

THE PHILOSOPHIC CLASSIFICATION OF MINERAL STRUCTURE*

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INTRODUCTION

The recent new edition of Kraus and Hunt's determinative tables inspires me to submit to the Mineralogical Society, and to them and other writers of mineral text books, the question whether the terms applied to the structure, habit and grain of minerals can be treated in a philosophic fashion so as to bring out their connection on the one hand, with the power of crystallization and with fundamental properties connected with the arrangement of the atomic network, and on the other hand, with the arrangement and frequency of the centers of crystallization. Though they do not depend wholly upon these factors and it is with diffidence that I present this tabulation for consideration, such a classification may make the terms seem more reasonable, interesting and important to the student and easier to remember, and of interest because of their indication of the surroundings not merely in determinative mineralogy but in genetic mineralogy as well. This merges into geology and the theory of ore deposits. The field of the habit of crystals has been developed more in Europe than in America and is perhaps worthy of more attention here.

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II. DEGREE OF DOMINANCE OF DIRECTION DEPENDENT
UPON TEMPERATURE AND RATE OF FORMATION

Generally speaking, the degree of apparent dominance of certain directions is inverse to the temperature and the slowness of formation. The higher the temperature, the less dominant is any one direction. Also, the slower the formation, the more the crystal approaches a polyhedron inscribed in a sphere. We can see a reason for this, because if the atoms which are added to a crystal drift in only slowly from outside, the forces and the direction of attraction from within a crystal will have much less importance than as though there were a large abundance of material to be put into shape. It will be only putting into a general law what Tammann found experimentally when he found that only one or two degrees below the melting point he had larger crystals with more numerous faces and less oriented axes than when the crystals were formed farther below the melting point.¹ This is, of course, not absolutely true, and the rule given above has exceptions. For instance, prismatic topaz has basal cleavage. I think, however, that in the study of the habit and structure of crystals, such as that of J. G. Koenigsberger on the crystals of Switzerland there are a good many facts that may be brought into line. As Koenigsberger says:² "It is a frequent peculiarity that the lower the temperature of formation of a crystal is, the more is it stretched in a dominant direction," and as he says³ "feebler kinetic (thermal) energy of the crystal lattice allows the differences of attraction in different directions to have more weight than when there are greater thermal oscillations of the atoms or atom groups."

For instance, in silica the less symmetrical quartz is prismatic in veins and stable below 575°. The shorter bipyramidal quartz such as the phenocrysts of quartz in quartz porphyry is stable from 575° to 875° and is more symmetrical. Tridymite is hexagonal and stable above 875° and the isometric cristobalite is formed at the highest temperature. The pyroxene of the basic rocks is short and in the large ophitic patches almost equi-dimensional. Salite is more prismatic. The hornblende is usually more elongated with a bet-

¹ G. Tammann, *Kristallisieren und Schmelzen*, 1903, p. 134.

² *Fortschritte der Mineralogie, Kristallographie und Petrographie*, 11 (1927) p. 11.

³ Ueber alpine Minerallagerstätten. Mineralklüfte und Differentiation ihrer Paragenese. *Schweiz. Mineralog. u. Petrogr. Mitteilungen*, V (1925), pp. 66 to 127, the quotation is from p. 127.

ter cleavage and I presume is formed at a lower temperature, especially in the schists, and the tremolite and asbestos possibly at lower temperatures still. Pyrite is isometric and more of a high temperature mineral than marcasite. Leucite is more of a high temperature mineral than orthoclase and is at high temperatures isometric. The igneous rocks generally are rocks formed at higher temperatures than the metamorphic rocks which are characterized by minerals in which there is a pronounced tendency to a direction of growth which determines the schistosity. It is also well known that slow formation and large crystals have modifications and complications tending to round off the forms. Small crystals are simple. The large masses of feldspar in a pegmatite show little dominant direction as compared with the trichitic feldspar of a basalt near the margin. Other factors, such as the character of the solution from which crystals form, and the curious orienting effect of other minerals, by which, for instance, flattened out and distorted hard tourmaline crystals occur parallel to the cleavage of the soft mica, seem more local and individual, though well worthy of attention. But they are not available as yet in classification.

I take it that the large nearly equidimensional highly modified crystals of calcite in the Lake Superior copper country are produced by relatively slow crystallization at relatively high temperatures and Koenigsberger says that in the Alps the lower the temperature of its formation, the more prismatic the calcite tends to be.

III. EFFECT OF DOMINANT DIRECTIONS ON STRUCTURE

When there are dominant directions, they may be classed as follows:

A. Dominant direction is that of greatest growth, in general that of greatest attraction and prismatic cleavage.

The prisms when fine and tough may be called fibrous, or if ductile, filiform, when brittle, acicular.⁴ The luster may be silky. When the centers of crystallization are relatively rare, we are likely to have radiated structures and these may make spherules, or if the centers are scattered over a surface, as along a crack, stellate. An aggregate of non-radiating spherules may give, if small

⁴ I find that for some brittleness is not a part of the connotation of the word acicular, but rather straightness. The minerals we denote as acicular are, however, much the same. There are many such points for mineralogists to consider.

as shad roe, an oolitic or, if like peas, pisolitic or spherulitic structure, or globular or orbicular, in order of size. If the spherules, interfering, give clustered rounded surfaces, they may give a structure like grapes which is called botryoidal, if larger, reniform, "kidneys" or mammillary structure.

B. Dominant direction may be that of least attraction and at right angles to it will be the greater growth. The mineral is then tabular, or if tough and flexible, foliated, and the luster is likely to be pearly on the surface. If highly tabular, it may be lamellar, or (especially if tough) foliated and micaceous.

C. Not infrequently the direction of greatest and of least attraction are both more or less dominant. Then we have it both elongated and flattened like laths, each cleaving in a structure known as bladed. If the centers of crystallization are relatively scarce, if arranged along a line, we may have the plumose structure; or the milled edge or sheaf of wheat structure of stilbite, prehnite, and calamine.

If centers are abundant in a solid mass of basaltic lava, we have the diabasic structure of feldspar "divergent strahlig."

D. If there are three dominant directions, which are practically all equal and not at right angles, the crystal approaches equidimensionality and it is very likely to be isometric. The cleavages may be three, (rhombohedral if not at right angles, cubic, if they are); or four (octahedral); or six (dodecahedral); and we have minerals like calcite which may be classed as tabular in some occurrence, prismatic in others, depending on the temperature and composition of the solution from which it crystallizes.

E. There are certain structures where the direction of growth of the individual crystal is not conspicuous.

The dendritic or arborescent are tree-like forms branching from sparse centers of crystallization without regard to dominant crystal directions, though at times branching is crystalline.

In the reticulated form the crystals are arranged in more of a network in the plane, and they are usually prismatic.

IV. STRUCTURES DEPENDENT ON ARRANGEMENT OF CENTERS OF CRYSTALLIZATION

A. Centers of crystallization float (Schwebend). This gives the structure of the phenocryst and porphyries and also of the porphyroblasts such as staurolite and garnet in schists. Besides these,

we also have, however, certain diagenetic crystals like the crystals of gypsum and the hopper shaped crystals of salt which sometimes occur in shales.

B. Centers of crystallization extremely sparse (Punktformig). This might apply to the rarer minerals of the pegmatites and is pretty nearly what is meant by disseminated or sparsely disseminated.

C. Centers of crystallization scattered on a thin crack.

1. If combined with a radiated structure, we have a stellate appearance as in wavellite.

2. If there is growth out in tree-like form from these centers, we have the dendritic form.

D. Centers of crystallization scattered on surface. We have the botryoidal, reniform, or mammillary structures above mentioned.

E. Crystallization growing in from the surface of the cavity. This is the drusy structure, when they differ from the wall rock, miarolitic when they are the minerals of the rock.

F. Crystallization centers scattered abundantly through the solid gives a granular structure: fine grained texture when less than a mm. apart; medium grained when one mm. to a cm.; coarse when over a cm.

NOTES AND NEWS

A NEW OCCURRENCE OF SYNGENITE

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Syngenite, $(\text{CaSO}_4 \cdot \text{K}_2\text{SO}_4 \cdot \text{H}_2\text{O})$, has previously been described only from salt deposits in association with halite, gypsum and anhydrite. I have recently identified as syngenite the mineral which appears to comprise over 99% of a fine white powder, whose maximum grain size is 0.3 mm., collected in 1902 by Whitman Cross on the island of Maui, Hawaiian Islands. One portion of the powder was designated "Crater of Haleakala. Incrustation on lava with solid crust"; another bears the label: "Haleakala. In the 'cave' used as retreat."

Qualitative tests showed the powder to be a hydrous potassium calcium sulphate.

The identification was made on the basis of the composition and of the following properties determined on the larger grains: good prismatic cleavage, twinning not infrequent, parallel (100); $c \wedge X = 4^\circ \pm 2^\circ$, $2V$ (estimated) 25° , $\rho < \nu$, strong. $\alpha = 1.500$, $\beta = 1.515$, $\gamma = 1.520$. These data are fairly close to the accepted values for syngenite.