**19.4-06** TEACHING OF CRYSTALLOGRAPHY: AN ALTERNATE CLASS-ROOM DERIVATION OF THE 32 CRYSTALLOGRAPHIC POINT GROUPS (1).

William G.R. de Camargo, Institute of Geosciences University of Sao Paulo, Sao Paulo, SP, Brazil and Adriana R. de Camargo, Faculdade de Arquitetura e Urbanismo, University of Sao Paulo, SP, Brazil.

In the derivation of cyclic geometric non-crystallographic groups (Camargo, W.G.R. & Camargo, L.A.R., VI Congresso Brasileiro de Cristalografia, Recife 1979) 5 groups may be derived for each odd value of n and 7 groups achieved for the even values of n, according to the two general tables below:

| (n) = odd | (n) = even |
|---|---|
| $\bar{x}$m | x/mmm |
| $\bar{x}$ | x/m |
| xm | xmm |
| x2 | x22 |
| x | x |
| | $\bar{x}$2m |
| | $\bar{x}$ |

In the first table (n-odd) the following rules must be obeyed: x or $\bar{x}$ = vertical, m = vertical, 2 = horizontal. In the second table (n= even), the rules are: x or $\bar{x}$ = vertical, /m horizontal, mm= vertical, 22 = horizontal, and the angles m Λ m = 2 Λ 2 = 2 Λ m = 360°/2n.
By extending such concepts to the crystal point groups, which may be regarded merely as examples of the whole set of geometrical groups, the following table summarizes the symbols of all crystallographic groups, according to the various crystal systems:

| Isometric | Trigonal | Monoclinic Triclinic |
|---|---|---|
| (4 x $\bar{3}$)m = m3m | ($\bar{3}$)m = $\bar{3}$m | ($\bar{1}$)m = 2/m |
| (4 x $\bar{3}$) = m3 | ($\bar{3}$) = $\bar{3}$ | ($\bar{1}$) = $\bar{1}$ |
| (4 x 3)m = $\bar{4}$3m | (3)m = 3m | (1)m = m |
| (4 x 3)2 = 432 | (3)2 = 32 | (1)2 = 2 |
| (4 x 3) = 23 | (3) = 3 | (1) = 1 |

| Tetragonal | Hexagonal | Orthorhombic Monoclinic |
|---|---|---|
| (4)/mmm = 4/mmm | (6)/mmm = 6/mmm | (2)mmm = mmm |
| (4)/m = 4/m | (6)/m = 6/m | (2)/m = 2/m |
| (4)mm = 4mm | (6)mm = 6mm | (2)mm = 2mm |
| (4)22 = 422 | (6)22 = 622 | (2)22 = 222 |
| (4) = 4 | (6) = 6 | (2) = 2 |
| ($\bar{4}$)2m = $\bar{4}$2m | ($\bar{6}$)2m = $\bar{6}$2m | ($\bar{2}$)2m = 2mm |
| ($\bar{4}$) = $\bar{4}$ | ($\bar{6}$) = $\bar{6}$ | ($\bar{2}$) = m |

Each crystal system is considered as a bunch of groups (symmetry classes), which have in common one or more rotation axes (proper and improper), the so called characteristic symmetry elements (between curved marks). Thirty six groups are then derived, but only 32 may be considered, because several groups are redundant cases. The monoclinic crystal classes could be derived, either in the orthorhombic or in the triclinic bunches of groups.
The proposed derivation may be viewed as an alternate class-room approach to the problem of elementary development of symmetry point groups, already pointed out elsewhere (Camargo, W.G.R. & Svisero, D.P., XI International Congress of Crystallography, Warsaw, Poland, 1978).

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**19.4-07** AN INTRODUCTION TO SUPERSPACE SYMMETRY: THE 3-DIMENSIONAL COLOURED CRYSTALS AS 4-DIMENSIONAL SEMI-CRYSTALS.

By Y. Billiet, CR5 Chimie et Symétrie, Faculté des Sciences et Techniques, 6, av. Le Gorgeu, 29283 Brest, and D. Weigel, Chimie Physique du Solide, Ecole Centrale des Arts et Manufactures, 92290 Chatenay-Malabry, France.

The main application of Shubnikov space groups is to describe coloured crystals such as magnetic crystals. It is possible to develop for Shubnikov space groups the well-known formalism of Wyckoff positions. Thus any position is associated with 4 parameters x, y, z, t. Of course x, y, z are the co-ordinates with respect to the standard setting; t is the colour parameter. For a set of equivalent positions, the values of the former 3 parameters are infinite in number since positions are repeated by the lattice translations of the 3-dimensional crystal; the colour parameter has a special rôle because it takes at the outside two values (t, -t) for a given set of equivalent positions. This 4-parameter formalism is an extension to dimension 4 of the formalism of 3-dimensional semi-crystals of crystal dimension 2. In these semi-crystals, the structure spreads (indefinitely or not) on both sides of a plane; the positions are repeated by a translation lattice parallel to the plane; there is not crystal-lattice repetition in the 3rd dimension. Any position is associated to 3 parameters x, y, t; x, y are the co-ordinates of its projection into the plane (with respect to a 2-dimensional standard setting); t is the height with reference to the plane. For a set of equivalent positions, the values of the former 2 parameters are infinite in number since the positions are repeated by the 2-dimensional lattice while the height parameter takes at the outside two values (t, -t). To generalize, the 3-dimensional coloured crystals are 4-dimensional semi-crystals of crystal dimension 3; it is possible to classify them with analogy to 3-dimensional semi-crystals of crystal dimension 2; the colour parameter plays the same rôle (with respect to a hyperplane of the 4-dimensional space) as the height parameter.
1st type, the 1-coloured crystals. They are analogous to semi-crystals whose equivalent positions are all situated on the same side of the plane, for a given set. Example: C2/m -$Ш_{12}^{58}$.
2nd type, the 2-coloured crystals based on ordinary lattices. They correspond to semi-crystals possessing equivalent positions situated on both sides of the plane; but this plane is neither a reflection plane nor a glide plane of the semi-crystal. Example: C2'/m' -$Ш_{12}^{62}$.
3rd type, the 2-coloured crystals based on coloured lattices. They correspond to semi-crystals with equivalent positions on both sides of the plane; this plane is a glide plane of the semi-crystal. Example: $P_{C}2_{1}$/m -$Ш_{11}^{57}$.
4th type, the grey crystals. They are analogous to semi-crystals with equivalent positions on both sides of the plane; this plane is a reflection plane of the semi-crystal. Example: C2/m1' -$Ш_{12}^{59}$.