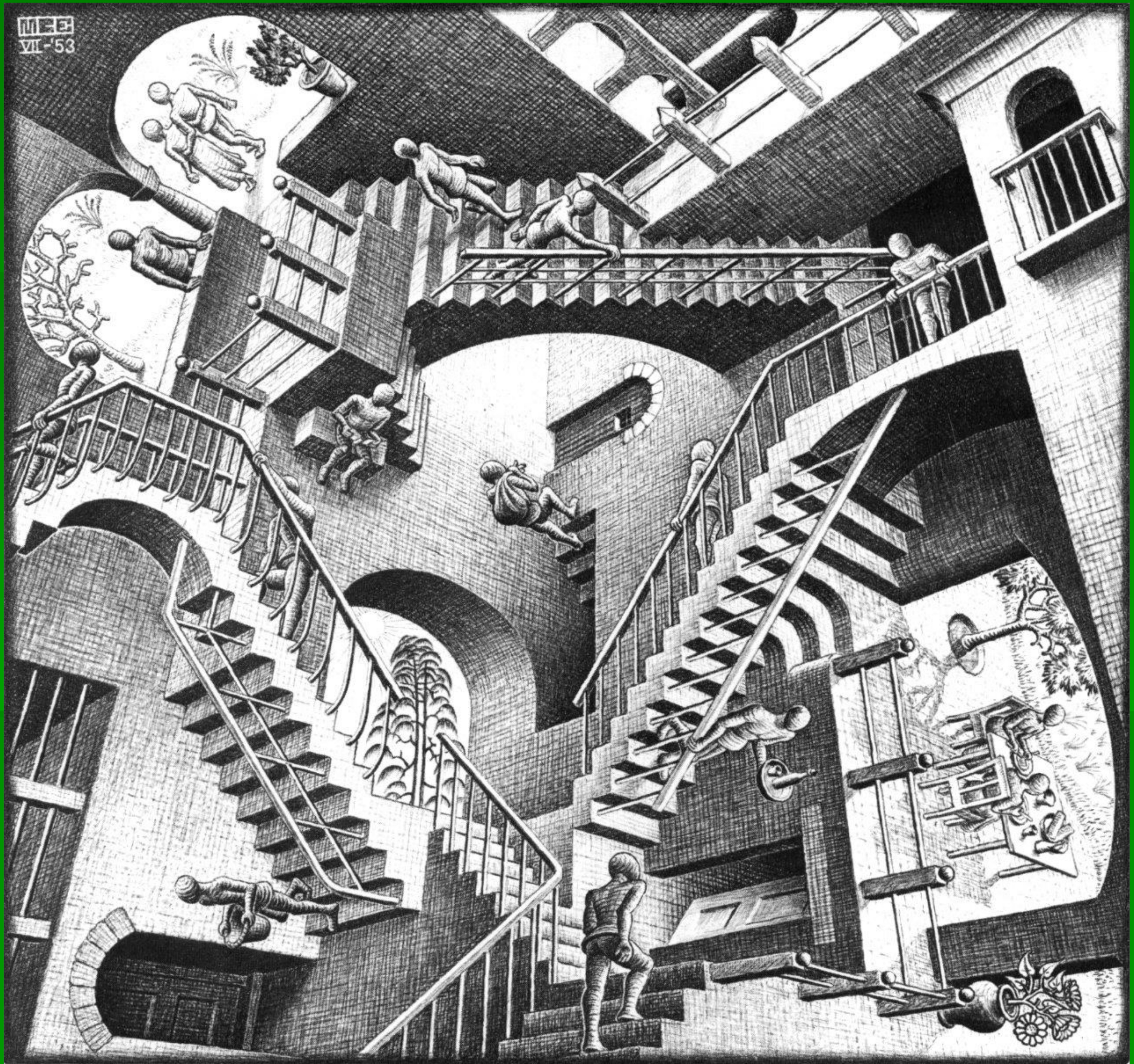
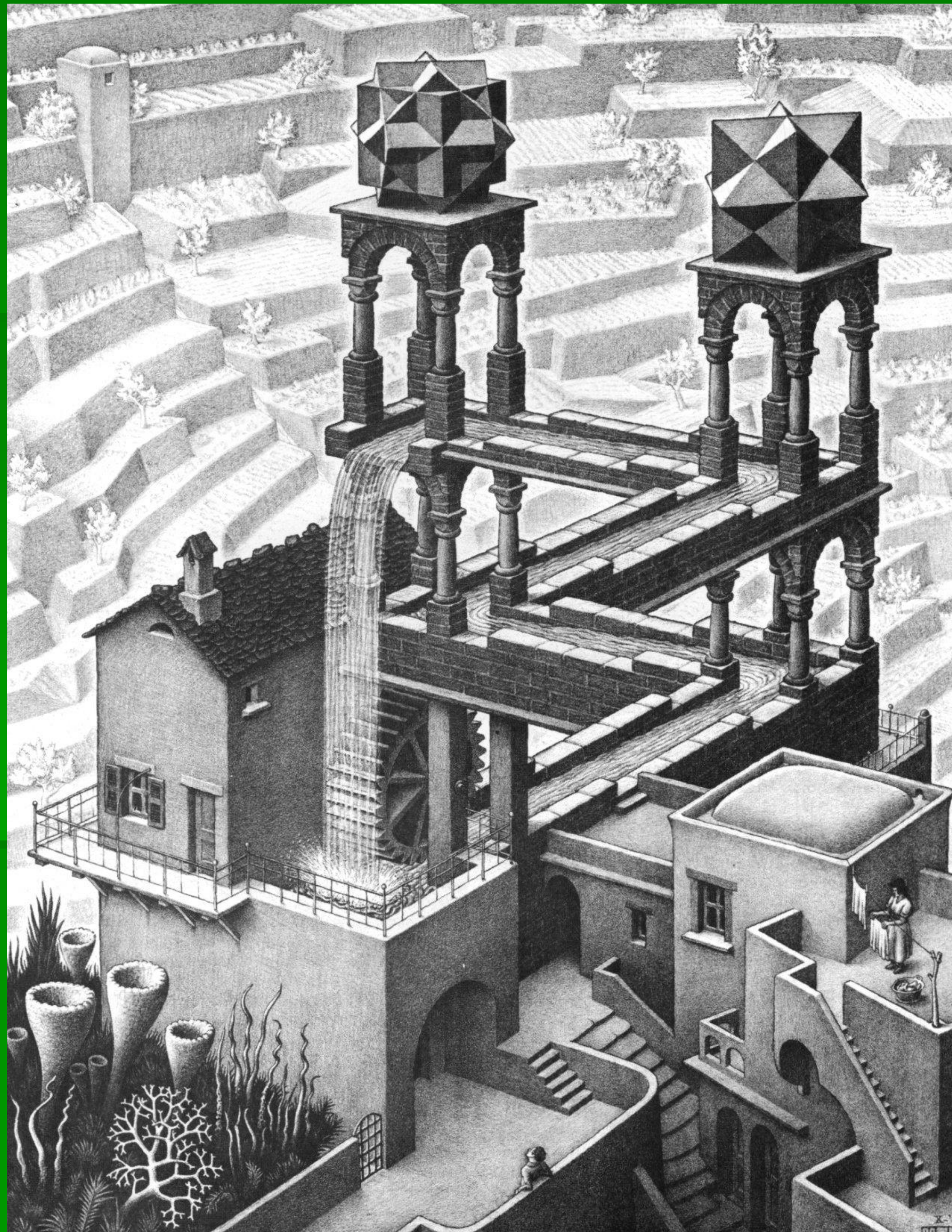
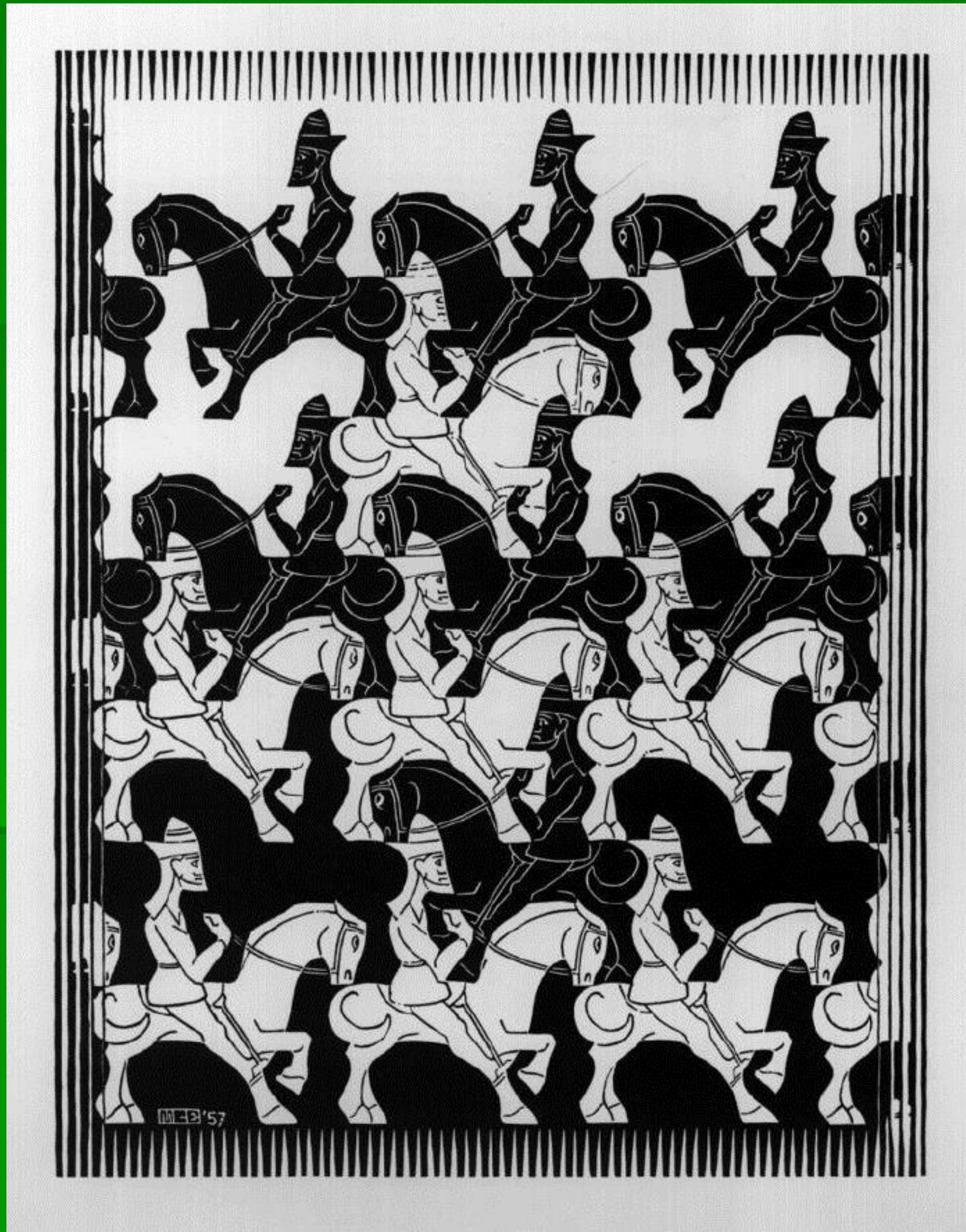
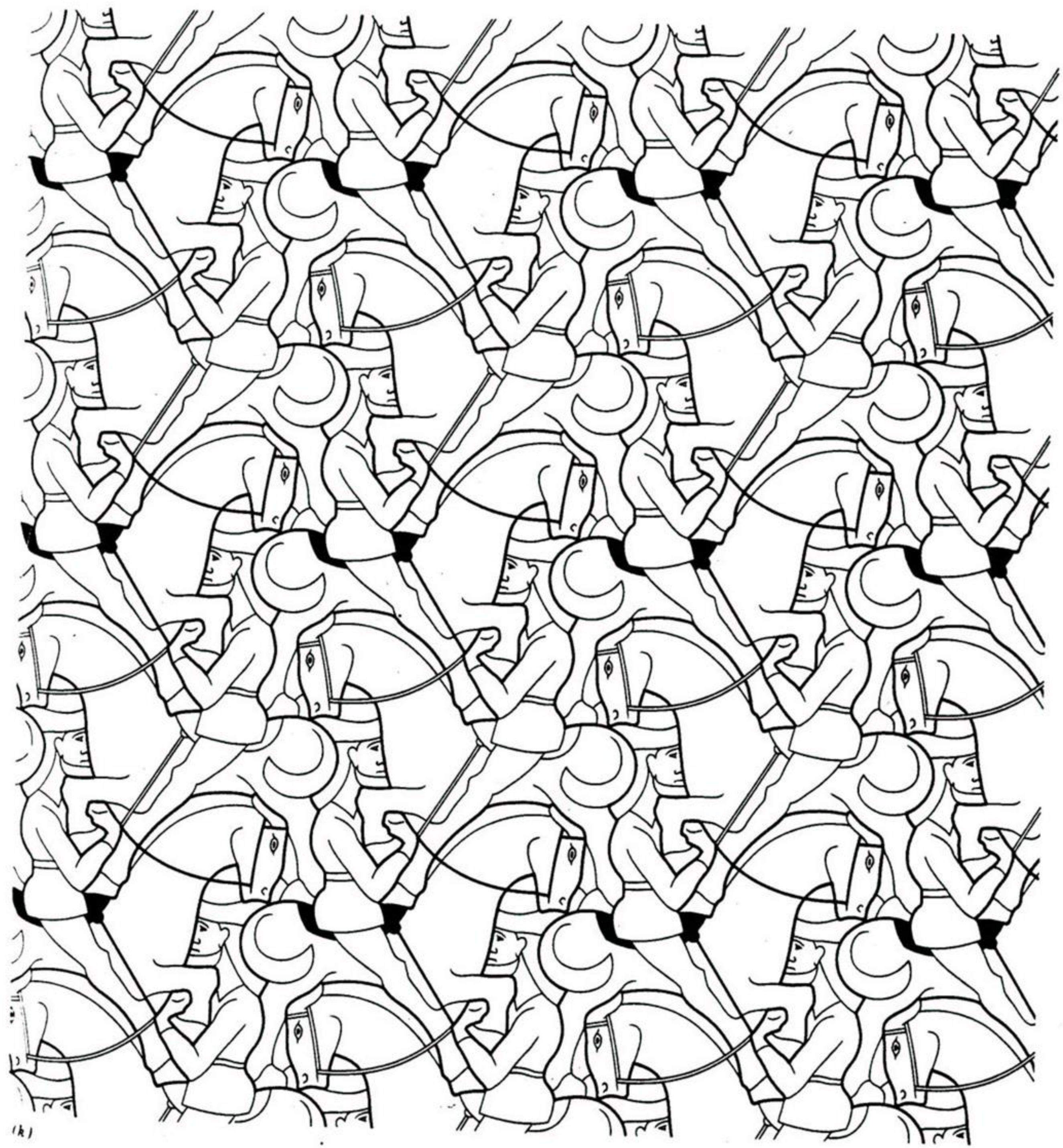
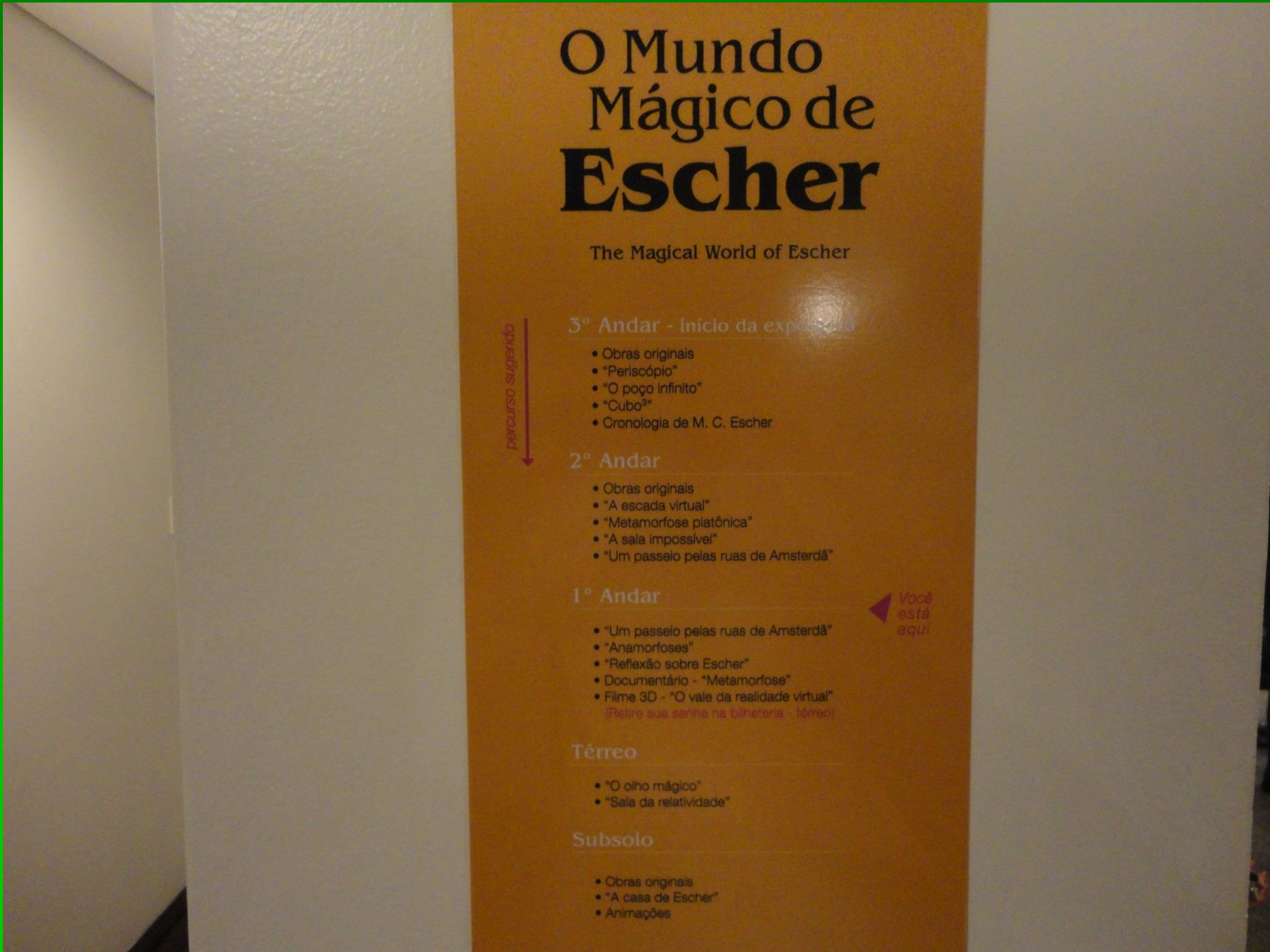

VII-'53






(k)

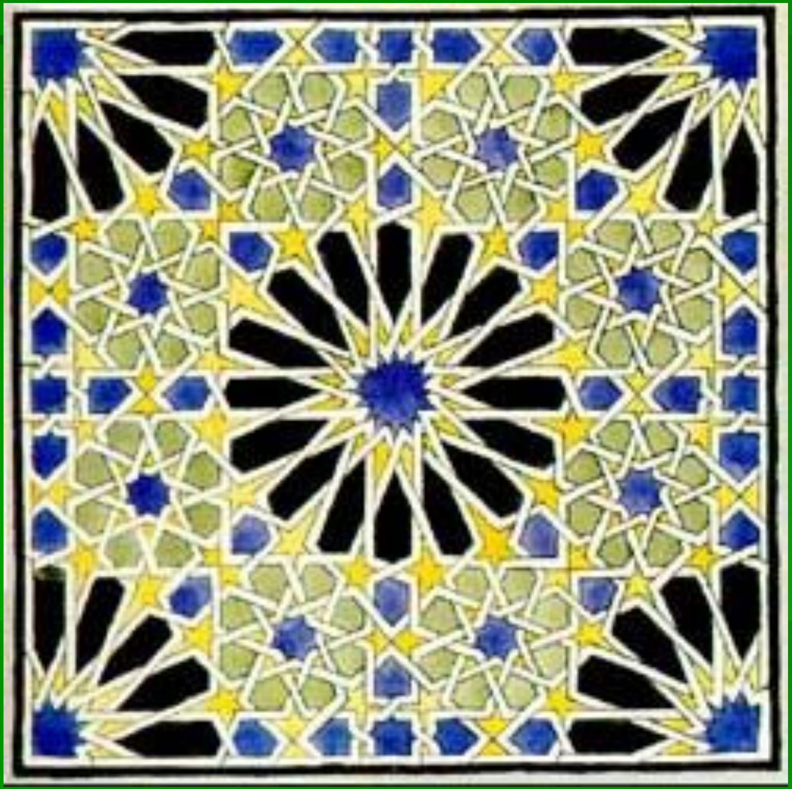

O Mundo
Mágico de
Escher
The Magical World of Escher
3º Andar - início da
• Obras originais
• "Periscópio"
• "O poço infinito"
• "Cubo³"
• Cronologia de M. C. Escher
percurso sugendo
2º Andar
• Obras originais
• "A escada virtual"
• "Metamorfose platônica"
• "A sala impossível"
• "Um passeio pelas ruas de Amsterdã"
1º Andar
Você está aqui
• "Um passeio pelas ruas de Amsterdã"
• "Anamorfoses"
• "Reflexão sobre Escher"
• Documentário - "Metamorfose"
• Filme 3D - "O vale da realidade virtual"
(Retire sua senha na bilheteria - térreo)
Térreo
• "O olho mágico"
• "Sala da relatividade"
Subsolo
• Obras originais
• "A casa de Escher"
• Animações

Maurits Cornelis Escher

Self-Portrait

The Beginnings

- The tilings in the Alhambra in Spain were laid out by the Moors in the 14th century.
- Colored tiles forming patterns
- Many truly symmetrical.
- They are not tessellations but they inspired young M.C Escher, who copied them into his notebooks and later converted some into true tessellations.
- These tilings never included animals or plants.
- Escher’s tessellations hardly ever left them out!



Escher's drawing of Alhambra tiling.

M. C. Escher

- Escher produced '8 Heads' in 1922 - a hint of things to come. Turn the picture upside-down if all the heads are not apparent.
- He took a boat trip to Spain and went to the Alhambra.
- There, he copied many of the tiling patterns.

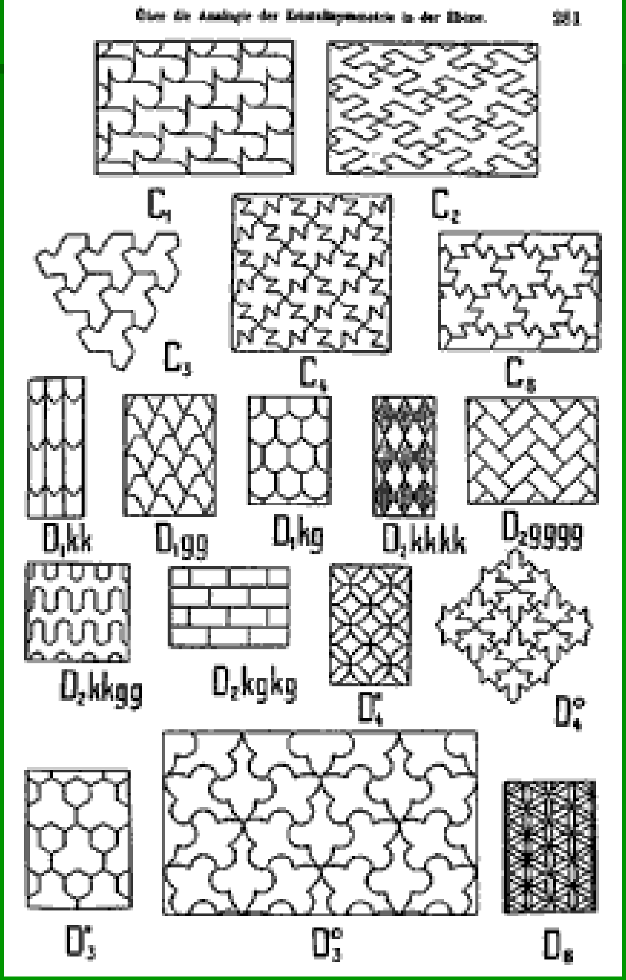
'8 Heads' - 1922

The Alhambra Palace, Granada, Spain, 12th-13th Century

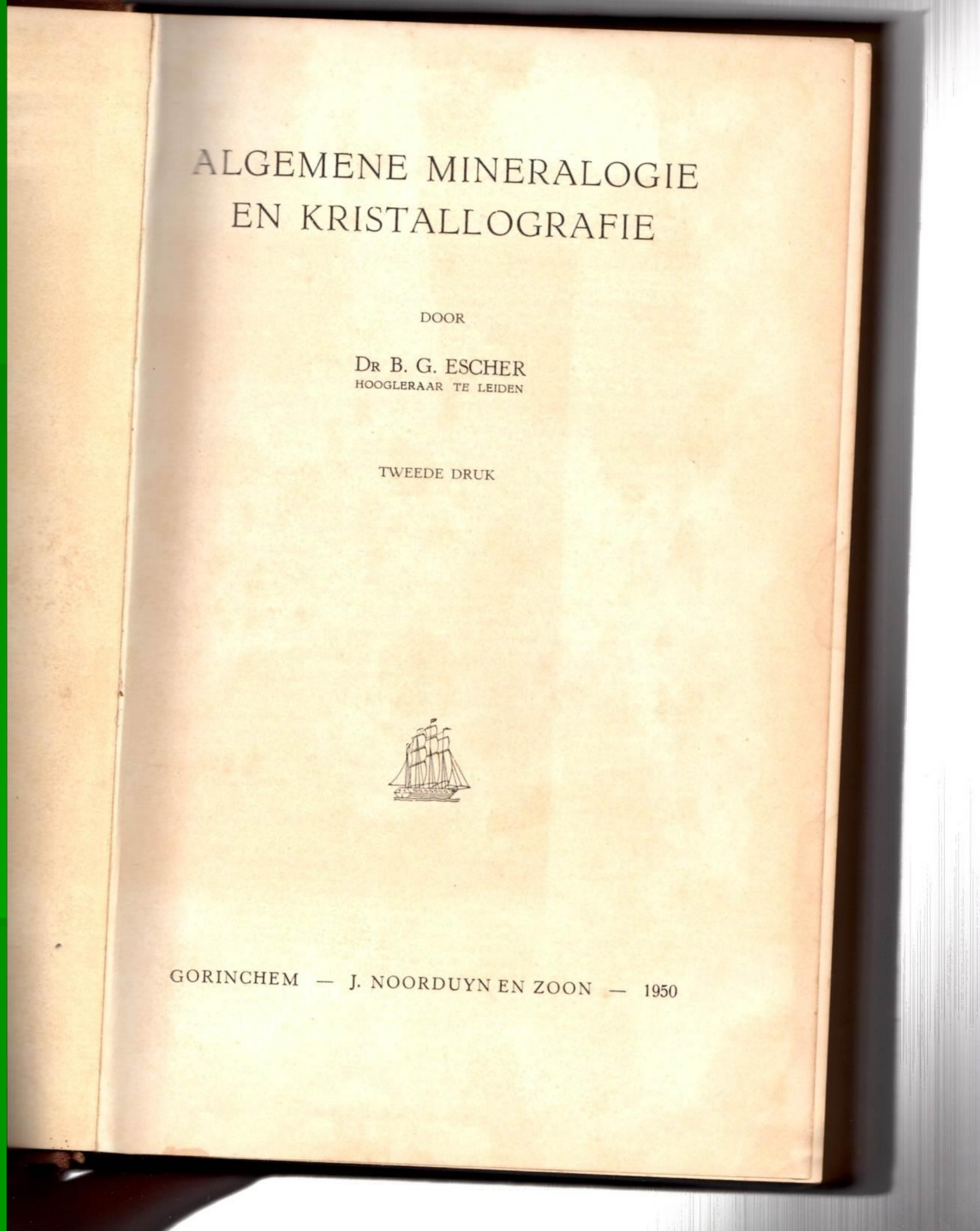
Reflective Symmetry noted in the lower tile patterns

Crystal Structures & Wallpaper

- Escher showed his brother some of his work.
- The brother noted that it was similar to crystal structures he had seen in a paper he read.
- The brother sent Professor George Pólya's wallpaper designs from a Brussels library, saying that an artist could make use of this knowledge.



Pólya 17 Symmetries



ALGEMENE MINERALOGIE
EN KRISTALLOGRAFIE

DOOR

DR B. G. ESCHER
HOOGLERAAR TE LEIDEN

TWEEDE DRUK

GORINCHEM — J. NOORDUYN EN ZOON — 1950

Berend George Escher

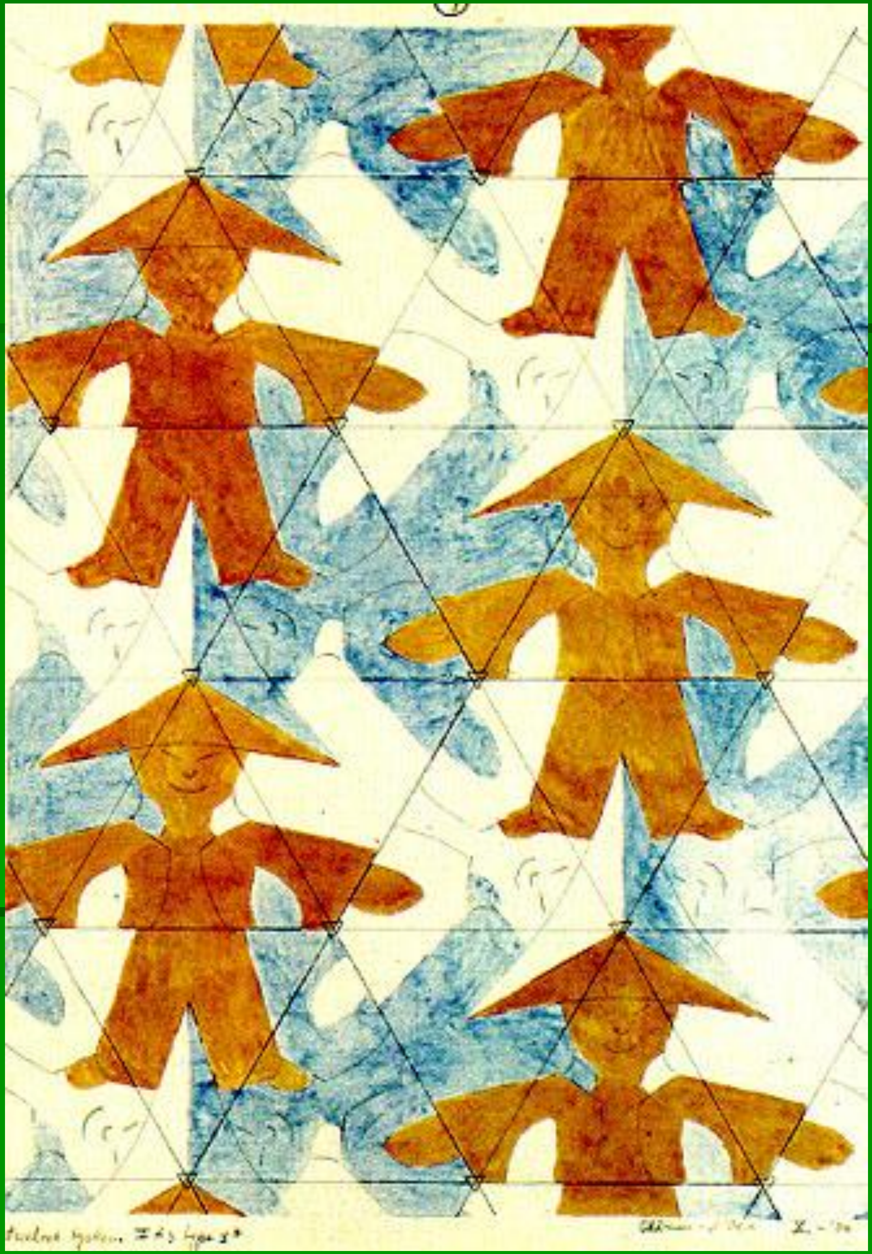
Escher's Last Tessellation

- His last tessellation was a solution to a puzzle sent to him by Roger Penrose, the mathematician. Escher solved it and, true to form, changed the angular wood blocks into rounded 'ghosts'.

Penrose 'Ghosts' - 1971

China Boy, 1936

Tessellation by M. C. Escher

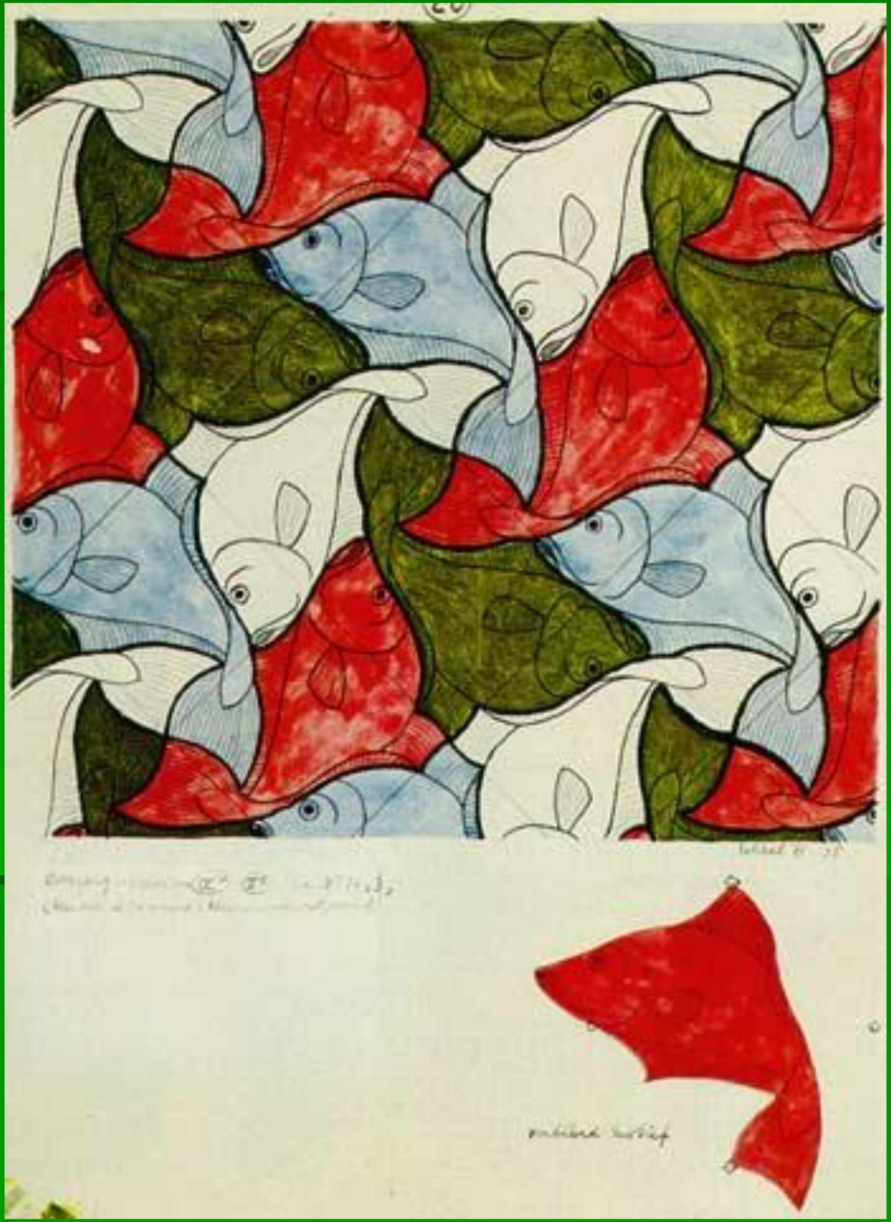


Squirrels, 1936

Tessellation by M. C. Escher

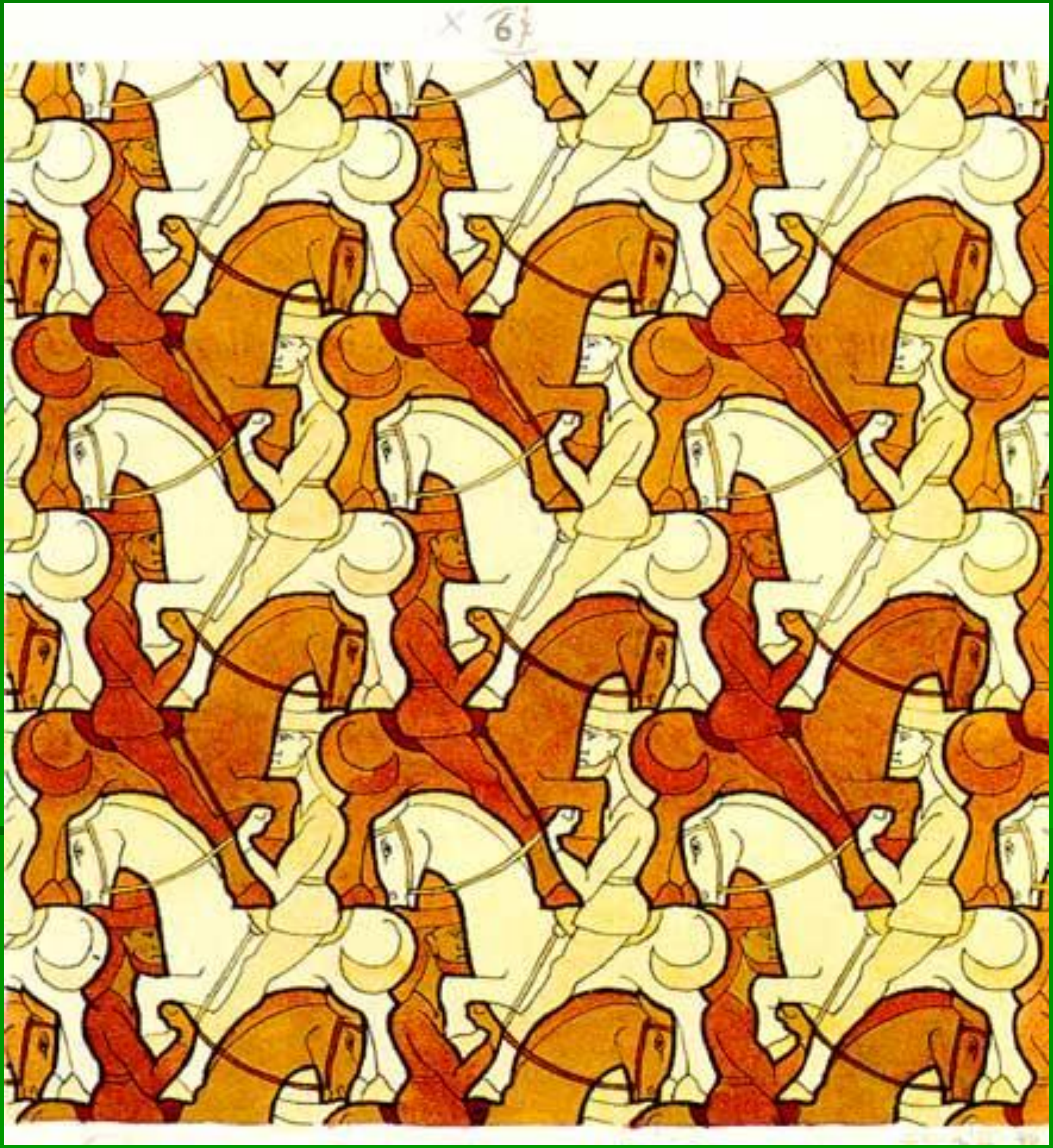
Fish, 1938

Tessellation by M. C. Escher



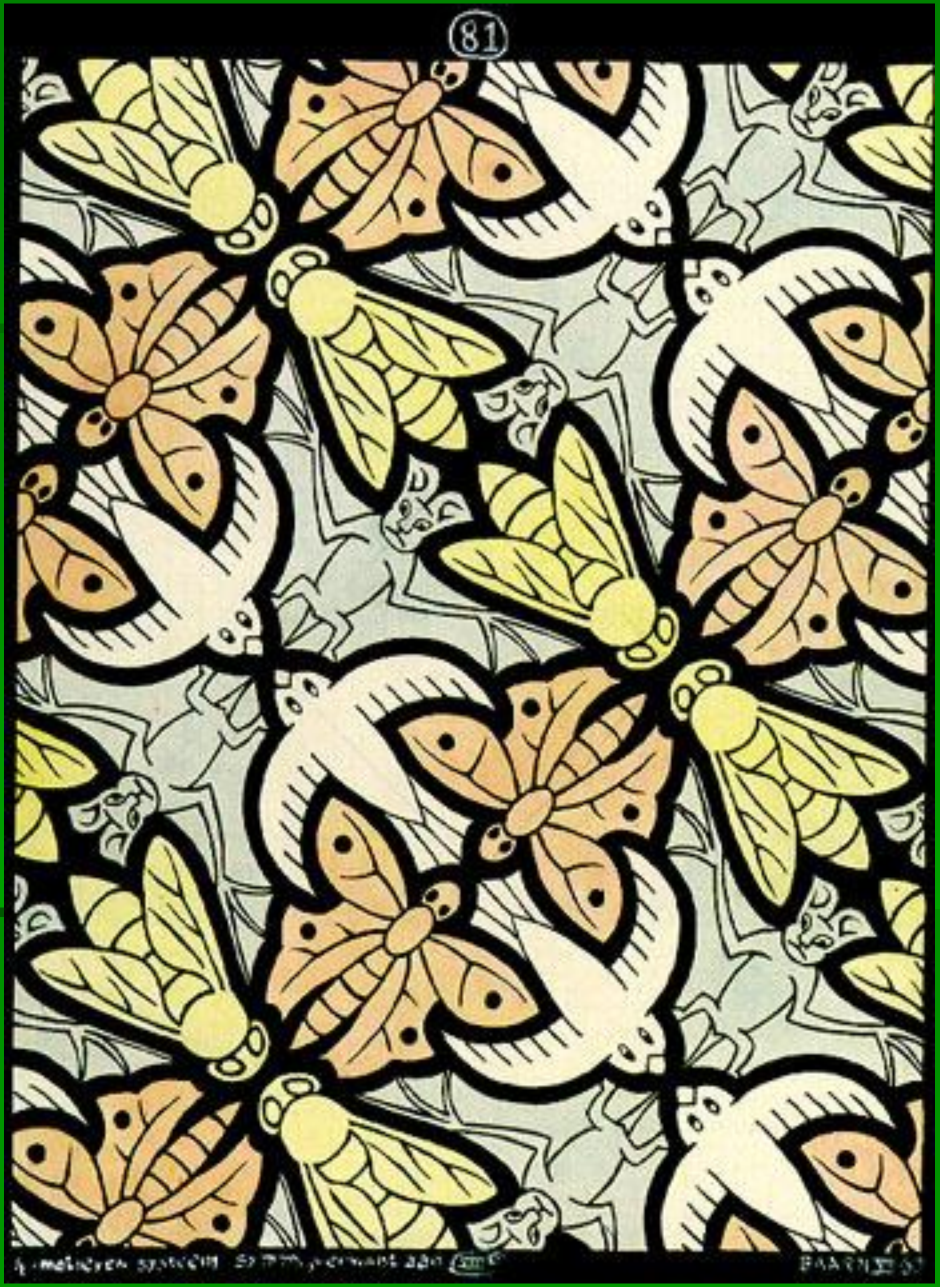
Horsemen, 1946

Tessellation by M. C. Escher



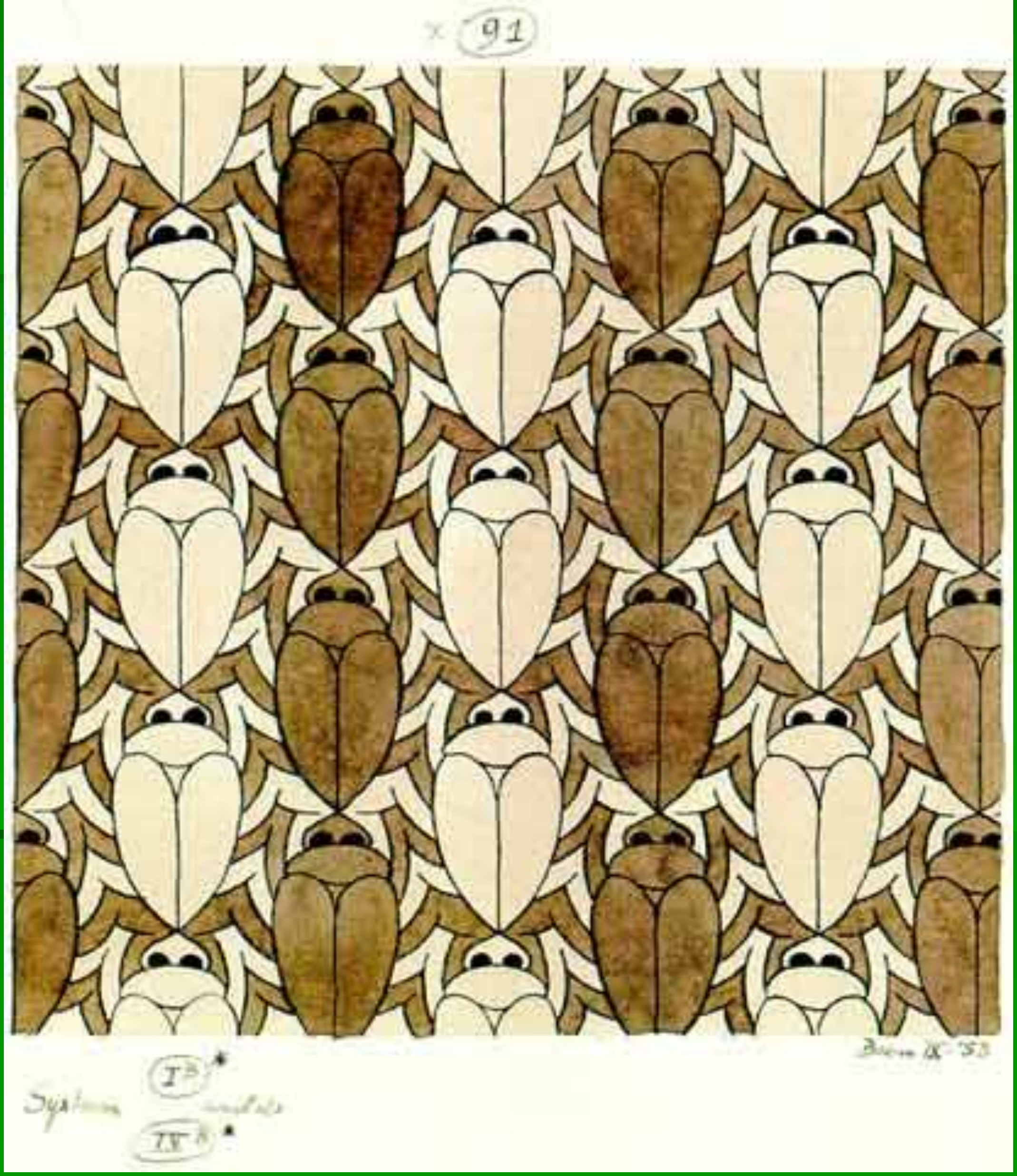
4 Motifs, 1950

Tessellation by M. C. Escher



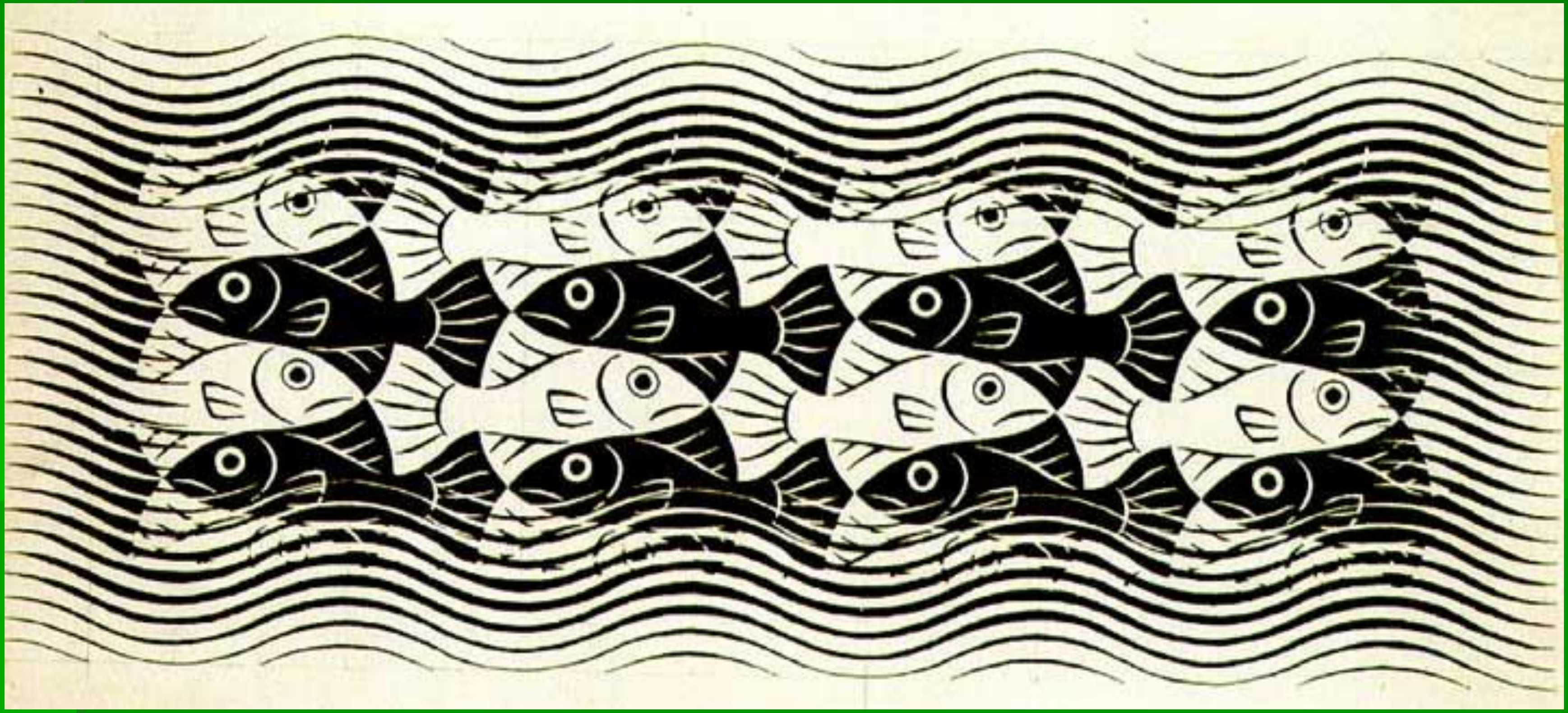
Scarabs, 1953

Tessellation by M. C. Escher



Fishes, 1958 Mural

Tessellation mural by M. C. Escher

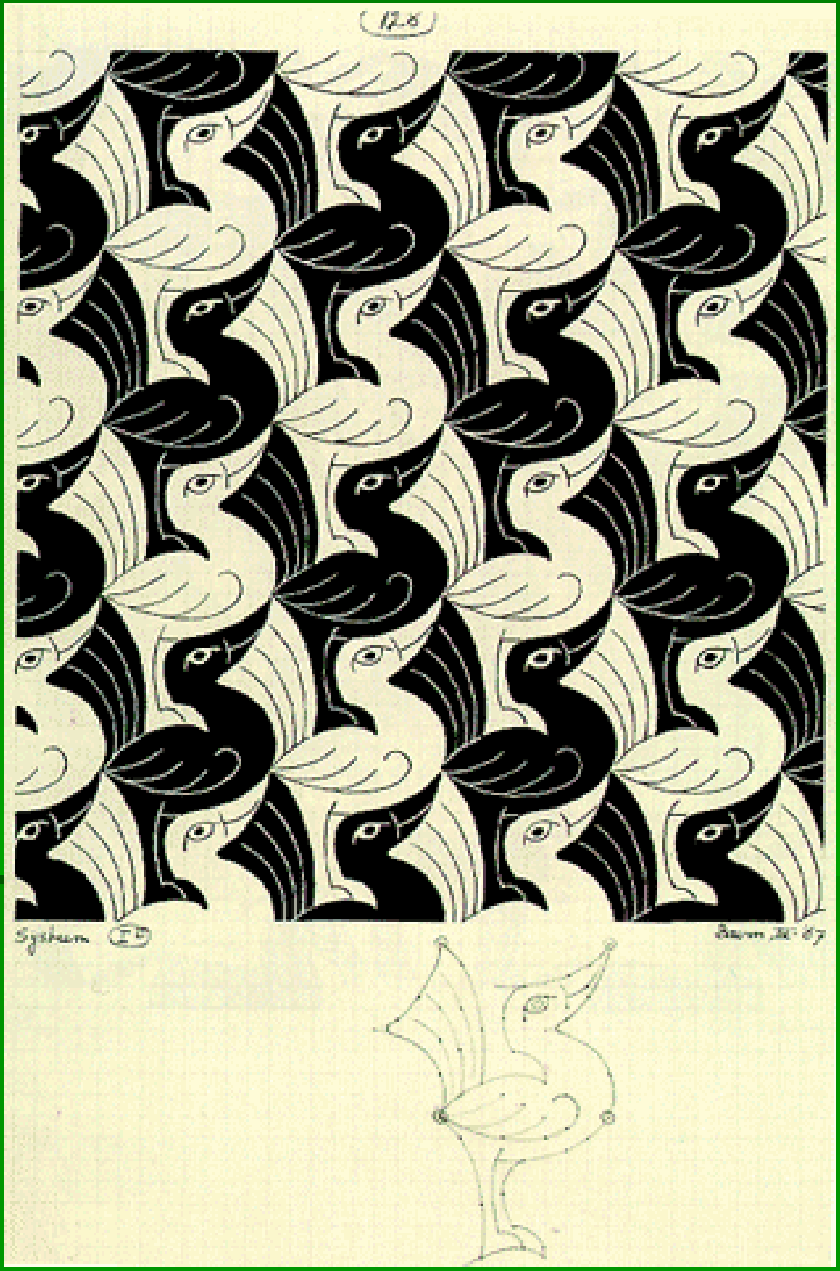


Pegasus, 1959

Tessellation by M. C. Escher

Birds, 1967

Tessellation by M. C. Escher



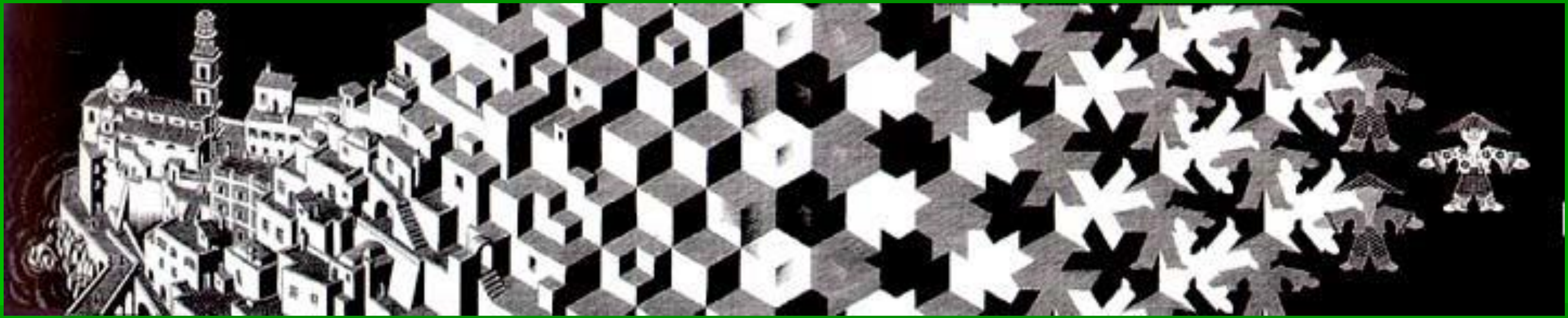
Realism & Tessellations Combined

- Sometimes, M. C. Escher would combine realism and tessellations.
- *Reptiles* is an example of this combination.

'Reptiles' - 1943

Metamorphosis I, 1937

by M. C. Escher

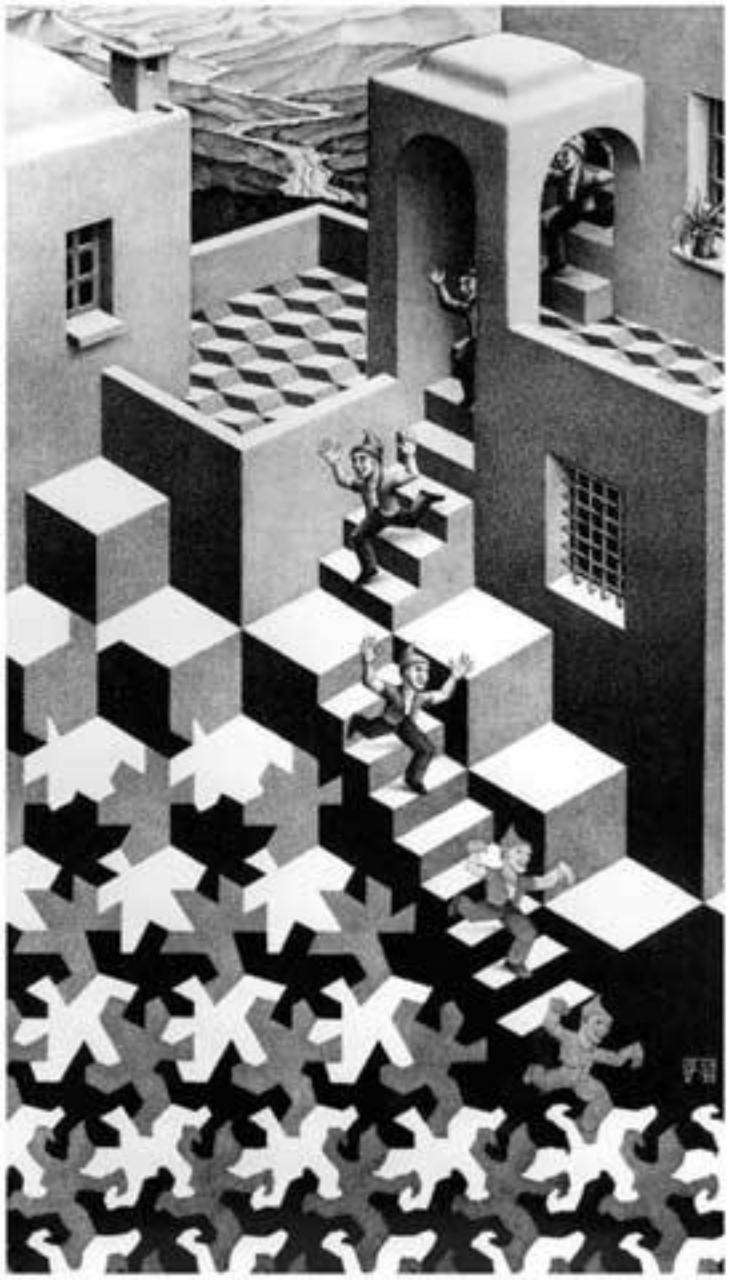


Realism & Tessellation Combined

Cycle, 1938

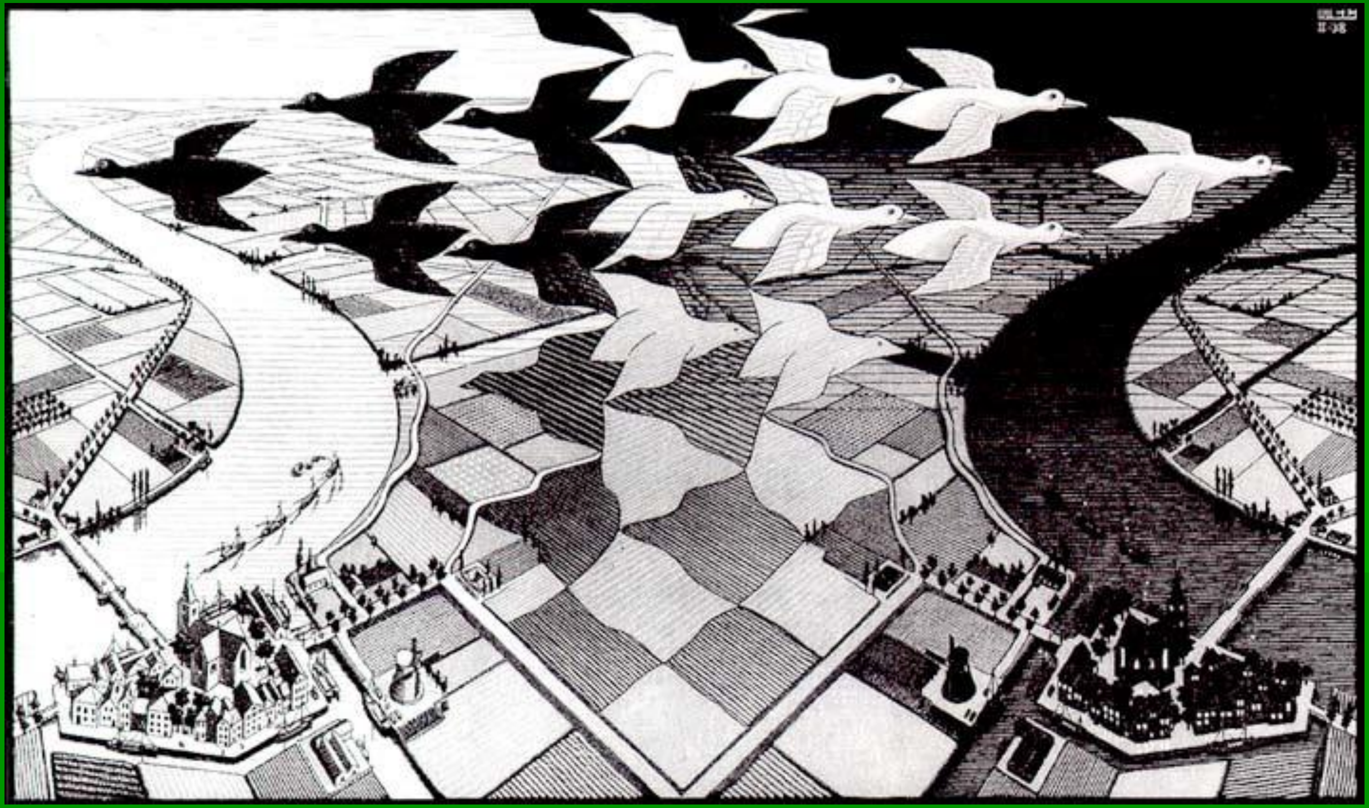
by M. C. Escher

Realism & Tessellation Combined



Day and Night, 1938

by M. C. Escher

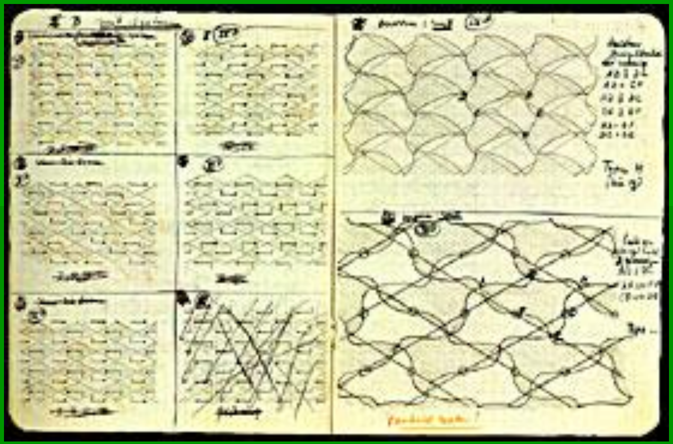


Realism & Tessellation Combined

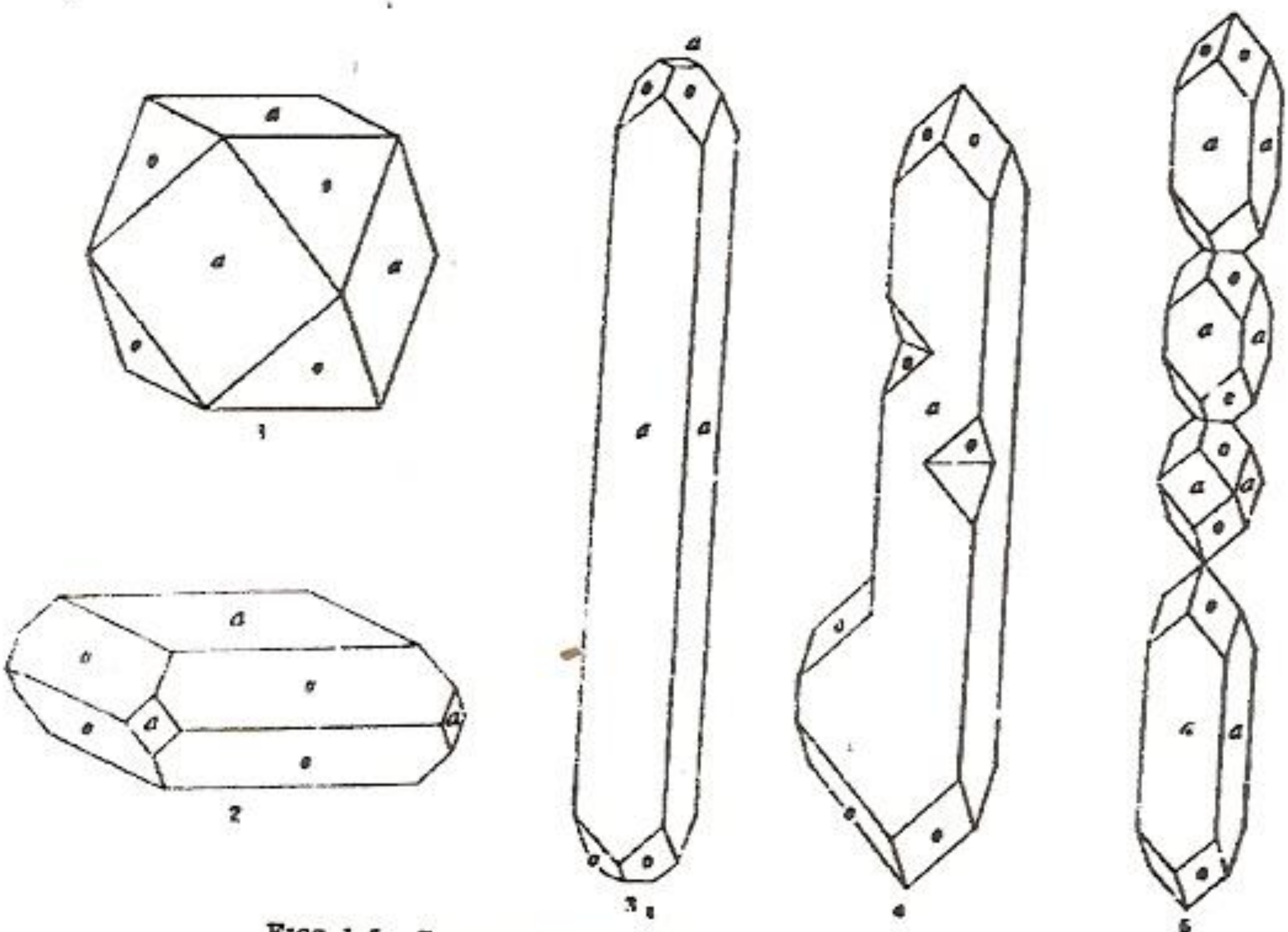
A Full Life

- Escher died on March 27, 1972.
- He had produced
  - 448 woodcuts, linocuts and lithos and
  - over 2,000 drawings.

M. C. Escher



Rhomboid possibilities - 1937 notebook



FIGS. 1-5.– PYRITE CRYSTALS FROM STILLWATER, ARK.

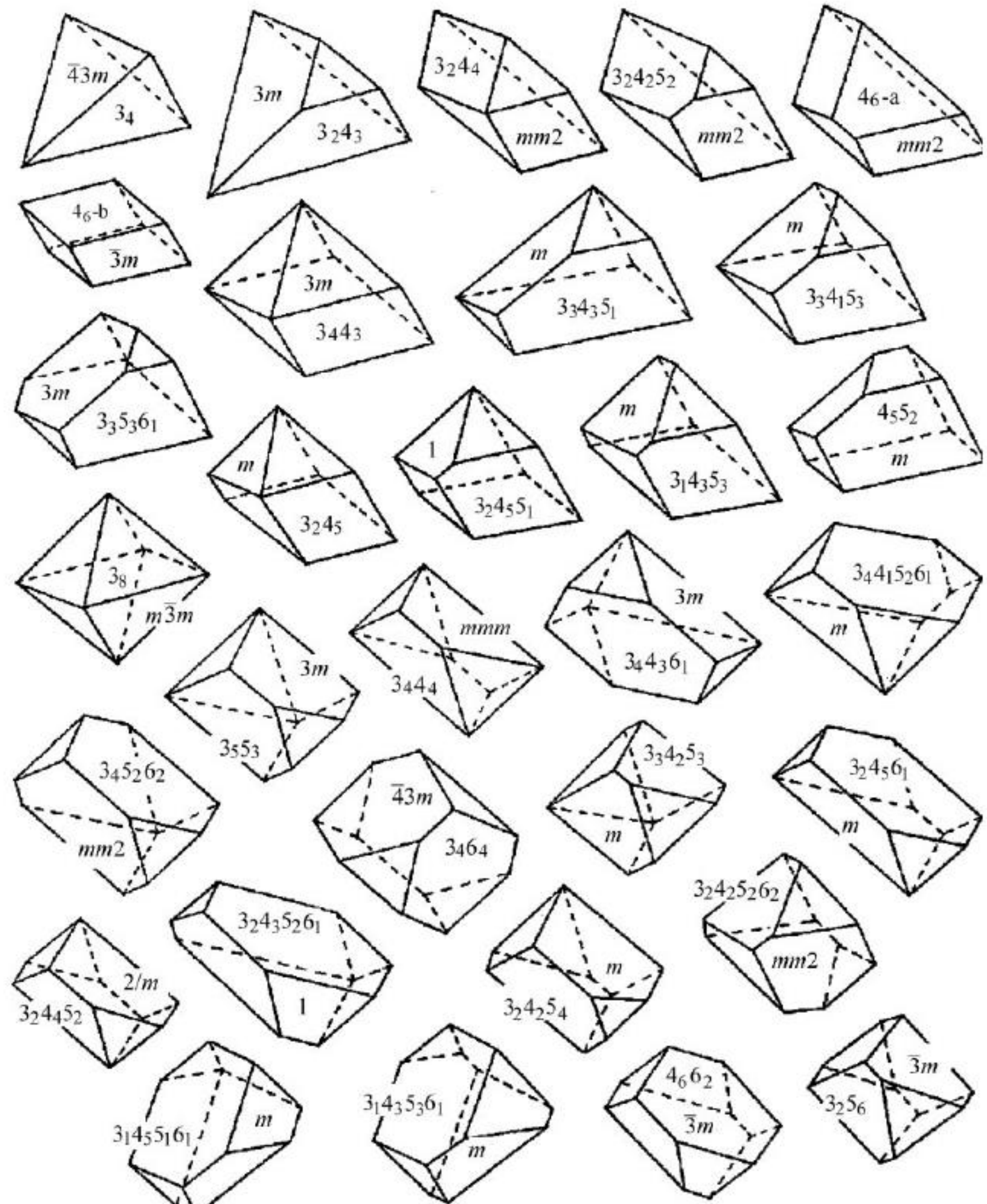


Figure 1
The real crystal octahedra. See text for the symbols.

AS 32 CLASSES CRISTALINAS

Sistema Cristalino	Classe Cristalina	Grau de Simetria	Nome da Classe
Triclínico	1	Sem simetria	Pedial
	$\bar{1}$	i	Pinacoidal
Monoclínico	2	1E2	Esfenoédrica
	m	1m	Domática
	2/m	1E2, 1m, i	Prismática
Ortorrômbico	222	3E2	Biesfenoédrica-rômbica
	mm2	1E2, 2m	Piramidal rômbica
	2/m2/m2/m	3E2, 3m, i	Bipiramidal rômbica
Tetragonal	4	1E4	Piramidal tetragonal
	$\bar{4}$	1E$\bar{4}$	Biesfenoédrica tetragonal
	4/m	1E4, 1m, i	Bipiramidal tetragonal
	422	1E4, 4E2	Trapezoédrica tetragonal
	4mm	1E4, 4m	Piramidal ditetragonal
	$\bar{4}$2m	1E$\bar{4}$, 2E2, 2m	Escalenoédrica tetragonal
	4/m2/m2/m	1E4, 4E2, 5m, i	Bipiramidal ditetragonal
Trigonal	3	1E3	Piramidal trigonal
	$\bar{3}$	1E$\bar{3}$	Romboédrica
(Classe Hexagonal -	32	1E3, 3E2	Trapezoédrica trigonal
Divisão Romboédrica)	3m	1E3, 3m	Piramidal ditrigonal
	$\bar{3}$ 2/m	1E$\bar{3}$, 3E2, 3m, i	Escalenoédrica hexagonal
Hexagonal	6	1E6	Piramidal hexagonal
	$\bar{6}$	1E$\bar{6}$	Bipiramidal trigonal
(Classe Hexagonal -	6/m	1E6, 1m, i	Bipiramidal hexagonal
Divisão Hexagonal)	622	1E6, 6E2	Trapezoédrica hexagonal
	6mm	1E6, 6m	Piramidal dihexagonal
	$\bar{6}$ m2	1E$\bar{6}$, 3E2, 3m	Bipiramidal ditrigonal
	6/m2/m2/m	1E6, 6E2, 7m, i	Bipiramidal dihexagonal
Isométrico	23	4E3, 3E2	Tetartoédrica
(Cúbico)	2/m$\bar{3}$	4E$\bar{3}$, 3E2, 3m, i	Diploédrica
	432	4E3, 3E4, 6E2	Giroédrica
	$\bar{4}$3m	4E3, 3E$\bar{4}$, 6m	Hexatetraédrica
	4/m$\bar{3}$2/m	4E$\bar{3}$, 3E4, 6E2, 9m, i	Hexaoctaédrica

TABLE 1–2

The Subgroups and Supergroups among the 32 Point Groups[a]

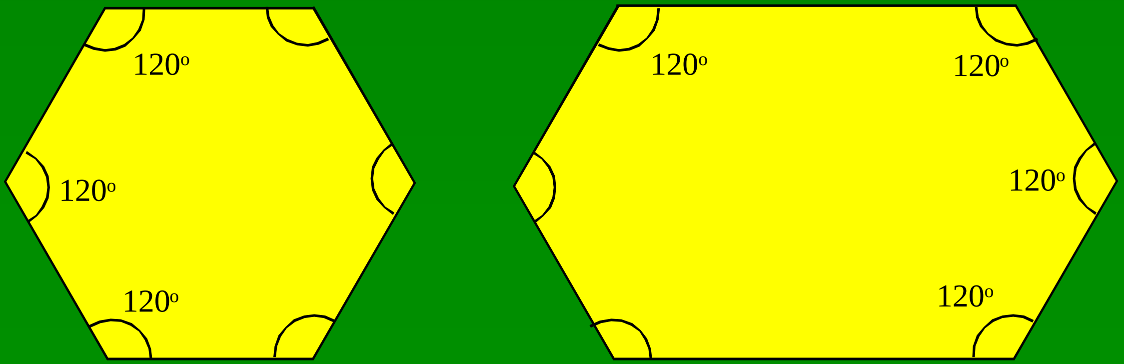
$4/m\,\bar{3}\,2/m$	*																															
$\bar{4}3m$	x	*																														
432	x		*																													
$2/m\,\bar{3}$	x			*																												
23	x	x	x	x	*																											
$6/m\,2/m\,2/m$						*																										
$\bar{6}m2$						x	*																									
$6mm$						x		*																								
622						x			*																							
$6/m$						x				*																						
$\bar{6}$						x	x			x	*																					
6						x		x	x	x		*																				
$\bar{3}\,2/m$	x					x							*																			
$3m$	x	x				x	x	x					x	*																		
32	x		x			x	x		x				x		*																	
$\bar{3}$	x			x		x				x			x			*																
3	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	*															
$4/m\,2/m\,2/m$	x																	*														
$\bar{4}2m$	x	x																x	*													
$4mm$	x																	x		*												
422	x		x															x			*											
$4/m$	x																	x				*										
$\bar{4}$	x	x																x	x			x	*									
4	x		x															x		x	x	x		*								
$2/m\,2/m\,2/m$	x			x		x												x							*							
$2mm$	x	x		x		x	x	x										x	x	x					x	*						
222	x	x	x	x	x	x			x									x	x		x				x		*					
$2/m$	x			x		x				x			x					x				x			x			*				
m	x	x		x		x	x	x		x	x		x	x				x	x	x		x			x	x		x	*			
2	x	x	x	x	x	x	x	x	x	x		x	x		x			x	x	x	x	x	x	x	x	x	x	x		*		
$\bar{1}$	x			x		x				x			x			x		x				x			x			x			*	
1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	*

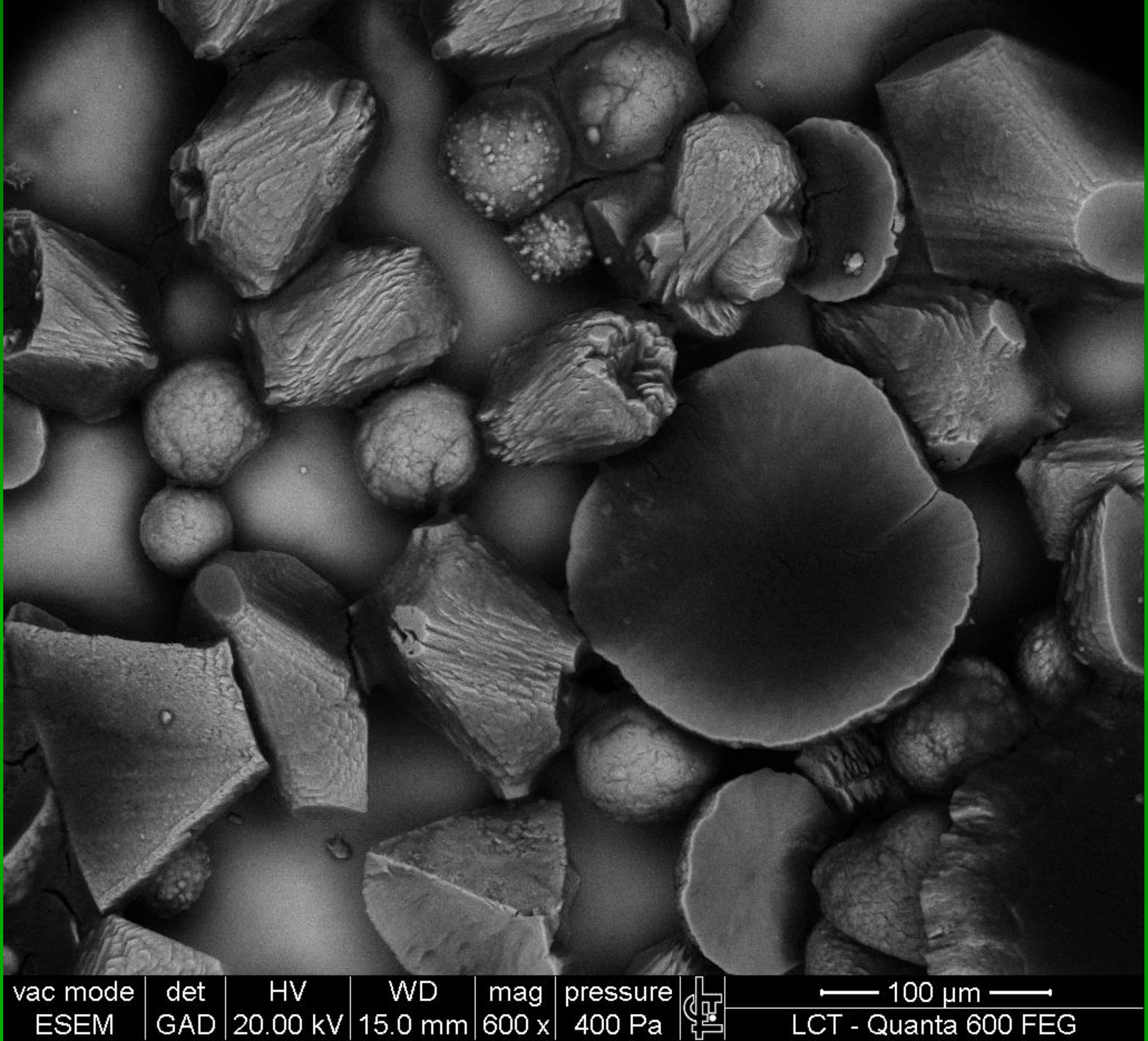
[a] The asterisk at the top of each vertical column indicates the supergroup; the x's vertically below it indicate the subgroups which belong to this supergroup. Figure 1–16 illustrates supergroup $2/m\,2/m\,2/m$ and its various subgroups.

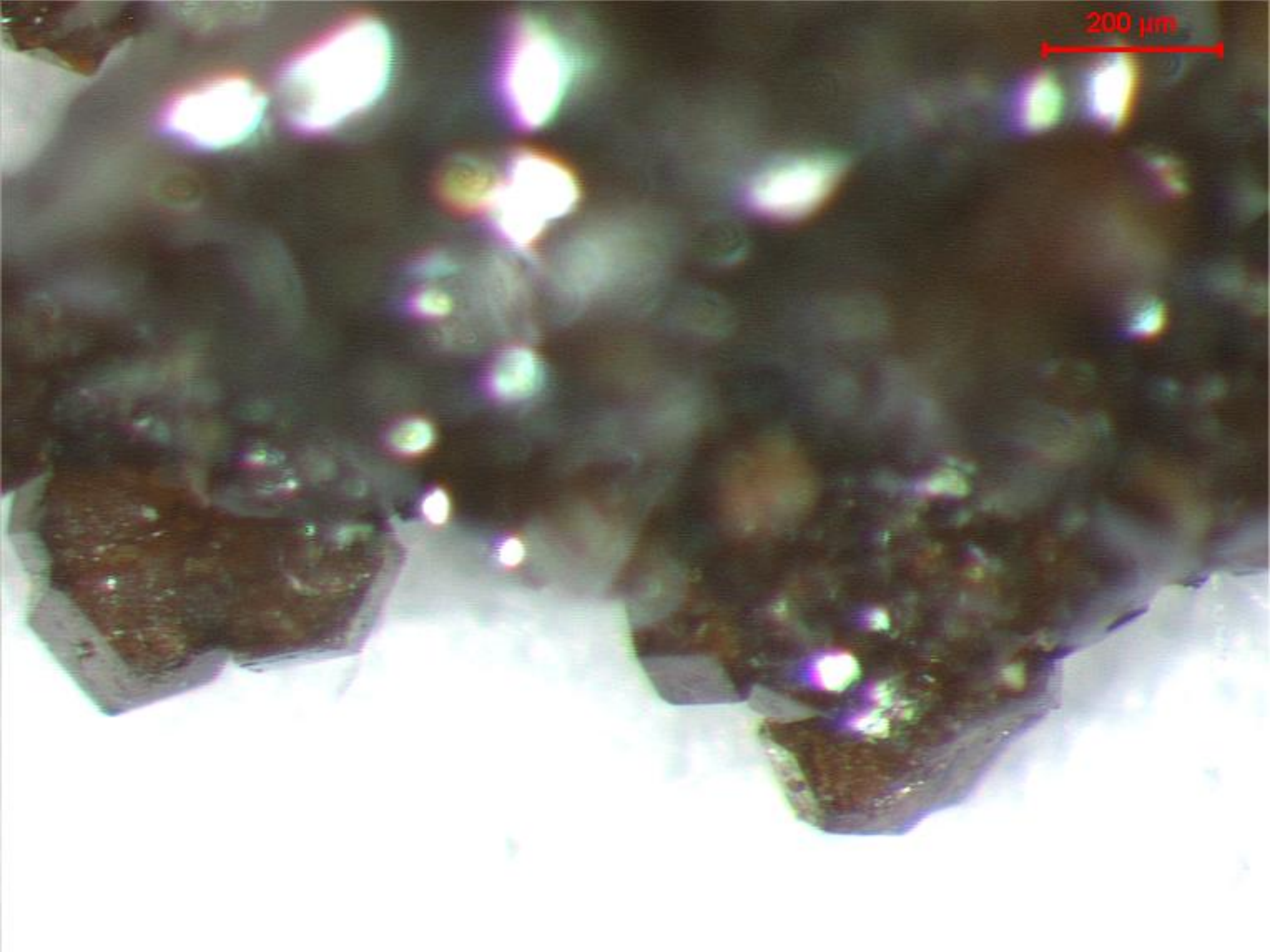
Nicholas Steno (1669):

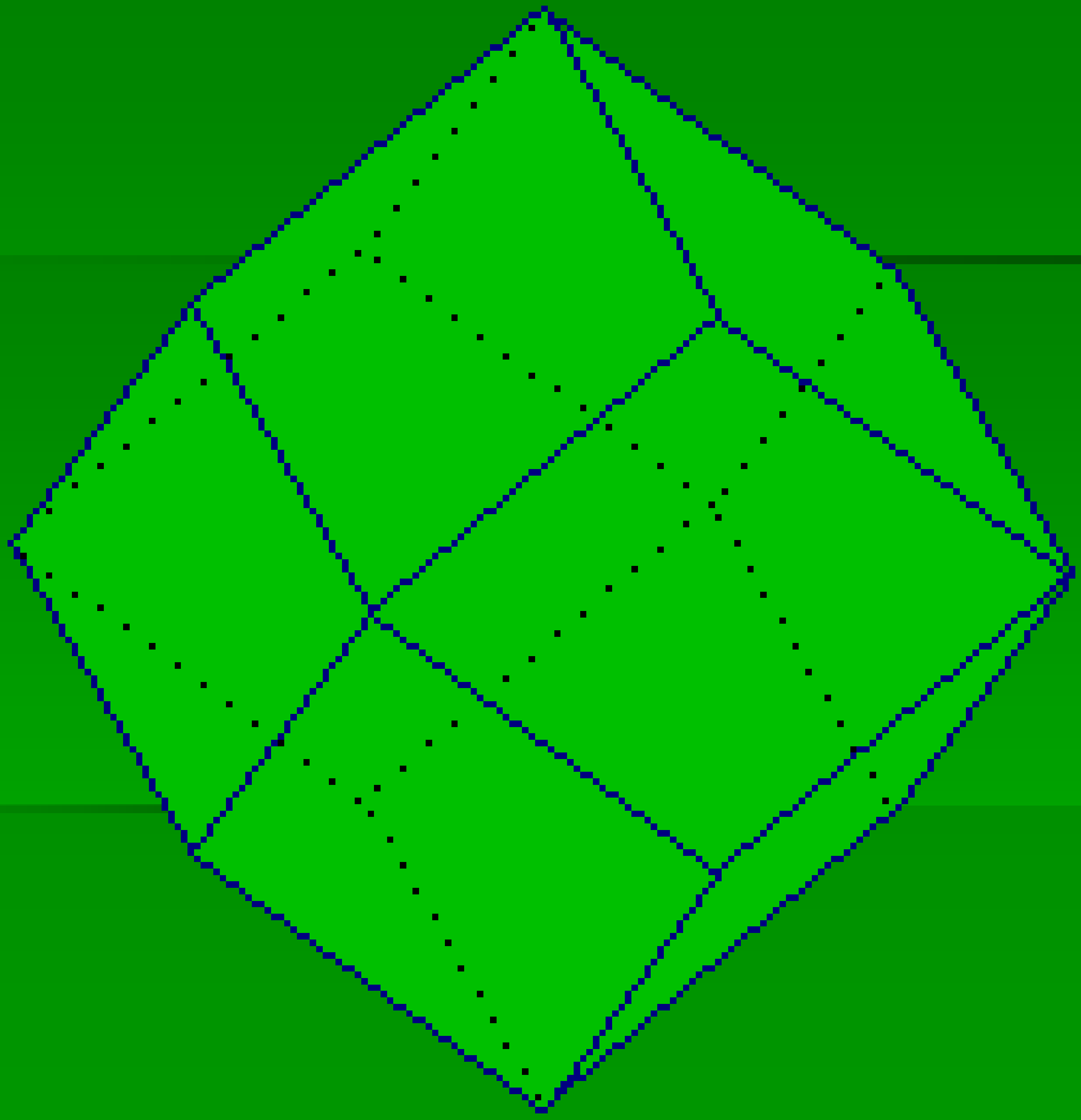
Lei da Constância dos Ângulos Interfaciais

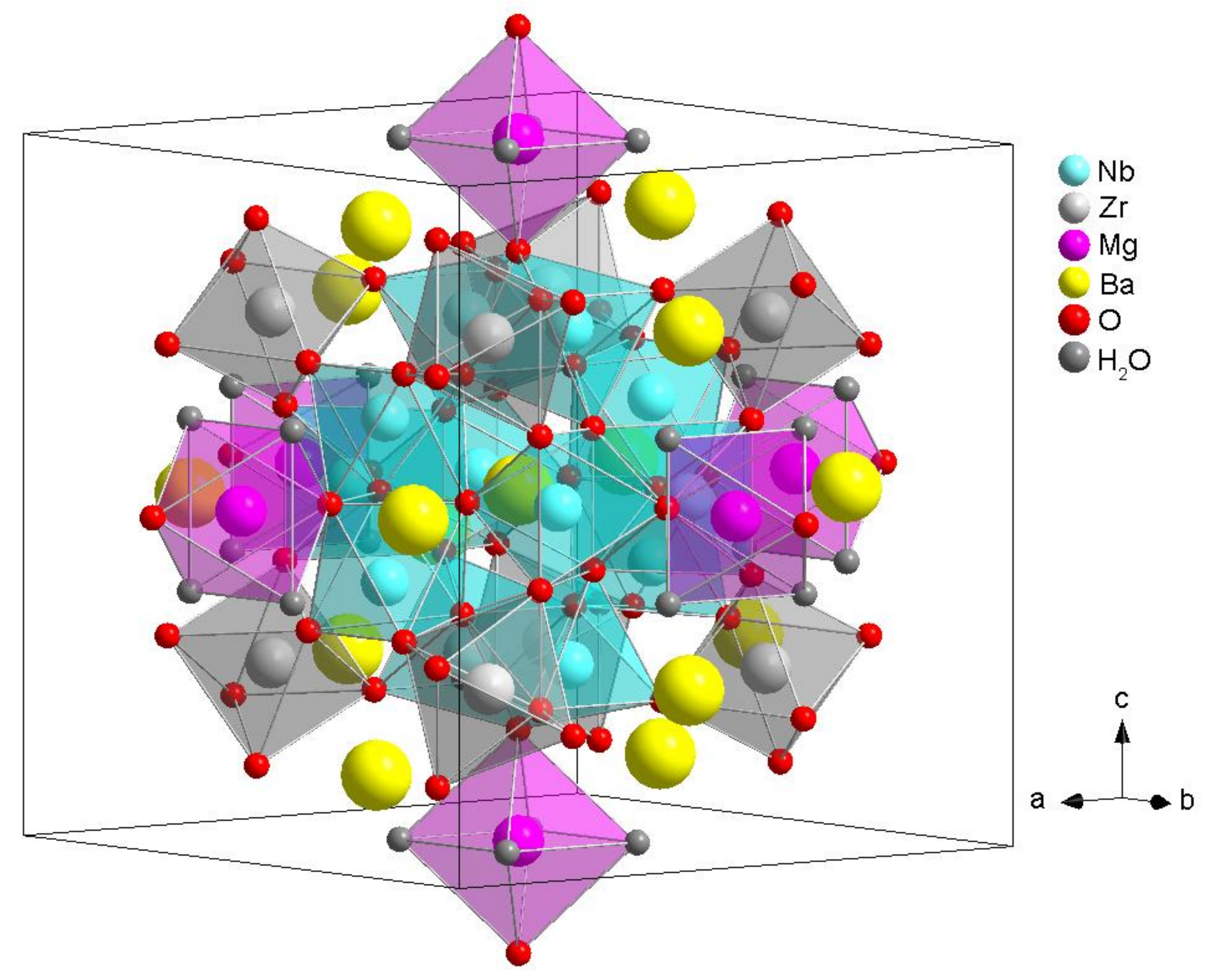
FIG. 1.4. Portrait of Niels Stensen (Latinized to Nicolaus Steno). Steno was born in Copenhagen, Denmark, in 1638 and died in 1686. (From Scherz, G., *Steno, Geological Papers.* Odense University Press, 1969.)



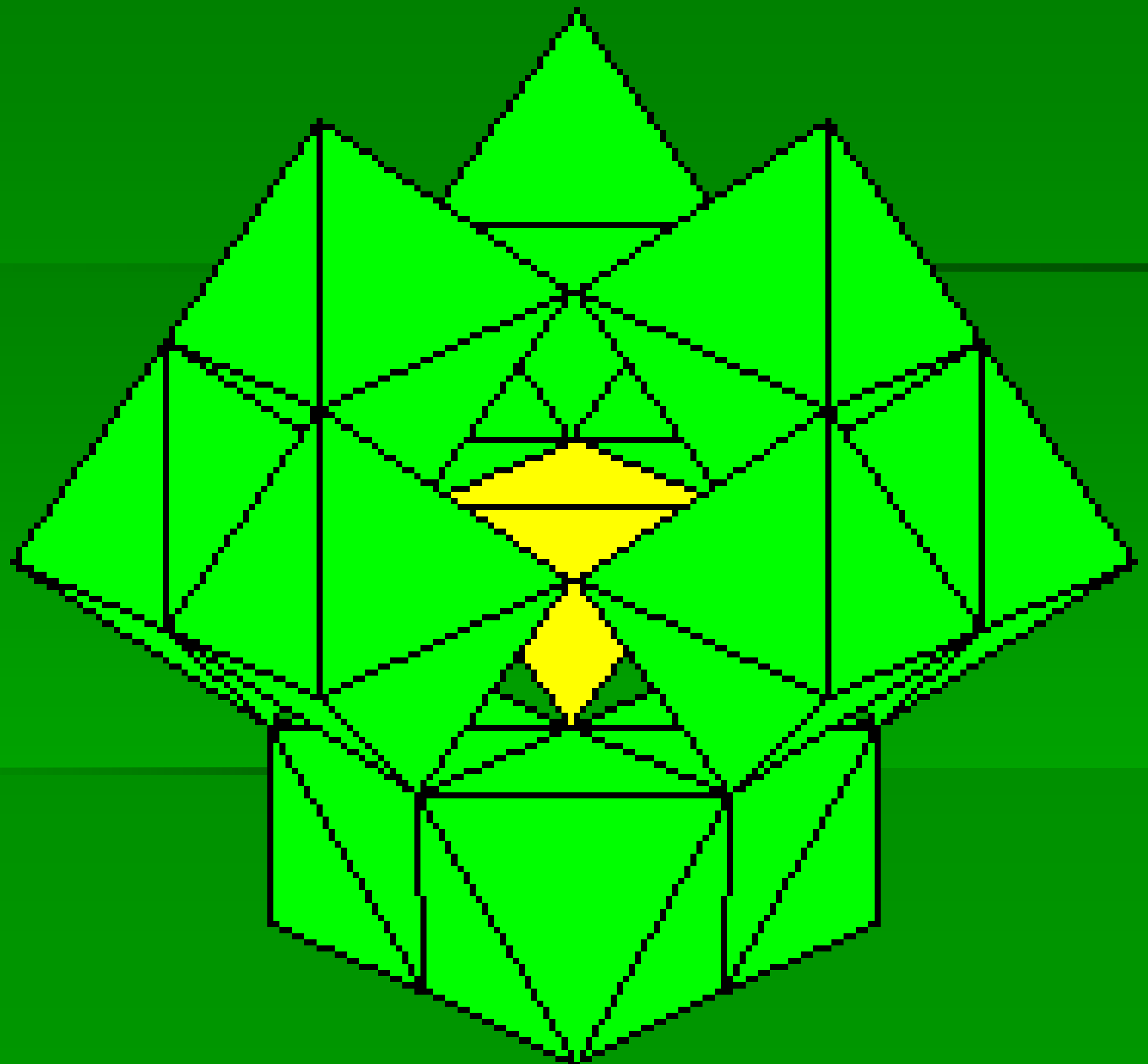

vac mode
ESEM
det
GAD
HV
20.00 kV
WD
15.0 mm
mag
600 x
pressure
400 Pa
100 µm
LCT - Quanta 600 FEG

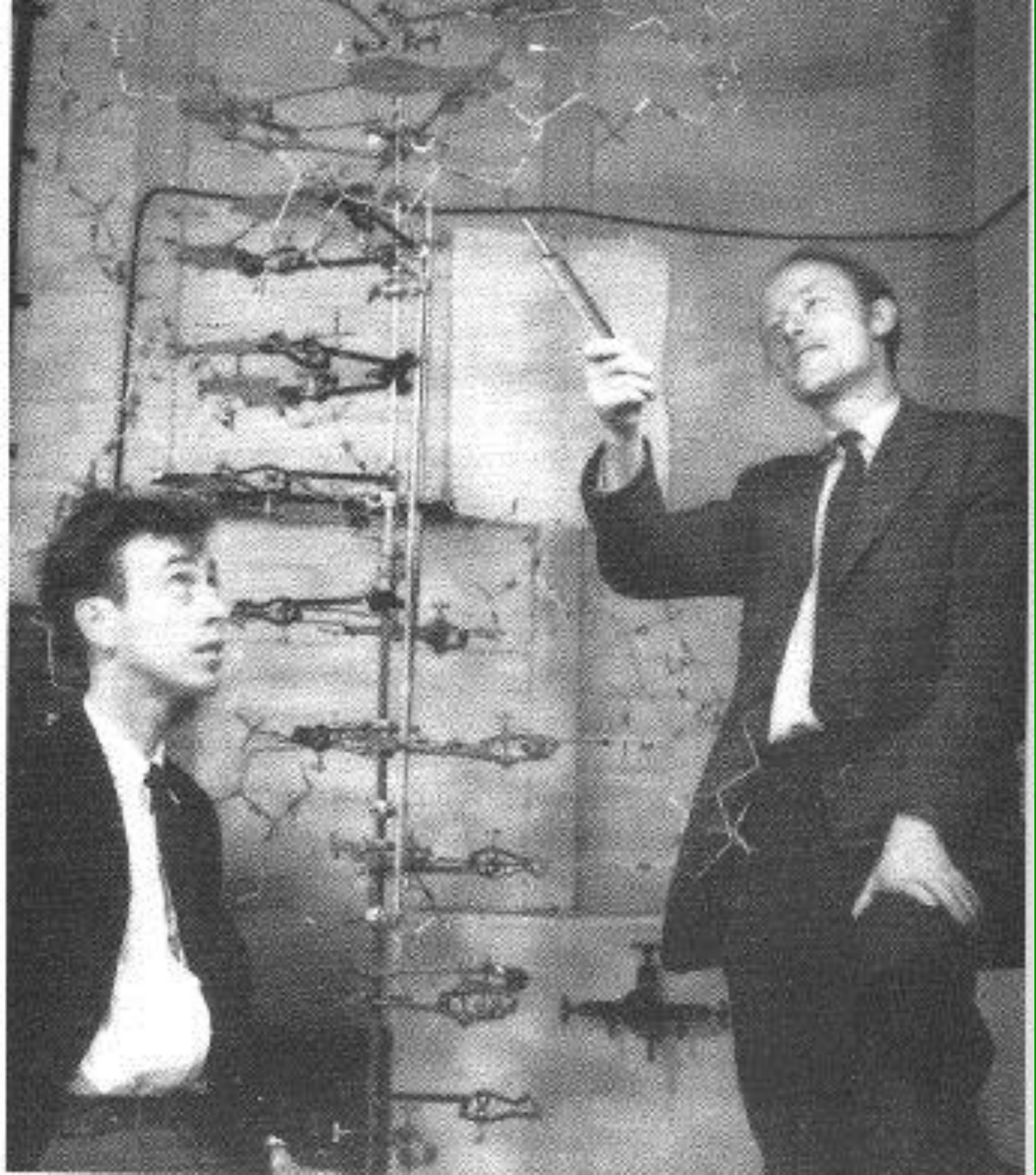

200 µm

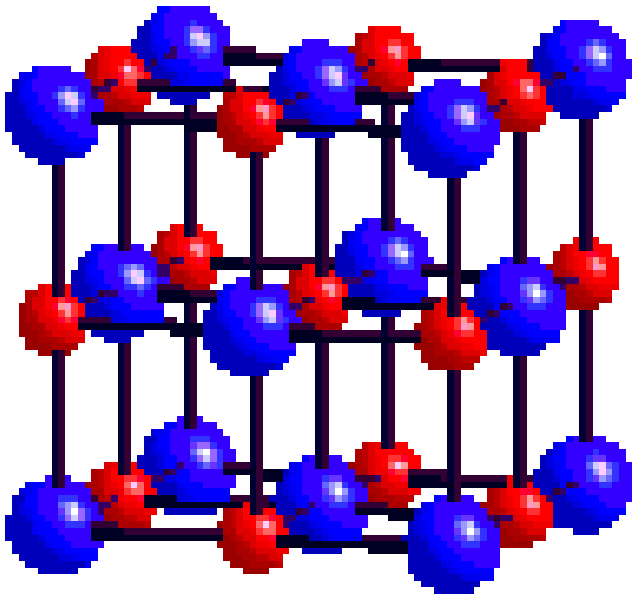


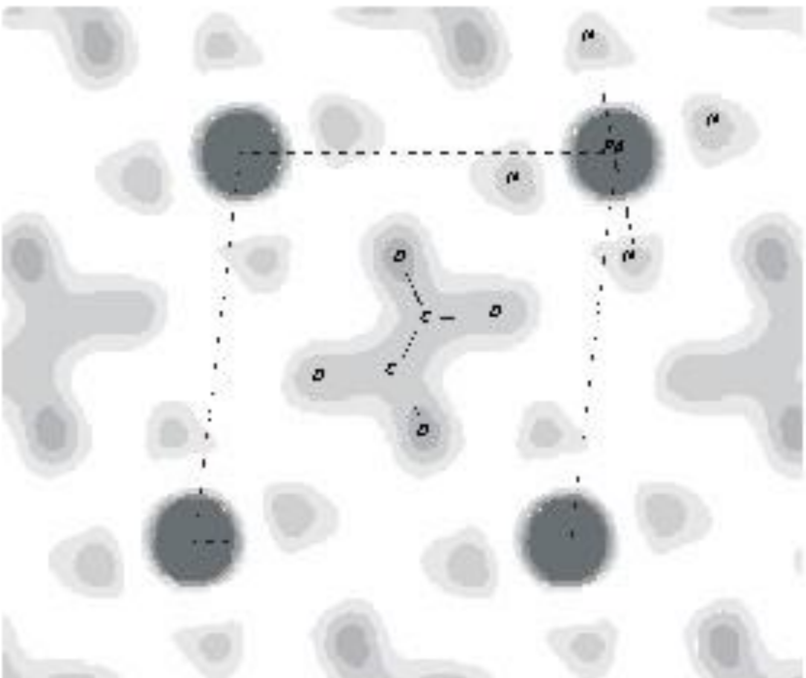


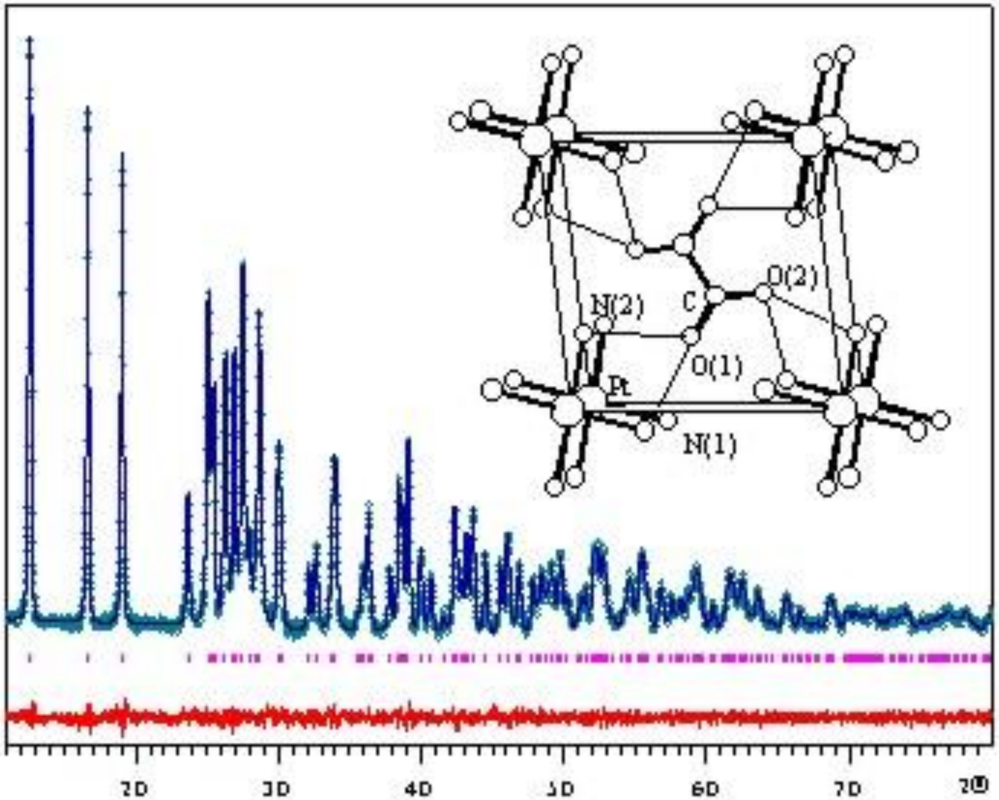
Nb
Zr
Mg
Ba
O
H_2O
c
a
b





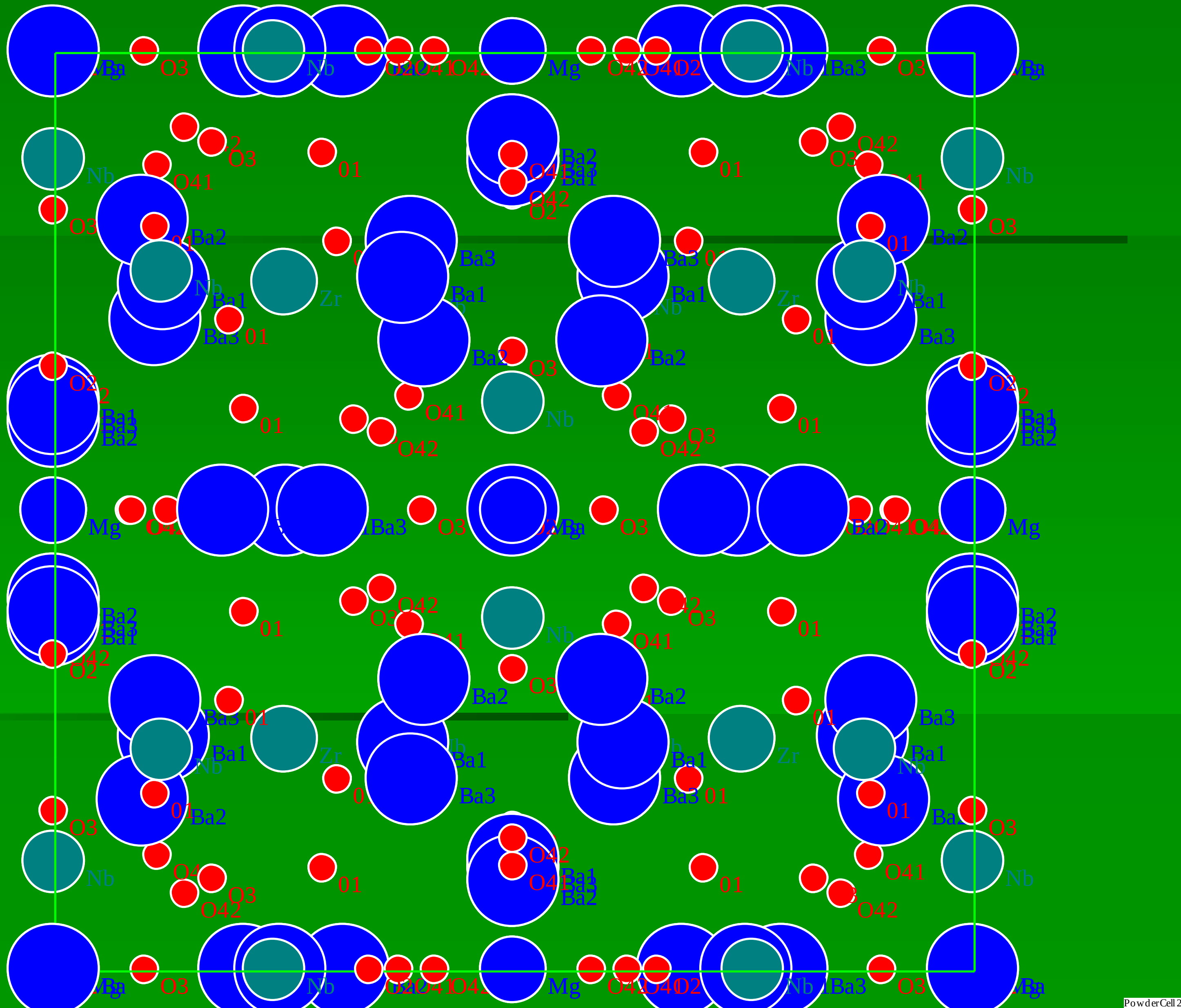


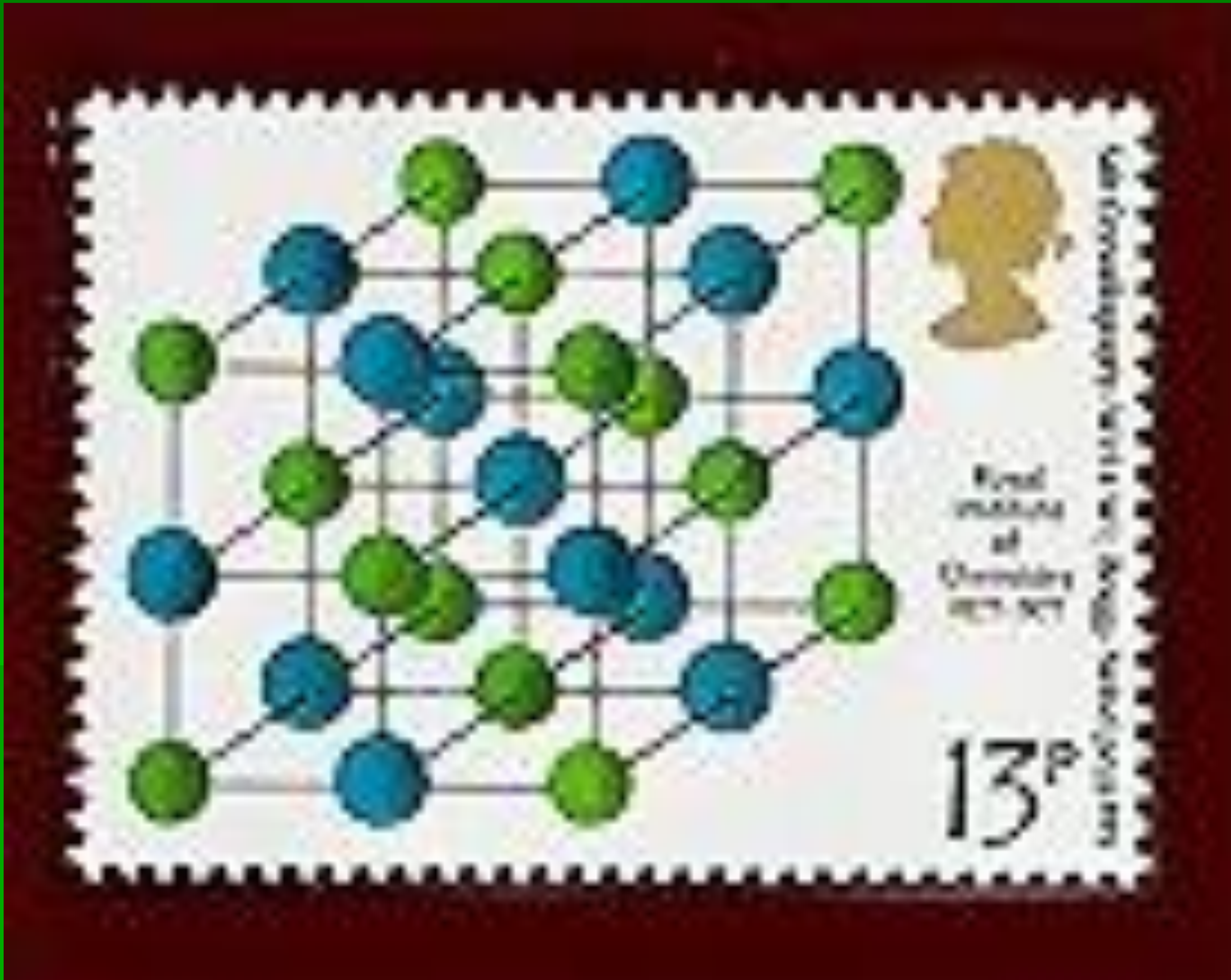

Pd
C
O

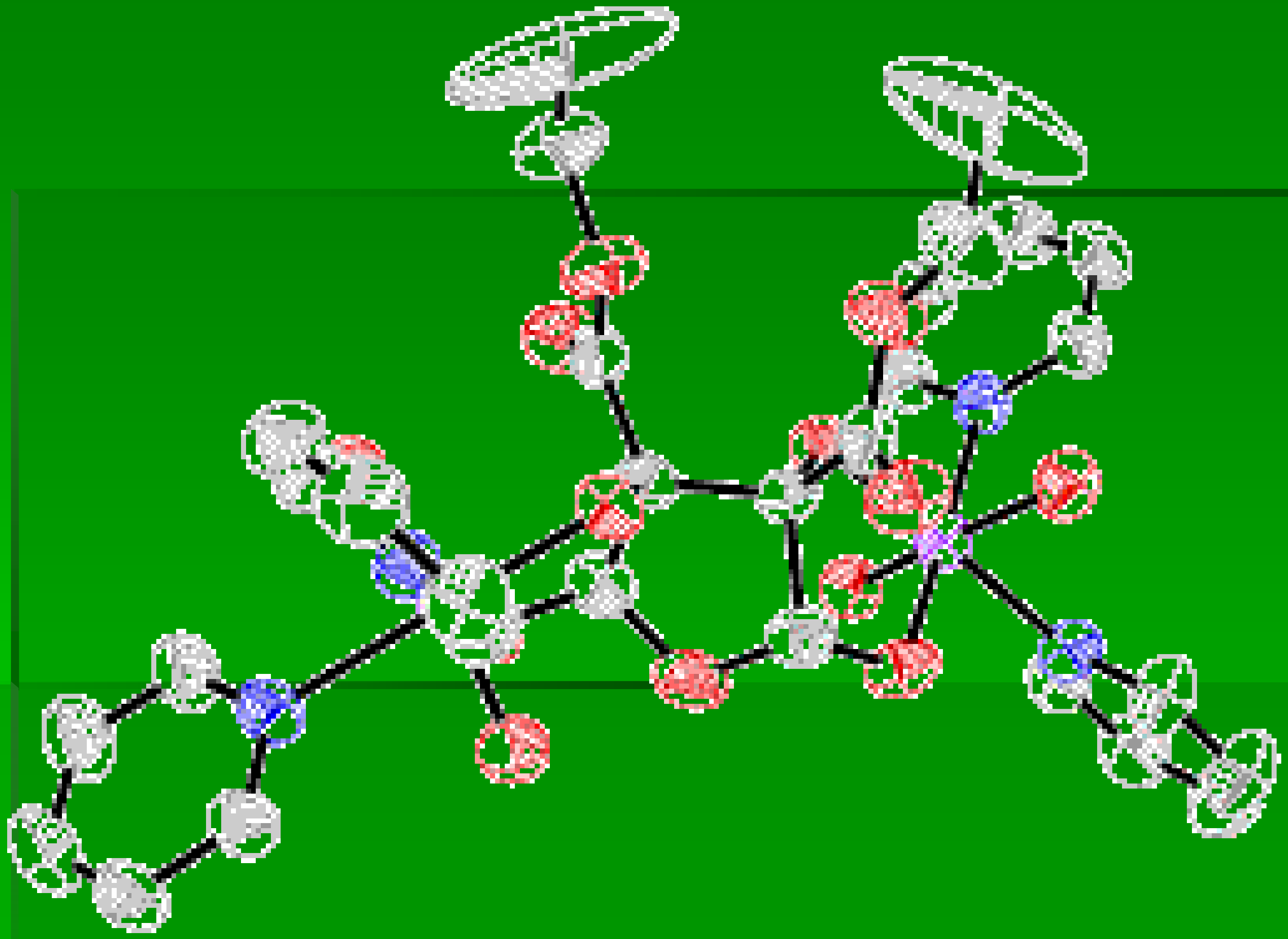

N(2)
C
O(2)
O(1)
Pt
N(1)
20
30
40
50
60
70
2θ

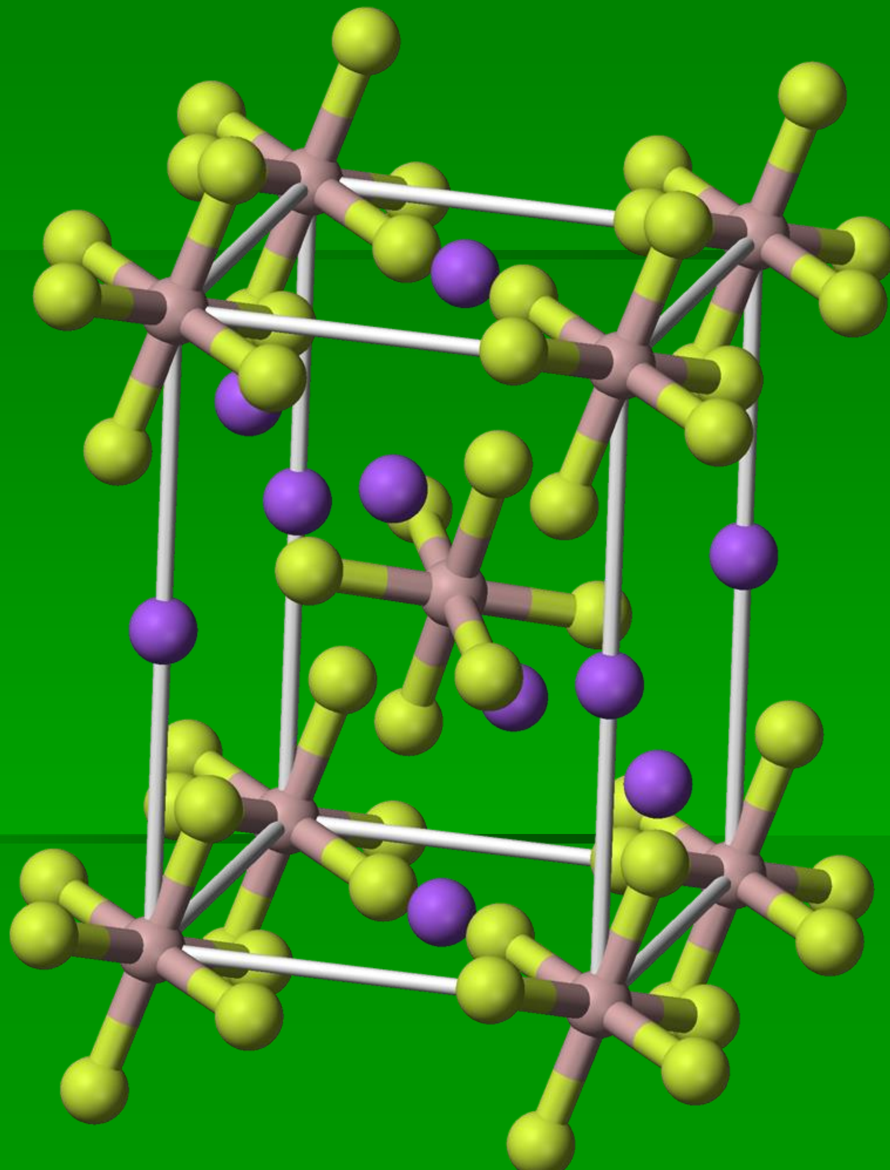
SIMETRIA INTERNA DOS CRISTAIS

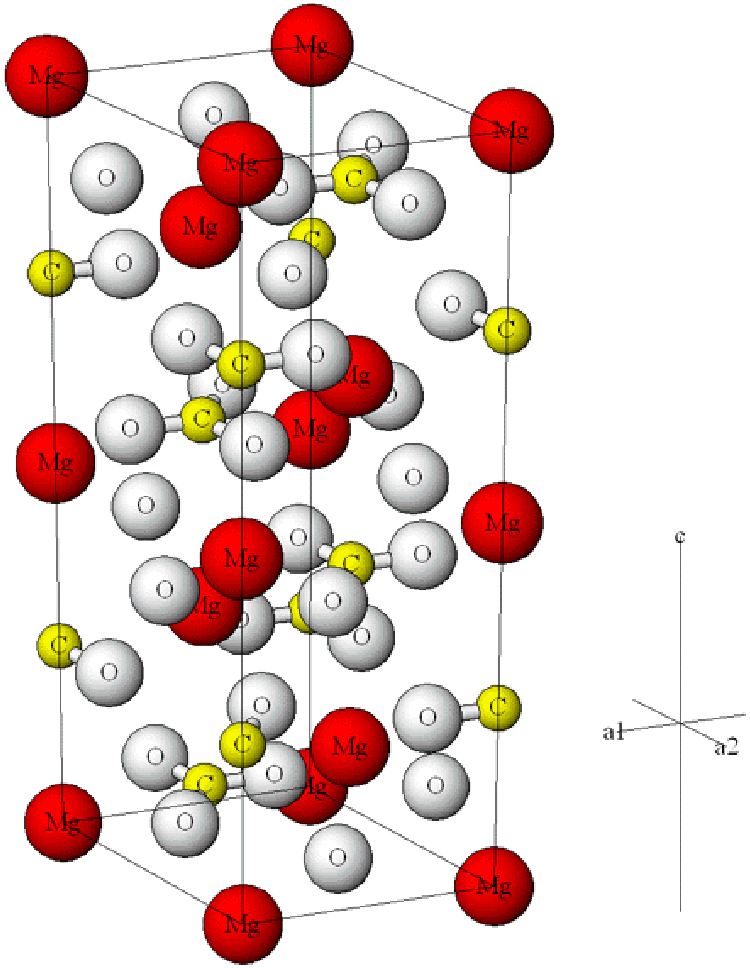
Daniel Atencio


Mg
Nb
Zr
Ba1
Ba2
Ba3
O1
O2
O3
O41
O42
PowderCell 2.0


13p






Mg
O
C
c
a1
a2

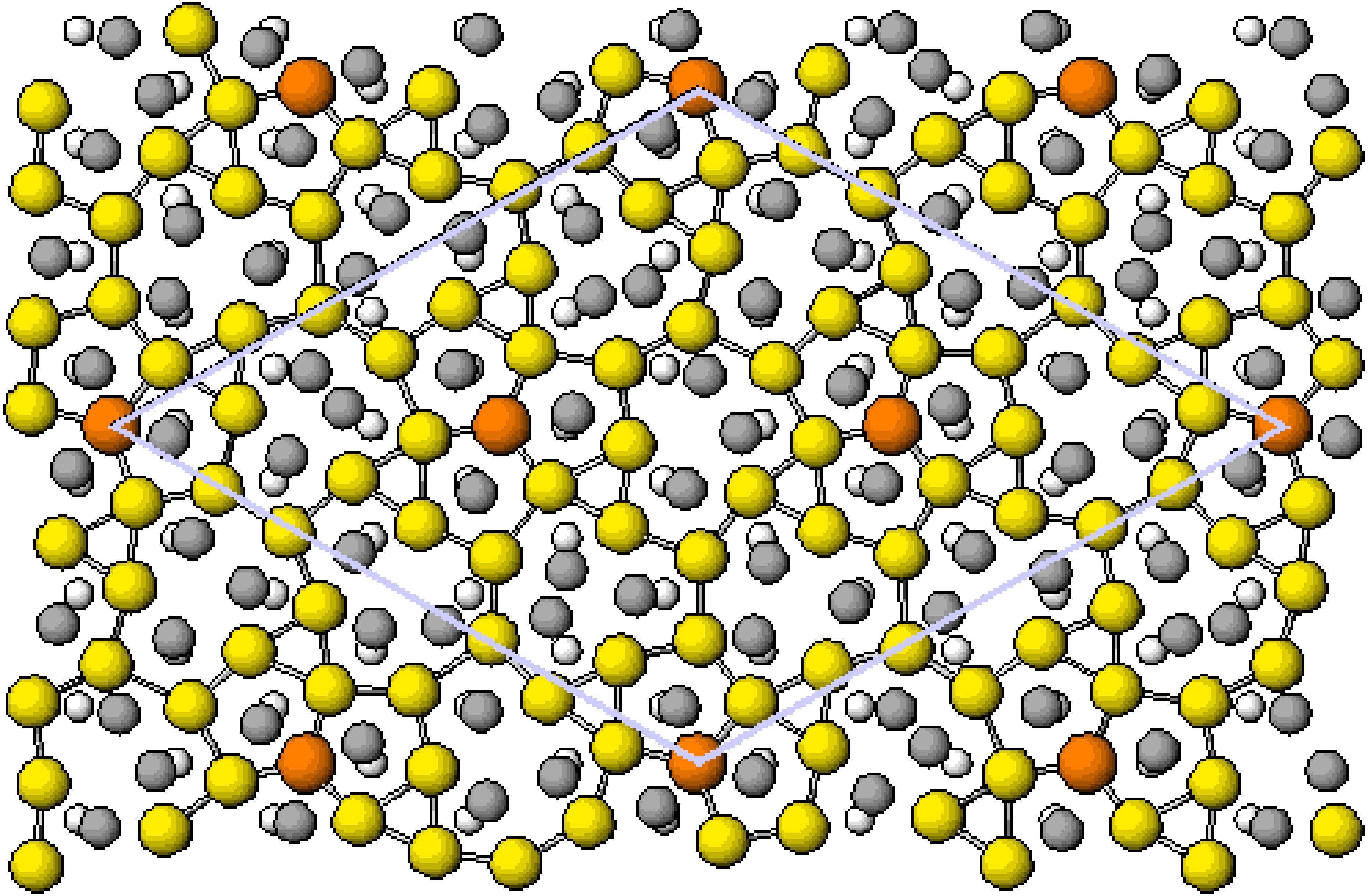
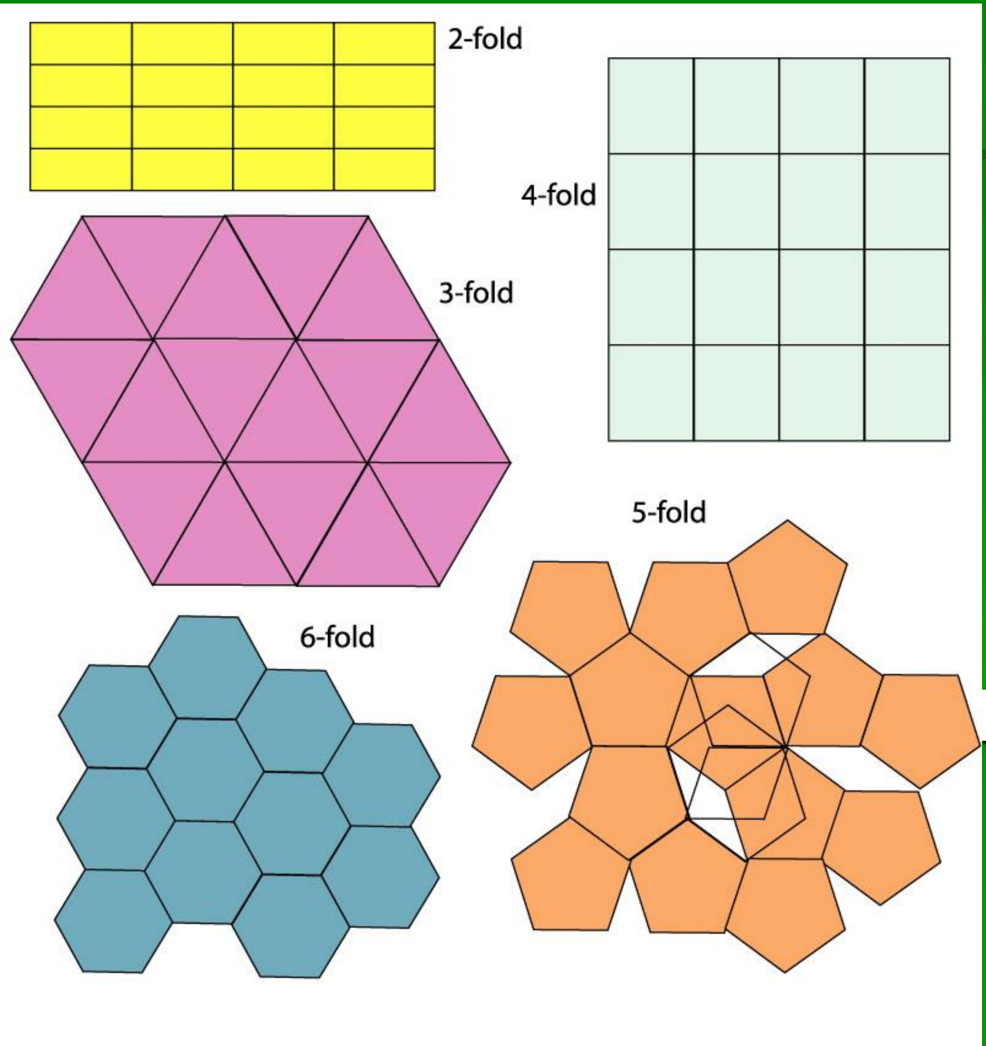


TABLE 12.3 The 230 Space Groups, and the 32 Crystal Classes (Point Groups). The Space Group Symbols Are, in General, Unabbreviated.

Crystal Class	*Space Group*
1	$P1$
$\bar{1}$	$P\bar{1}$
2	$P2$, $P2_1$, $C2$
m	Pm, Pc, Cm, Cc
$2/m$	$P2/m$, $P2_1/m$, $C2/m$, $P2/c$, $P2_1/c$, $C2/c$
222	$P222$, $P222_1$, $P2_12_12$, $P2_12_12_1$, $C222_1$, $C222$, $F222$, $I222$, $I2_12_12_1$
$mm2$	$Pmm2$, $Pmc2_1$, $Pcc2$, $Pma2$, $Pca2_1$, $Pnc2$, $Pmn2_1$, $Pba2$, $Pna2_1$, $Pnn2$, $Cmm2$, $Cmc2_1$, $Ccc2$, $Amm2$, $Abm2$, $Ama2$, $Aba2$, $Fmmc$, $Fdd2$, $Imm2$, $Iba2$, $Ima2$
$2/m2/m2/m$	$P2/m2/m2/m$, $P2/n2/n2/n$, $P2/c2/c2/m$, $P2/b2/a2/n$, $P2_1/m2/m2/a$, $P2/n2_1/n2/a$, $P2/m2/n2_1/a$, $P2_1/c2/c2/a$, $P2_1/b2_1/a2/m$, $P2_1/c2_1/c2/n$, $P2/b2_1/c2/m$, $P2_1/n2_1/n2/m$, $P2_1/m2_1/m2/n$, $P2_1/b2/c2_1/n$, $P2_1/b2_1/c2_1/a$, $P2_1/n2_1/m2_1/a$, $C2/m2/c2/m$, $C2/m2/c2_1/a$, $C2/m2/m2/m$, $C2/c2/c2/m$, $C2/m2/m2/a$, $C2/c2/c2/a$, $F2/m2/m2/m$, $F2/d2/d2/d$, $I2/m2/m2/m$, $I2/b2/a2/m$, $I2/b2/c2/a$, $I2/m2/m2/a$,
4	$P4$, $P4_1$, $P4_2$, $P4_3$, $I4$, $I4_1$
$\bar{4}$	$P\bar{4}$, $I\bar{4}$
$4/m$	$P4/m$, $P4_2/m$, $P4/n$, $P4_2/n$, $I4/m$, $I4_1/a$
422	$P422$, $P42_12$, $P4_122$, $P4_12_12$, $P4_222$, $P4_22_12$, $P4_322$, $P4_32_12$, $I422$, $I4_122$
$4mm$	$P4mm$, $P4bm$, $P4_2cm$, $P4_2nm$, $P4cc$, $P4nc$, $P4_2mc$, $P4_2bc$, $I4mm$, $I4cm$, $I4_1md$, $I4_1cd$
$\bar{4}2m$	$P\bar{4}2m$, $P\bar{4}2c$, $P\bar{4}2_1m$, $P\bar{4}2_1c$, $P\bar{4}m2$, $P\bar{4}c2$, $P\bar{4}b2$, $P\bar{4}n2$, $I\bar{4}m2$, $I\bar{4}c2$, $I\bar{4}2m$, $I\bar{4}2d$
$4/m2/m2/m$	$P4/m2/m2/m$, $P4/m2/c2/c$, $P4/n^2/b^2/m$, $P4/n2/n2/c$, $P4/m2_1/b2/m$, $P4/m2_1/n2/c$, $P4/n2_1/m2/m$, $P4/n2_1/c2/c$, $P4_1/m2/m2/c$, $P4_2/m2/c2/m$, $P4_2/n2/b2/c$, $P4_2/n2/n2/m$, $P4_2/m2_1/b2/c$, $P4_2/m2_1/n2/m$, $P4_1/n2_1/m2/c$, $P4_2/n2_1/c2/m$, $I4/m2/m2/m$, $I4/m^2/c^2/m$, $I4_1/a2/m2/d$, $I4_1/a2/c2/d$
3	$P3$, $P3_1$, $P3_2$, $R3$
$\bar{3}$	$P\bar{3}$, $R\bar{3}$
32	$P312$, $P321$, $P3_112$, $P3_121$, $P3_212$, $P3_221$, $R32$
$3m$	$P\bar{3}m1$, $P\bar{3}1m$, $P\bar{3}c1$, $P\bar{3}1c$, $R\bar{3}m$, $R\bar{3}c$
$\bar{3}2/m$	$P31m$, $P31c$, $P3m1$, $P3c1$, $R3m$, $R3c$
6	$P6$, $P6_1$, $P6_5$, $P6_2$, $P6_4$, $P6_3$
$\bar{6}$	$P\bar{6}$
$6/m$	$P6/m$, $P6_3/m$
622	$P622$, $P6_122$, $P6_522$, $P6_222$, $P6_422$, $P6_322$
$6mm$	$P6mm$, $P6cc$, $P6_3cm$, $P6_3mc$
$\bar{6}m2$	$P\bar{6}m2$, $P\bar{6}c2$, $P\bar{6}2m$, $P\bar{6}2c$
$6/m2/m2/m$	$P6/m2/m2/m$, $P6/m2/c2/c$, $P6_3/m2/c2/m$, $P6_3/m2/m2/c$
23	$P23$, $F23$, $I23$, $P2_13$, $I2_13$
$2/m\bar{3}$	$P2/m\bar{3}$, $P2/n\bar{3}$, $F2/m\bar{3}$, $F2/d\bar{3}$, $I2/m\bar{3}$, $P2_1/a\bar{3}$, $I2_1/a\bar{3}$
432	$P432$, $P4_232$, $F432$, $F4_132$, $I432$, $P4_332$, $P4_132$, $I4_132$
$\bar{4}3m$	$P\bar{4}3m$, $F\bar{4}3m$, $I\bar{4}3m$, $P\bar{4}3n$, $F\bar{4}3c$, $I\bar{4}3d$
$4/m\bar{3}2/m$	$P4/m\bar{3}2/m$, $P4/n\bar{3}2/n$, $P4_2/m\bar{3}2/n$, $P4_2/n\bar{3}2/m$, $F4/m\bar{3}2/m$, $F4/m\bar{3}2/c$, $P4_1/d\bar{3}2/m$, $F4_1/d\bar{3}2/c$, $I4/m\bar{3}2/m$, $I4_1/a\bar{3}2/d$

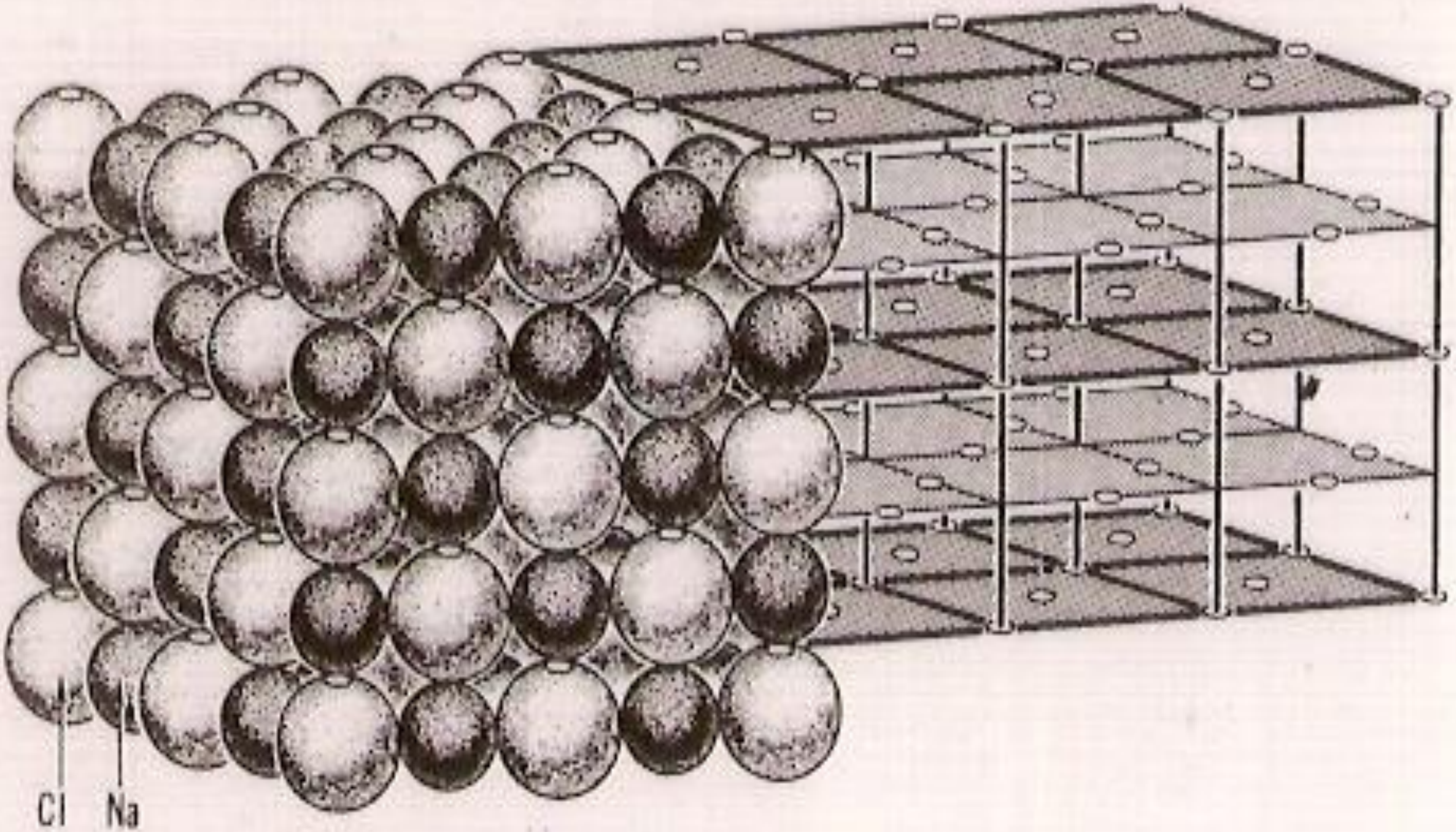
SOURCE: From *International Tables for Crystallography*, vol. A, 1983, D. Reidel Publishing Co., Dordrecht, The Netherlands.

Translações



- A simetria do retículo e a simetria do grupo pontual se inter-relacionam, porque ambas são propriedades do padrão de simetria global

- Este é o motivo pelo qual eixos de simetria rotacional de ordem 5 e > 6 não funcionam em cristais



Cl
Na

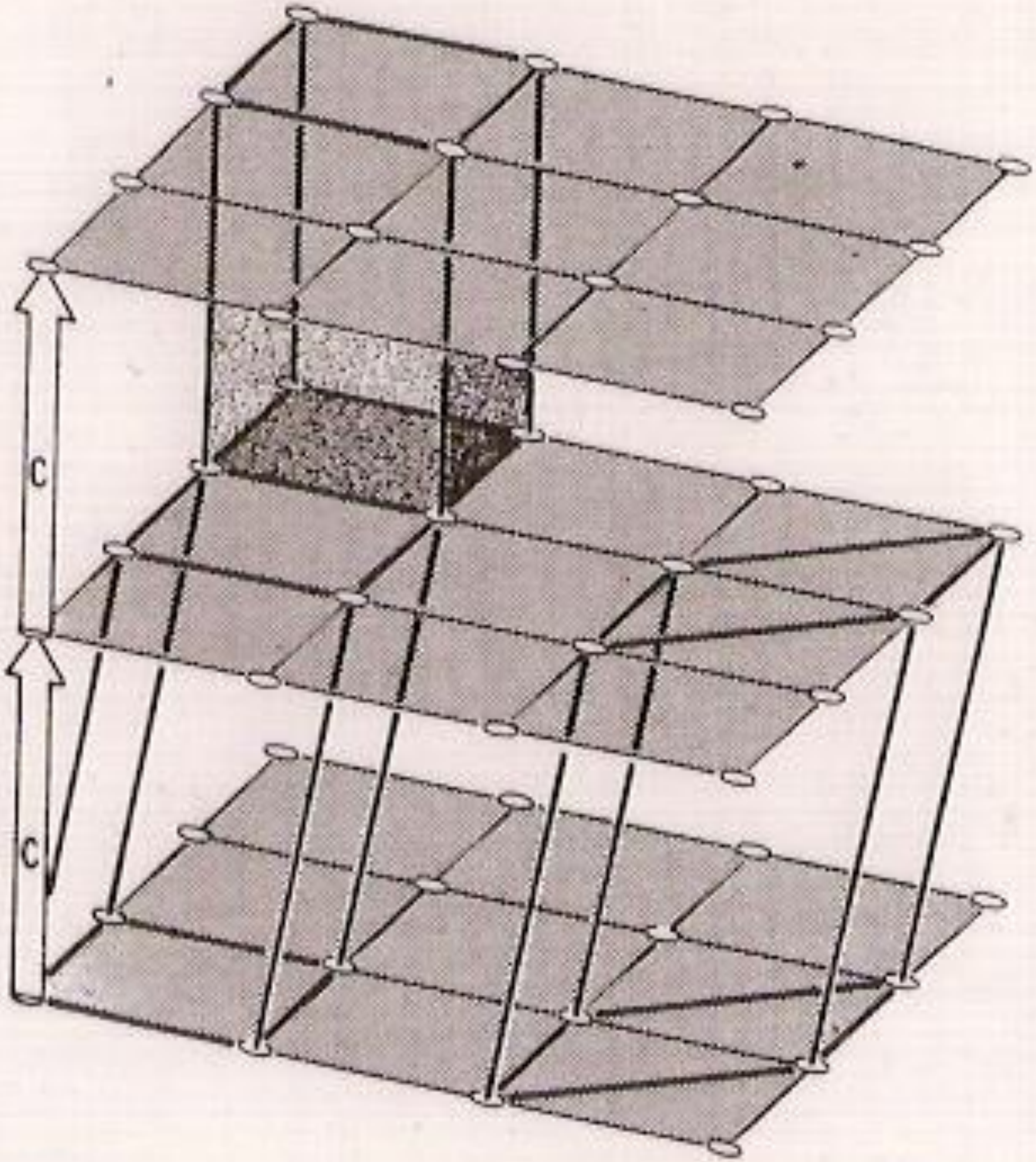


FIGURE 6-12

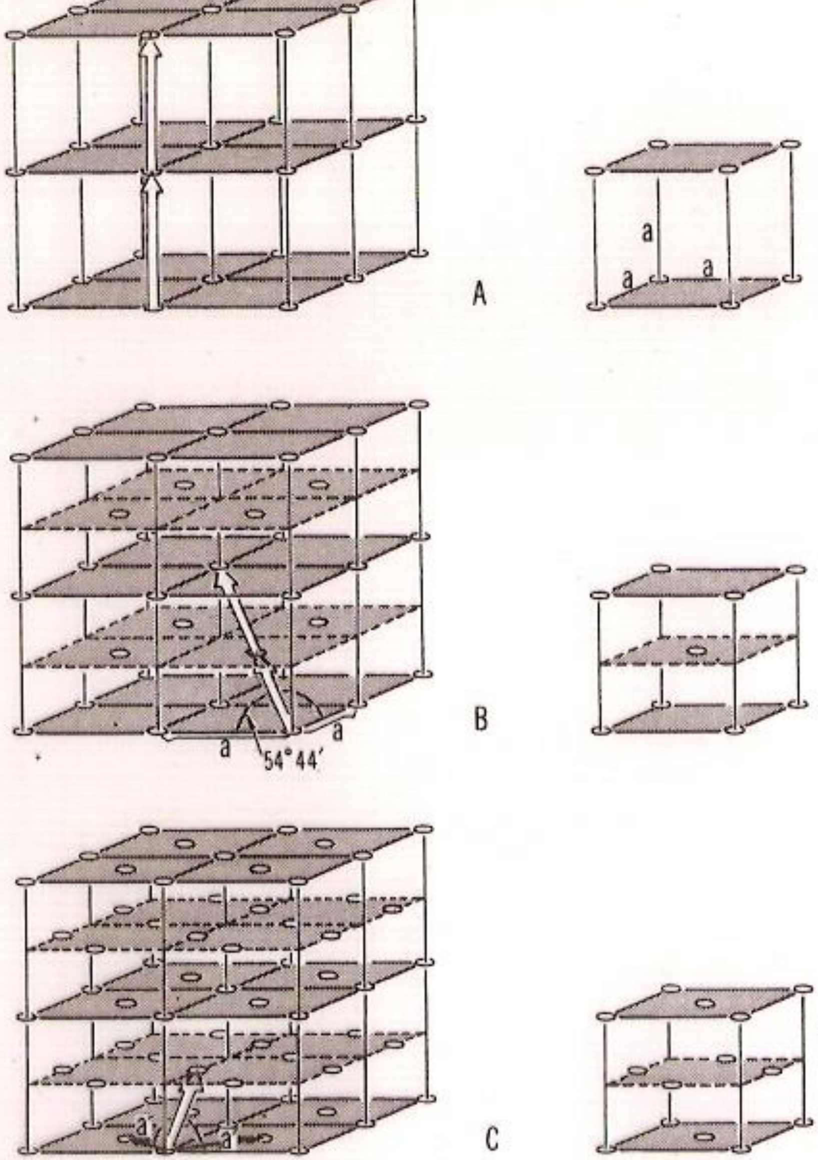


FIGURE 6–7

The three types of isometric lattices: (A) primitive P, (B) body centered I, (C) face centered F. These lattices result if tetranets are translated by a stacking vector (hollow arrow) which is (A) at 90° to the tetranet and equal in length to **a**, the shortest unit of translation *within* the plane of the tetranet; (B) at 54°44′ to each **a** vector but equal in length to 0.866 **a**; (C) at 45° to the tetranet but at 60° to each of the within-net vectors labeled **a′**, the stacking vector now equaling **a′** in length. A single unit cell is shown at the right for each lattice.

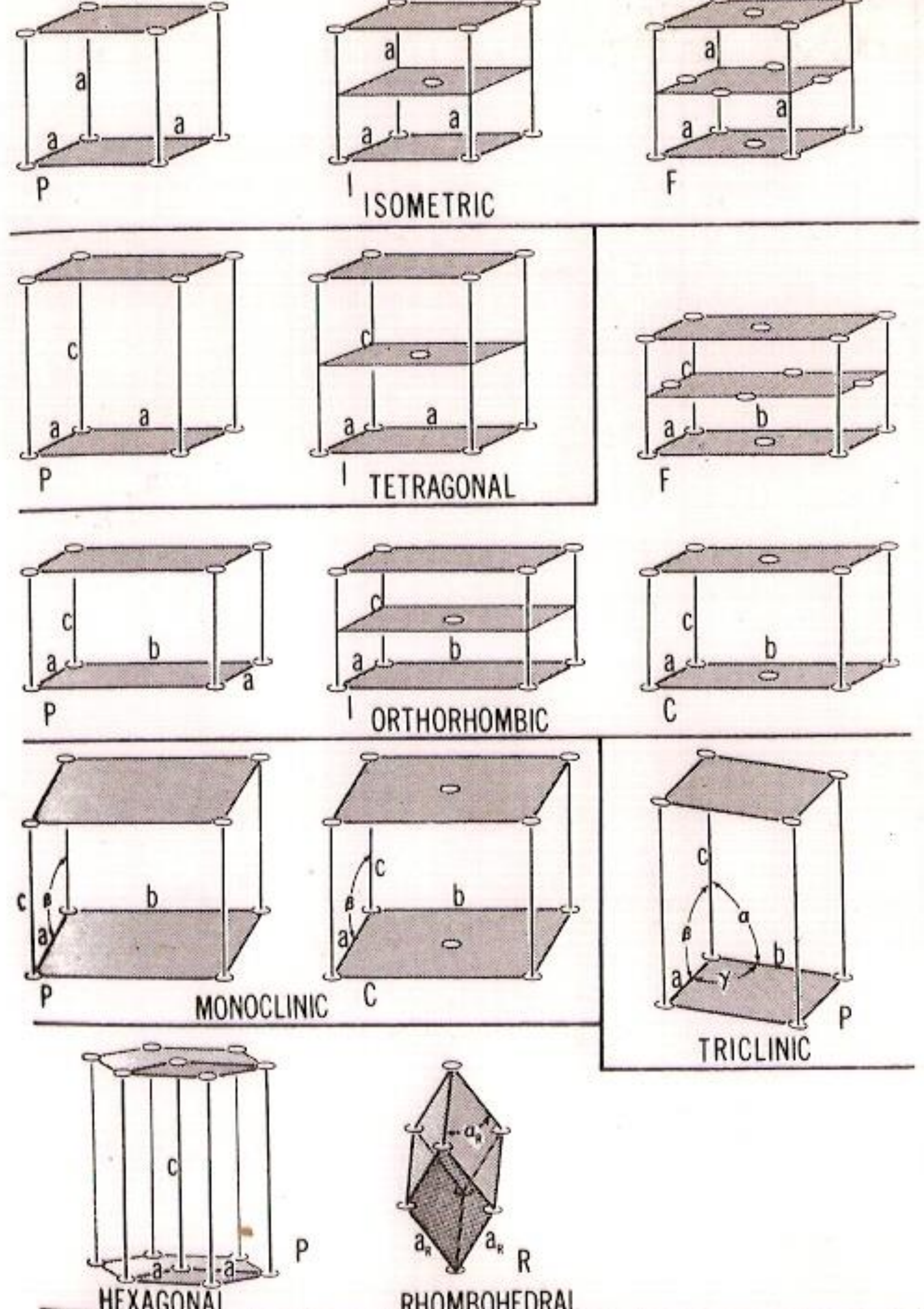


FIGURE 6–13

The unit cells for the 14 possible types of space lattices.

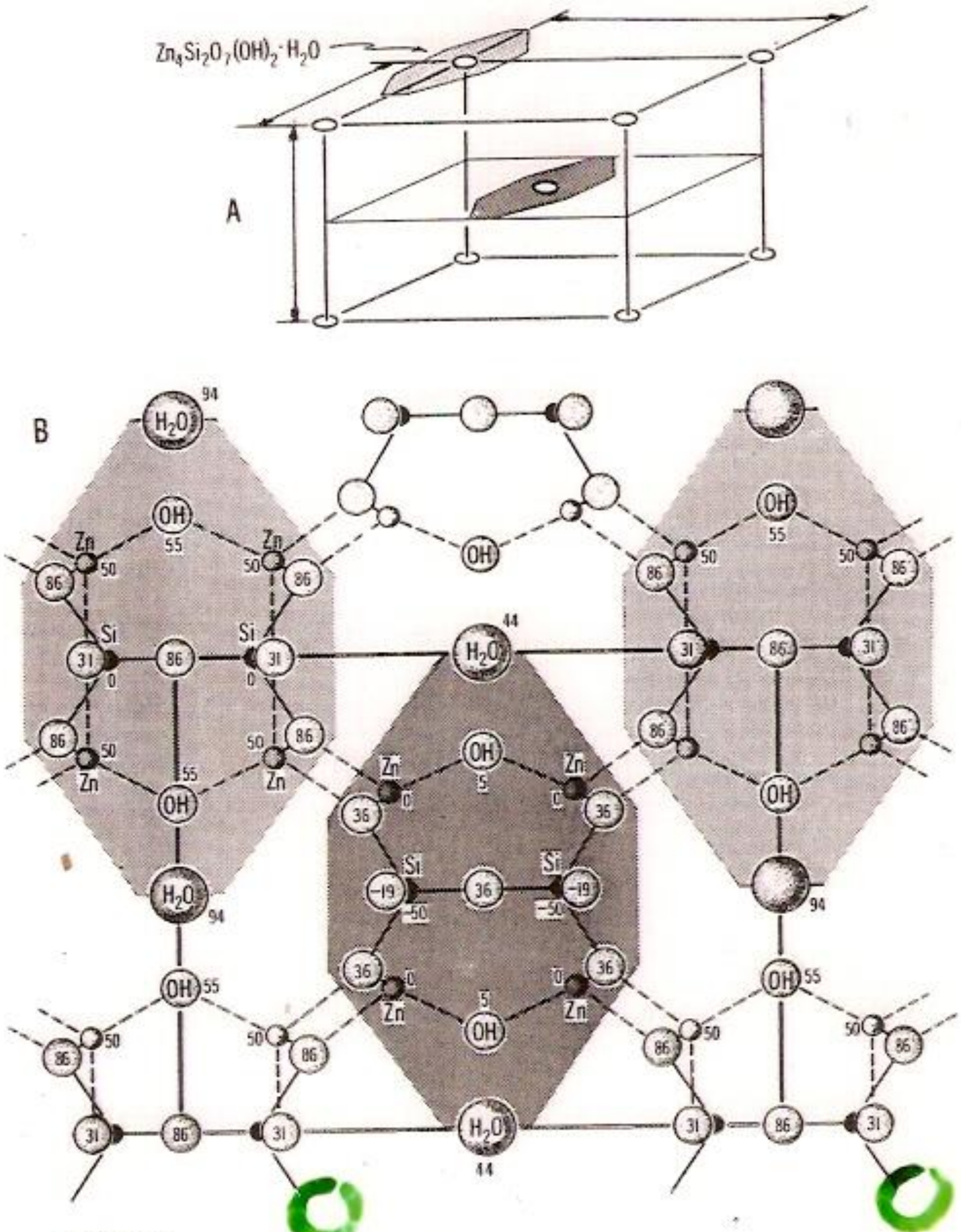
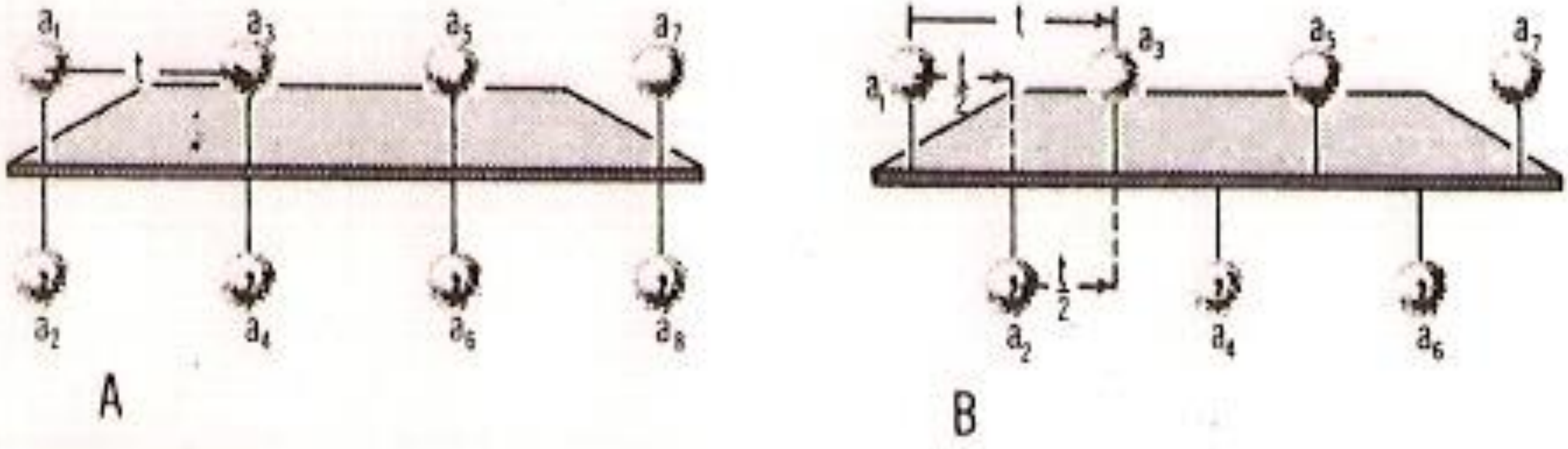


FIGURE 7-1


a1
a3
a5
a7
t
a2
a4
a6
a8
A
t
a1
t/2
a3
a5
a7
a2
t/2
a4
a6
B

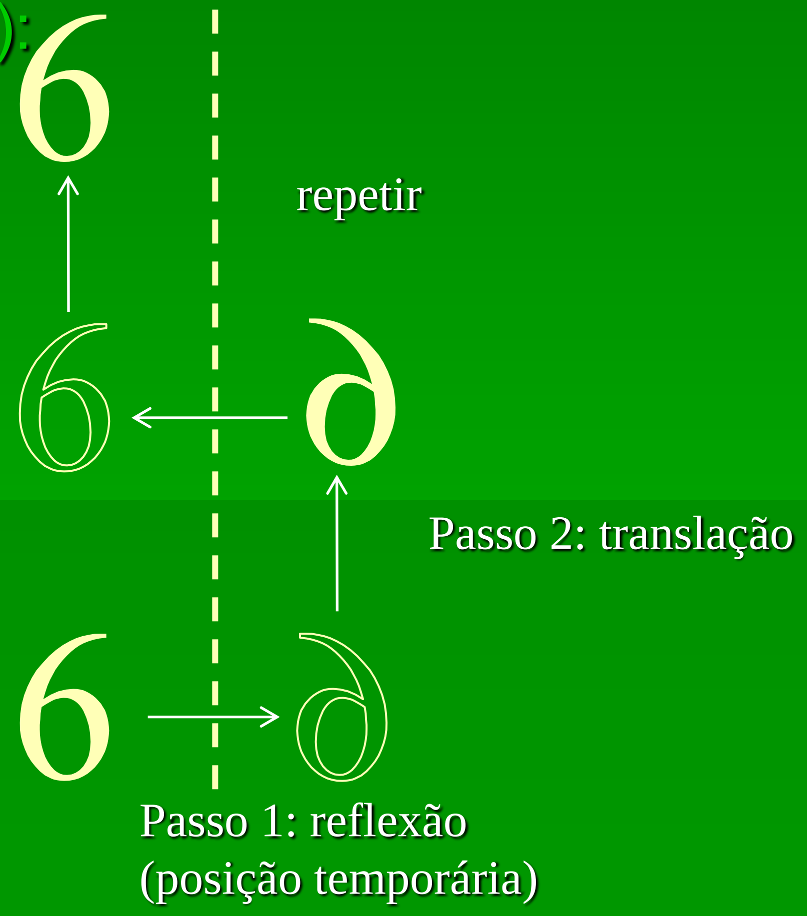
Translações

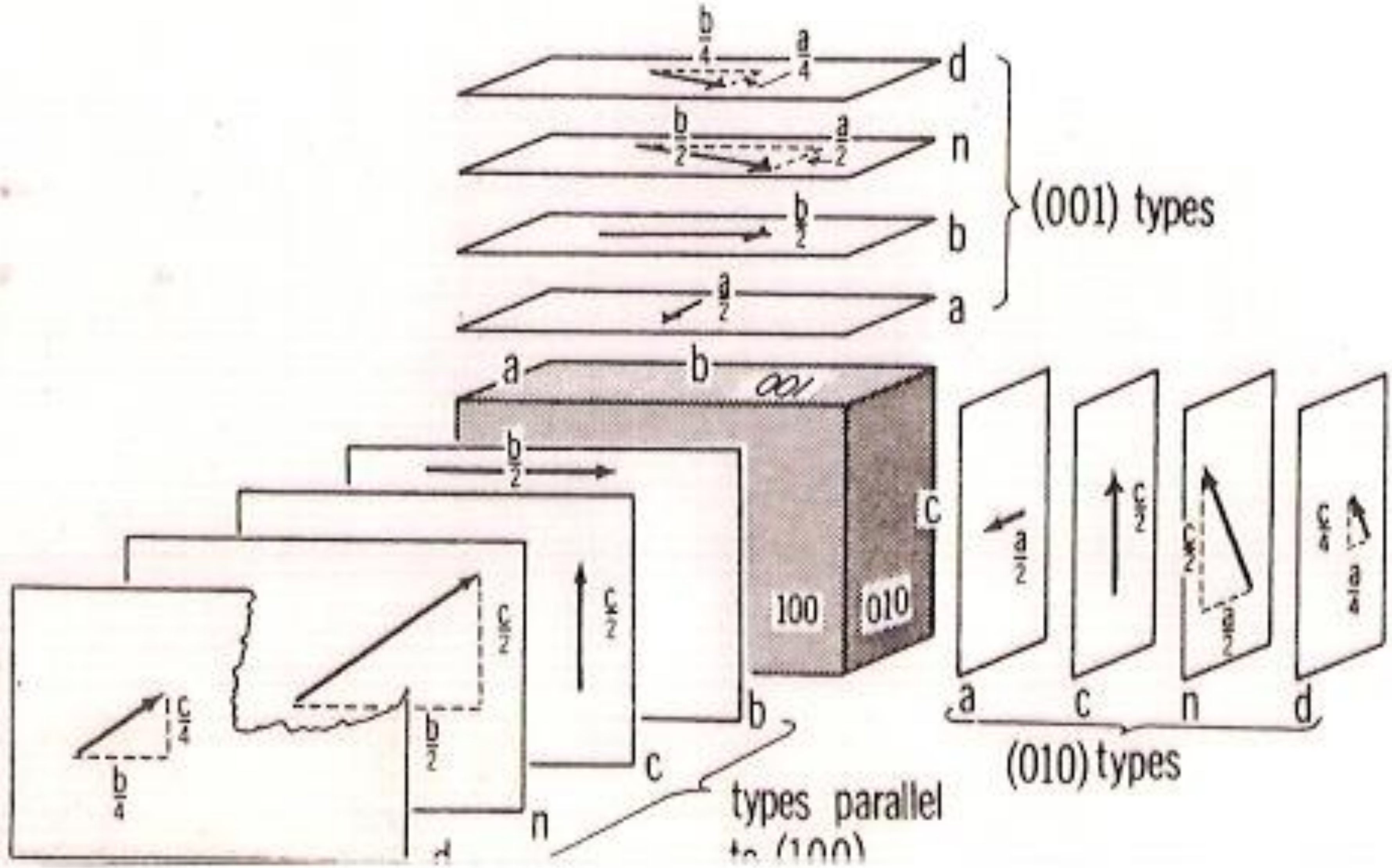
Existe uma nova operação de simetria 2-D quando consideramos translações

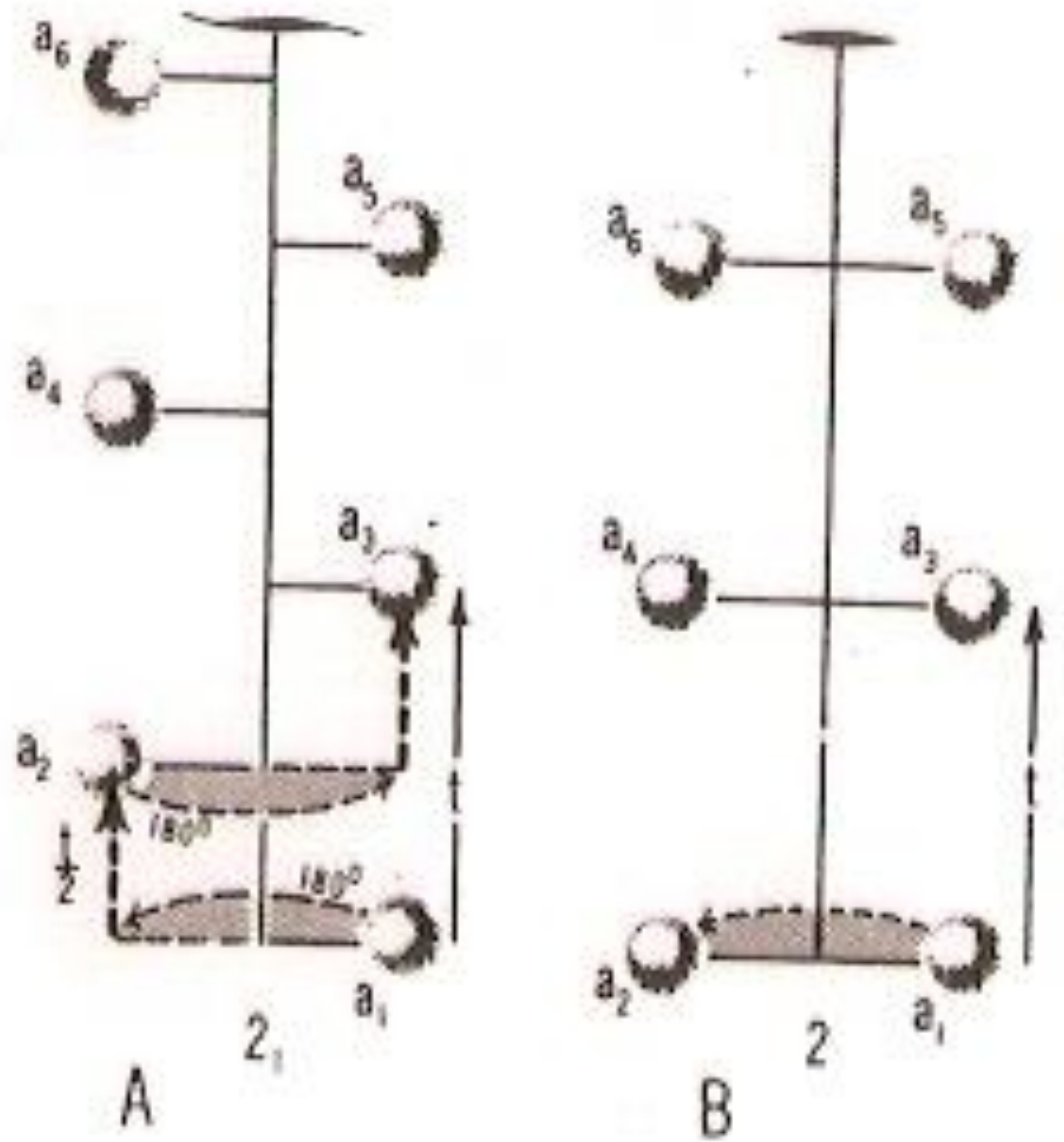
O Plano Deslizante ("Glide Plane"):

Uma reflexão combinada

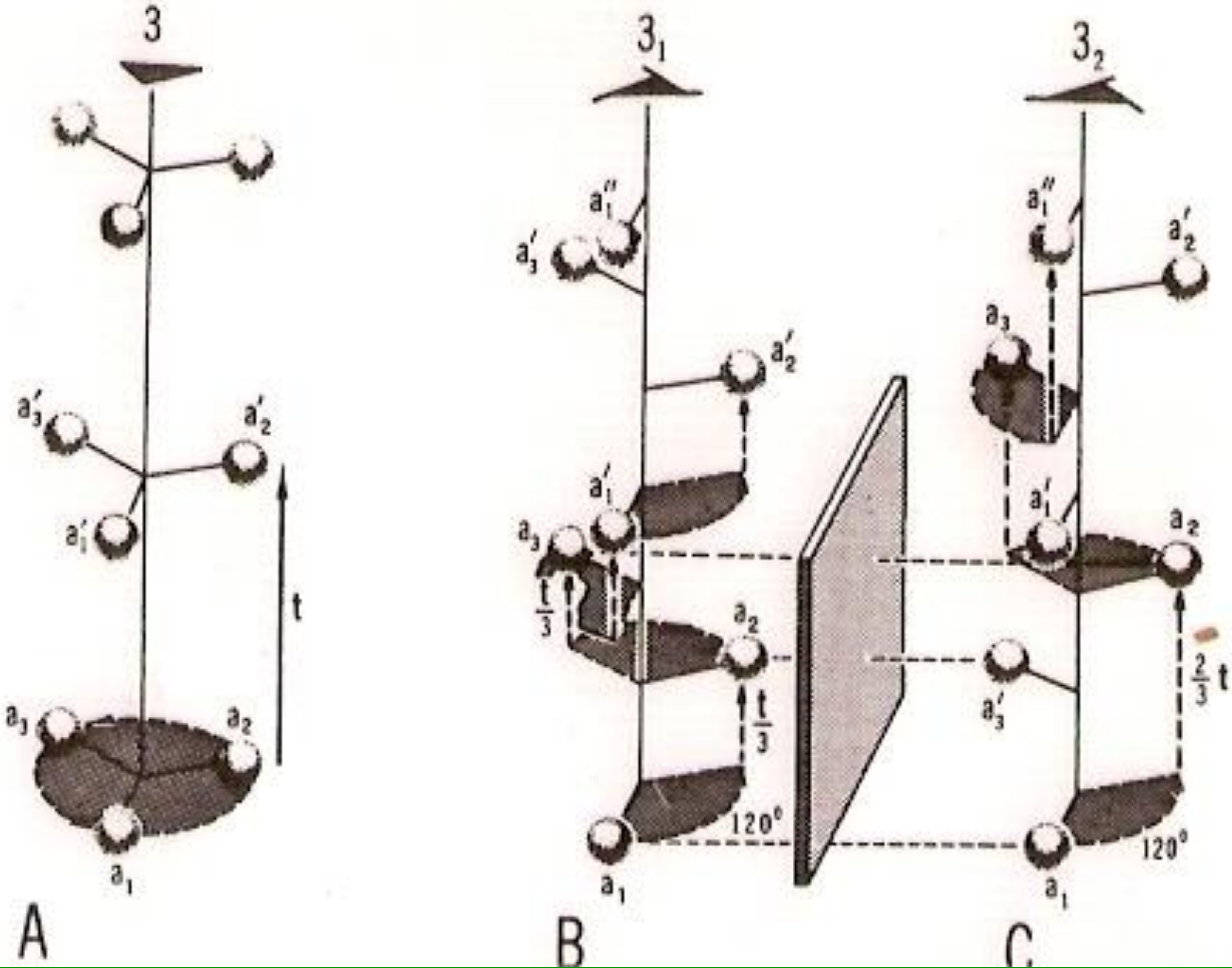
com translação

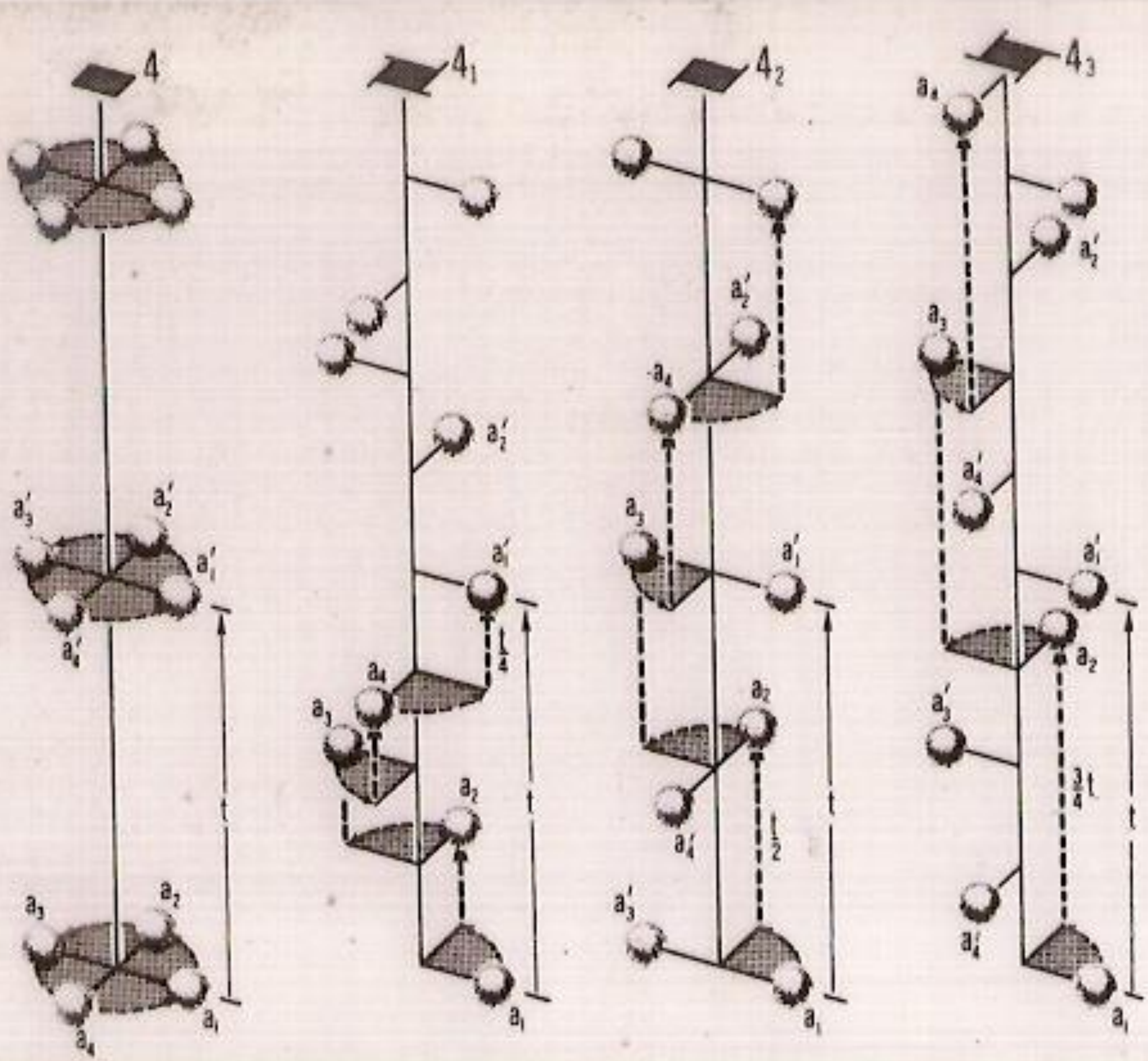



d
n
b
a
(001) types
001
100
010
a
c
n
d
(010) types
b
c
n
types parallel



a6
a5
a4
a3
a2
180°
1/2
180°
a1
2₁
A
a6
a5
a4
a3
a2
a1
2
B




4
4_1
4_2
4_3
a_1
a_2
a_3
a_4
a'_1
a'_2
a'_3
a'_4
$-a_4$
t
$\frac{t}{4}$
$\frac{t}{2}$
$\frac{3}{4}t$

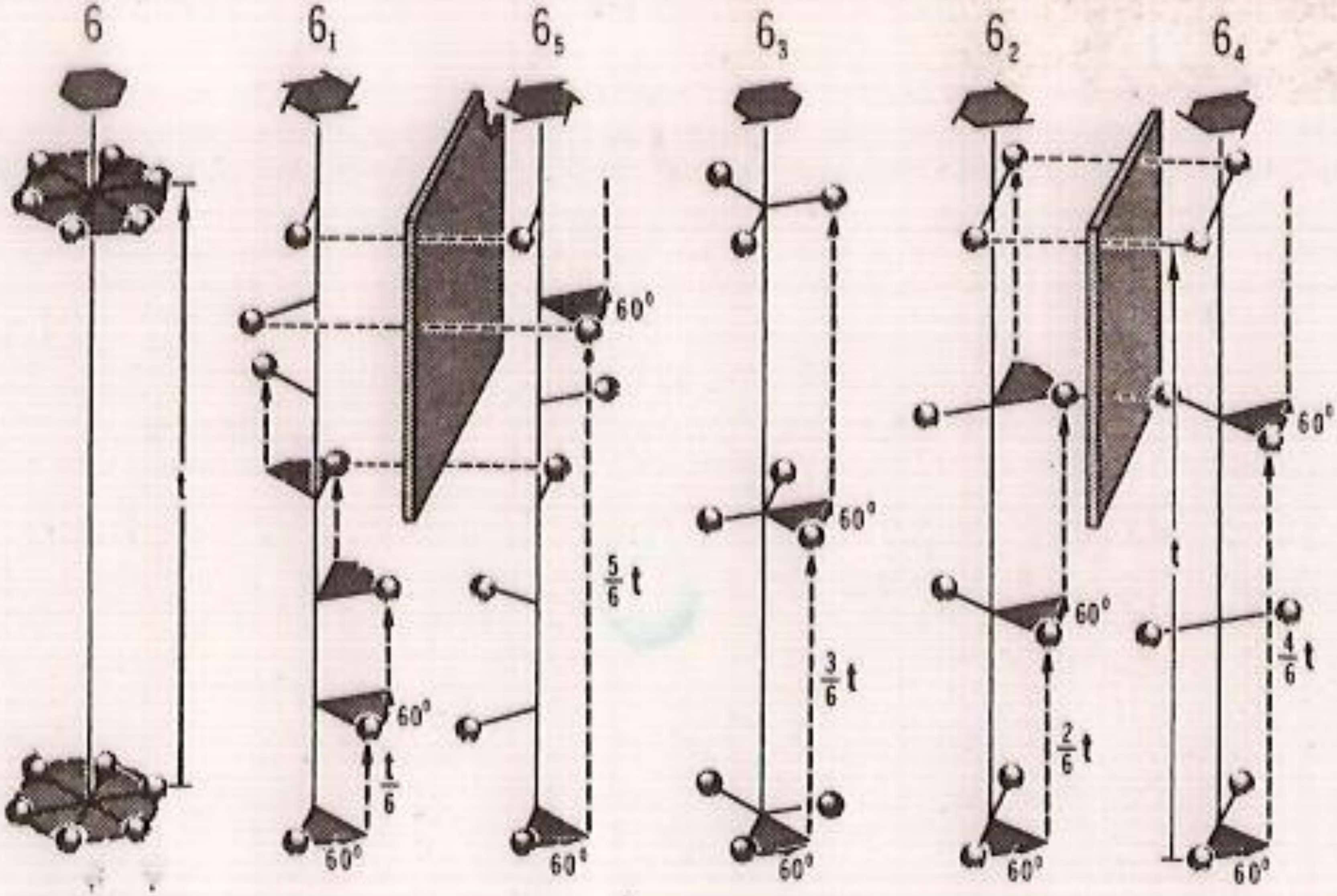
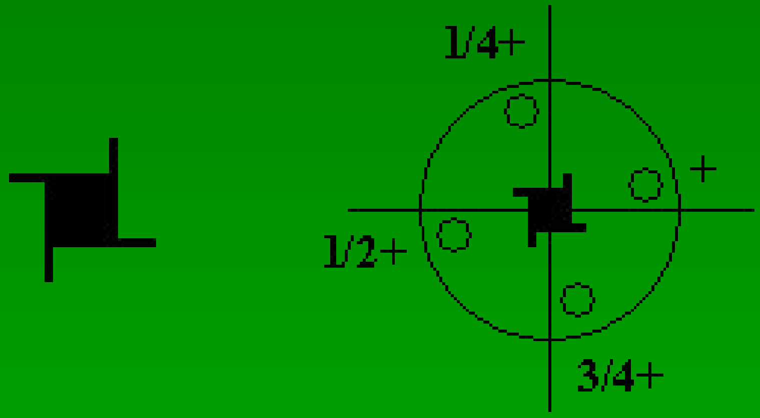


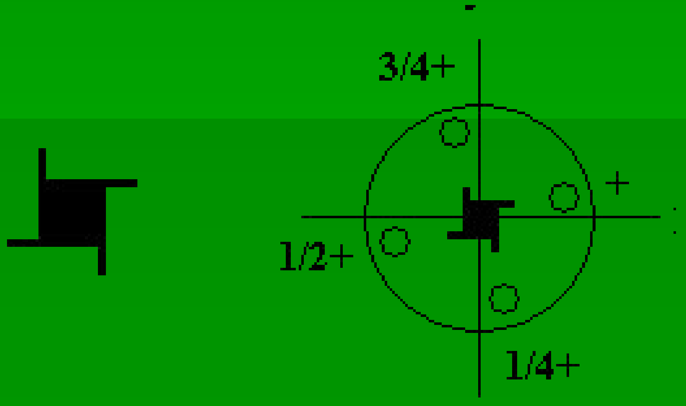
FIGURE 7–7

Exemplos de
eixos helicoidais:

4_1



4_3



Projeções de eixos de rotação e eixos helicoidais

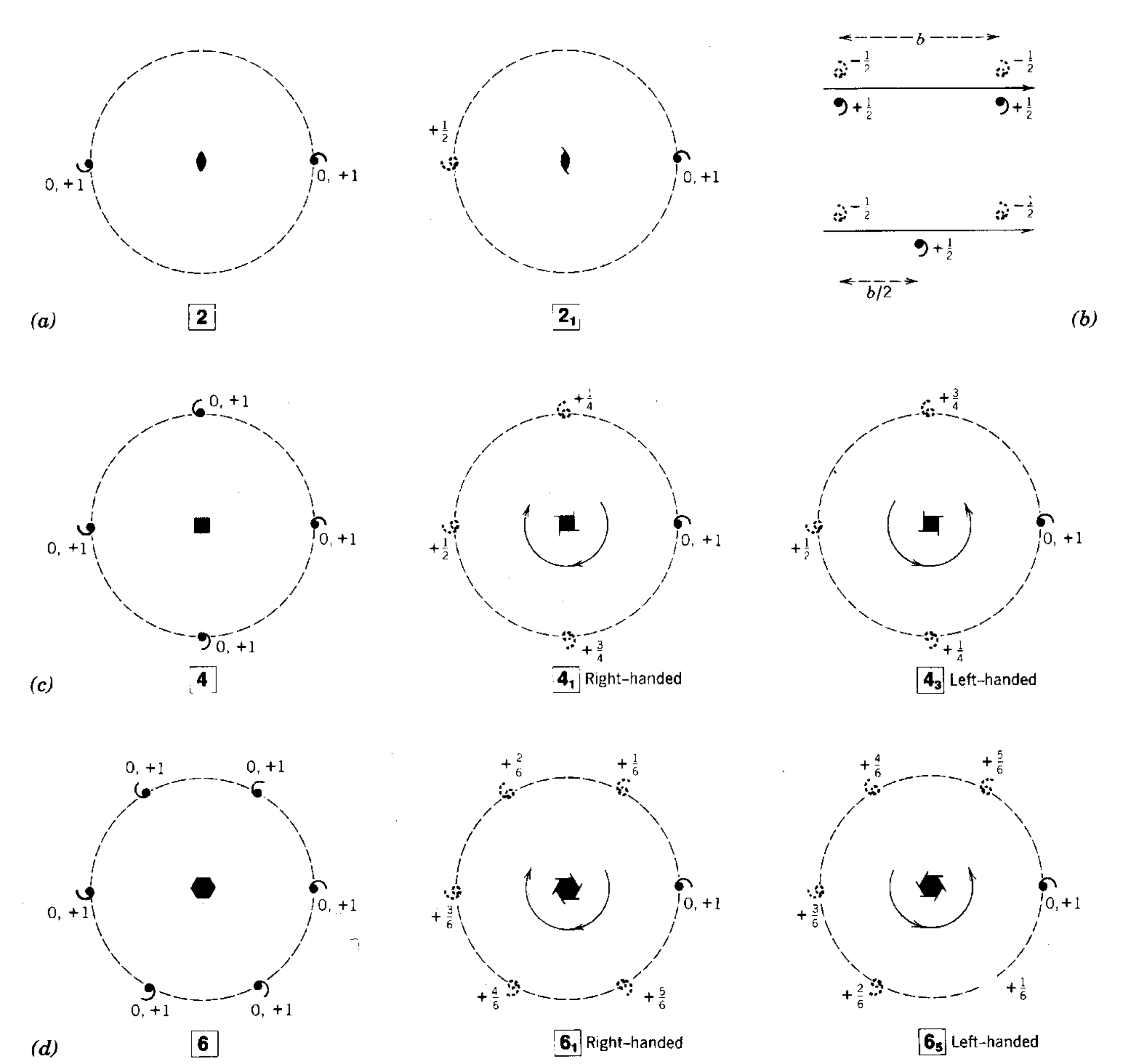


FIGURE 11.6 Graphical derivation of the total symmetry content in C222. See text for discussion.

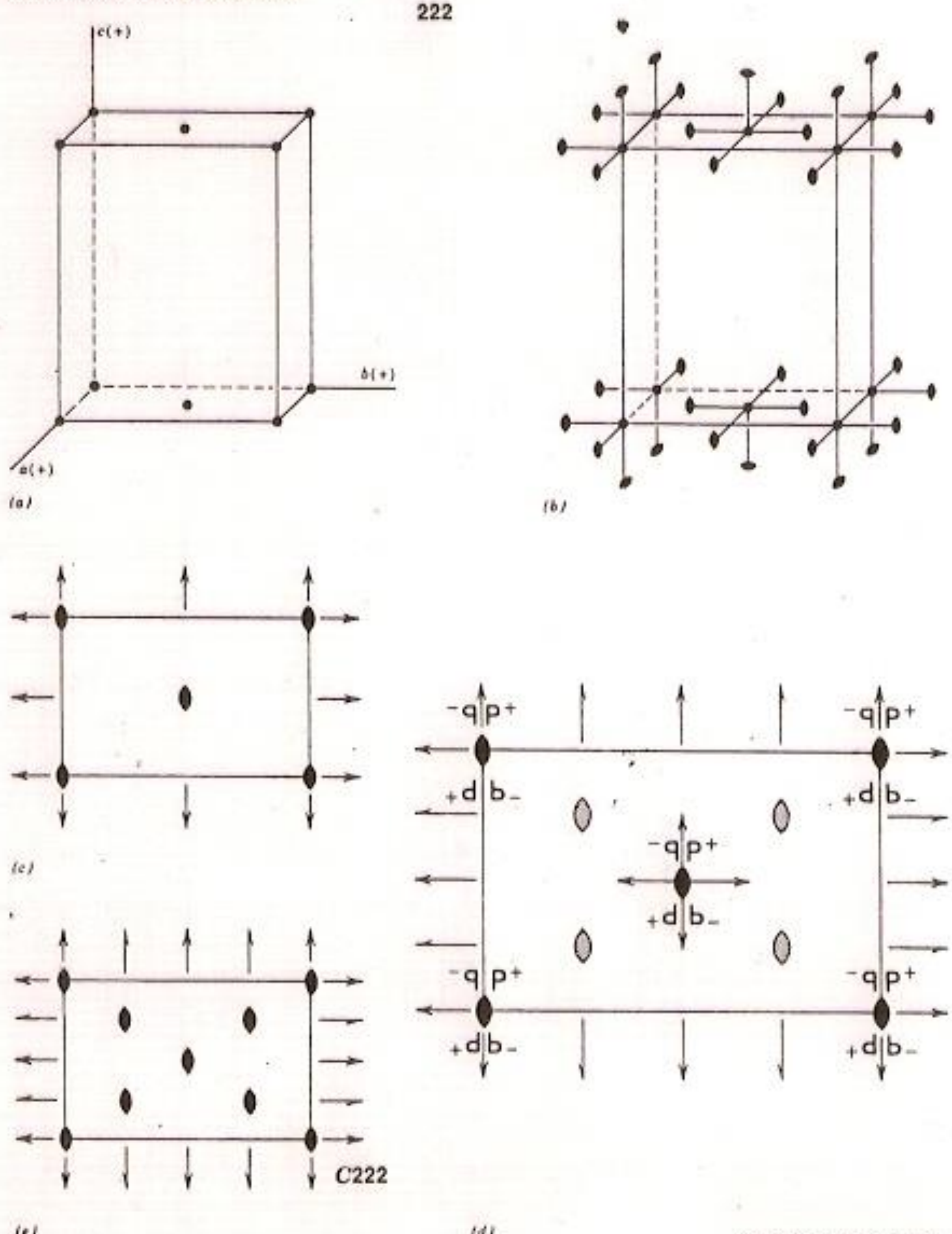
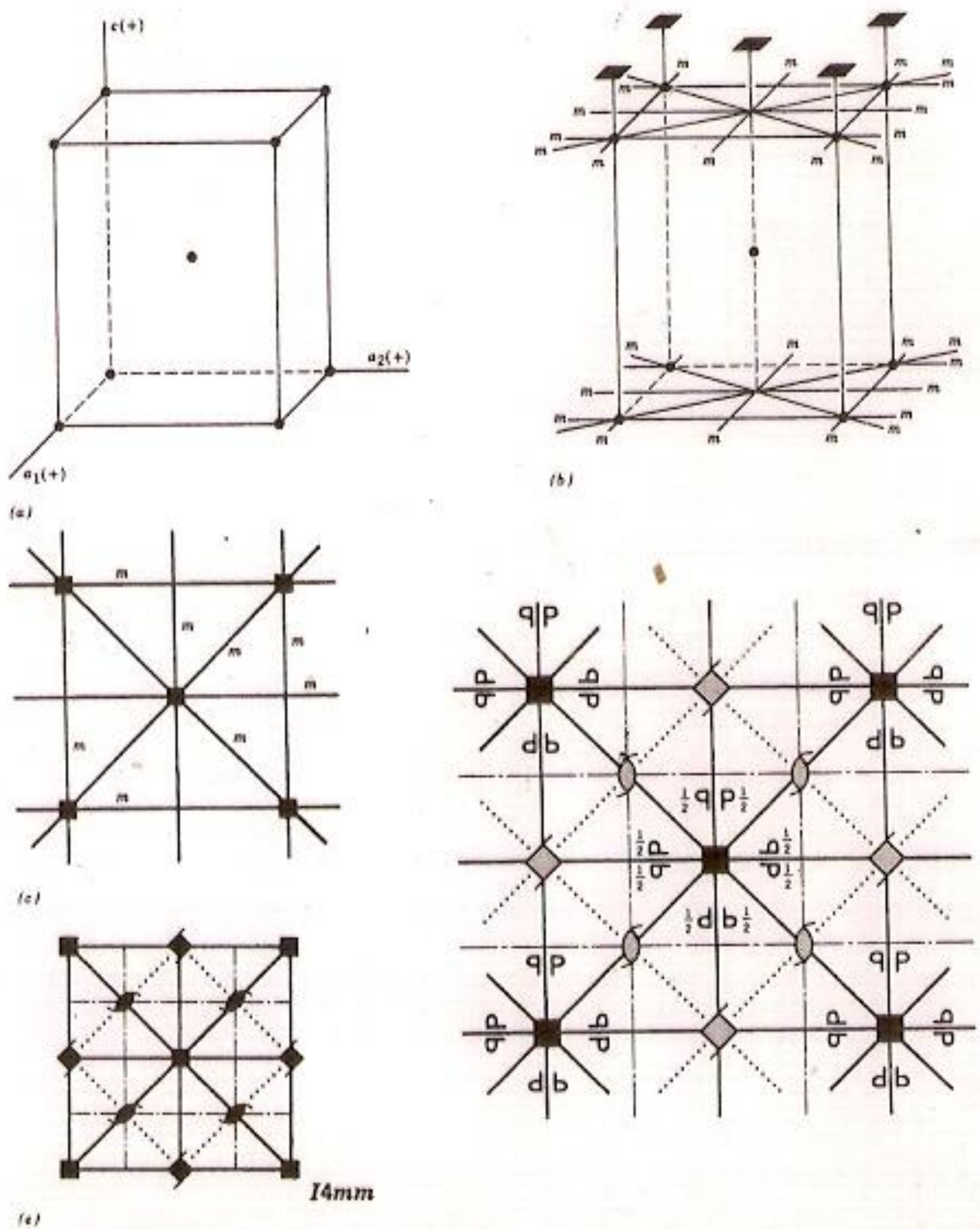
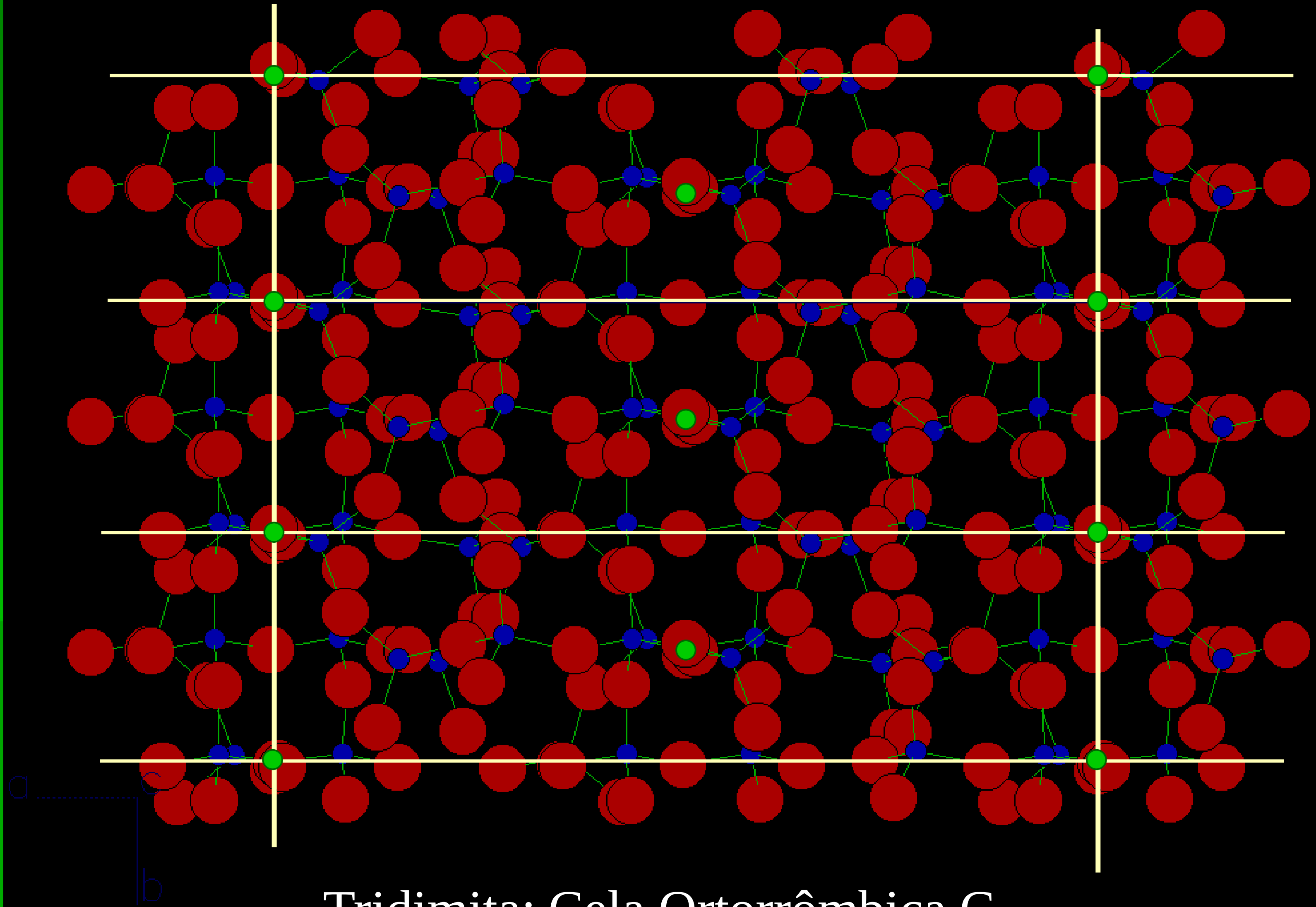


FIGURE 11.7 Graphical derivation of the total symmetry content in *I4mm*. See text for discussion.



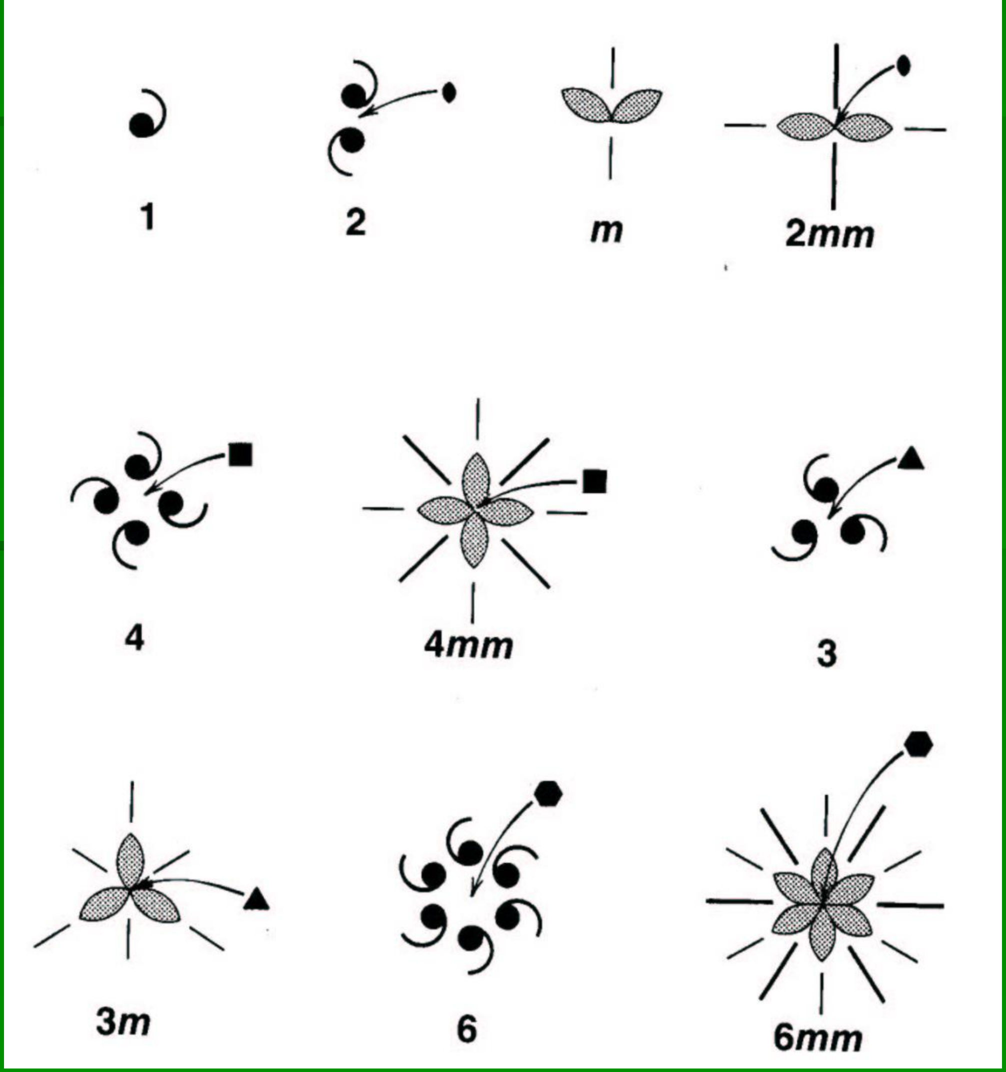


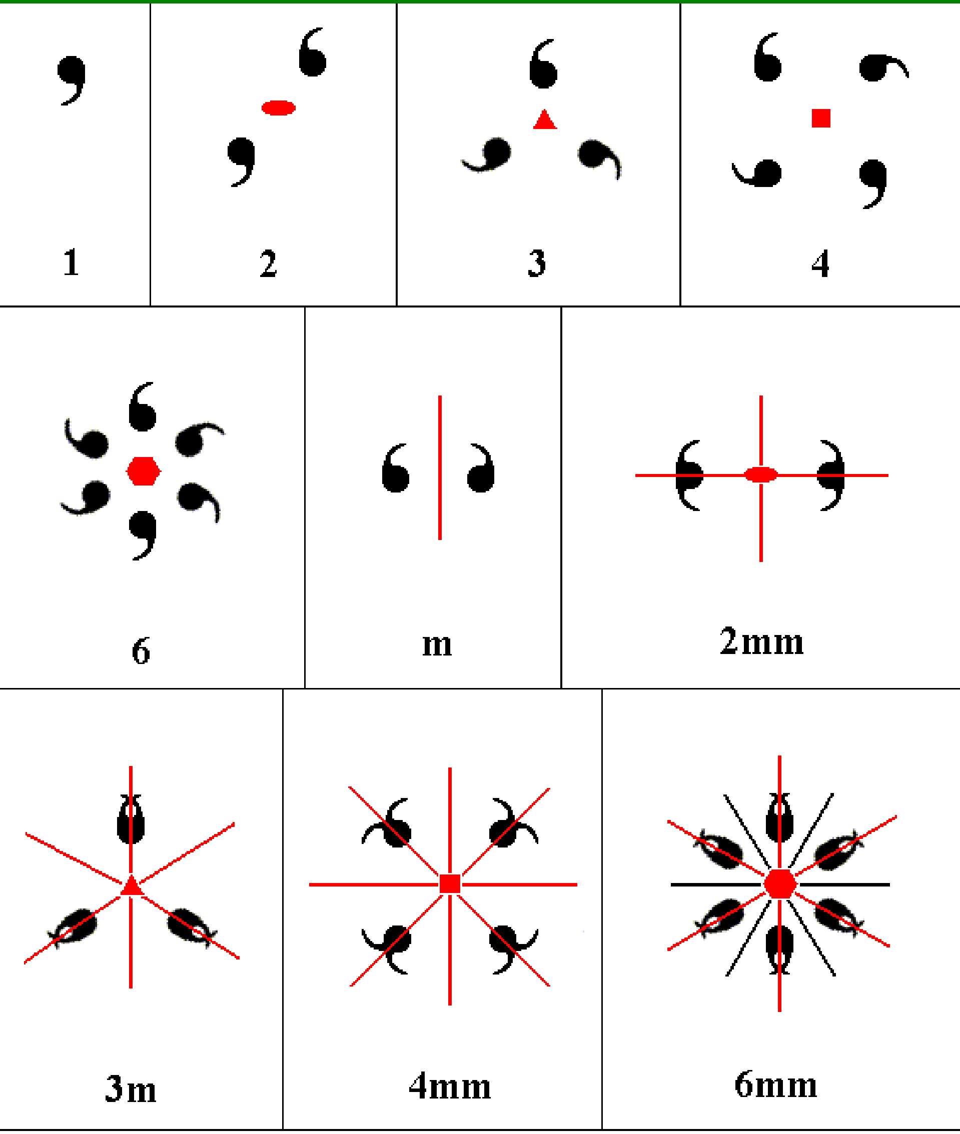
Tridimita: Cela Ortorrômbica C

Simetria

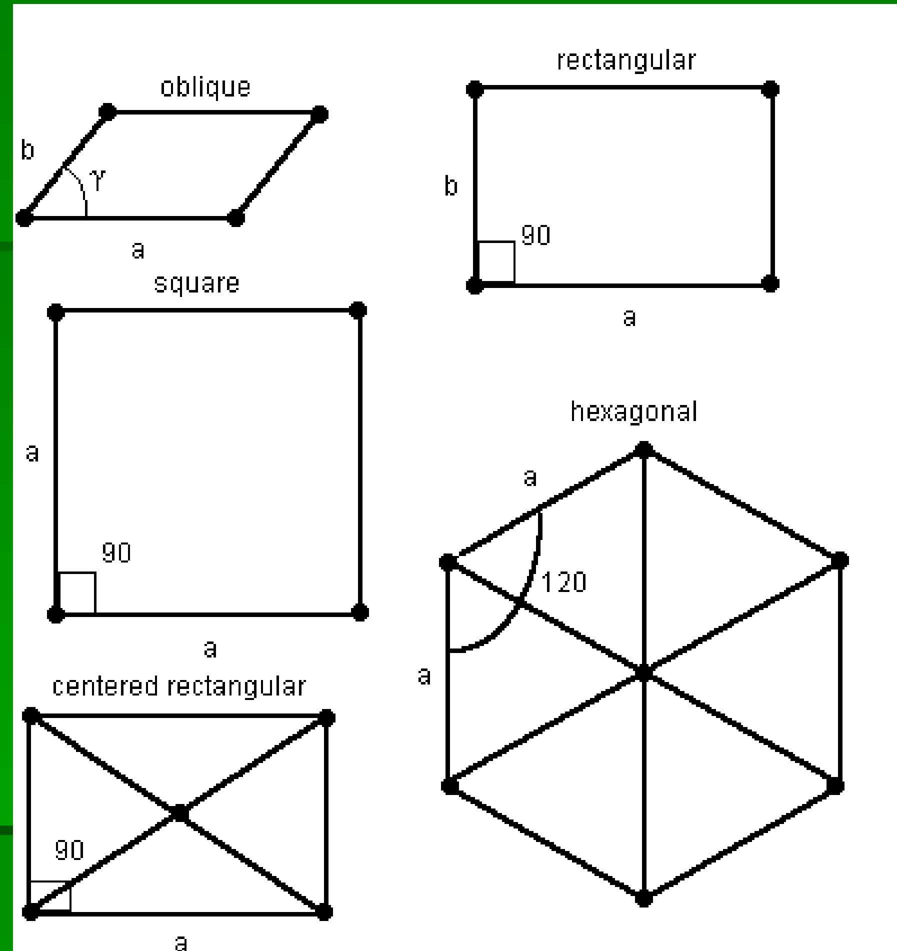
Motivos planos (2-D)

Apenas 10 possibilidades de simetria





The Ten Planar Point Groups



= 17 grupos planares

Os 17 Grupos Espaciais 2-D

- Grupos Espaciais 2-D resumem todas as possibilidades de combinação de retículos e motivos 2-D

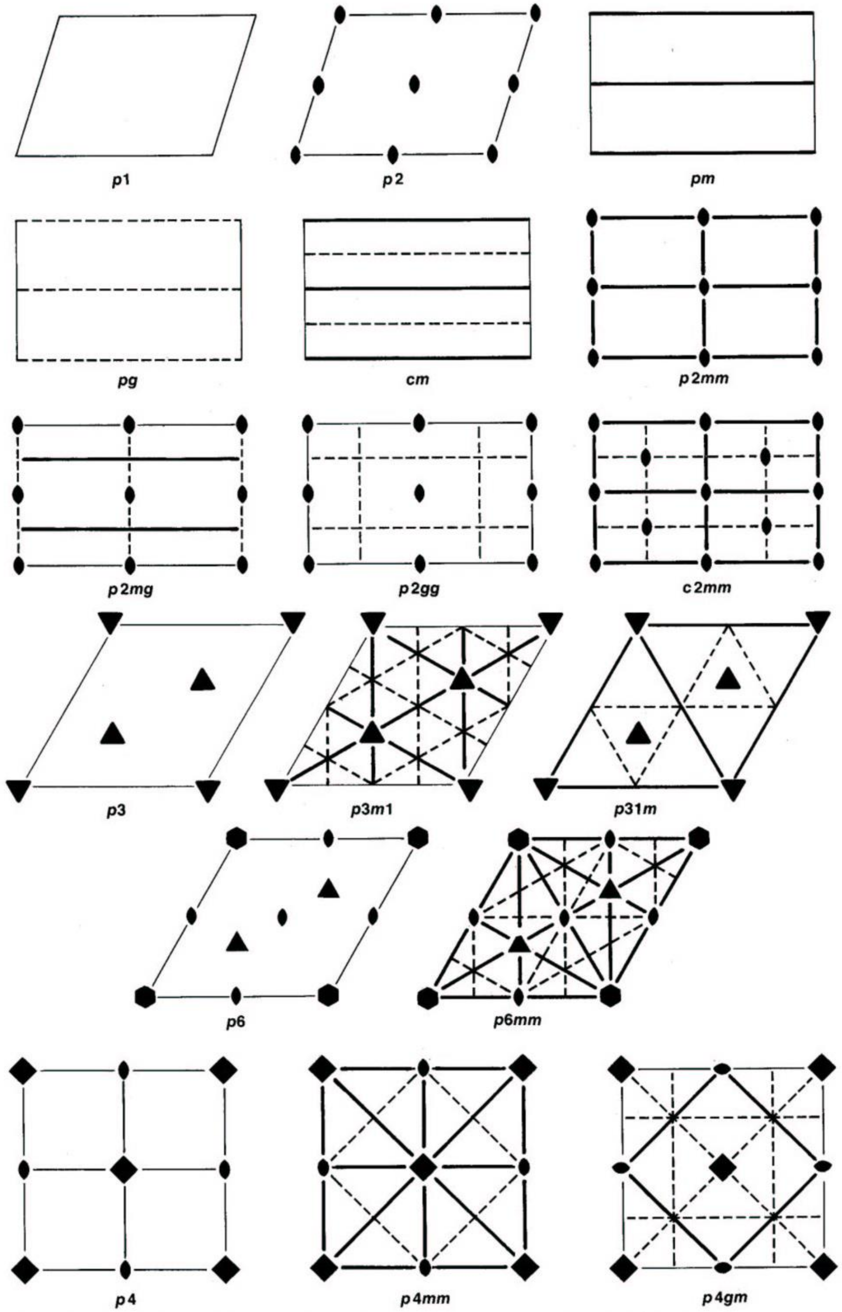


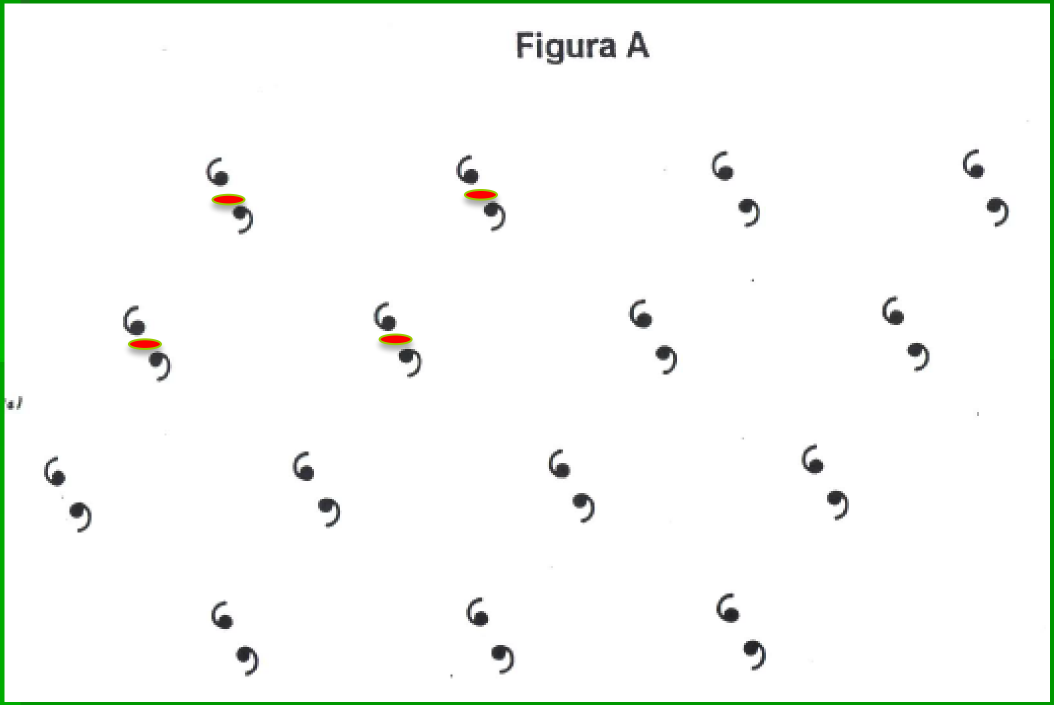
FIG. 3.14 Graphic representation of the symmetry content of the 17 plane groups. Heavy solid lines and dashed lines represent mirrors and glide lines, respectively, perpendicular to the page.

- Única operação simetria adicional planos deslizantes

Lattice	Point Group	Plane Group
Oblique P	1	P 1
	2	P 2
Rectangular P and C	m	P m Pg Cm
	2 m m	P 2 m m P 2 m g P 2 g g C 2 m m
Square P	4	P 4
	4 m m	P 4 m m P 4 g m
Hexagonal P	3	P 3
	3 m	P 3 m1 P 3 1m
	6	P 6
	6 m m	P 6 m m

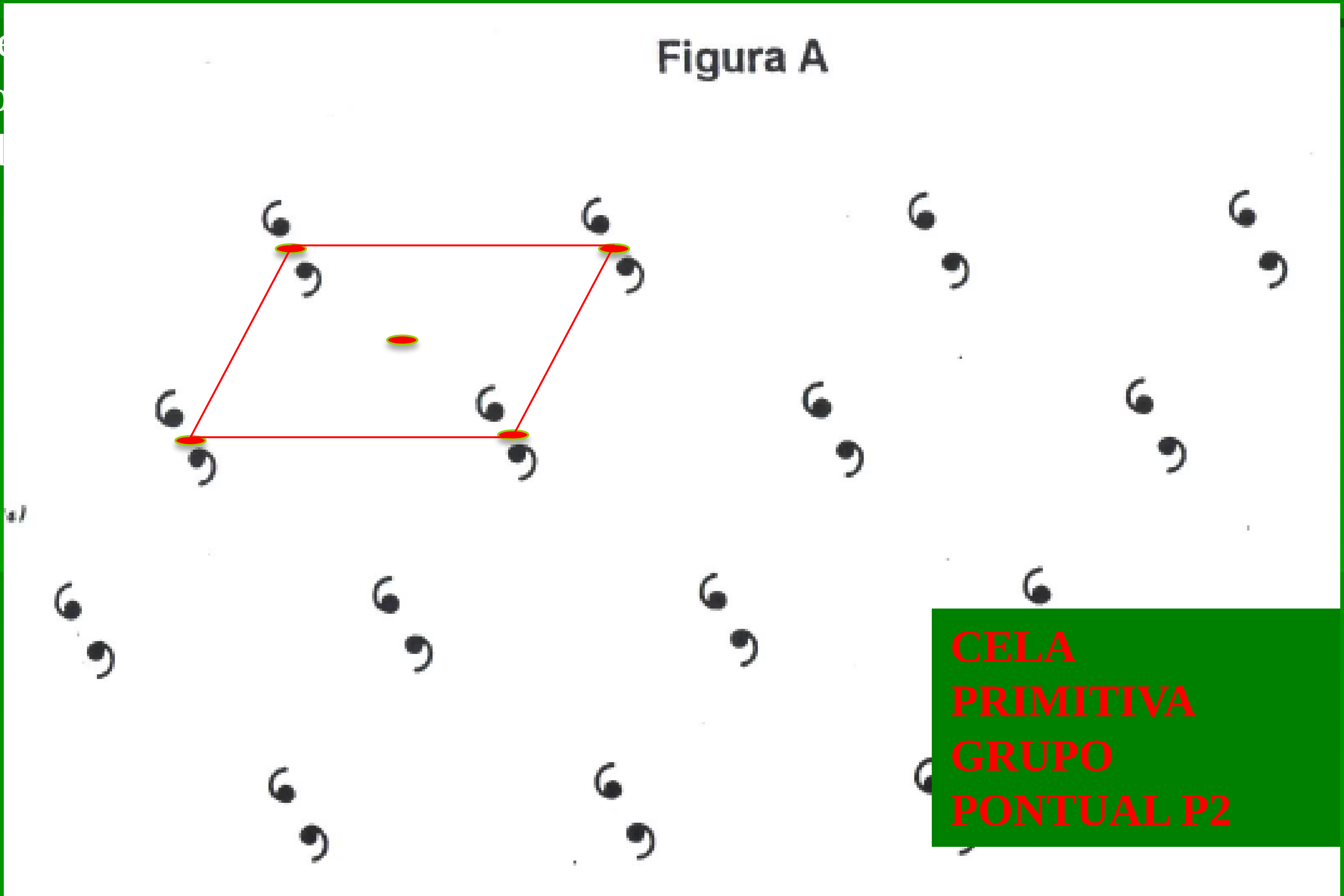
Simetria dos motivos

- Primeiro passo: determinar simetria do modelo



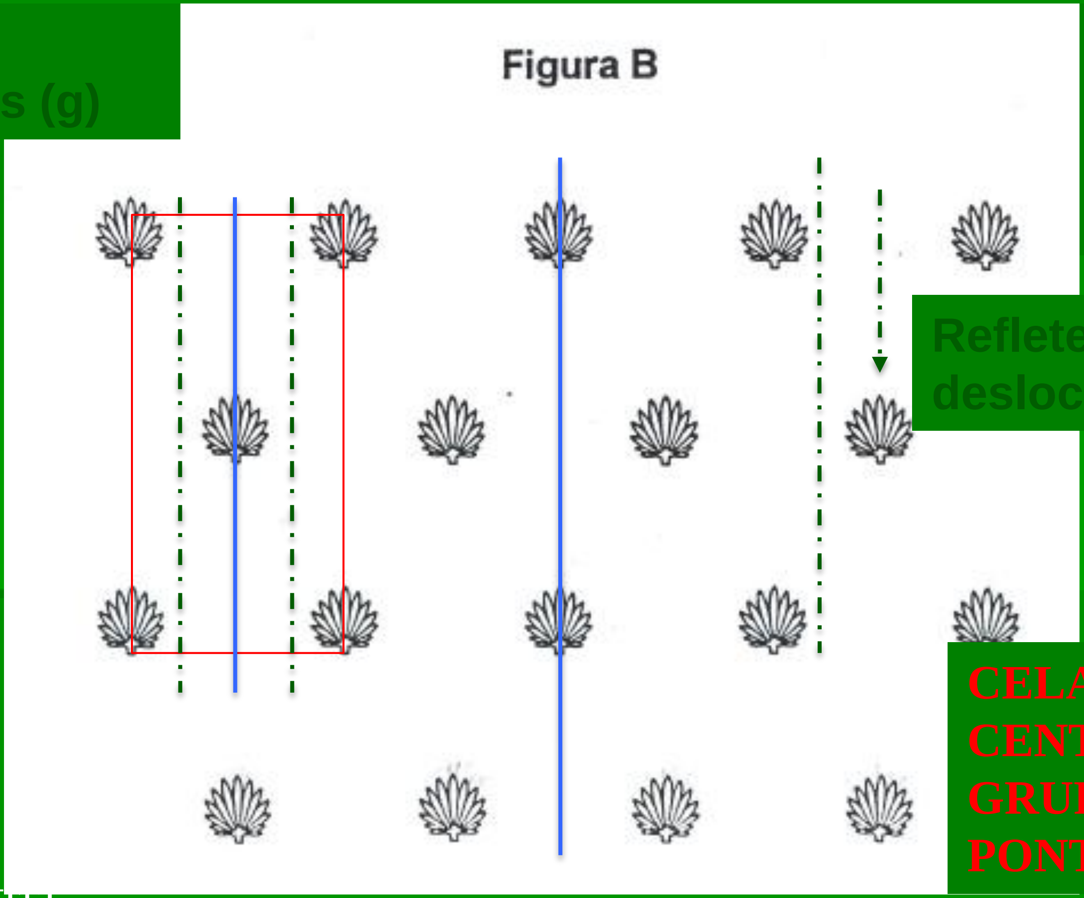
Simetria dos motivos

De
po
ad



Simetria dos motivos

Planos deslizantes (g)



Celas oblíquas violariam a simetria do motivo!

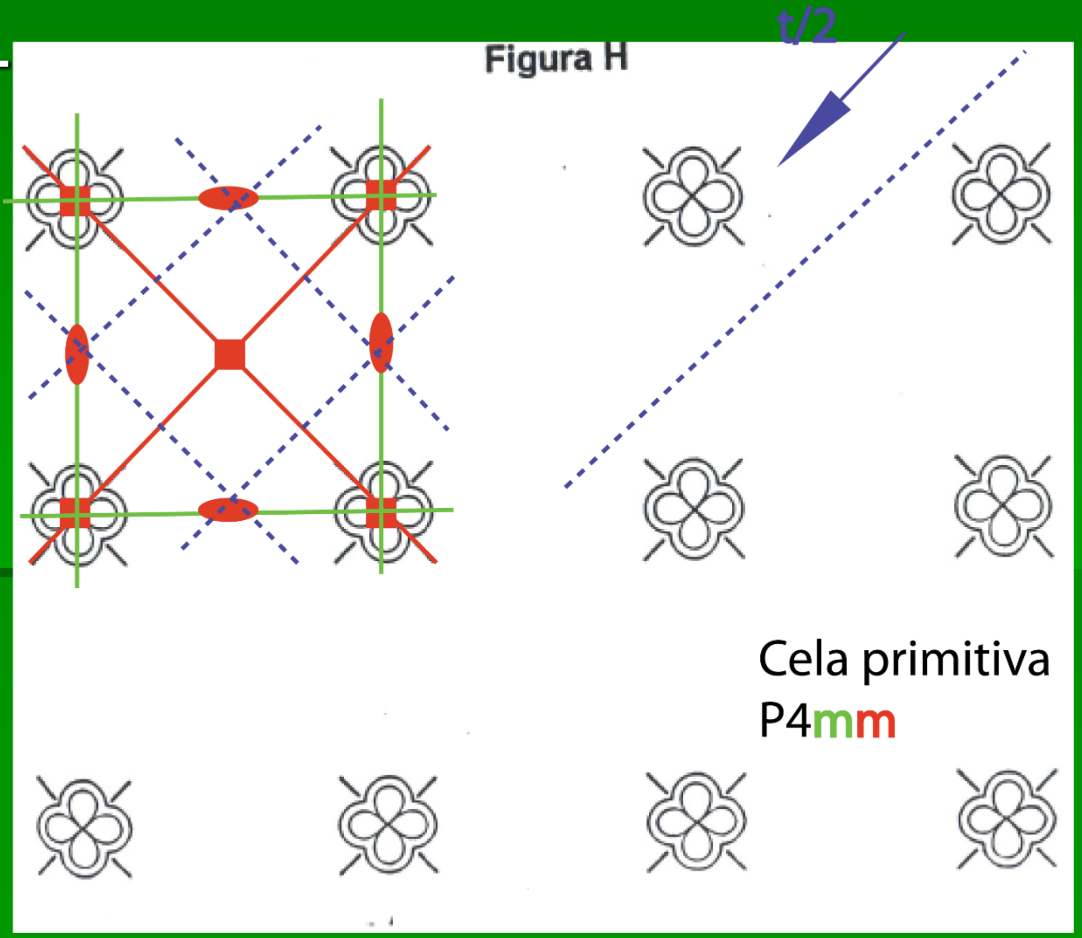
Reflete e desloca ½ de t

CELA CENTRADA GRUPO PONTUAL C2mg

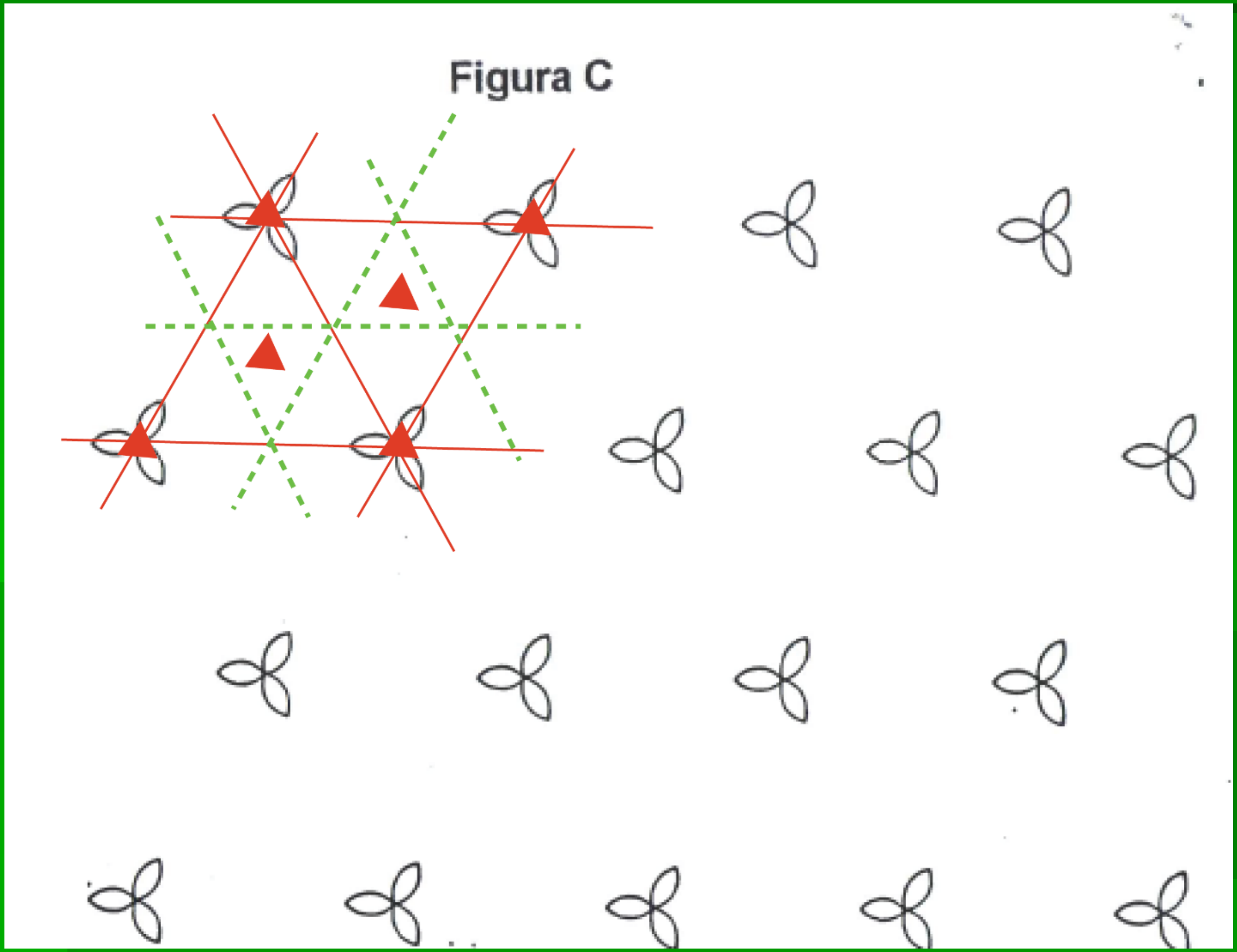
Planos de simetria

Simetria dos motivos

- Um pouco + difícil



Simetria dos motivos



CELA PRIMITIVA GRUPO PONTUAL P3m

1. Simetria do motivo?

R: 2

2. Vetores de translação?

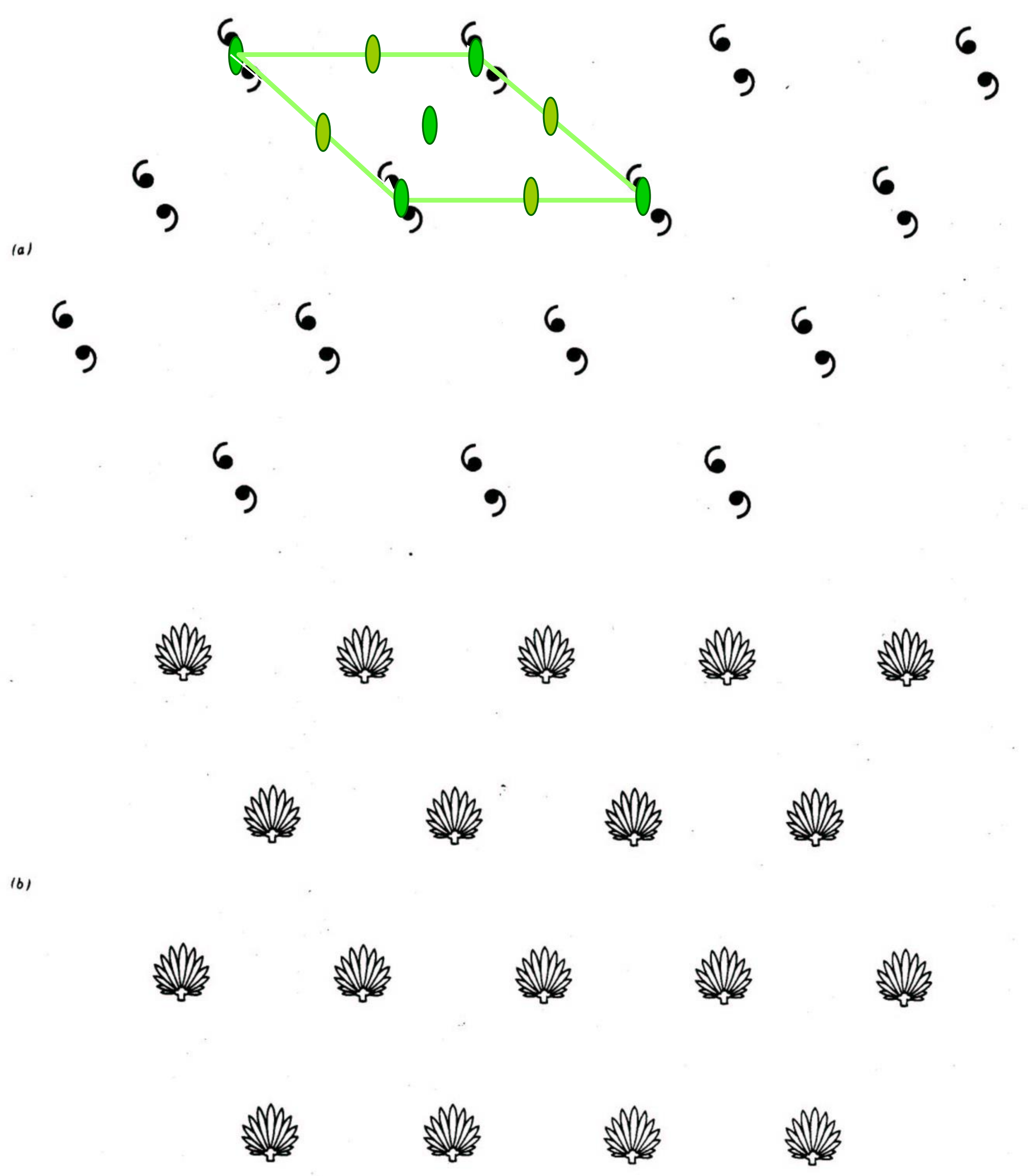
3. Cela unitária?

4. Z?

R: 1 (cela P)

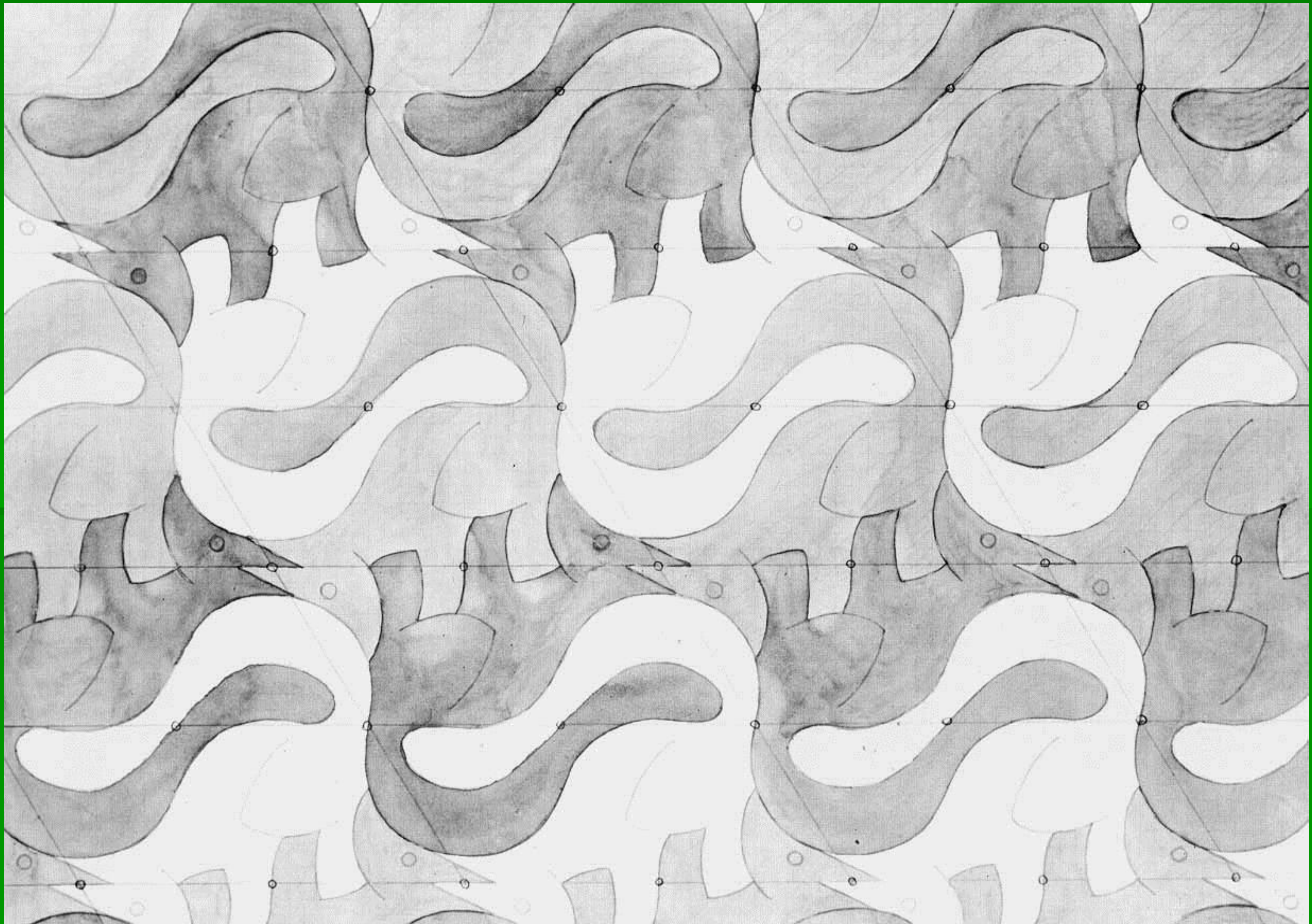
5. Grupo Espacial 2-D?

R: P 211



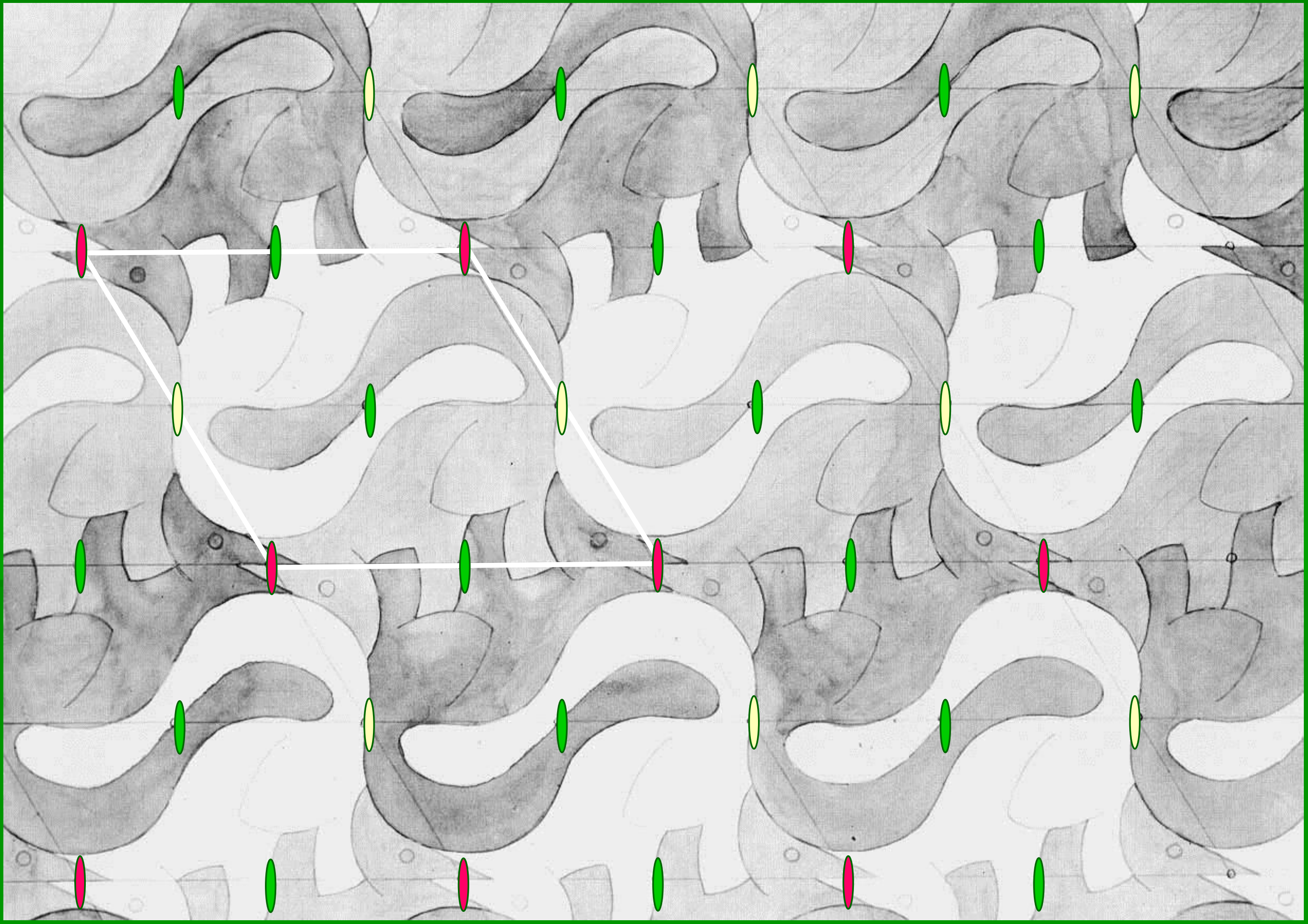
Simetria de Grupos Planares

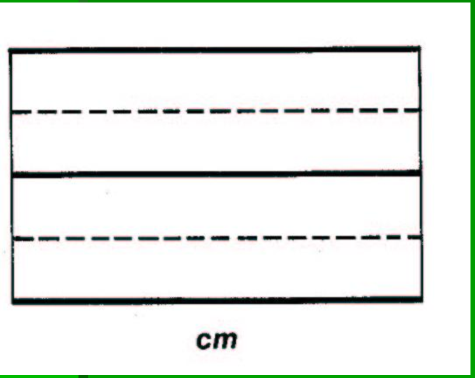
Combinando translações e grupos pontuais



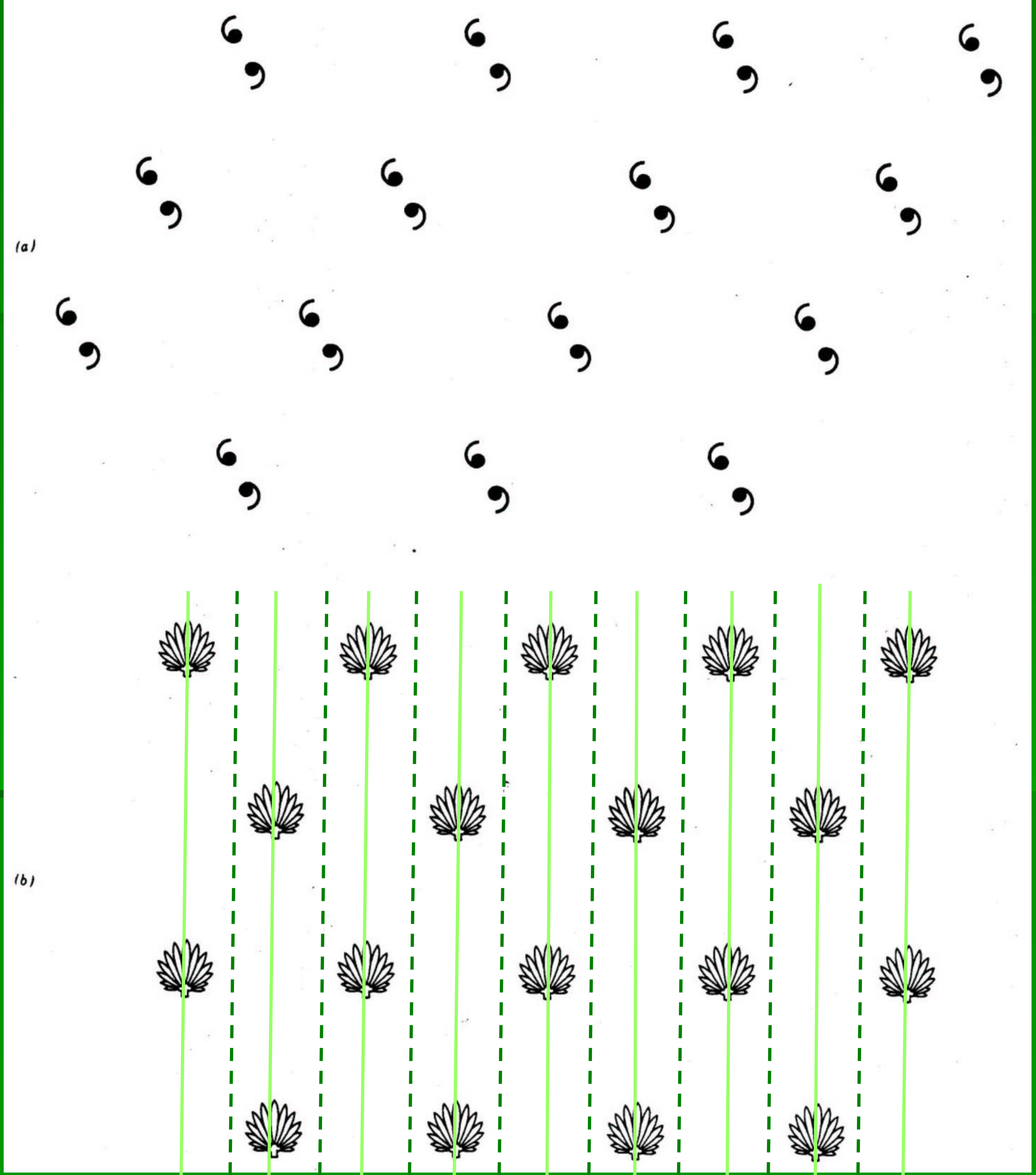
Simetria de Grupos Planares

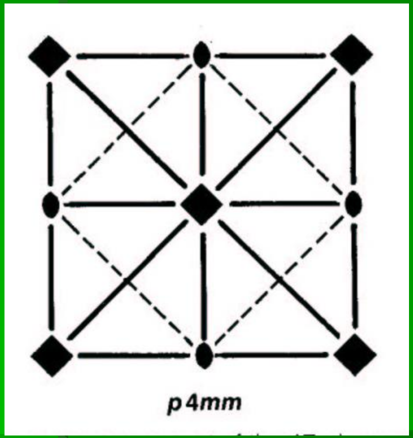
p211



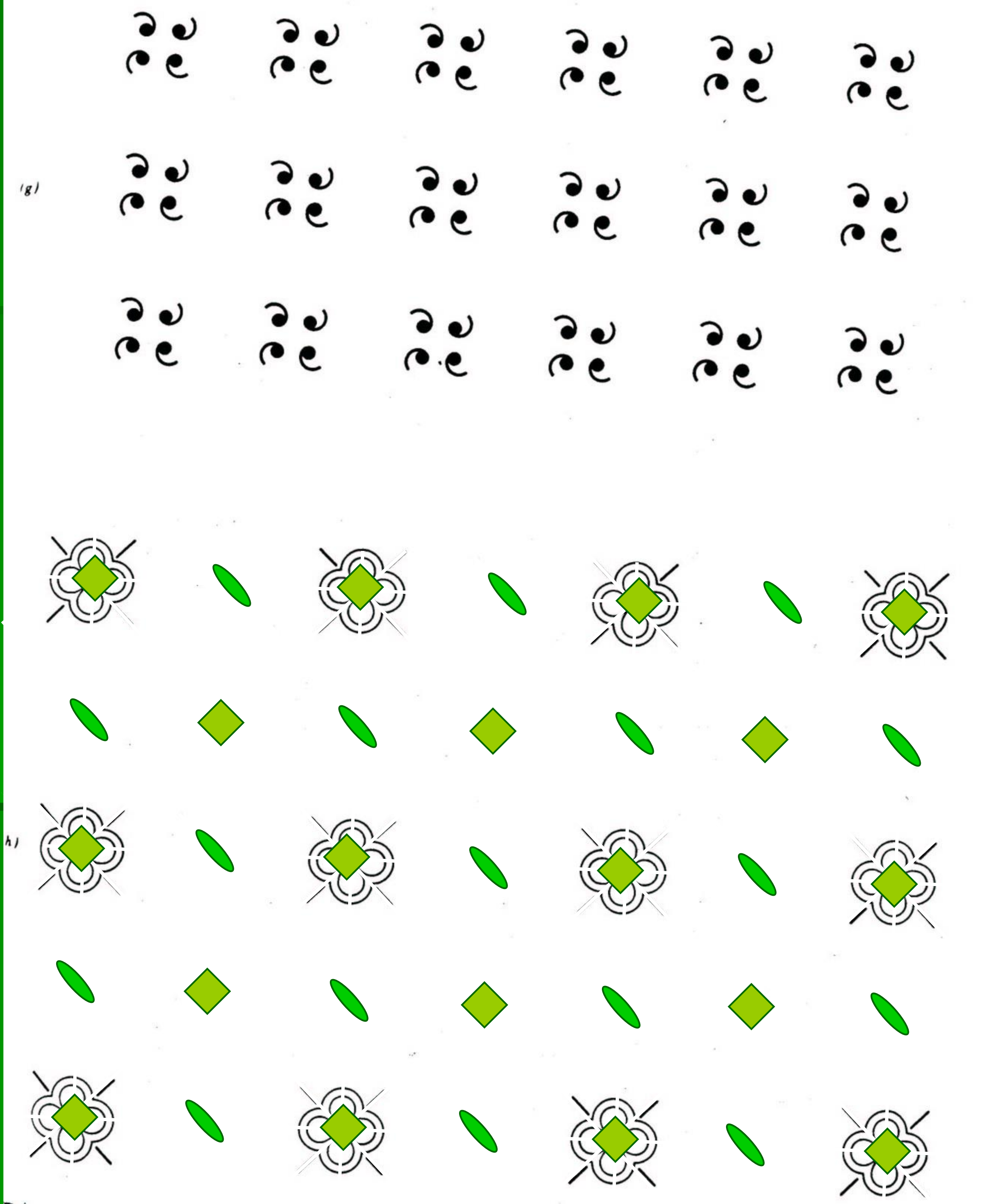


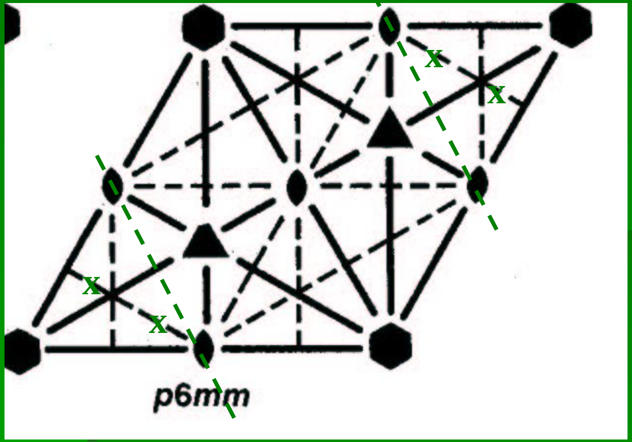
c m



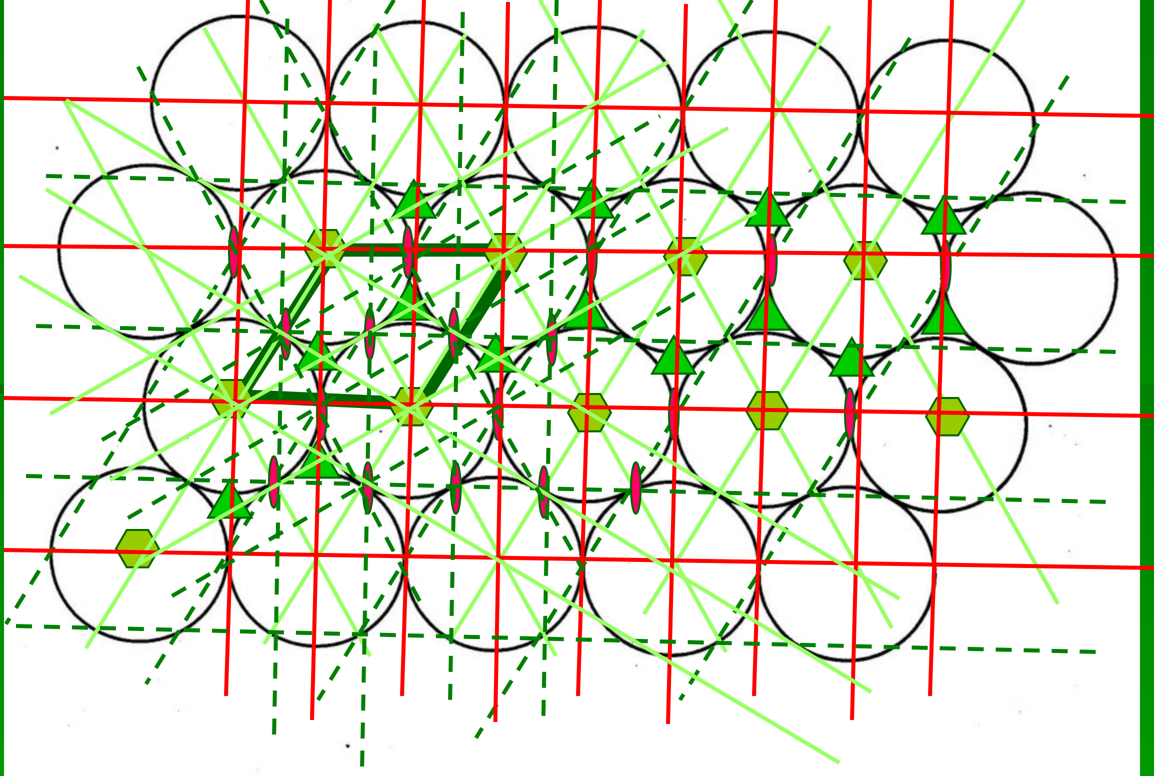


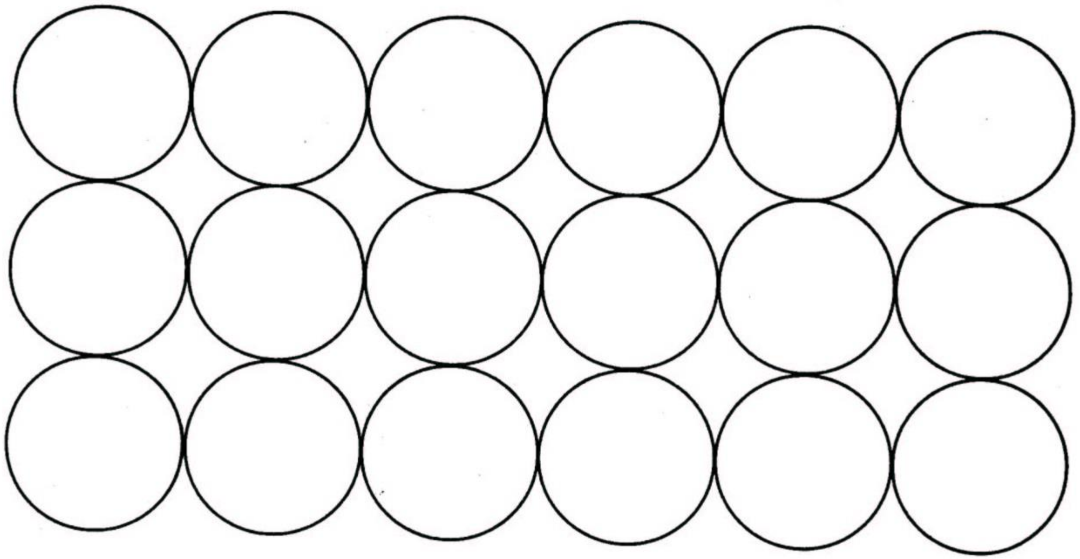
p4mm

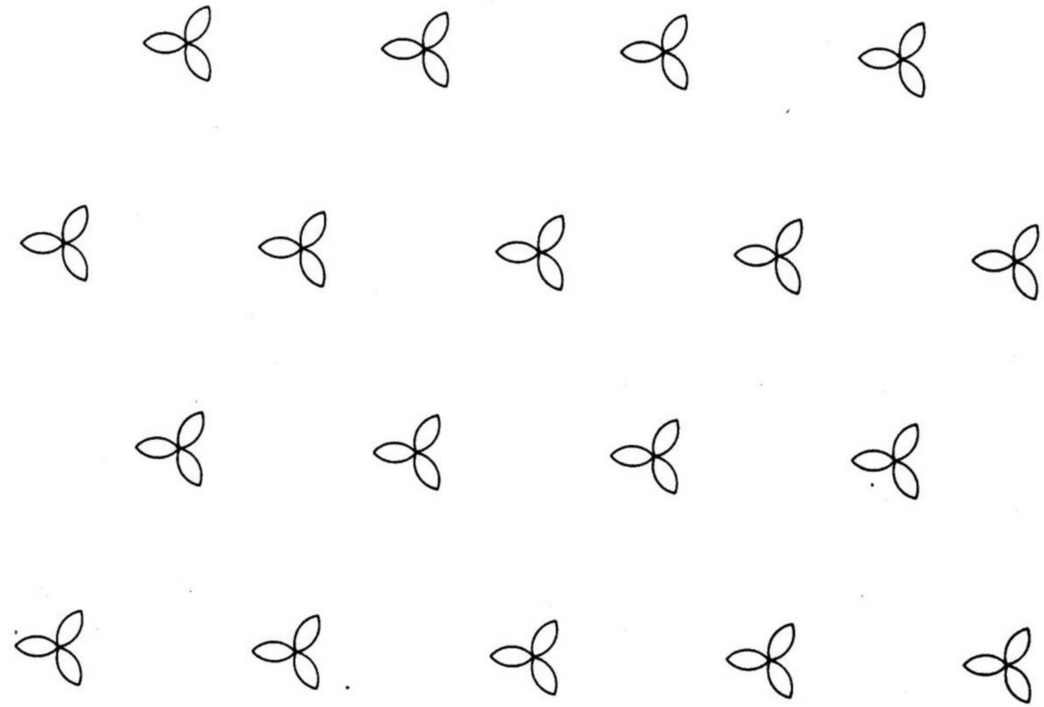




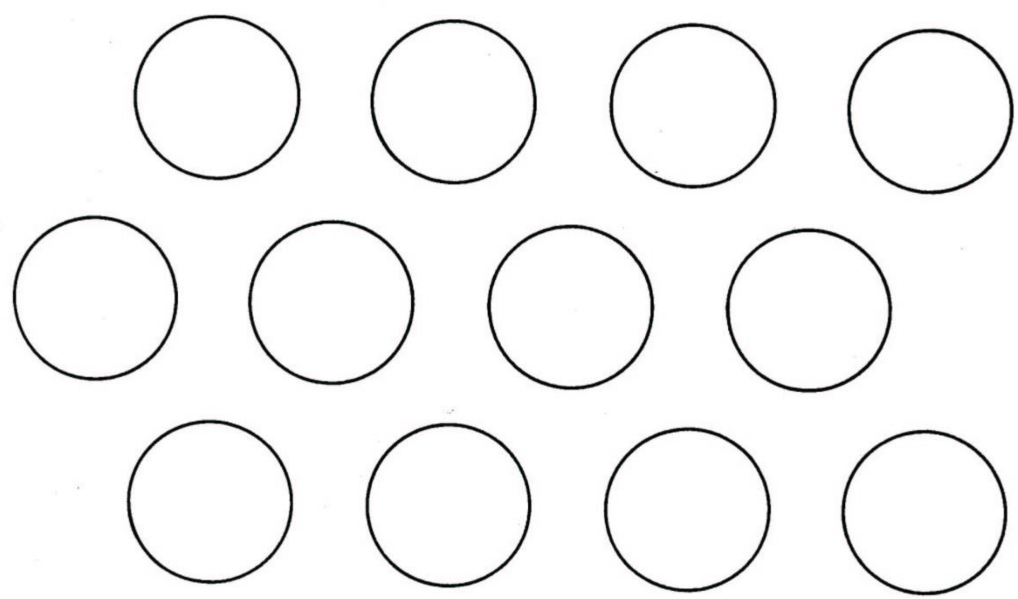
p 6mm





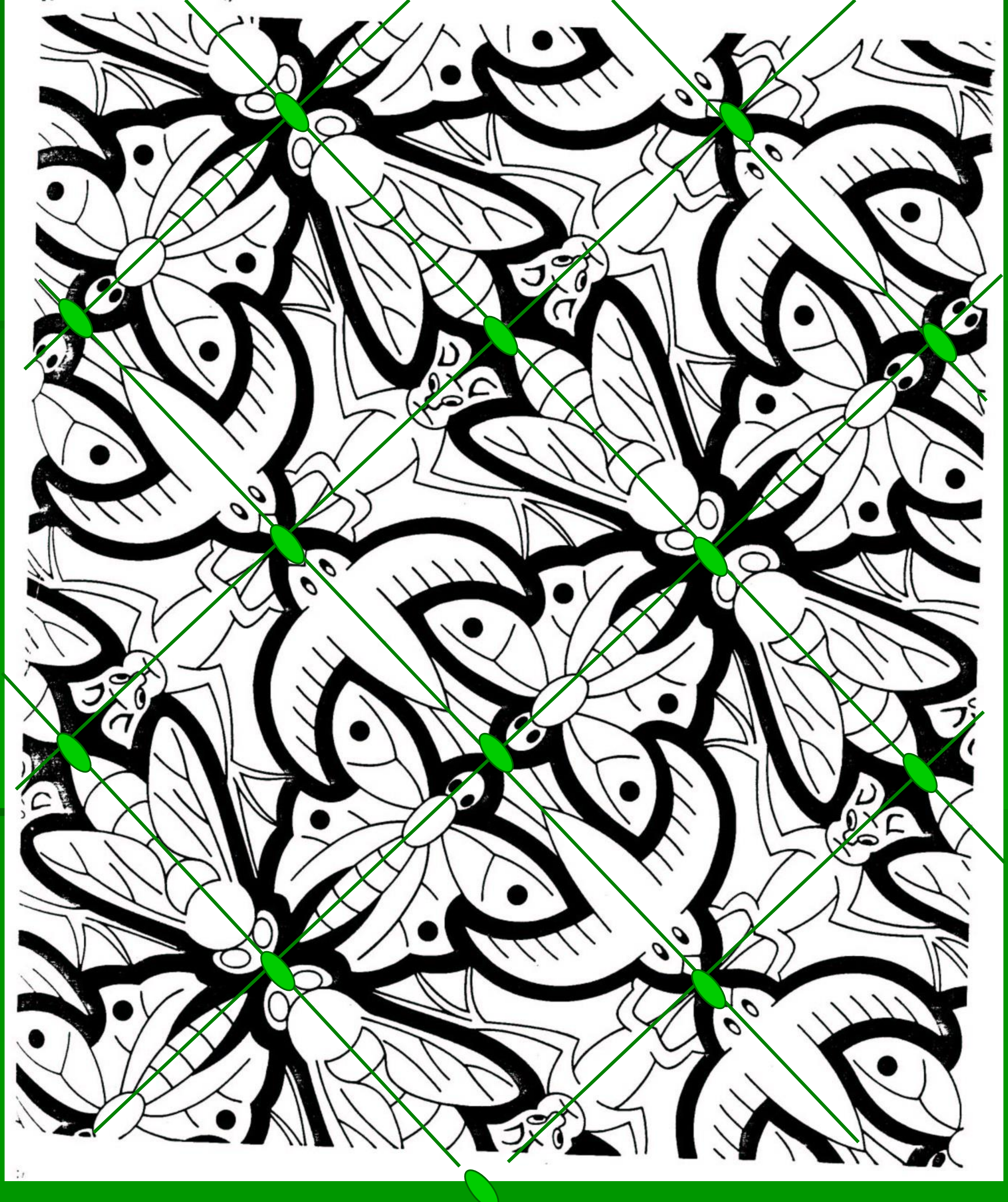


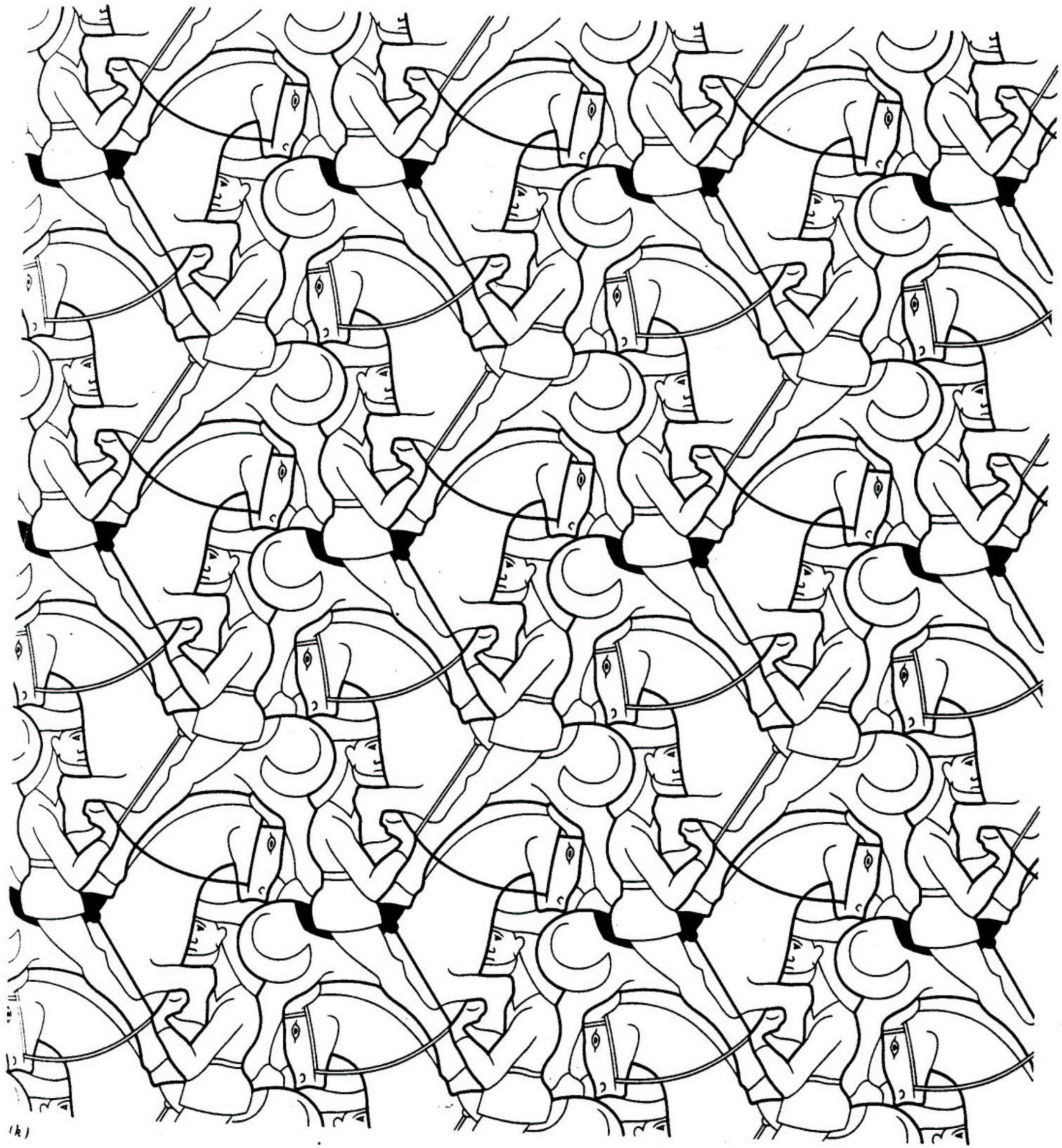
(c)

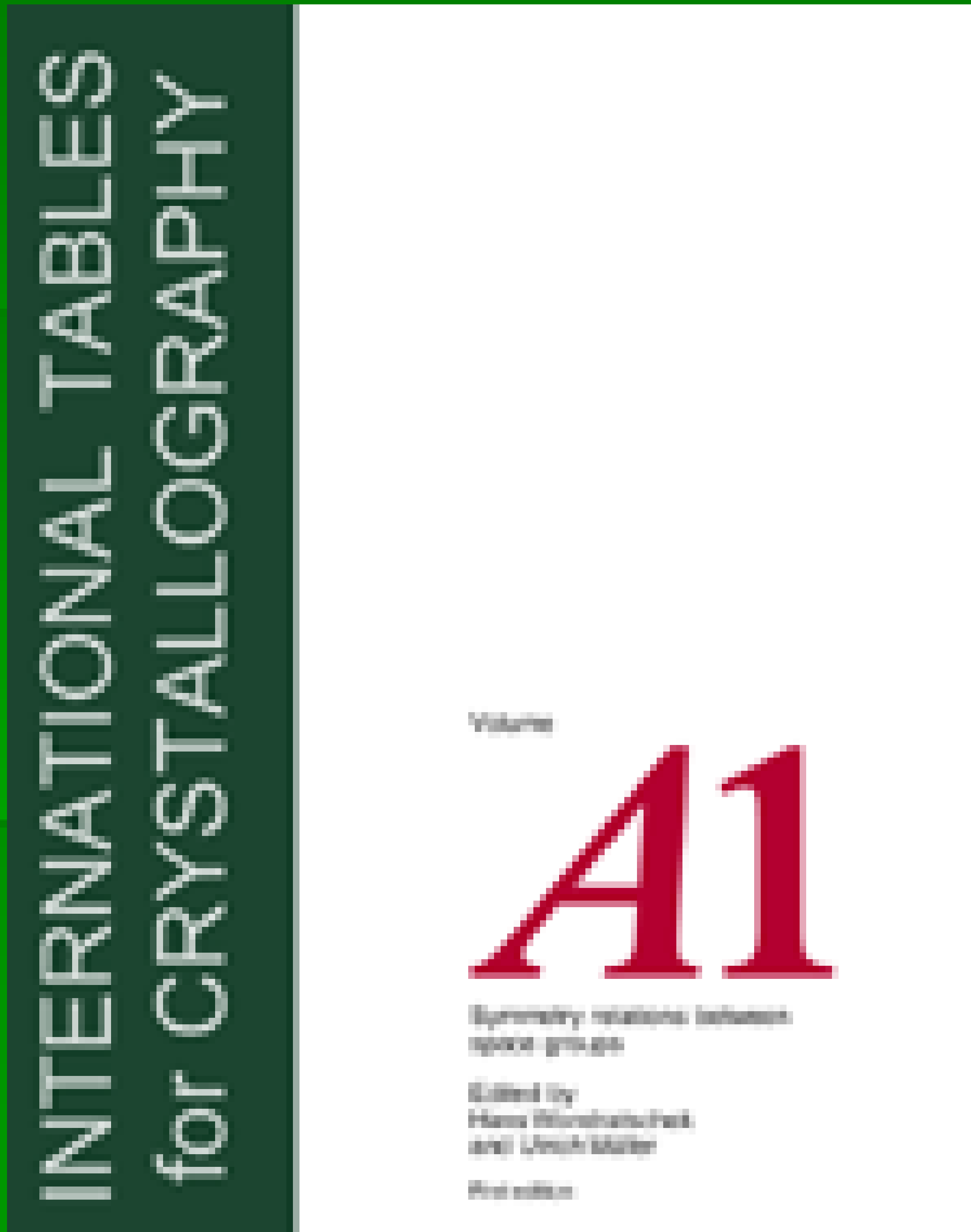


(d)

p 2mm




(k)


INTERNATIONAL TABLES
for CRYSTALLOGRAPHY
Volume
A1

Cristalografia estrutural

Simetria interna

- Simetria de translação: retículos planos
- Retículos tridimensionais (Bravais)
- Novos elementos de simetria:

  Planos deslizantes (reflexão + translação)

  Eixos helicoidais (rotação + translação)
- Os 230 Grupos Espaciais
- DRX e a estrutura interna dos cristais

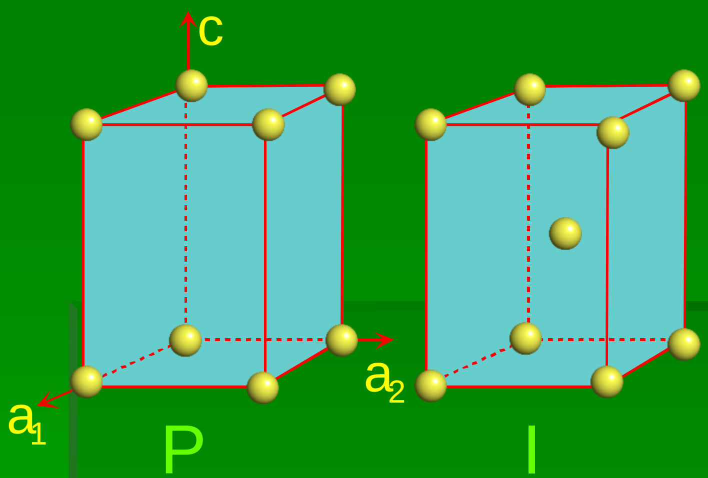
TABLE

Atomic co-ordinates ($\times 10^4$) with estimated standard deviations in parentheses

ATOM	x	y	z
C-1	3183(3)	7374(5)	1797(9)
C-2	3020(4)	7831(5)	3692(9)
C-3	3718(4)	8265(5)	4581(9)
C-4	4106(3)	9097(5)	3345(10)
C-5	4236(4)	8566(5)	1481(10)
C-6	4575(4)	9337(6)	83(10)
O-1	3635(2)	6403(3)	2060(6)
O-2	2683(3)	7034(4)	4839(8)
O-3	3543(3)	8701(4)	6333(7)
Cl-4	3561(1)	10338(1)	3106(3)
O-5	3552(2)	8166(3)	712(6)
O-6	4782(3)	8691(4)	-1490(7)
C-1'	3567(4)	5937(5)	-1160(9)
C-2'	3569(4)	5510(5)	827(9)
C-3'	2929(3)	4700(5)	1311(9)
C-4'	3300(4)	3741(5)	2262(10)
C-5'	4078(4)	3745(5)	1470(10)
O-2'	4236(2)	4905(3)	1152(7)
O-3'	2407(3)	5277(4)	2410(8)
O-4'	2960(3)	2700(4)	1939(8)
C-6'	4626(4)	3242(6)	2788(11)
Cl-1'	3643(1)	4812(2)	-2727(3)
Cl-6'	5548(1)	3304(2)	1922(3)

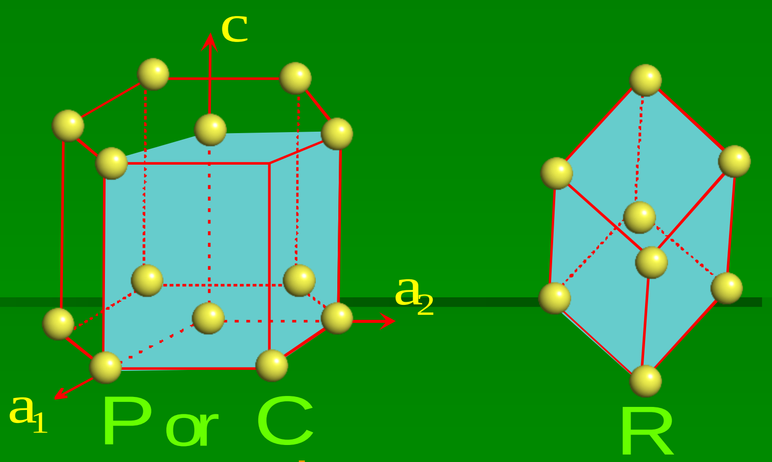
Table 4. Atomic coordinates for Catalão gorceixite indexed as monoclinic. (*) The equivalent isotropic displacement coefficients have been calculated from the published (Radoslovish, 1982) refined isotropic thermal parameters and kept constant during Rietveld refinement.

Atom	Wyckoff	Symmetry	Occupation	x	y	z	Uiso*100 (Å^2) (*)
Ba1	2a	m	0.76	0	0	0	0.671
Ca1	2a	m	0.19	0	0	0	
Sr1	2a	m	0.10	0	0	0	
P1	2a	m		0.2990(15)	0	0.9202(20)	0.861
P12	2a	m		0.6555(13)	0	0.0767(21)	0.431
Al1	2a	m	0.91	0.9833(14)	0	0.4785(26)	0.469
Fe1	2a	m	0.09	0.9833(14)	0	0.4785(26)	
Al2	4b	1	0.91	0.7491(13)	0.2400(18)	0.5088(22)	0.443
Fe2	4b	1	0.09	0.7491(13)	0.2400(18)	0.5088(22)	
O1	2a	m		0.4372(26)	0	0.1933(30)	0.507
O12	2a	m		0.598(4)	0	0.8247(27)	1.102
O2	2a	m		0.1514(15)	0	0.825(4)	0.823
O22	2a	m		0.8230(14)	0	0.173(4)	0.697
O3	4b	1		0.3614(15)	0.1478(25)	0.8400(25)	1.051
O33	4b	1		0.6722(25)	0.1920(19)	0.1989(25)	0.823
OH1	2a	m		0.2733(28)	0	0.425(5)	0.899
OH12	2a	m		0.7260(29)	0	0.594(5)	1.254
OH2	4b	1		0.9147(14)	0.1980(24)	0.5738(29)	0.443
OH22	4b	1		0.0734(14)	0.1855(24)	0.4314(30)	0.621



Tetragonal

$\alpha = \beta = \gamma = 90^o$ $a_1 = a_2 \neq c$



Hexagonal

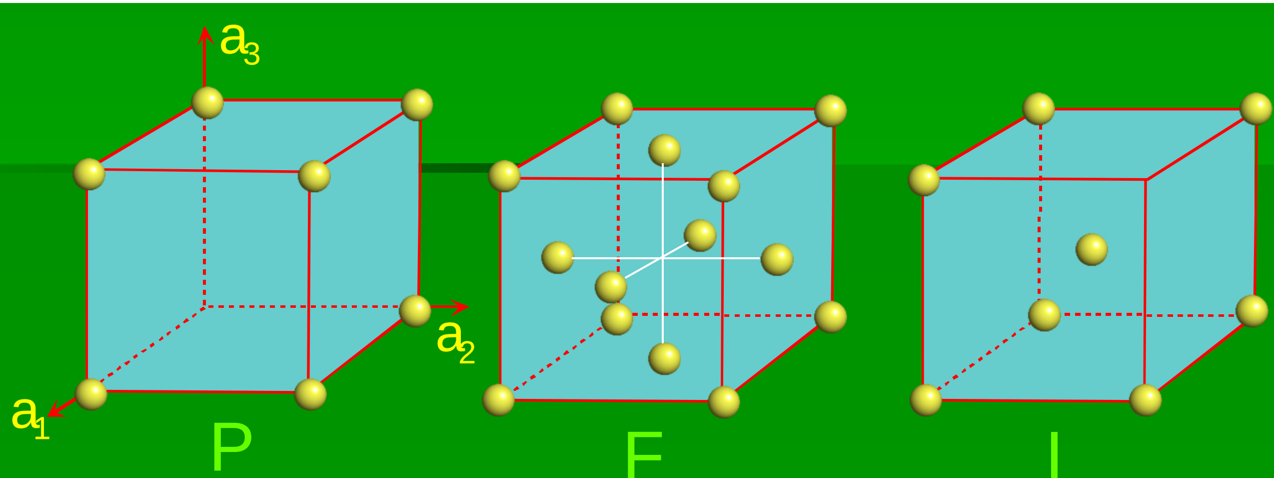
$\alpha = \beta = 90^o$ $\gamma = 120^o$

$a_1 = a_2 \neq c$

Rhombohedral

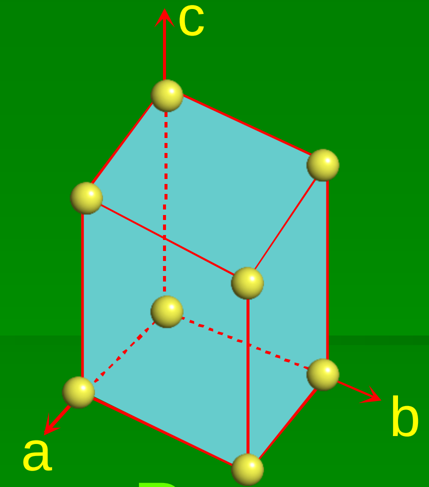
$\alpha = \beta = \gamma \neq 90^o$

$a_1 = a_2 = a_3$



Isométrico

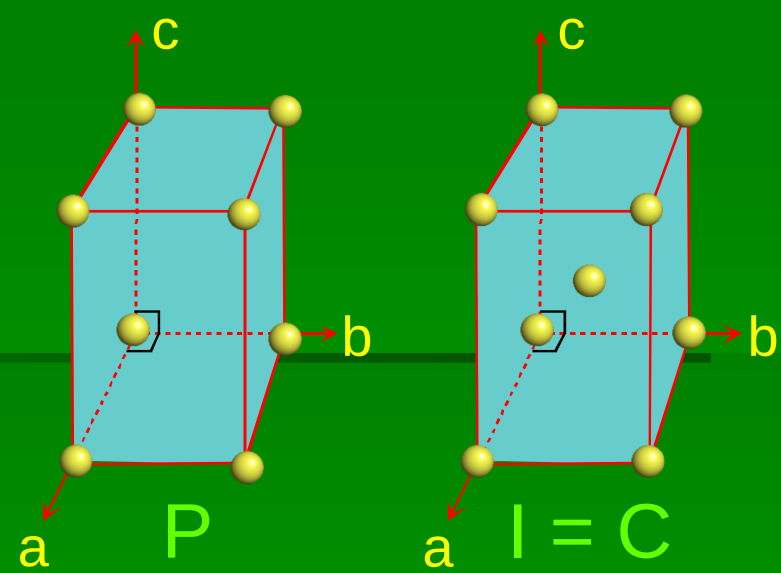
$\alpha = \beta = \gamma = 90^o$ $a_1 = a_2 = a_3$



Triclínico

$\alpha \neq \beta \neq \gamma$

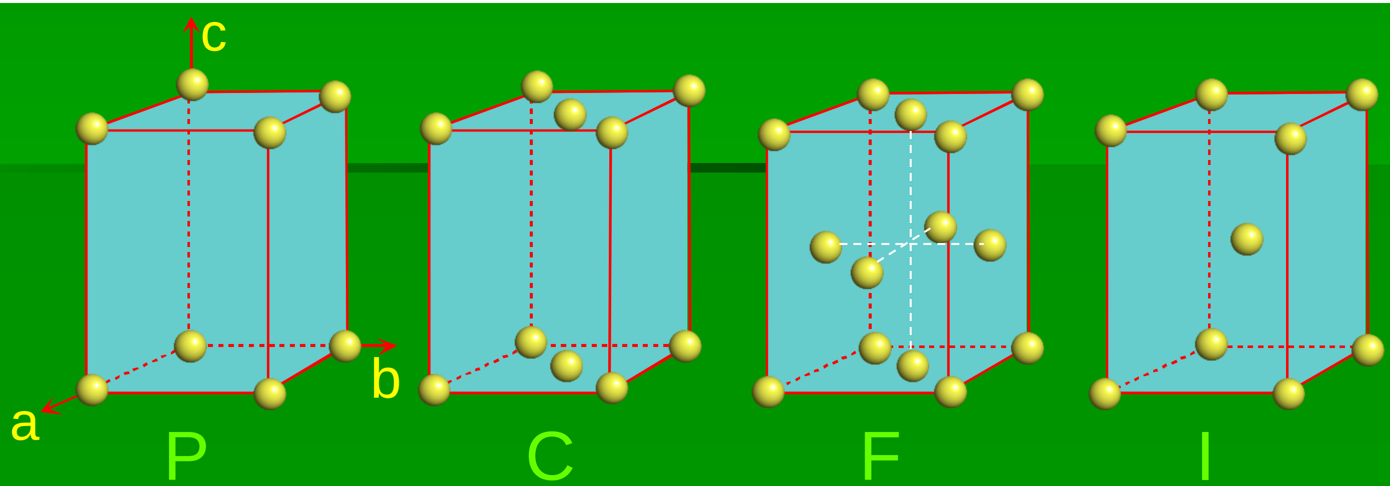
$a \neq b \neq c$



Monoclínico

$\alpha = \gamma = 90^{o} \neq \beta$

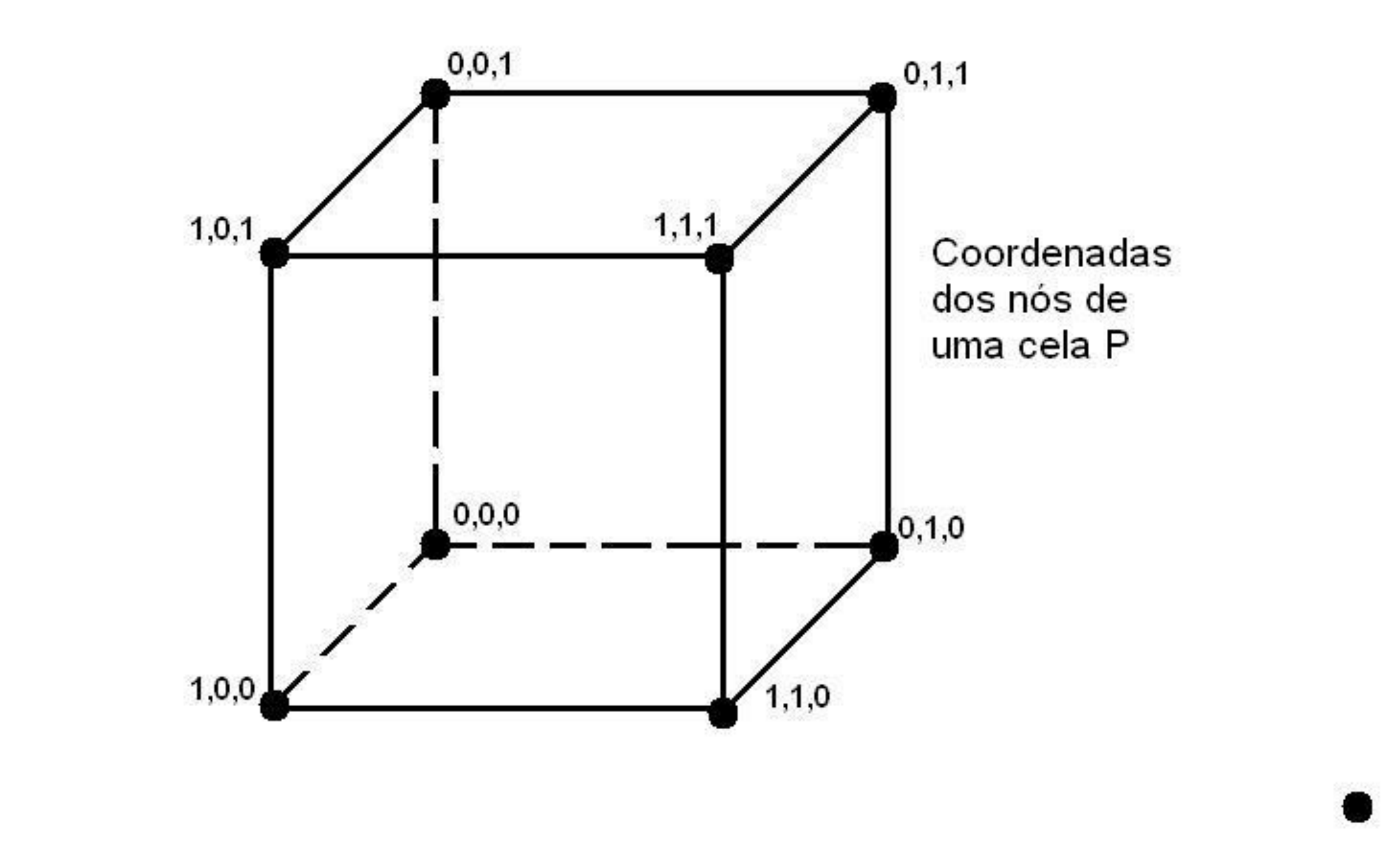
$a \neq b \neq c$



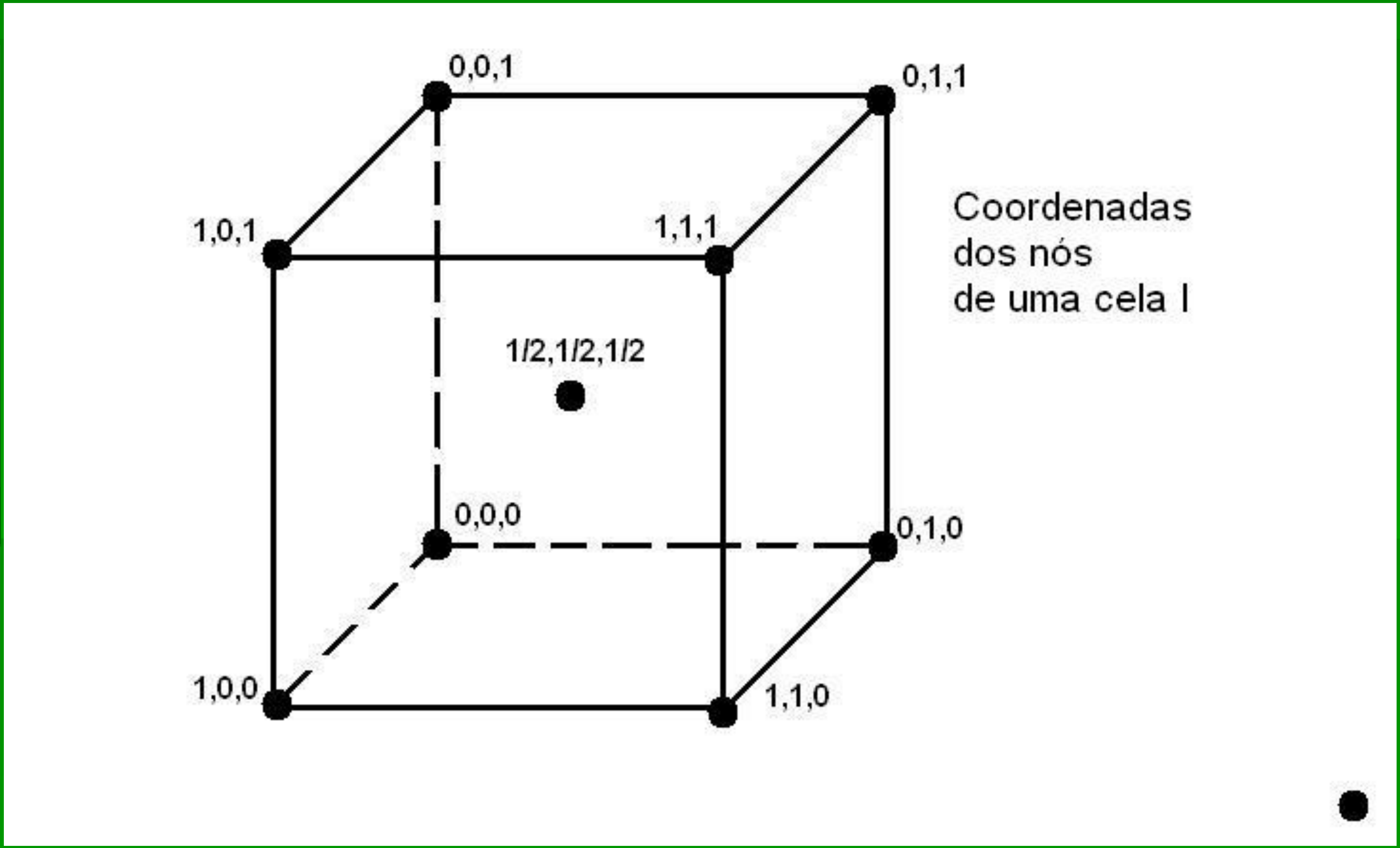
Ortorrômbico

$\alpha = \beta = \gamma = 90^{o}$ $a \neq b \neq c$

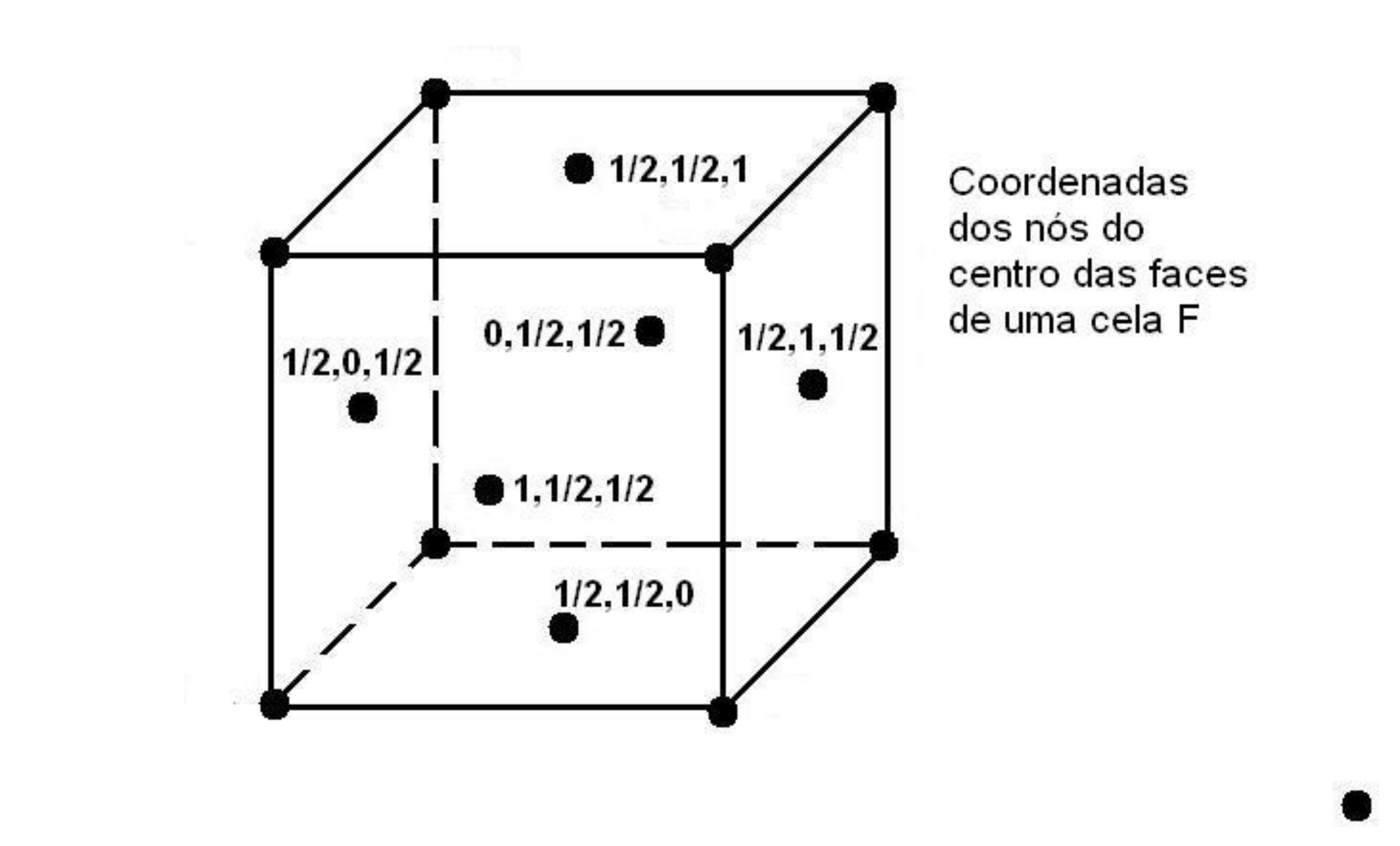
Cela genérica P: coordenadas dos nós (apenas nos vêrtices!)



- Celas I (de corpo centrado) – coordenadas dos nós:



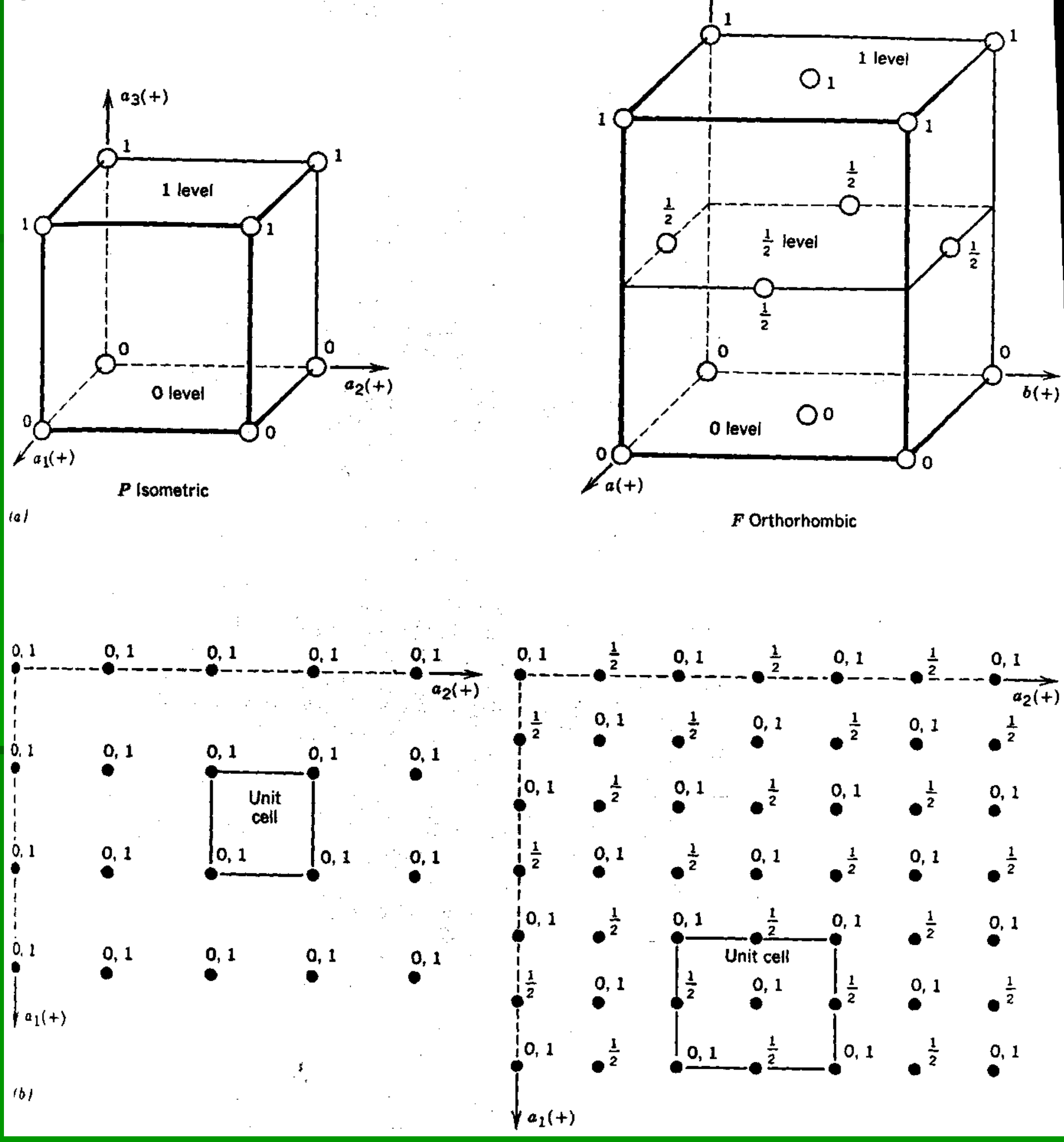
Celas F – coordenadas dos nós do centro das faces;



Projeções ortográficas de retículos de Bravais

(projeções no plano $(001)_0$)

FIGURE 11.3 Unit cells and their projections. (*a*) Perspective views of an isometric *P* cell and an orthorhombic *F* cell. (*b*) Projection of these same cells onto the plane of the page (= 0 level) in extended lattices.

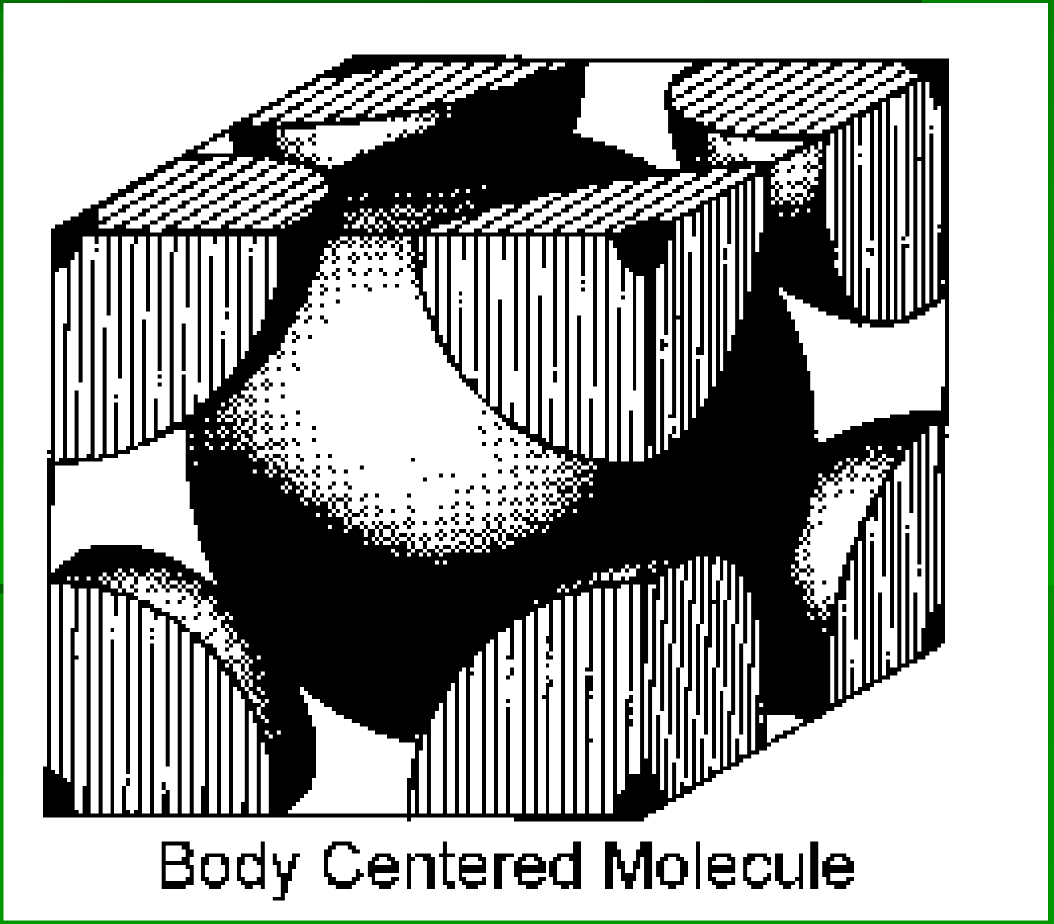


Cela unitária do Fe metálico – perspectiva:

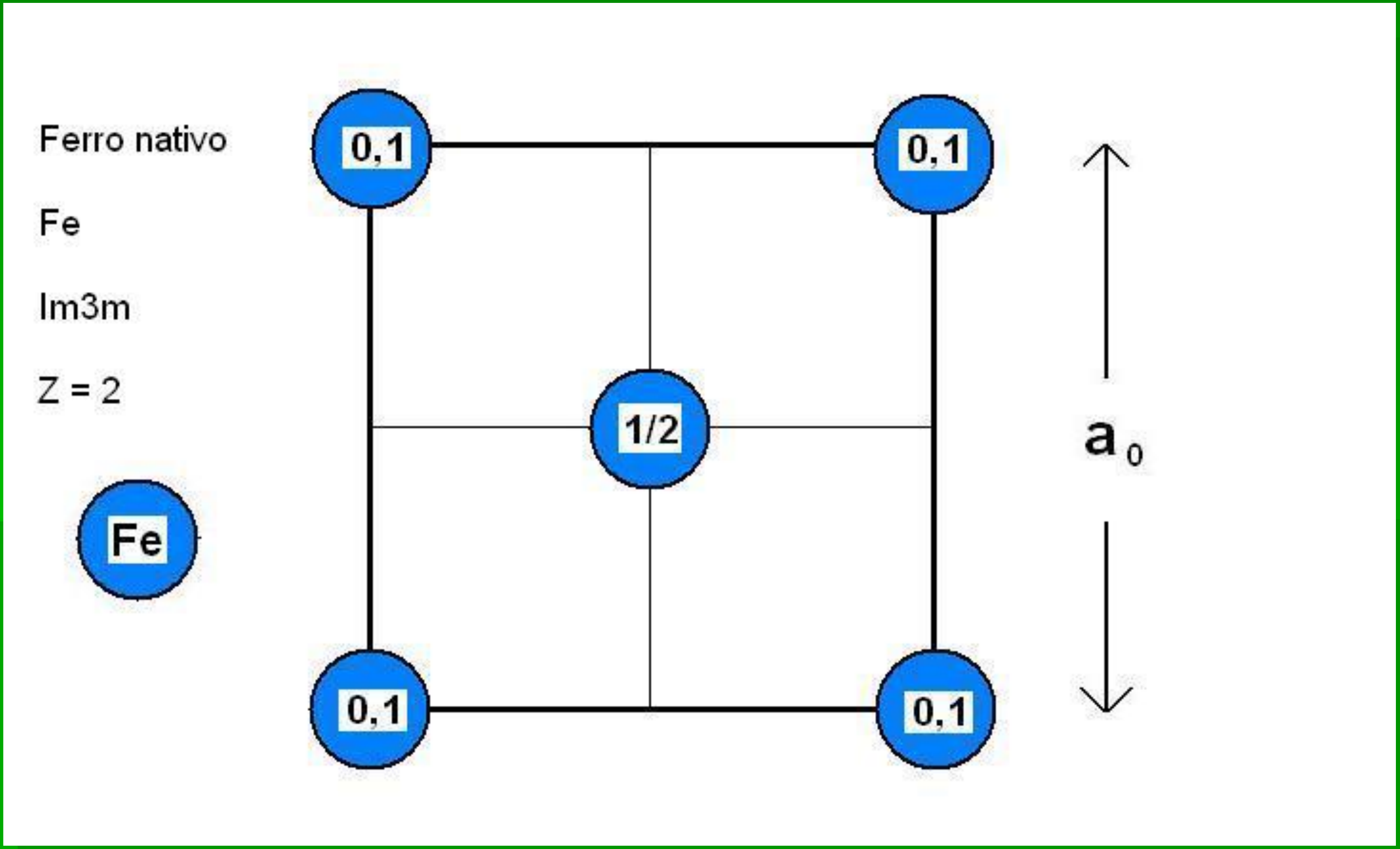
Conteúdo atômico
da cela:

Z = 2

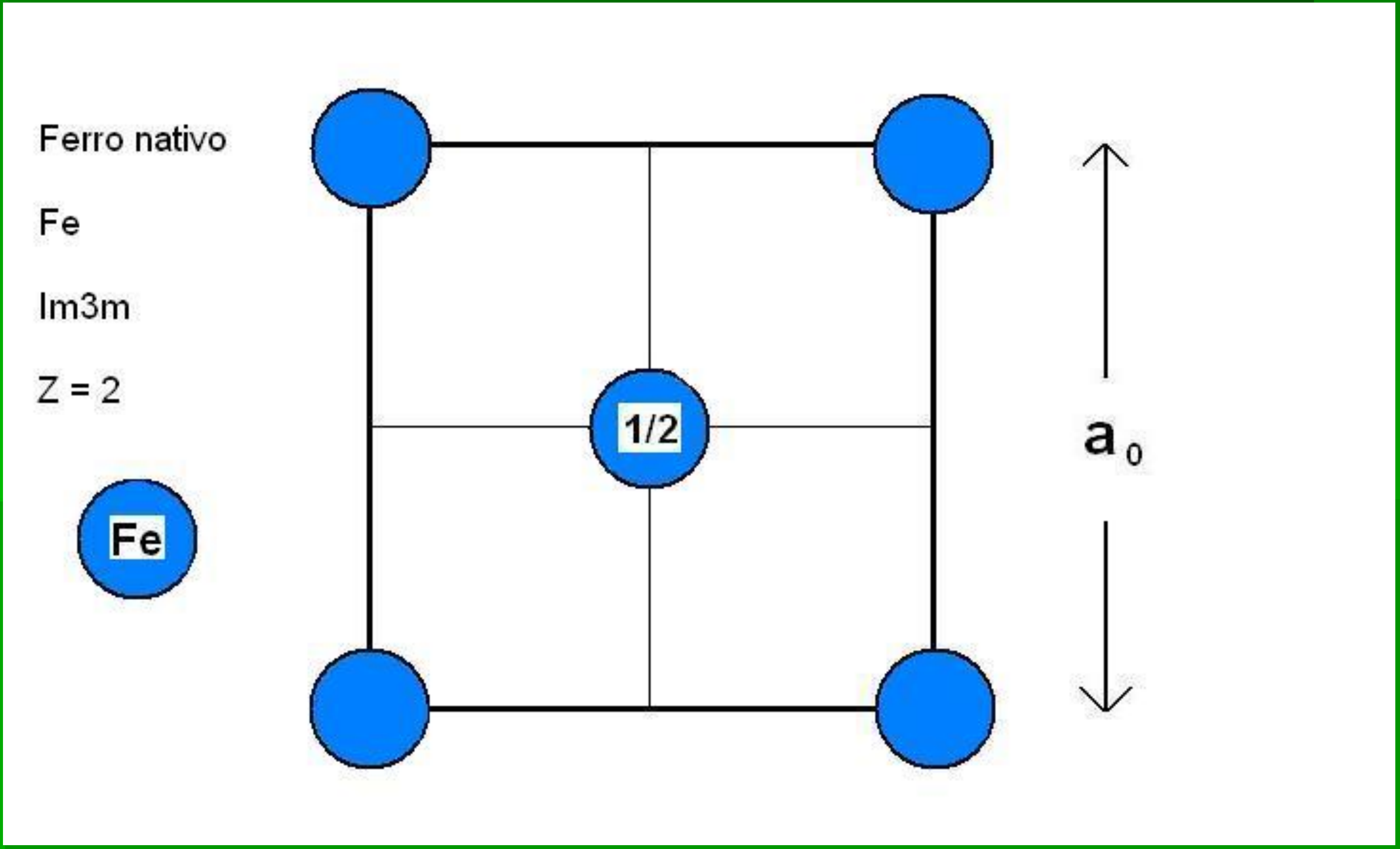
8 x 1/8 (vêrtices) +
1 x 1 (centro)



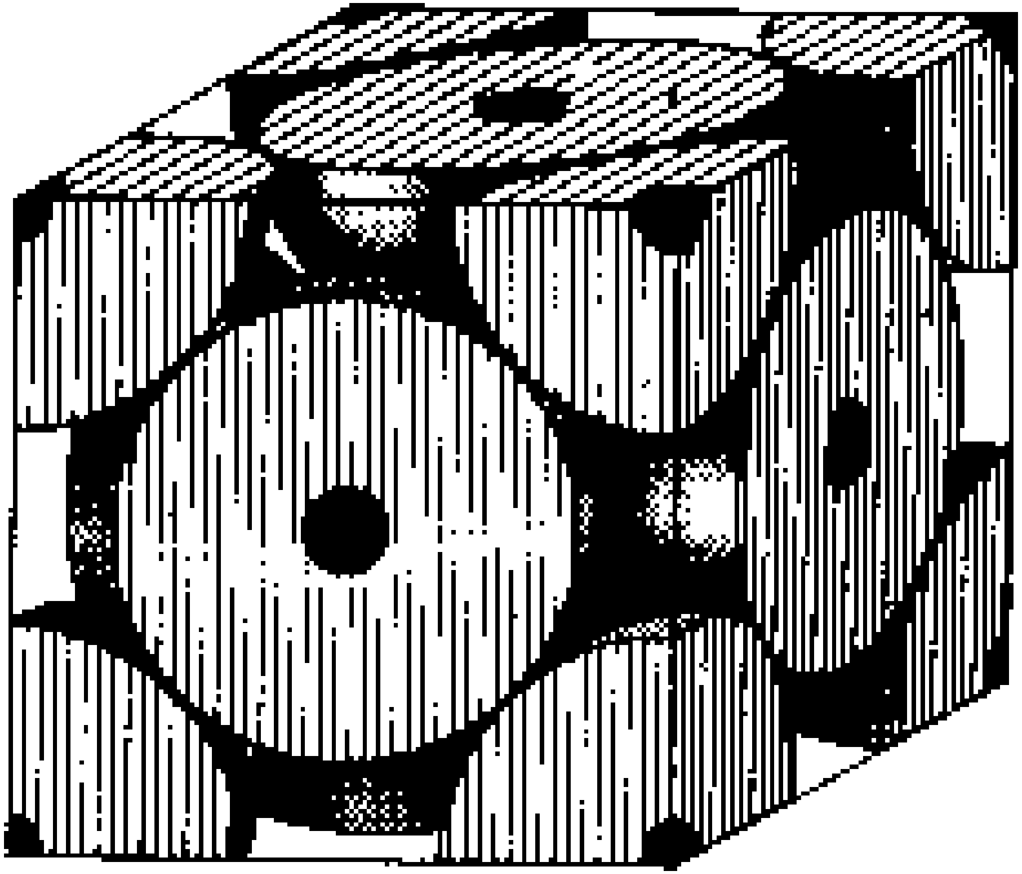
Projeção de cela unitária: ferro nativo (Fe):



Projeção da cela unitária do ferro nativo (Fe), sem a indicação das cotas 0 e 1:

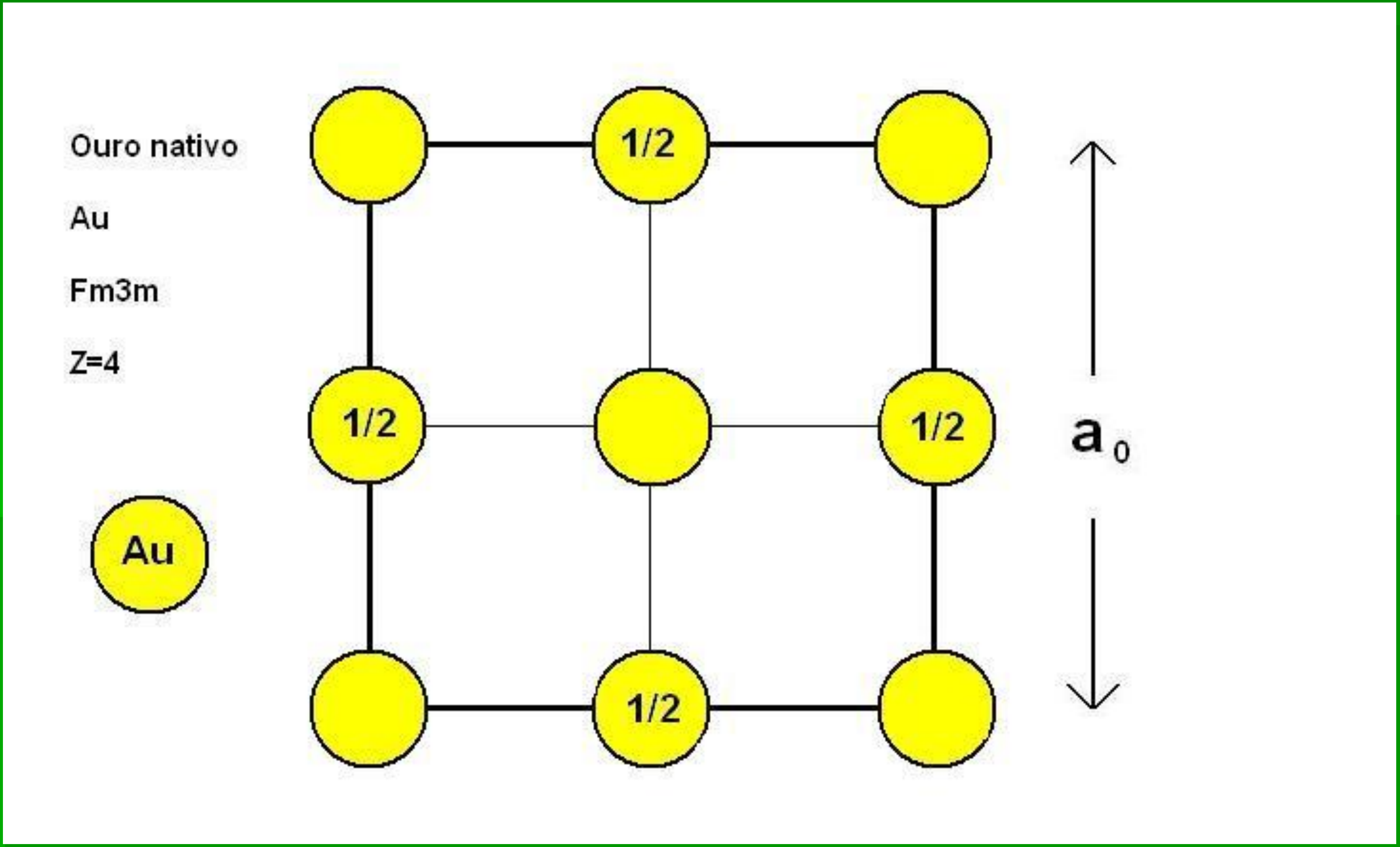


Cela unitária do ouro – perspectiva:

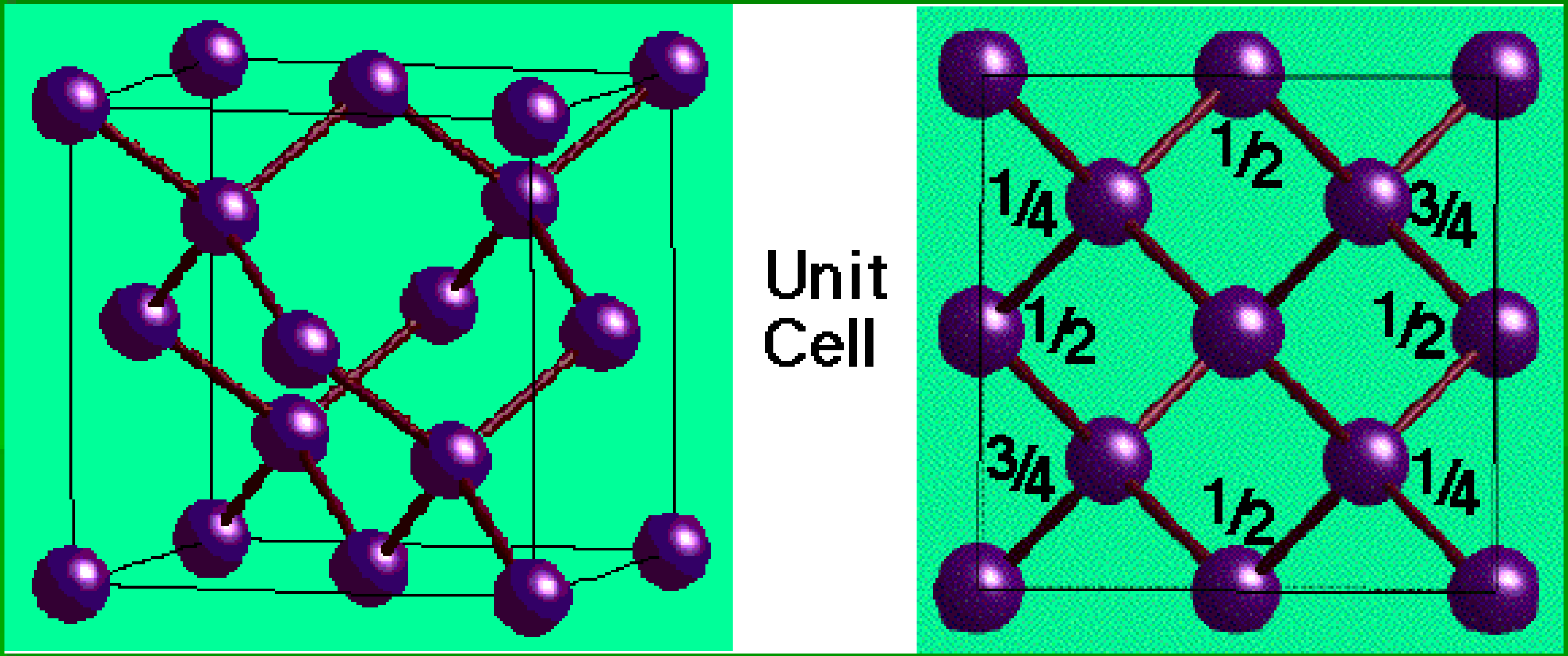


Face Centered Molecule

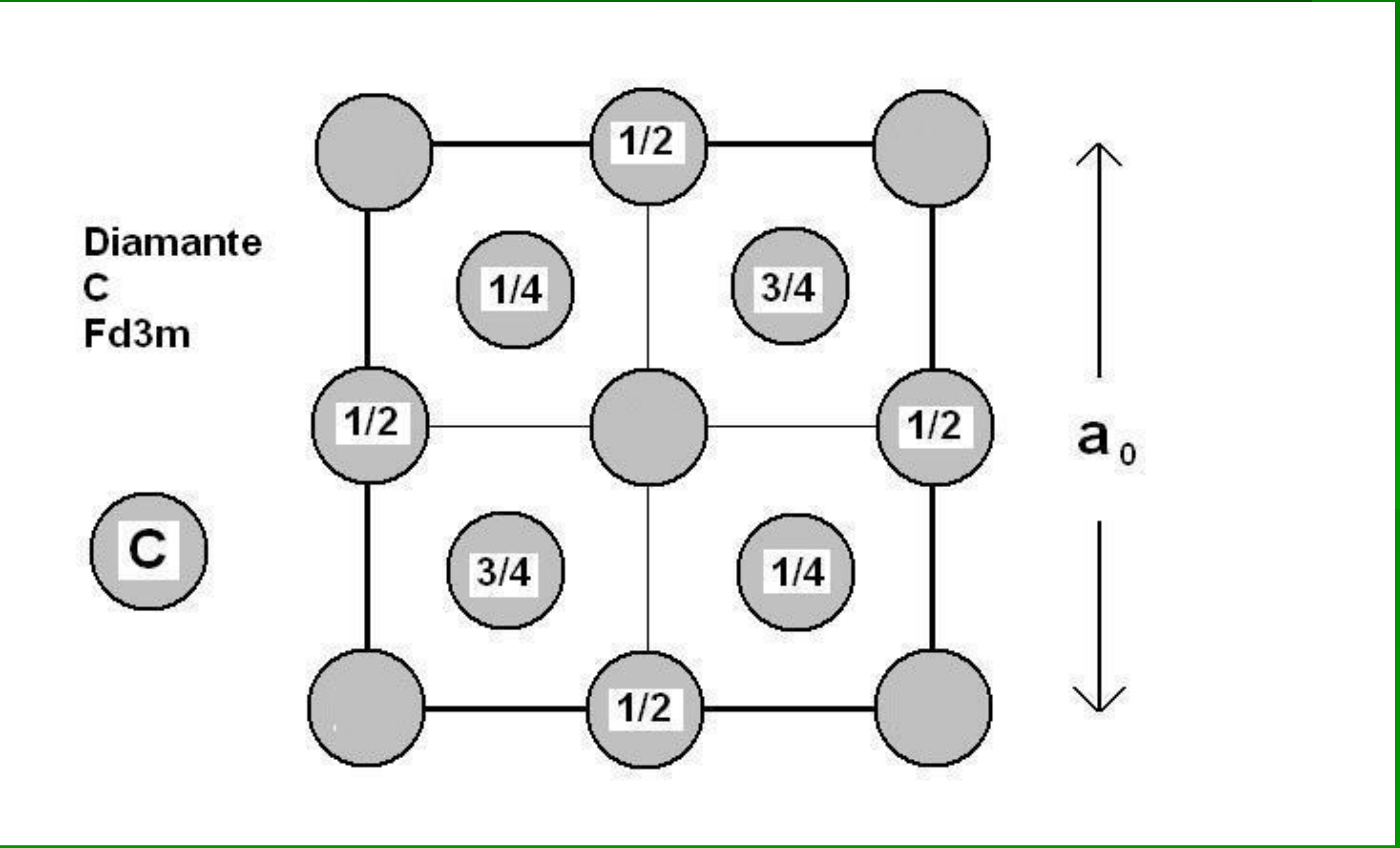
Projeção da cela unitária do ouro:



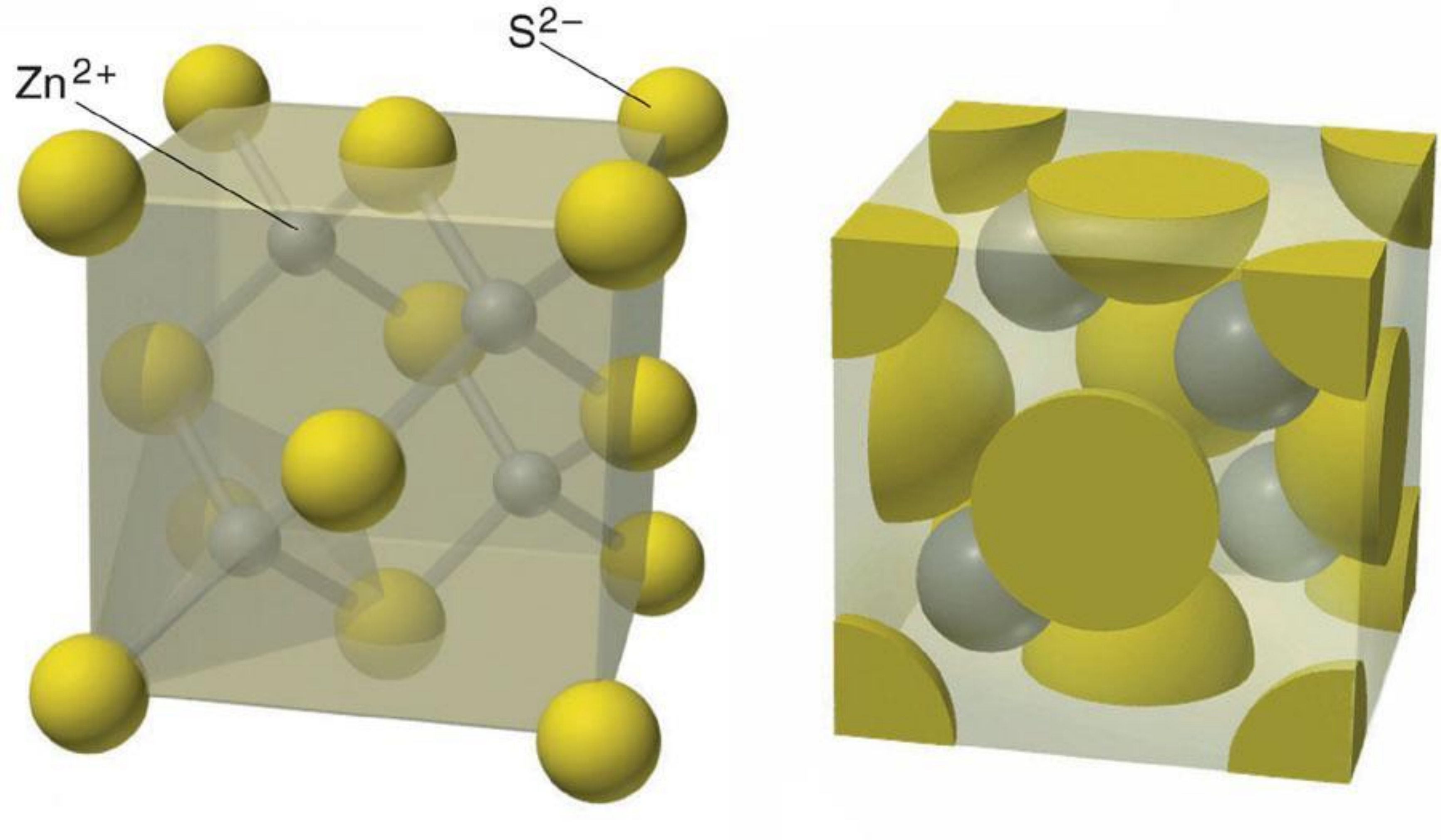
Estrutura do diamante – C – perspectiva e projeção:



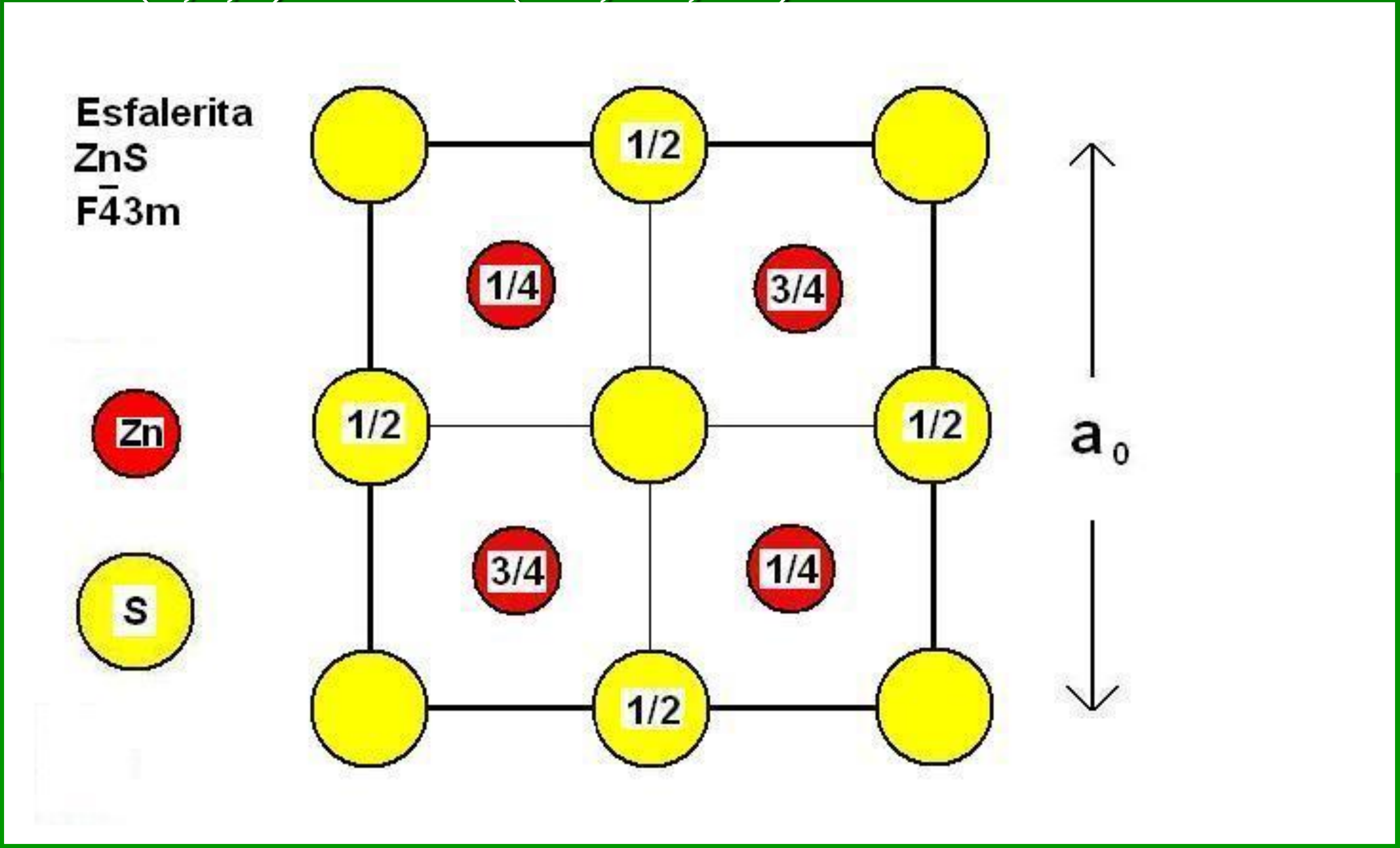
Exemplo de projeção da cela unitária: diamante, C, Fd3m, com átomos de C em (0,0,0) e (1/4,1/4,1/4)



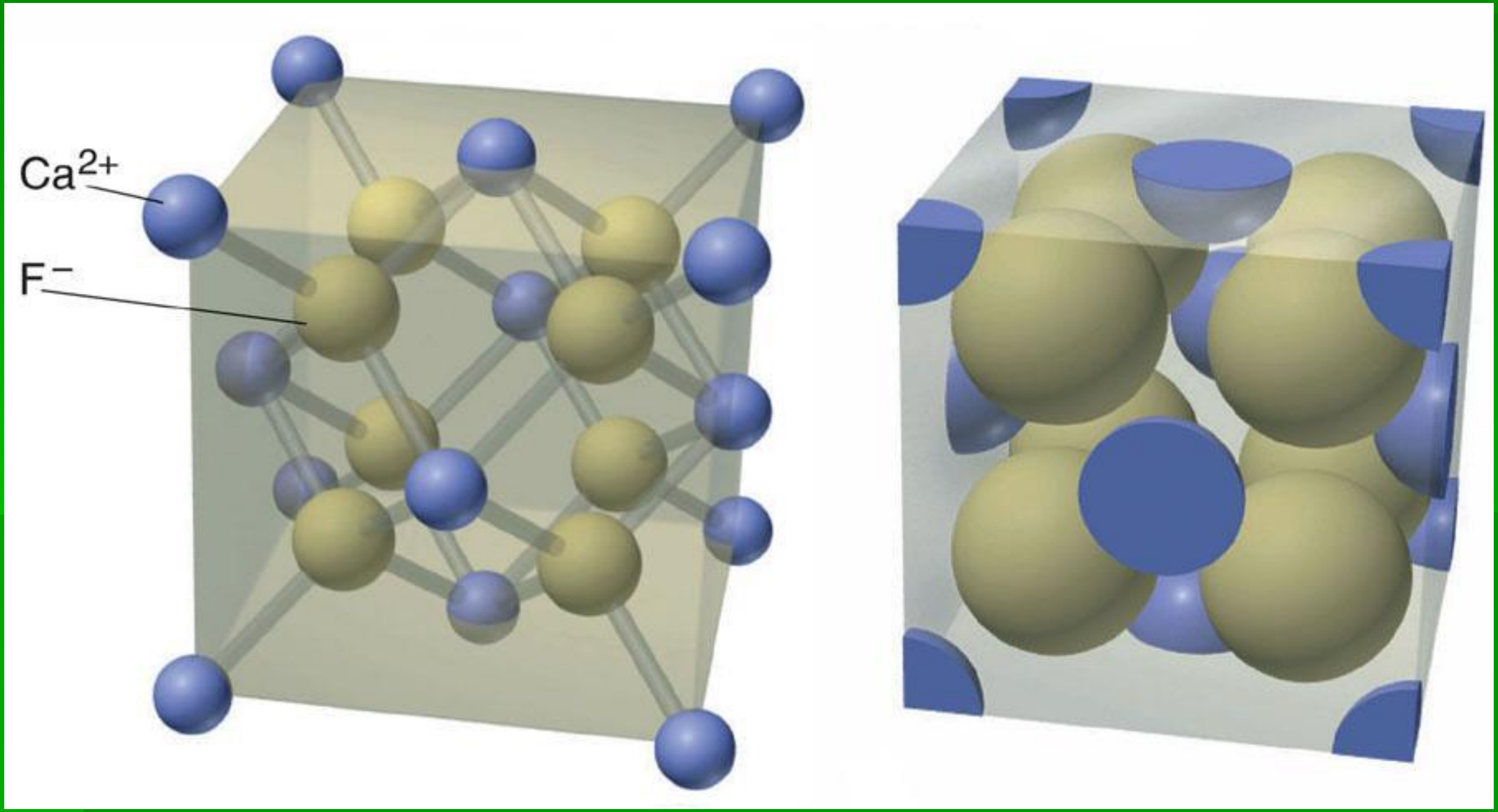
Estrutura da esfalerita – ZnS – em perspectiva:



Exemplo de projeção da cela unitária: esfalerita, ZnS, $F\bar{4}3m$, com S em (0,0,0) e Zn em (1/4,1/4,1/4)



Estrutura da fluorita - CaF_2 – em perspectiva:



Exemplo de projeção da cela unitária: fluorita, CaF_2, Fm3m, com Ca em (0,0,0) e F em (1/4,1/4,1/4) e (3/4,1/4,1/4)