A TABULATION OF CRYSTAL FORMS AND DISCUSSION OF FORM-NAMES

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The writer presents herewith a tabulation of the names of crystal forms, all of which are based upon the geometrical method of Fedorov. This paper also affords an occasion to discuss the standardization of names of forms as proposed by members of the Fedorov Institute of Leningrad[1] and by Wherry.[2] Let it be emphasized that no new names are introduced by the writer. After a perusal of a compilation of the various form-names used by crystallographers for the past hundred years or so, such as is being made by the writer, one would be bold indeed to propose any new names. For example, more than 30 different names have been used for the $\{hkl\}$ form in the ditetragonal dipyramidal class. Names in great sufficiency are available; it is only necessary to choose the best ones for our purpose.

There are two general methods of naming forms. One method is to name the form according to the number and shape of faces; the other method is to name the form according to the position of the constituent faces with respect to the axes of reference.

The first method is used universally for crystal forms of the isometric, tetragonal, and hexagonal systems, but for forms of the other three systems both methods are employed. The practice of naming forms according to the position of faces relative to the axes of reference in the orthorhombic, monoclinic, and triclinic systems is a glaring inconsistency in the opinion of the writer.

FEDOROV'S PLAN OF NAMING FORMS

Fedorov[3] was the first to propose that the names of crystal forms in all systems should depend upon the intrinsic character of the form and not upon the attitude of the faces with respect to axes of reference. Fedorov's method was soon adopted by Groth[4] and by Liebisch[5] and later by other crystallographers, but for some unexplained reason it has not received the support that it deserves.

[1] See Boldyrev, *Zeit. f. Kryst.*, vol. **62**, pp. 145–150, 1925.
[2] *Am. Mineral.*, vol. **15**, pp. 418–427, 1930.
[3] *Zeit. f. Kryst.*, vol. **21**, pp. 574–600, 1893.
[4] *Physikalische Krystallographie*, 3er Auflage, Leipzig, 1895.
[5] *Grundriss der Physikalischen Krystallographie*, Leipzig, 1896.

Fedorov was a geometer of some note as well as a crystallographer and his plan of naming forms according to their geometry merits careful consideration.

Let us contrast Fedorov's names of forms with the older names used. In the rhombic dipyramidal class, it was formerly the custom to speak of the $\{hk0\}$ form as a rhombic prism and of the $\{h0l\}$ and $\{0kl\}$ forms as domes. Fedorov calls all three of them rhombic prisms. The placing of one of them, $\{hk0\}$, in a vertical position parallel to the c-axis does not change the character of the other two. They are still rhombic prisms and should be called such. Fedorov distinguished the three forms mentioned by the addition of a phrase such as "of the first kind," but the writer prefers simply to distinguish them by the appropriate Miller type symbol. These three forms on a crystal or model are noted as rhombic prisms when they are first encountered. As soon as the crystal is oriented, the type or literal symbols may be assigned to the forms.

The term "dome" used by many crystallographers for the $\{0kl\}$ and $\{h0l\}$ forms of the rhombic dipyramidal class should then be reserved for the two-faced forms astride a plane of symmetry, which are limited to the rhombic pyramidal and domatic classes.

In the holosymmetric class of the monoclinic system, the general form $\{hkl\}$ is not a "hemi-pyramid" because it intersects all three axes of reference. Here $\{hkl\}$ and $\{hkl\}$ together do not form a pyramid. Geometrically it is a rhombic prism and should be called such. In a monoclinic crystal of unknown identity, $\{hkl\}$, $\{hk0\}$, and $\{0kl\}$ may be interchanged in position. The character of these three forms is the same regardless of orientation. Why should the form selected for $\{hk0\}$ be called a rhombic prism any more than the others? A similar argument may be used for the $\{h0l\}$ form. Why should $\{h0l\}$ be called a hemi-dome? It is a pinakoid because it consists of two opposite parallel faces. It might be selected as the $\{001\}$ or $\{100\}$ form. The forms $\{100\}$, $\{h0l\}$, $\{001\}$, and $\{h0l\}$ are all pinakoids in this class. In order to distinguish them it is only necessary to use the Miller type symbols.

In the pinakoidal class of the triclinic system why should $\{hkl\}$ be called a "tetra-pyramid," when it is a form that consists of two opposite parallel faces and is obviously a pinakoid? Why should $\{hk0\}$ be named a "hemi-prism" and $\{0kl\}$ and $\{h0l\}$, "hemi-domes" when they are all pinakoids? It may be urged that the older names should be used in order to distinguish the various forms, but the distinctions in the older names cannot be made until the crystal is oriented. When oriented, it is just as easy to use the type symbols.

Two curious attempts to combine the supposed advantages of the two methods of nomenclature have come to the notice of the writer. Tutton,[6] for example, uses the term "bipyramidal pinakoid" for the {*hkl*} form in the pinakoidal class and Wherry[7] uses a similar term "pyramidopinakoid" for the same form. For the {0*kl*} and {*h*0*l*} forms of the rhombic dipyramidal class they use respectively "brachydomal prism," "macrodomal prism" and "brachydomoprism," "macrodomoprism." In the opinion of the writer these names are even less satisfactory than the older names they are intended to supplant. Their intelligent use would demand a knowledge of the history of geometrical crystallography which the student cannot be expected to possess. It is doubtful whether they will ever gain wide acceptance.

Some of the critics of the Fedorov method will doubtless contend that the older names mentioned have priority over Fedorov's names. Let us look into the historical record. The term "horizontale Prismen" was used by Mohs[8] as early as 1822. In this usage he was followed by Naumann (1826), Hartmann (1829), G. Rose (1833), Miller (1845), Kenngott (1846), and J. D. Dana (1850). "Prisma transversum" was used by Hessel (1830) with the same meaning. "Dome" in the older sense, on the other hand, was first introduced into crystallographic literature by Breithaupt in 1836.

G. Rose in 1833 and Hartmann in 1843 used the term "Prismen rhombische schiefe" for the {*hkl*} form in the prismatic class of the monoclinic system, but Naumann's (1826) name, "hemipyramid," was taken up by Breithaupt (1836), Hausmann (1847), Kopp (1849), and J. D. Dana (1850) and came into general use instead of the more logical term, prism.

Fedorov and Groth used the term bipyramid for a double-ended form. The equivalent of this term has priority over the term "pyramid" which is used by some crystallographers even at the present time. Weiss (1818), Grassmann (1829), Kupffer (1831), and Frankenheim (1842) used the term "Doppelpyramiden." Hessel (1830) used "Dipyramis" for the double-ended form. The usage

[6] *Crystallography and Practical Crystal Measurement*, 1st ed., p. 284, London, 1911.
[7] *Loc. cit.*, p. 427.
[8] *Grundriss der Mineralogie*, 1er Theil, p. 111, Dresden, 1812.

of "pyramid" for the double-ended form is due largely to Naumann (1841). In geometry a pyramid is a one-ended form. This is a geometrical term and crystallographers should not change the essential meaning of it.

The illogical nomenclature of the older form-names is due in part to the fact that only four crystal systems were recognized at first by Weiss and Mohs. For some years after this, monoclinic and triclinic crystals were considered to be hemihedral forms of orthorhombic crystals. The name hemi-pyramid for {*hkl*} in the monoclinic system would seem a natural name for a hemihedral form of the {*hkl*} pyramid in the orthorhombic system. And similarly {*hkl*} of the triclinic system might be regarded as a tetartohedral form of the {*hkl*} pyramid of the orthorhombic system and so would be called a tetrapyramid.

Inadequacy of the Older Form-Names

It should be pointed out that the older names were perhaps adequate a half century ago when only part of the crystal classes were well known. During the past few decades nearly all the crystal classes have become so well understood that we need an adequate nomenclature suitable for all possible crystal forms, known as well as unknown. It is my conviction that this is admirably supplied by the Fedorov method. Although trained in the older method, as soon as I encountered the Fedorov nomenclature in a book by the late Professor Alfred J. Moses,[9] I was convinced of its value. Since 1905 I have consistently used Fedorov's names of forms both with elementary and advanced students.

The apparent simplicity of the older nomenclature displayed in some textbooks is due to the fact that the less important crystal classes are inadequately treated.

Tabulation of the Forty-Eight Possible Crystal Forms

Now we come to the tabulation itself. The various forms are listed in ten horizontal divisions giving the number of faces in the forms. These numbers are 1, 2, 3, 4, 6, 8, 12, 16, 24, and 48. There are two vertical columns, one on the left with open forms and the other on the right with closed forms. In all, there are 18 open forms and 30 closed forms. Of the closed forms, 15 are isometric. Invariable forms or those in which the interfacial angles are always the same,

[9] *Characters of Crystals*, New York, 1899.

I. Tabulation of the Forty-Eight Possible Crystal Forms

No. of faces	Open Forms		Closed Forms	
1 face	Pedion	GL		
2 faces	*Pinakoid	GL		
	Sphenoid	GL		
	Dome	GL		
3 faces	*Trigonal Prism	L		
	Trigonal Pyramid	GL		
4 faces	Rhombic Prism	GL	Rhombic Disphenoid	G
	Rhombic Pyramid	G	Tetragonal Disphenoid	GL
	*Tetragonal Prism	L	*Tetrahedron	L
	Tetragonal Pyramid	GL		
6 faces	*Hexagonal Prism	L	*Cube	L
	Hexagonal Pyramid	GL	Rhombohedron	GL
	Ditrigonal Prism	L	Trigonal Dipyramid	GL
	Ditrigonal Pyramid	GL	Trigonal Trapezohedron	G
8 faces	Ditetragonal Prism	L	*Octahedron	L
	Ditetragonal Pyramid	GL	Rhombic Dipyramid	G
			Tetragonal Dipyramid	GL
			Tetragonal Scalenohedron	G
			Tetragonal Trapezohedron	G
12 faces	Dihexagonal Prism	L	Ditrigonal Dipyramid	G
	Dihexagonal Pyramid	G	Hexagonal Dipyramid	G
			Hexagonal Scalenohedron	G
			Hexagonal Trapezohedron	G
			*Dodecahedron	L
			Pyritohedron	L
			Tristetrahedron	L
			Deltohedron	L
			Tetartoid	G
16 faces			Ditetragonal Dipyramid	G
24 faces			Dihexagonal Dipyramid	G
			Trapezohedron	L
			Trisoctahedron	L
			Tetrahexahedron	L
			Hextetrahedron	G
			Diploid	G
			Gyroid	G
48 faces			Hexoctahedron	G

(*=invariable forms; the others are variable. G=general form, L=limit form) are marked with an asterisk. The unmarked forms have variable interfacial angles. The tetragonal prism, for example, is an invariable form since the angle $(110:1\bar{1}0)$ or $(hk0:\bar{k}h0)$ is always 90°; the rhombic prism, on the other hand, is variable.

There are 48 kinds of forms possible. Of these, all but four have actually been found on crystals. The four forms not yet discovered are the ditetragonal pyramid, the hexagonal trapezohedron, the dihexagonal pyramid, and the gyroid.[10] The tetragonal trapezohedron was first found as late as 1907 (on methyl ammonium iodid), and the ditrigonal dipyramid as late as 1909 (on benitoite).

General Forms

Of the 48 forms, 32 are general forms and may be derived directly from the symmetry by a well-known procedure. A list of these general forms is given. This list gives the name of the general form, the number of faces in the form, and the symmetry from which the general form is derived. The symbols for the symmetry elements are discussed in a paper by the writer.[11] The symbol AP_n stands for a rotatory-reflection axis and CA_n for a rotatory-inversion axis. According to the writer's method of deriving each face of the general form directly from the initial face,[12] it is necessary to employ both kinds of composite axes of symmetry. The parentheses around a symmetry element indicates that the particular element is included in another symmetry element listed. For example, (C) is included in AP_6 or $4AP_6$ and (P) is included in CA_6. The brackets indicate that one or more of the operations of the symmetry element enclosed is also included in another symmetry element listed. For example, in classes 25 and 27, the elements, A_6, (AP_6), and (CA_6) have rotations of 120° and 240° in common.

Limit Forms

The other 16 forms $(48-32=16)$ are limit forms (see Table IIb), the faces of which have a special position with respect to *symmetry directions*.[13] These forms are called limit forms since they may be derived from general forms by decreasing certain interfacial angles,

[10] The apparent gyroid found on cuprite is probably due to symmetrical malformation, for etch-figures prove that cuprite belongs to the hexoctahedral class.

[11] *Am. Mineral.*, vol. **13**, pp. 571–577, 1928.

[12] *Proc. Amer. Acad. Arts and Sciences*, vol. **61**, p. 162, 1926.

[13] I use this term for directions fixed by symmetry which are axes of symmetry or lines normal to planes of symmetry.

IIa. Table of General Forms

General Form	Faces	Symmetry
Pedion	1	
Pinakoid	2	C
Dome	2	P
Sphenoid	2	A_2
Trigonal Pyramid	3	A_3
Tetragonal Pyramid	4	A_4
Hexagonal Pyramid	6	A_6
Rhombic Pyramid	4	$A_2 \cdot 2P$
Ditrigonal Pyramid	6	$A_3 \cdot 3P$
Ditetragonal Pyramid	8	$A_4 \cdot 4P$
Dihexagonal Pyramid	12	$A_6 \cdot 6P$
Rhombic Prism	4	$A_2 \cdot P \cdot C$
Trigonal Dipyramid	6	$\text{CA}_6 \cdot (P)$
Tetragonal Dipyramid	8	$A_4 \cdot [\text{Æ}_4] \cdot P \cdot C$
Hexagonal Dipyramid	12	$A_6 \cdot [\text{Æ}_6] \cdot [\text{CA}_6] \cdot (P) \cdot (C)$
Rhombic Disphenoid	4	$A_2 \cdot 2A_2$
Trigonal Trapezohedron	6	$A_3 \cdot 3A_2$
Tetragonal Trapezohedron	8	$A_4 \cdot 4A_2$
Hexagonal Trapezohedron	12	$A_6 \cdot 6A_2$
Rhombic Dipyramid	8	$A_2 \cdot 2A_2 \cdot 3P \cdot C$
Ditrigonal Dipyramid	12	$\text{CA}_6 \cdot (P) \cdot 3A_2 \cdot 3P$
Ditetragonal Dipyramid	16	$A_4 \cdot [\text{Æ}_4] \cdot 4A_2 \cdot 5P \cdot C$
Dihexagonal Dipyramid	24	$A_6 \cdot [\text{Æ}_6] \cdot [\text{CA}_6] \cdot 6A_2 \cdot 6P \cdot (P) \cdot (C)$
Tetragonal Disphenoid	4	$\text{Æ}_4 \cdot$
Rhombohedron	6	$\text{Æ}_6 \cdot (C)$
Tetragonal Scalenohedron	8	$\text{Æ}_4 \cdot 2A_2 \cdot 2P$
Hexagonal Scalenohedron	12	$\text{Æ}_6 \cdot 3A_2 \cdot 3P \cdot (C)$
Tetartoid	12	$4A_3 \cdot 3A_2$
Gyroid	24	$3A_4 \cdot 4A_3 \cdot 6A_2$
Diploid	24	$4\text{Æ}_6 \cdot 3A_2 \cdot 3P \cdot (C)$
Hextetrahedron	24	$4A_3 \cdot 3\text{Æ}_4 \cdot 6P$
Hexoctahedron	48	$3A_4 \cdot [3\text{Æ}_4] \cdot 4\text{Æ}_6 \cdot 6A_2 \cdot 9P \cdot (C)$

IIb. Table of Limit Forms

Prisms	Trigonal Prism	Limit Form of Trigonal Dipyramid
	Tetragonal Prism	Limit Form of Tetragonal Dipyramid
	Hexagonal Prism	Limit Form of Hexagonal Dipyramid
	Ditrigonal Prism	Limit Form of Ditrigonal Dipyramid
	Ditetragonal Prism	Limit Form of Ditetragonal Dipyramid
	Dihexagonal Prism	Limit Form of Dihexagonal Dipyramid
Isometric Forms	Trisoctahedron	Limit Form of Hexoctahedron
	Trapezohedron	Limit Form of Hexoctahedron
	Tetrahexahedron	Limit Form of Hexoctahedron
	Deltohedron	Limit Form of Hextetrahedron
	Tristetrahedron	Limit Form of Hextetrahedron
	Pyritohedron	Limit Form of Diploid
	Dodecahedron	Limit Form of Trisoctahedron or Tetrahexahedron
	Cube	Limit Form of Trapezohedron or Tetrahexahedron
	Octahedron	Limit Form of Trapezohedron or Trisoctahedron
	Tetrahedron	Limit Form of Deltohedron or Tristetrahedron

thus obtaining other general forms until they finally approach the desired form as a limit. For example, starting with the general form {211} in the ditetragonal dipyramidal class, we may decrease *per saltum*, the angle $(hkl:hk\bar{l})$ thus obtaining the forms {632}, {421}, {631}, {841}, {10.5.1}, etc., with a constantly increasing value of k/l. As the angle mentioned becomes smaller and smaller it approaches 0°, and we finally obtain the ditetragonal prism {210}, which is said to be the limit, or limiting, form of the ditetragonal dipyramid {211}.

An excellent example of the limit forms in the hexoctahedral class is shown in the frontispiece of Williams' textbook.[14]

Six of the limit forms are prisms; the other prism (rhombic prism) is the general form in the prismatic class of the monoclinic system. The other ten limit forms are isometric. Of these, the last four listed cannot be derived directly from general forms. They are limit forms of other limit forms as will be noted.

It is thus possible to derive all of the 48 forms either directly or indirectly from the symmetry without recourse to merohedrism.

Some of the forms are general forms in a particular class and also limit forms either in the same class or another class. For example,

[14] *Elements of Crystallography*, 3rd ed., New York, 1892.

the rhombic prism is a general form in the prismatic class and limit forms $\{hk0\}$ and $\{0kl\}$ in the same class and also limit forms $\{hk0\}$, $\{h0l\}$, and $\{0kl\}$ in the rhombic dipyramidal class.

Remarks on Some of Wherry's Form-Names

Before I comment on the individual forms, some general remarks on Wherry's names of forms may be made, especially since he has invited criticism. Wherry objects to form-names that indicate the *shape* of faces. His objection is based upon . . . "the extreme rarity of crystals bounded by single forms (except of course (100) and (111)) . . . ."[15] He advocates names that indicate the *number* of faces present. This plan has been followed to some extent in names in general use, but I believe it is a mistake to push the matter to its logical conclusion. There are no less than ten distinct 12-faced forms; to call more than one of these a dodecahedron is to create confusion. As to names based upon shapes of crystals, I do not believe that Wherry's objections are very serious. In the study of geometrical crystallography, models of simple forms are practically always available. The naming of minor forms on models or crystals is a valuable exercise; it helps develop the imagination and this is one of the principal benefits of the study of geometrical crystallography. An objection can also be raised to using names based upon the number of faces. In many cases the total theoretical number of faces of a form is not present on a crystal; this point has been emphasized by Victor Goldschmidt. The fact that some names are based upon the shape of faces and some upon the number of faces is not a very serious matter. In any event the nomenclature is too well established to insist upon a strictly consistent and logical set of names.

Comments on the Names of Forms

Pedion, introduced by Groth[16] in 1895 and adopted by Lewis[17] is a very useful term for the one-faced form. "Plane" or "face" has been used to designate such a form, but there is need of a definite technical word to replace these terms which have a more general meaning. Pedion is better than Fedorov's name "hemi-pinakoid." It is shorter and simpler than "monohedron" which was proposed by the Fedorov Institute[18] and also recommended by Wherry.

[15] *Loc. cit.*, p. 418.

[16] *Loc. cit.*, p. 337.

[17] *A Treatise on Crystallography*, p. 148, London, 1899.

[18] Boldyrev, *loc. cit.*, p. 146.

The term pinakoid is used by the older crystallographers for forms with faces that are parallel to two axes of reference and cut a third, except for forms in the isometric and tetragonal systems. Fedorov expanded it to include all forms with two opposite parallel faces in whatever system they are found and whatever their position on the crystal may be.

The terms sphenoid and dome have been combined into the single term "dihedron" by the members of the Fedorov Institute. This is, in my opinion, a backward step. Altho both of these are non-parallel two-faced forms, one of them is the result of the operation of rotation and the other of the operation of reflection. It is important to distinguish these two forms so as to have distinctive names for the general forms of the merosymmetric classes of the monoclinic system. Wherry also uses "dihedron" as a substitute for dome.

As to the seven kinds of prisms, there is little to be said except to protest against Wherry's proposal to use "duploprism," instead of ditetragonal and dihexagonal prisms. Altho Wherry's term is shorter, it can only be used in connection with the particular system, so we need qualifying terms such as ditetragonal and dihexagonal. The same objection can be urged against Wherry's terms "normo-prism" and "chordo-prism." The names of forms according to Fedorov's plan are independent of both crystal systems and axes of reference and this is very desirable.

I can see no particular advantage in Wherry's "trigonoprism" over trigonal prism. Trigonal is analogous to tetragonal and hexagonal.

The names pyramid and dipyramid are much to be preferred to the alternative terms, "hemimorphic pyramid" and "pyramid." The Russian crystallographer Vulf (G. Wulff) not many years ago proposed that dipyramid be used instead of bipyramid and he has generally been followed by advocates of the Fedorov plan. It is rather inconsistent to use such a term as *di*trigonal *bi*pyramid (*di* is Greek and *bi* is Latin) since pyramid is derived from the Greek.

The general form in the rhombic disphenoidal class and the tetragonal disphenoidal class is often called a "sphenoid" but since these forms are double-ended, this term is not satisfactory. We need another term such as disphenoid or sphenohedron; between these two there is little choice except that disphenoid has been used more often in recent years. The Fedorov Institute proposes to call these forms rhombic tetrahedron and tetragonal tetrahedron, but it seems better to restrict tetrahedron entirely to the regular tetrahedron.

Rhombohedron is used almost universally for the six-faced form with a rotatory-reflection axis. I am surprised to learn that Wherry would like to substitute such a term as "ditrihedron" for it. Probably no other form name has fewer synonyms than rhombohedron; this in itself is an excellent argument for retaining the name.

We have two scalenohedrons, one variously distinguished as tetragonal, quadratic, ditetragonal, or didigonal; the other as hexagonal, dihexagonal, or ditrigonal. I prefer to choose the simplest of these terms which are tetragonal and hexagonal. Their plan views are respectively bounded by a square and a regular hexagon. Both terms tetragonal scalenohedron and hexagonal scalenohedron were used by Naumann in 1854. Wherry's substitutes for these, which are "duplo-disphenoid" and "duplo-ditrihedron," have not very much to recommend them.

There are three trapezohedrons, distinguished as trigonal, tetragonal, and hexagonal. These names have very wide usage and are probably as good as any that could be devised. They are recommended by the Fedorov Institute. Wherry however proposes to call them respectively "gyro-trigonodipyramid," "gyro-dipyramid," and "gyro-dipyramid." The last term can only be used in connection with a particular crystal system. It is not likely that these terms will come into general use.

Finally we come to the fifteen isometric forms. Of these, J. D. Dana's (1850) hexoctahedron is preferred to Miller's (1839) hexakisoctahedron. Similarly, hextetrahedron, tetrahexahedron, and trisoctahedron are better than hexakistetrahedron, tetrakishexahedron, and triakisoctahedron, respectively. The Greek syllable *-kis-* (times) may be omitted in order to simplify the words which are complex enough even at their best.

The only difficulty with trapezohedron is its possible confusion with the trigonal, tetragonal, and hexagonal trapezohedrons. Trapezohedron without a qualifying term signifies the one in the isometric system. Icositetrahedron is too long and besides there are five other isometric forms with 24 faces. Tetragonal trisoctahedron is also too long.

In the name pyritohedron we have another difficulty. It is the sole survivor of an old custom of naming crystal forms after the names of minerals. Formerly leucitoid or leucitohedron was used for the trapezohedron, fluoroid for the tetrahexahedron, galenoid for the trisoctahedron, adamantoid (from diamond) for the hexoctahedron, granitoid for the dodecahedron, cuproid (from copper) for tristetrahedron, borazitoid for the hextetrahedron, quartzoid for the hexagonal dipyramid, berylloid for the dihexagonal dipyramid, and zirkonoid for the ditetragonal dipyramid. This custom fortunately has been discontinued. One objection to it is that the mineral that furnishes the name may prove to have symmetry different from the one that was first assigned to it. The other names for the pyritohedron are not satisfactory. It is not, strictly speaking, a pentagonal dodecahedron, for the faces are not regular pentagons. "Dyakishexahedron" and "dihexahedron" are not well suited names for this form. There is nothing in the appearance of the form to suggest a cube, which is not the case with the tetrahexahedron. "Dihexahedron" was formerly a widely used term for the hexagonal dipyramid. For the want of a better name, the term pyritohedron is used.

Deltohedron was introduced by Haidinger in 1845 for the $\{hkl\}$ form in the hextetrahedral and tetartoidal classes. It was adopted by J. D. Dana and replaced deltoid dodecahedron. Another synonym of it is tetragonal tristetrahedron which is too long. Wherry calls it "hemicositetrahedron," which is equally bad.

Haidinger's term diploid is probably the best one for the $\{hkl\}$ form in the diploidal class of the isometric system. Wherry says " . . . the complex expressions often used for the $\{hkl\}$ form may be simplified to *didodecahedron*." But what name for this form could be simpler than diploid?

Haidinger's (1845) term gyroid seems better than gyrohedron (Quenstedt, 1854), plagihedron (Haidinger used this for the trigonal trapezohedron), pentagonal icositetrahedron, pentagontrioctahedron (Fedorov Institute), or gyricositetrahedron (Wherry). Since gyroid is the only form name in the list in which "gyro" appears, it is distinctive.

Tetartoid introduced by Haidinger in 1845 is the simplest name for the general form of the tetartoidal class. It is better than tetartohedron, "gyrotritetrahedron" (Wherry), or tetrahedral-pentagonal-dodecahedron. Tetartoid is the only name in the entire list that shows the influence of the concept of merohedrism.

It is a question whether dodecahedron or rhomb-dodecahedron (or rhombododecahedron) should be used for {110} in the isometric system. If dodecahedron is used, there is possible confusion with the non-crystallographic regular dodecahedron of geometry, but on the other hand, it is the only form-name in the entire list with dodecahedron in it. For this reason dodecahedron is retained.

Octahedron is now used universally for the {111} form and such terms as quadratic octahedron and rhombic octahedron have fortunately almost disappeared from crystallographic literature. Cube seems better to me than hexahedron. There is general agreement on the term tetrahedron.

With the possible exceptions of trapezohedron and pyritohedron the form-names given in the list are believed to be entirely satisfactory. They are comparatively simple, consistent, and free from ambiguity. I do not mean to say that if one were free to choose his own terms untrammeled by former usage he could not do better. But for the sake of continuity with the past it seems advisable to use well-established terms, tho not necessarily those with priority.

What I urge especially is the plan of Fedorov, adopted by Groth, of naming forms according to their geometry.

Names of Symmetry Classes

The fact that the general form is distinctive for each symmetry class suggests, as it did to Groth, that the names of general forms might be used as class names. This, in my opinion, is the most satisfactory method of designating the crystal classes. The names are entirely free from ambiguity; it is doubtful whether this is true of any other method.

Since the crystal classes are derived from the various types of symmetry without regard to crystal systems, this fact should be reflected in the class names. This is only true, I believe, of class names based upon the names of general forms.

The class names used by Miers[19] and adopted by Phillips[20] have some decided advantages, but a serious disadvantage is that they require a new set of names. In the Fedorov-Groth scheme of nomenclature one set of names is used for both general forms and classes; this is a decided boon to the student.

Names based upon merohedrism used by various crystallogra-

[19] *Mineralogy*, p. 280, London, 1902.
[20] *Mineralogy*, New York, 1912.

phers show a notable lack of uniformity. For the rhombohedral class [$Æ P_6 \cdot (C)$] the following names based upon merohedrism have been used: rhombohedral hexagonal-tetartohedral, rhombohedral tetartohedral, hexagonal tetartohedral of the second sort, rhombohedral paramorphic, rhombohedral parahemihedral, and parallel-faced hemihedral. There has never been any generally accepted set of names for the merosymmetric classes of the various crystal systems that are based upon merohedrism.

Names of classes based upon general forms, on the other hand, show little variation at the hands of their supporters. The differences are small, as, for example, hexakisoctahedral and hexoctahedral. It is important to note that practically all crystallographers who base class names upon general forms use Fedorov's plan of naming forms.

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