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IMA/COM REPORT ON SYMBOLS AND DEFINITIONS*

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Introduction

The symbols currently used for the reflectance properties of the various optical classes of opaque minerals are numerous and inconsistent. A committee on symbols and definitions of the Commission on Ore Microscopy (COM) of the International Mineralogical Association (IMA) was formed in 1974 to examine these and to recommend one set of symbols. An interim report of this committee was presented and approved at the COM meeting in Novosibirsk in 1978. Publication of the report was delayed, however, pending the report of the editorial committee of the Quantitative Data File (Criddle 1980). The amended report, which follows, was approved for publication at the COM meeting in Orléans in 1980.

Optical Constants

Two systems are in current use; these share the symbol n, but differ confusingly in the symbols for absorption and in the names for these.

French system

χ Indice d'extinction (Greek chi)
k Coefficient d'absorption
n Indice de réfraction
$\chi = nk$ defining equation

Anglo-German system

k Absorption coefficient
κ Absorption index (Greek kappa)
n Index of refraction
$k = n\kappa$ defining equation

The symbol k (Anglo-German) refers to one wavelength in vacuum (or air), whereas the symbol κ (kappa) refers to one wavelength inside the substance. Either may be preferable in physics according to the purpose, but in our data we need only one. The symbol referring to one wavelength in vacuum is clearly the more suitable for our purpose. If we were to drop the use of the kappa symbol, any possible confusion between the two systems would disappear. It is proposed to retain the use of both systems, but to drop the use of the pair of symbols called k in the French system and κ (kappa) in the Anglo-German.

Optical Classes

The term *optical class* means the grouping into which a substance can be put on the basis of the particular study specified; there is no unique type of optical classification.

We leave out the property of optical activity and consider only those called *ellipsoid properties* in dealing with transparent crystalline substances; the variation of such properties with direction can be represented by ellipsoids when the absorption is zero.

Optical class	CUBIC	UNIAXIAL	ORTHORHOMBIC MONOCLINIC TRICLINIC
Shape of surface of representation	Sphere	Surface of revolution	Geometrically triaxial ellipsoid, with two optic axes, hence called biaxial. The three classes are distinguishable by the effect of symmetry control on the orientation of the ellipsoid.

Note: Because of the lack of a means of determining the orientation of a grain in reflected light, the distinction among the three biaxial classes can be made only on oriented sections, so that for polycrystalline specimens, only three optical classes can be distinguished in practice: cubic, uniaxial and biaxial.

Extension of the term *biaxial* is quite proper because the n surface possesses two singular directions, although these cannot be detected.

Symbols for Reflectance at Normal Incidence in Air (see Note 1 for oil immersion)

R: Cubic minerals.
R': Amorphous substances and in the case of a mineral where doubt exists concerning its

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true symmetry (*e.g.*, in grains of minerals with very low to negligible bireflectance, or that are too small to be X-rayed). It is also used where the substance is known to be noncubic but where reflectance measured at a given wavelength is constant (*i.e.*, within measurement error).

R_oR_e: Where the mineral is uniaxial and the two vibrations can be named as ordinary and extraordinary, respectively, these symbols are used.

R'_e: If the vibration along the optic axis can be obtained, R_e is used; otherwise the symbol is given a dash (on the R and not on the subscript, where it could be confused with a comma).

R_1R_2: If no precise direction can be ascribed to the vibration measured, the subscripts 1 and 2 should be used. The allocation is made by giving the subscript 2 to the vibration having the higher luminance (Y) for the C illuminant, as calculated from the spectral reflectances, and the subscript 1 to the vibration of lower luminance. These subscripts do not imply a magnitude relation of R at any particular wavelength because the two curves may cross (Note 2). They are always used with biaxial, unoriented sections.

With a substance of very low bireflectance, known or suspected to be uniaxial, it may be impossible to be sure which vibration is the ordinary; in such cases R_1 and R_2 are used. Where it is believed that the ordinary vibration can be recognized, although not with certainty, the symbols may be used with a question mark: $R_1 \stackrel{?}{=} R_o$ or $R_2 \stackrel{?}{=} R_o$.

$R_aR_bR_c$: These symbols are used where oriented sections of an orthorhombic mineral are measured; the middle one can be used for a monoclinic mineral where a section parallel to the y axis is measured, the other principal vibrations not being measurable in practice. The lengths of the sides of the unit cell that correspond to the choice of these axes must be given to identify the vibration directions (Note 3).

R_{st} or R_{ref}: These subscripts are used where it is necessary to distinguish between the reflectance of the specimen and that of the standard (or reference material).

$R(546)$: Parentheses are used to enclose information that is needed as, for example, a wavelength, where the symbol occurs by itself.

R^* (with the appropriate subscript): In a few cases it is required to give another column (or part of a column) of values for the same grain; the asterisk should be used with a note of explanation attached. For example, this need occurs where different values of reflectance (R_o) are found depending on whether the measurement is made on the basal plane or on another section in a uniaxial mineral.

Note 1: Where the reflectance is measured in any medium other than air, the front superscript *im* is added, as in ${}^{im}R$; a note specifying the medium is then attached.

N: The symbol N is reserved for the index of refraction of an immersion medium, with a note attached specifying the medium.

Note 2: In the supplementary cards of the second issue of the IMA/COM Quantitative Data File, there will not be sufficient data for the calculation of the luminance (Y). On such cards the symbol R_2 will be allocated to the set of spectral reflectances having the greater value of $R(546)$; if the two curves should happen to cross at that wavelength, the greater value of $R(589)$ will be used instead to make the allocation of symbol. It should be noted that the luminance rule and the rule of higher value at a specified wavelength can be at variance with each other; in such a case, the luminance rule takes precedence, and this is to be calculated for the C illuminant. In the case where the two luminances turn out to be equal, the other rule is used to make the allocation.

Note 3: In the case of a section parallel to the y axis in a monoclinic mineral, the symbol R_b is used for the vibration along this axis; for the other, which cannot be specified optically, the symbol R_1 or R_2 is used depending on whether the set of spectral reflectances has the smaller luminance or the greater.

Symbols for Hardness

In micro-indentation-hardness testing, a mass in grams (g) is selected. This acts as a load (force), and in the equation it should be specified as the gram force (gf). The standard mass is 100 g, but a smaller mass can be used with grains that are very small or very soft; with very hard minerals the mass can be increased to 200 g. A nonstandard mass should be indicated in parentheses. The loading speed of the indenter should be 10–20 μm/second and the duration of the indentation 15 seconds. Measurement should be made in green light, $\sim$546 nm, with an objective of numerical aperture $\sim$0.65.

The Vickers indenter is used to obtain values of micro-indentation hardness in the determination of ore minerals, and the symbol used in the IMA/COM Quantitative Data File is *VHN*.

Names and Symbols for Color

In matters pertaining to color, the COM takes as its guide-lines the recommendations of the *Commission Internationale de l'Éclairage* (CIE). In a cubic substance all vibrations are equal. In anisotropic sections the color applies to a specified vibration, and so it is convenient to call this a vibration color where it is necessary to distinguish it (Note 1).

Color values have to be specified for a given illuminant, and two illuminants are in use for the colors of ore minerals. The standard one is the *C* illuminant, which is white and is obtained by the insertion of the appropriate filter in the beam from an *A* illuminant. The *A* illuminant is obtained by running a tungsten-filament lamp under the specified conditions.

The calculation of color values from spectral reflectances yields the rectangular coordinates x y, Y (Note 2). The first two specify the chromaticity, but not in such a way as to enable this to be easily visualized. However, it is simple to transform these to a set of modified polar coordinates that do enable easy visualization of the color appearance. To either set of two-dimensional coordinates we can add the vertical axis Y, which is the luminance factor in per cent. Thus there are two ways of expressing chromaticity coordinates:

(1) rectangular coordinates: x abscissae, y ordinates; (2) polar-type coordinates: chromaticity λ_d, the direction of dominant wavelength (Note 3), and purity p_e, the proportion along the direction from the illuminant point to the chromaticity point as a percentage of the distance to the spectral locus (Note 4).

Note 1: The colors seen when anisotropic sections are in the 45° position between crossed polars are called anisotropic rotation colors; these are expressed only qualitatively.

Note 2: The color-matching data used in microscopy are the CIE (1931) set for a field not exceeding 4° subtense in the eye. This defines the part of the retina that is used in staring fixedly at a very small area, *i.e.* when one looks closely at the color of a small grain under the microscope.

Note 3: If the color is in the purple sector, the complementary wavelength (λ_c) is used, and this is denoted as, for example, in 546c.

Notre 4: The symbol p_e is used for the excitation purity to distinguish it from the colorimetric purity (p_c); only the former is now used in the West, but the latter is found in publications from the U.S.S.R.

Reference

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