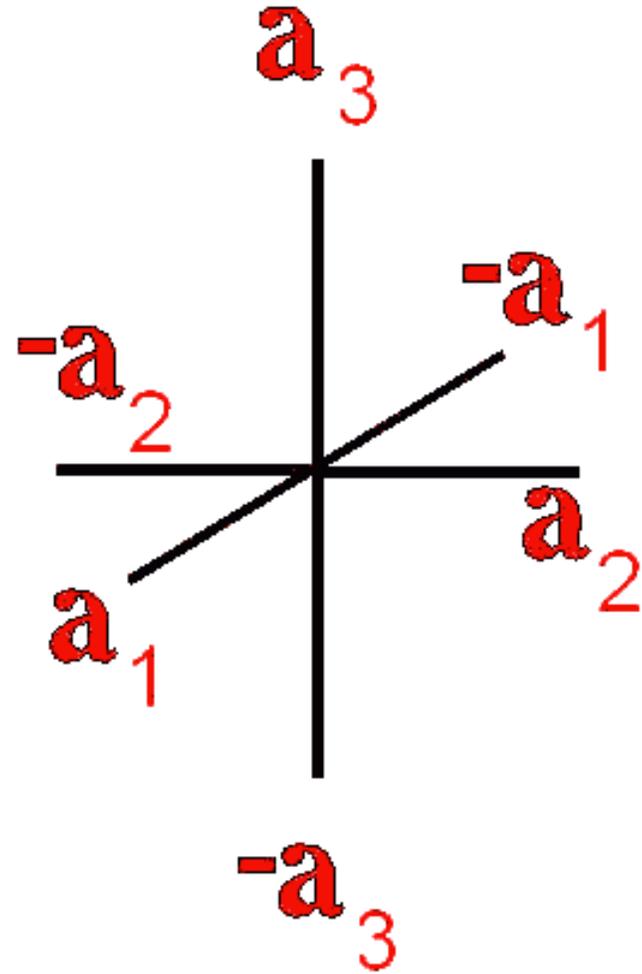
impróprios – *rotação + inversão*

Centro de simetria – i - *inversão*

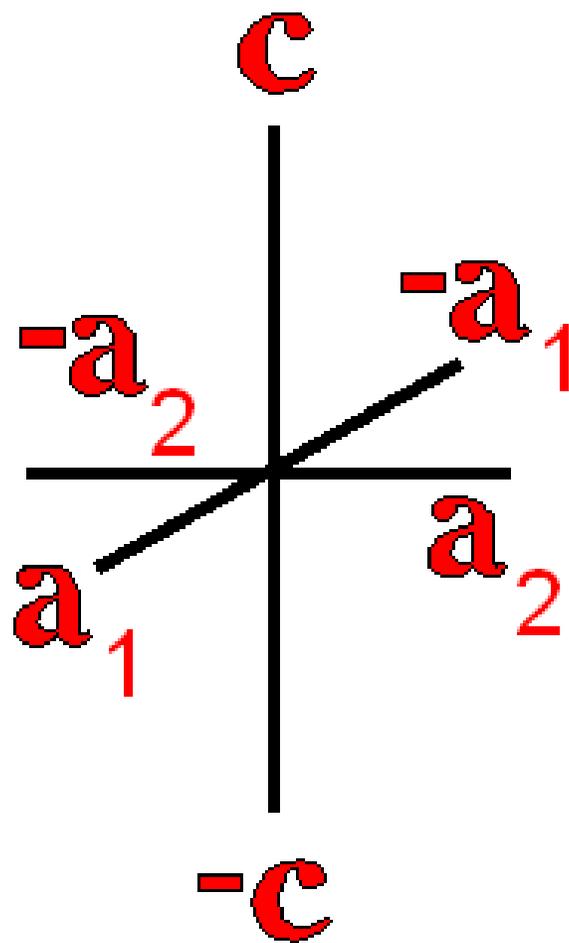
AS 32 CLASSES CRISTALINAS

Sistema Cristalino	Classe Cristalina	Grau de Simetria
Triclínico	1	Sem simetria
	$\bar{1}$	i
Monoclínico	2	1E2
	m	1m
	2/m	1E2, 1m, i
Ortorrômico	222	3E2
	mm2	1E2, 2m
	2/m2/m2/m	3E2, 3m, i
Tetragonal	4	1E4
	$\bar{4}$	1E $\bar{4}$
	4/m	1E4, 1m, i
	422	1E4, 4E2
	4mm	1E4, 4m
	$\bar{4}2m$	1E $\bar{4}$, 2E2, 2m
	4/m2/m2/m	1E4, 4E2, 5m, i
Trigonal	3	1E3
	$\bar{3}$	1E $\bar{3}$
	32	1E3, 3E2
	3m	1E3, 3m
	$\bar{3}2/m$	1E $\bar{3}$, 3E2, 3m, i
Hexagonal	6	1E6
	$\bar{6}$	1E $\bar{6}$
	6/m	1E6, 1m, i
	622	1E6, 6E2
	6mm	1E6, 6m
	$\bar{6}m2$	1E $\bar{6}$, 3E2, 3m
	6/m2/m2/m	1E6, 6E2, 7m, i
Isométrico (Cúbico)	23	4E3, 3E2
	2/m $\bar{3}$	4E $\bar{3}$, 3E2, 3m, i
	432	4E3, 3E4, 6E2
	$\bar{4}3m$	4E3, 3E $\bar{4}$, 6m
	4/m $\bar{3}2/m$	4E $\bar{3}$, 3E4, 6E2, 9m, i

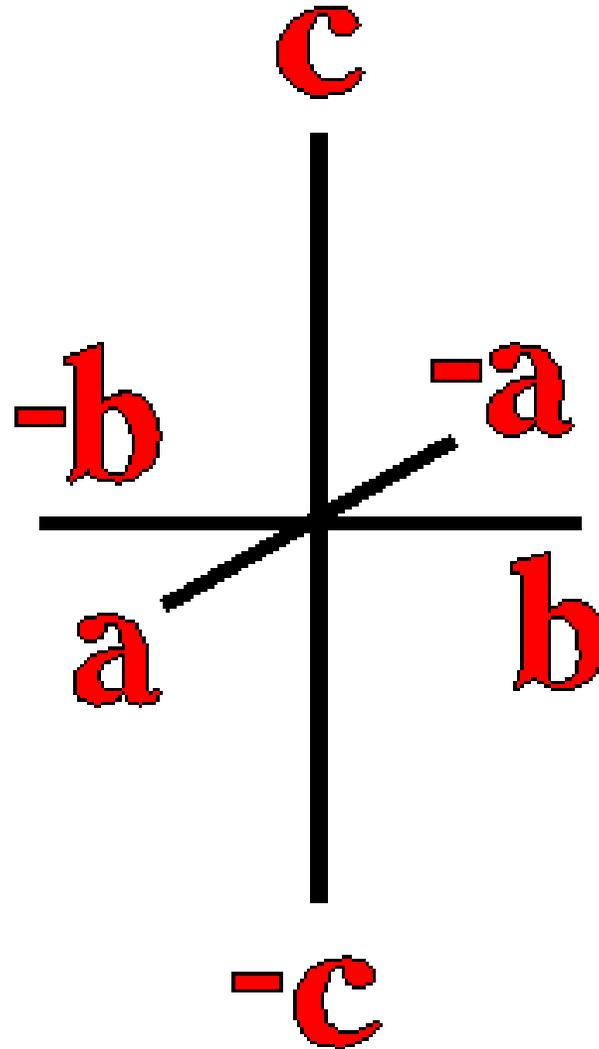
Isométrico



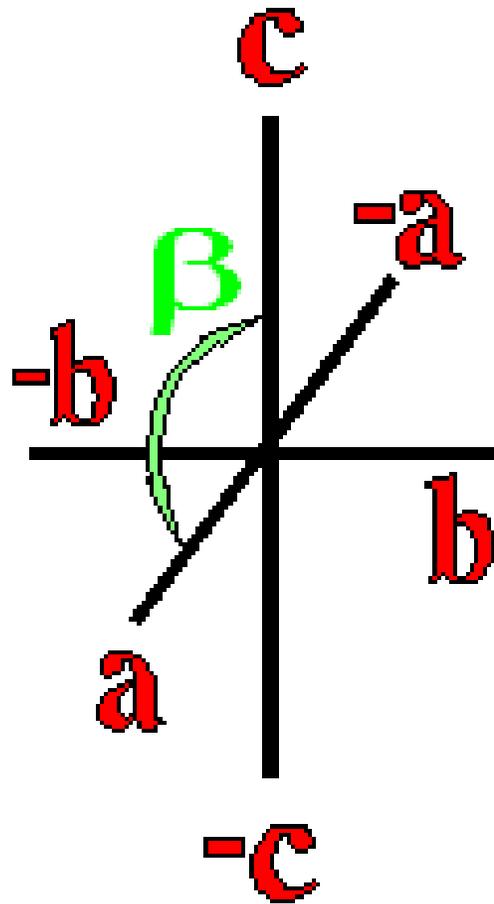
Tetragonal



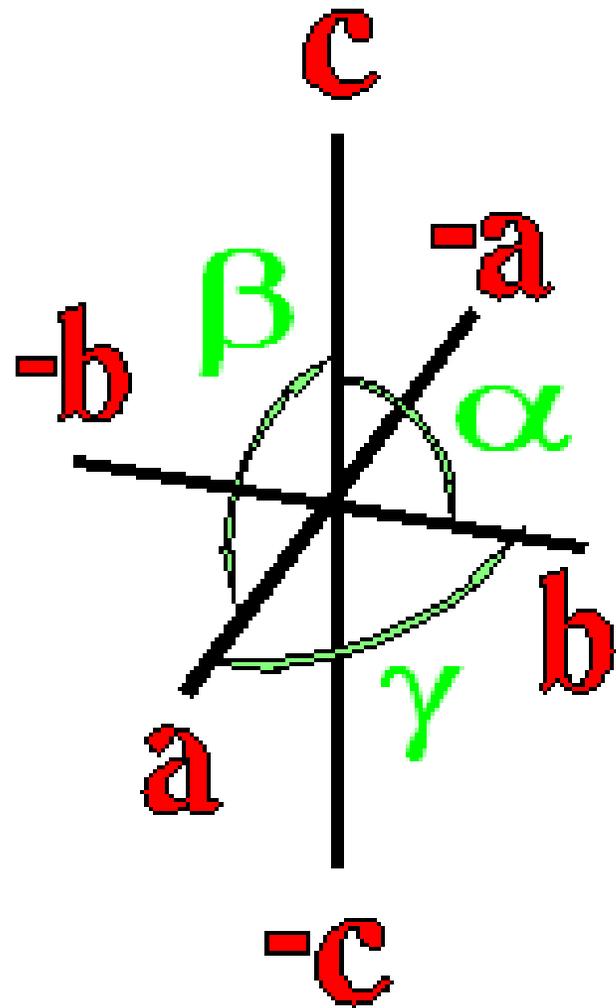
Ortorrômico



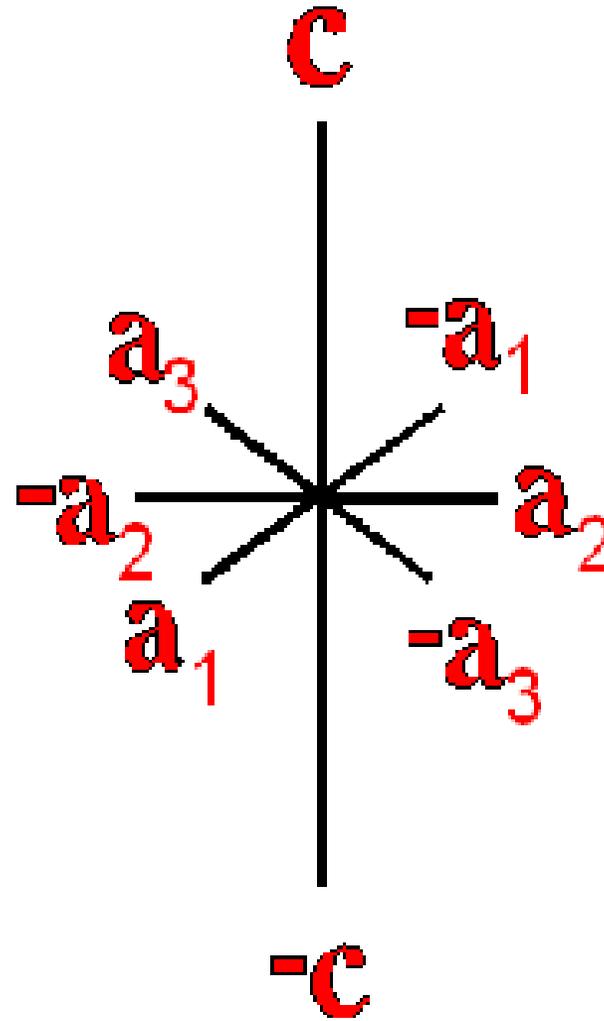
Monoclínico



Triclínico



Trigonal e hexagonal



	1º.	2º.	3º.
cúbico	a_1, a_2, a_3	vértices do cubo-guia	centro das arestas do cubo-guia
tetragonal	c	a_1, a_2	bissetrizes de a_1 e a_2
ortorrômbico	a	b	c
monoclínico	b	-	-
triclínico	-	-	-
hexagonal	c	a_1, a_2, a_3	bissetrizes de a_1, a_2 e a_3
trigonal	c	a_1, a_2, a_3	

Table 1

Distribution of forms in the triclinic, monoclinic, and orthorhombic systems

Number of faces	Name	Point group								
		1	$\bar{1}$	2	m	$\frac{2}{m}$	2 2 2	$m m 2$	$\frac{2}{m} \frac{2}{m} \frac{2}{m}$	Unique in
1	pedion	+		+	+			+		
2	pinacoid		+	+	+	+		+		+
	sphenoid			+	+			+		
4	prism					+	+	+		+
	disphenoid						+			2 2 2
	pyramid							+		$m m 2$
8	dipyramid								+	$\frac{2}{m} \frac{2}{m} \frac{2}{m}$



Fig. 2. Pediton (or monohedron, a form consisting of a single plane surface).



Fig. 3. Pinacoid (a form consisting of a pair of parallel plane surfaces).

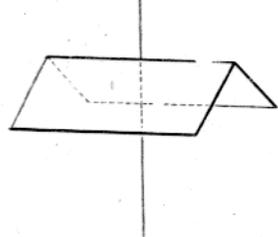


Fig. 4i. Sphenoid (or dihedron) of class 2.

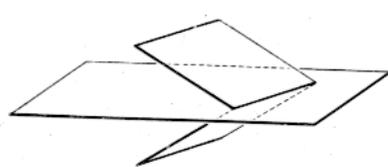


Fig. 4ii. Sphenoid (or dihedron) of class m .

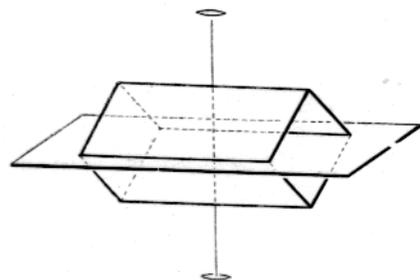
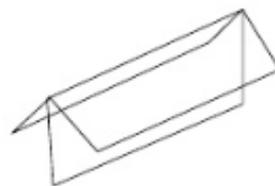


Fig. 5. Prism.

Domo



Esfenoide

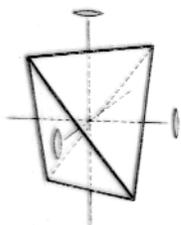
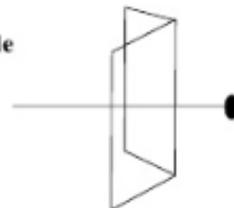


Fig. 6. Rhombic disphenoid.

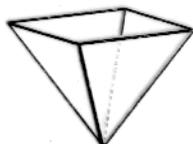


Fig. 7. Rhombic pyramid.

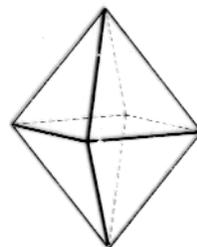


Fig. 8. Rhombic dipyramid.

Table 2
Distribution of forms in the tetragonal system

Number of faces	Name	Point group						Unique in
		4	$\bar{4}$	$\frac{4}{m}$	422	$4mm$	$\bar{4}2m$	
1	pedion	+				+		
2	pinacoid		+	+	+		+	+
4	tetragonal prism	+	+	+	+	+	+	+
	tetragonal pyramid	+				+		
	tetragonal disphenoid		+				+	
8	ditetragonal prism				+	+	+	+
	tetragonal dipyramid		+	+			+	+
	tetragonal trapezohedron				+			422
	ditetragonal pyramid					+		$4mm$
	tetragonal scalenohedron						+	$\bar{4}2m$
16	ditetragonal dipyramid						+	$\frac{4}{m}\frac{2}{m}\frac{2}{m}$

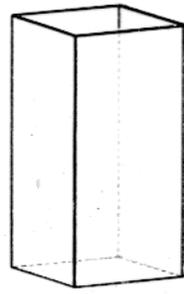


Fig. 9. Tetragonal prism.

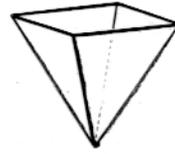


Fig. 10. Tetragonal pyramid.

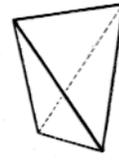


Fig. 11. Tetragonal disphenoid.

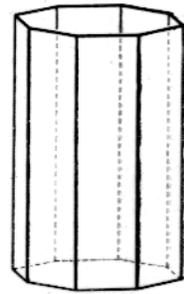


Fig. 12. Ditetragonal prism.

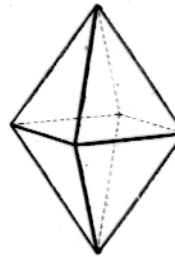


Fig. 13. Tetragonal dipyramid.

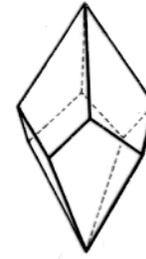


Fig. 14. Tetragonal trapezohedron.

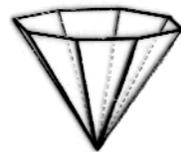


Fig. 15. Ditetragonal pyramid.



Fig. 16. Tetragonal scalenohedron.

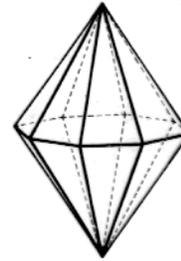


Fig. 17. Ditetragonal dipyramid.

Table 3
Distribution of forms in the hexagonal system

Number of faces	Name	Point group											Unique in		
		3	$\bar{3}$	3 2	3 m	$\bar{3} \frac{2}{m}$	6	$\bar{6}$	$\frac{6}{m}$	6 2 2	6 m m	$\bar{6} m 2$		$\frac{6}{m} \frac{2}{m} \frac{2}{m}$	
1	pedion	+			+		+				+				
2	pinacoid		+	+		+		+	+	+			+		+
3	trigonal prism	+		+	+			+					+		
	trigonal pyramid	+			+										
6	hexagonal prism		+	+	+	+		+		+	+	+	+		+
	rhombohedron		+	+		+									
	ditrigonal prism			+	+								+		
	trigonal dipyrarnid			+				+					+		
	hexagonal pyramid				+			+			+				
	trigonal trapezohedron			+											3 2
	ditrigonal pyramid				+										3 m
12	hexagonal dipyrarnid					+			+	+			+		+
	dihexagonal prism					+				+	+				+
	hexagonal scalenohedron					+									$\bar{3} \frac{2}{m}$
	hexagonal trapezohedron									+					6 2 2
	dihexagonal pyramid										+				6 m m
	ditrigonal dipyrarnid												+		$\bar{6} m 2$
24	dihexagonal dipyrarnid													+	$\frac{6}{m} \frac{2}{m} \frac{2}{m}$

F
P

F
P



Fig. 18. Trigonal prism.

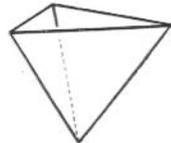


Fig. 19. Trigonal pyramid.

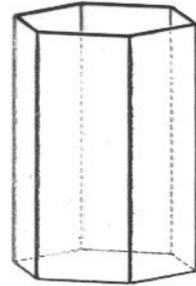


Fig. 20. Hexagonal prism.

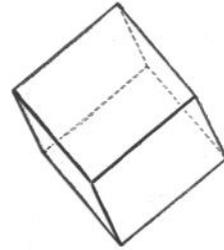


Fig. 21. Rhombohedron.

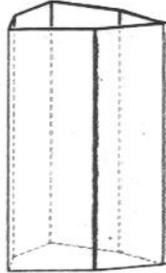


Fig. 22. Ditrigonal prism.

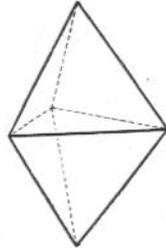


Fig. 23. Trigonal dipyramid.

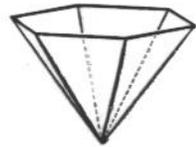


Fig. 24. Hexagonal pyramid.

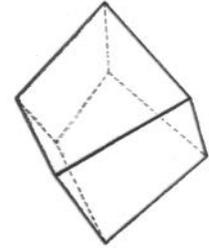


Fig. 25. Trigonal trapezohedron.

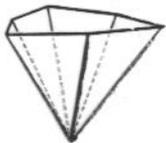


Fig. 26. Ditrigonal pyramid.

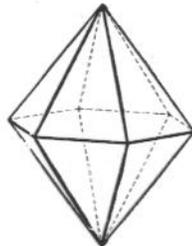


Fig. 27. Hexagonal dipyramid.

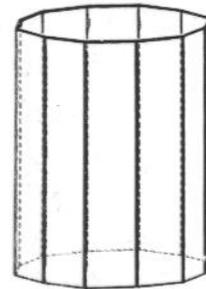


Fig. 28. Dihexagonal prism.

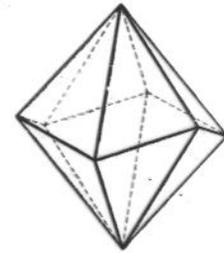


Fig. 29. Hexagonal scalenohedron.

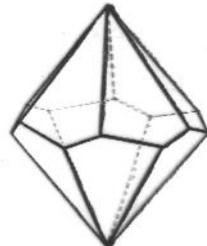


Fig. 30. Hexagonal trapezohedron.

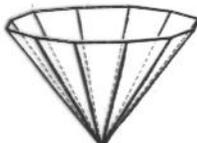


Fig. 31. Dihexagonal pyramid.

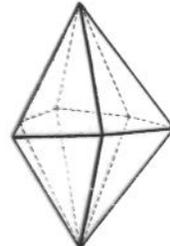


Fig. 32. Ditrigonal dipyramid.

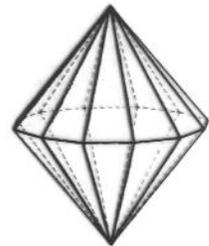


Fig. 33. Dihexagonal dipyramid.

Table 4
Distribution of forms in the isometric system

Number of faces	Name	Point group					Unique in
		2 3	$\frac{2}{m} \bar{3}$	$\bar{4} 3 m$	4 3 2	$\frac{4}{m} \bar{3} \frac{2}{m}$	
4	tetrahedron	+		+			
6	cube	+	+	+	+	+	
8	octahedron		+		+	+	
12	dodecahedron	+	+	+	+	+	
	pyritohedron	+	+				
	deltohedron	+					
	tristetrahedron	+					
	tetartoid	+					2 3
24	trisoctahedron		+		+	+	
	trapezohedron		+		+	+	
	tetrahexahedron				+	+	
	diploid		+				$\frac{2}{m} \bar{3}$
	hextetrahedron			+			$\bar{4} 3 m$
	gyroid				+		4 3 2
48	hexoctahedron					+	$\frac{4}{m} \bar{3} \frac{2}{m}$

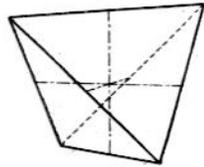


Fig. 34. Tetrahedron.

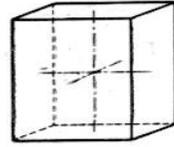


Fig. 35. Cube.

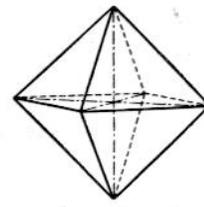


Fig. 36. Octahedron.

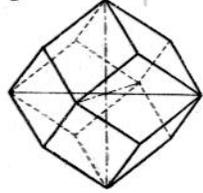


Fig. 37. Dodecahedron.

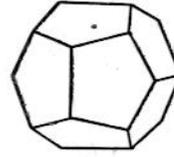


Fig. 38. Pyritohedron.

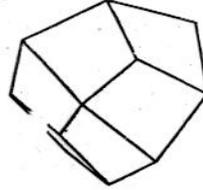


Fig. 39. Deltohedron.

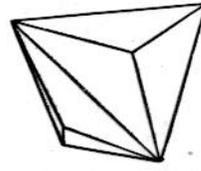


Fig. 40. Tristetrahedron.

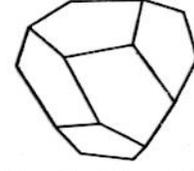


Fig. 41. Tetartoid.

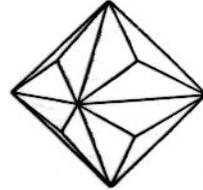


Fig. 42. Trisoctahedron.

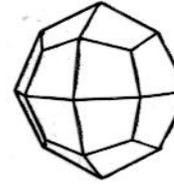


Fig. 43. Trapezohedron.

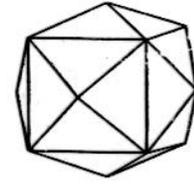


Fig. 44. Tetrahexahedron.



Fig. 45. Diploid.

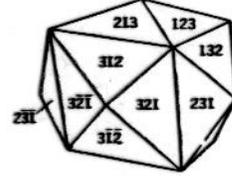


Fig. 46. Hextetrahedron.

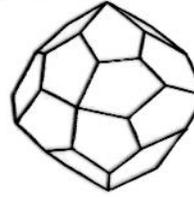


Fig. 47. Gyroid.

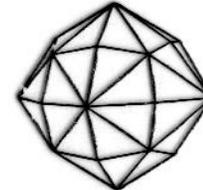


Fig. 48. Hexoctahedron.

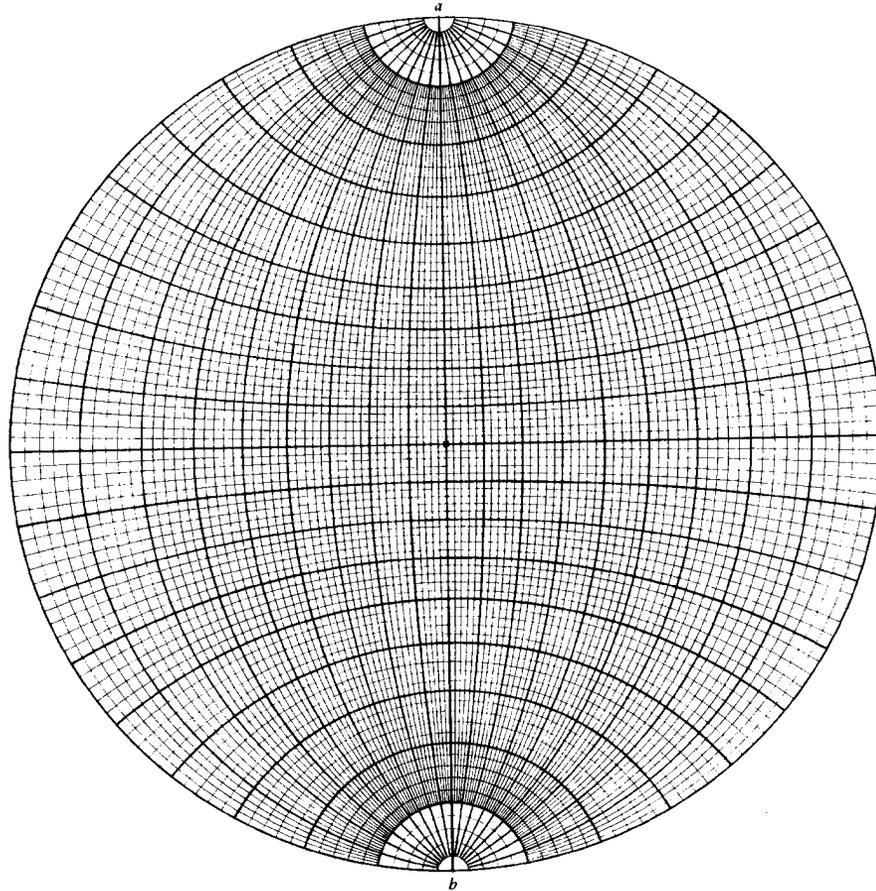


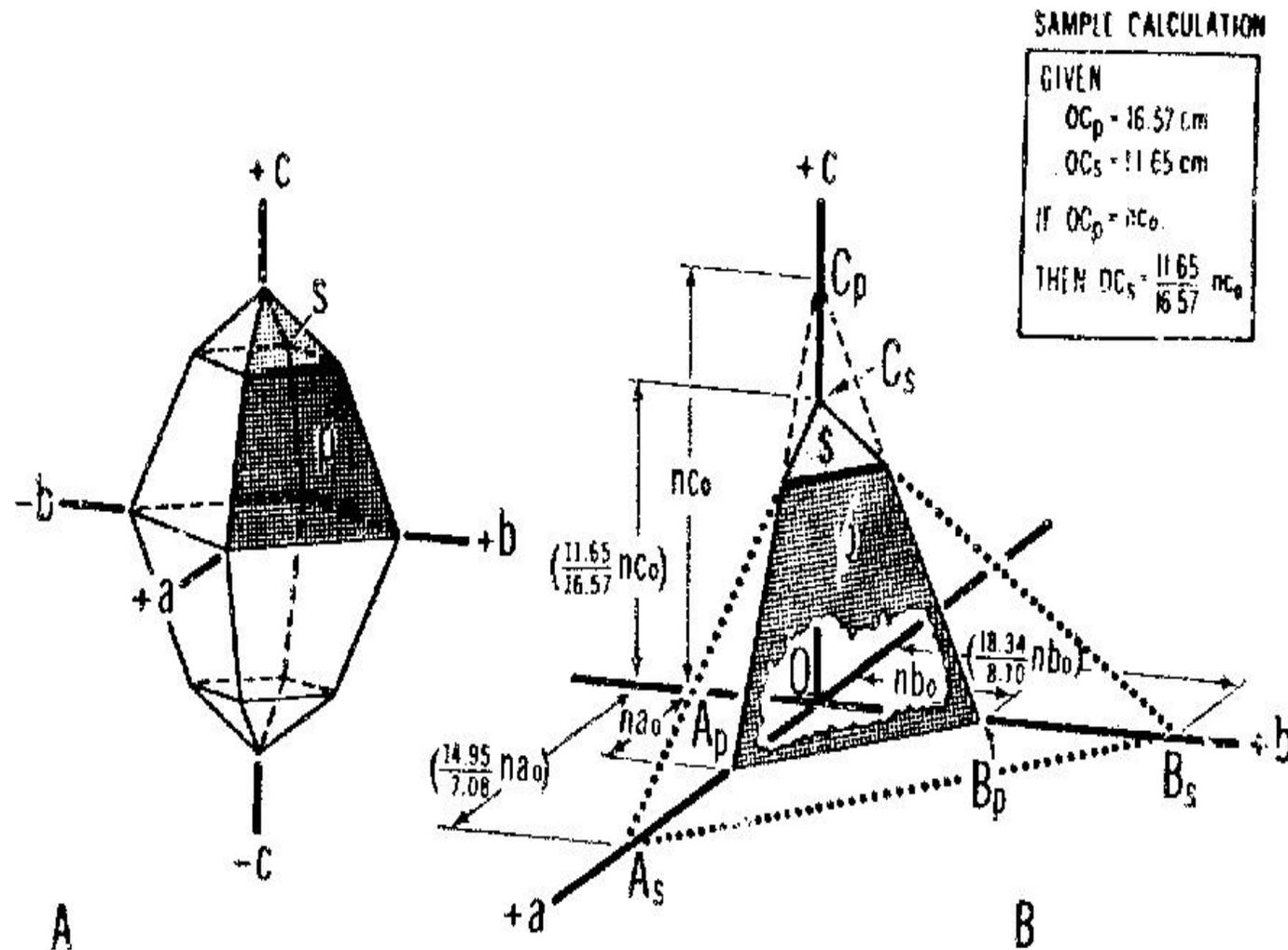
Diagrama de Wulff (projeção estereográfica)

Cristal em três dimensões
representar em duas:

>>> **Projeção cristalográfica**

- ✓ manter a relação geométrica
- ✓ manter os ângulos entre as faces

Face paramétrica = face fundamental = (111)



1. Contraste com clareza os sólidos amorfos e os cristalinos. Mostre em um diagrama esquemático o comportamento de fusão em cada caso.
2. Construa projeções ortográficas ilustrando a operação de cada um dos eixos de simetria próprios e impróprios. Qual a diferença entre motivos relacionados entre si por operações próprias e impróprias de simetria?
3. Mostre com projeções que as seguintes afirmações são verdadeiras:
 - a. se um eixo próprio par contém um centro de simetria, então existe obrigatoriamente um plano de simetria normal a este eixo, passando pelo referido centro;
 - b. se um eixo próprio ímpar contém um centro de simetria, então este eixo é na verdade um eixo impróprio.
4. Indique quais grupos pontuais são gerados:
 - a. pela adição de um centro de simetria (i) aos grupos 4 , 3 , $\bar{4}$, $\bar{3}$, $\bar{6}$, $6mm$, 432 e $\bar{4}3m$;
 - b. pela interação entre planos de simetria com ângulos entre si de 30° , 45° , 60° e 90° .
 - c. explique o significado da notação completa de Hermann-Mauguin para as classes cristalinas.

5. Faça um esquema da cruz axial de cada sistema cristalino, indicando as constantes lineares e angulares. Indique a simetria mínima possível (característica) em cada caso e correlacione a orientação dos eixos de simetria possíveis com os eixos cristalográficos.
7. As olivinas $[(\text{Fe}, \text{Mg})_2\text{SiO}_4]$ apresentam relação axial próxima de $a:b:c = 0,5:1:0,6$. O intercepto em b da face (010) de uma determinada amostra é $4,20\text{mm}$. Calcule para esta amostra os interceptos de possíveis faces com os índices de Miller: (111) , (100) , (110) , (001) , (101) e (011) .
9. A. Faça desenhos, em escala adequada da cruz axial para um cristal ortorrômbico. Represente nos desenhos uma face paramétrica (111) e adicione faces com índices de Miller (010) , (100) , (121) , (131) , $(\bar{2} \ 1 \ \bar{1})$ e $(\bar{3} \ 1 \ \bar{1})$.
- B. Em outros desenhos, para o mesmo cristal, represente pelo menos 4 possíveis faces pertencentes às zonas $[001]$, $[010]$ e $[100]$ e indexe-as com índices de Miller.

A projeção ortográfica é uma forma de representar graficamente objetos tridimensionais em superfícies planas, de modo a transmitir suas características com precisão e demonstrar sua verdadeira grandeza.

A propriedade mais destacada dos **sólidos amorfos** é a falta de um ponto fixo de **fusão**, de modo que sua passagem para o estado líquido se verifica ao longo de um intervalo de temperaturas durante o qual adoptam o chamado estado plástico