

ART. XVIII.—*Crystalline form not necessarily an indication of definite Chemical Composition: or, on the possible variation of constitution in a mineral species independent of the Phenomena of Isomorphism.* By JOSIAH P. COOKE, Jr., A.A.S., Professor of Chemistry and Mineralogy in Harvard College.*

IN a memoir presented to the American Academy of Arts and Sciences in September, 1855,† I described two new compounds of zinc and antimony which I named *stibiobizincyle* and *stibiotrizincyle*, on account of their analogy in composition to the metallic radicals of organic chemistry. The symbols of these compounds are Sb Zn^2 and Sb Zn^3 ; and they are distinguished by the high perfection of their crystalline forms, the last being still further characterized by a most remarkable property of decomposing water quite rapidly at 100°C . I stated in the same memoir that crystals of these two compounds could be obtained containing proportions of zinc and antimony differing very widely from those required by the law of definite proportions; and I also traced out the relation between the composition of the crystals, and that of the menstruum in which they are formed. It is my object in the present paper to consider the bearing of these facts, already fully described, on the idea of mineral species, and to offer a few suggestions which I hope may be of service in determining the true chemical formulæ of many minerals, and thus in simplifying the science of mineralogy. But in order to render myself intelligible, it will be necessary to recapitulate very briefly the facts in question, referring to the original memoir for the full details.

The crystals both Sb Zn^2 and Sb Zn^3 can be obtained with great readiness. It is only necessary to melt together the two metals in the atomic proportions, and when the metals are fully alloyed, to proceed exactly as in crystallizing sulphur. The melted mass is allowed to cool until a crust forms on the surface, which then is broken, and the liquid metal remaining in the interior poured out. On subsequently breaking the crucible, the interior is found lined with magnificent metallic crystals, which, when not tarnished by oxydation have a silver-white lustre. In the course of my investigations on these compounds, crystallizations were made, or attempted, of alloys, differing in composition by one half to five per cent, according to circumstances, from the alloy containing 95 per cent of zinc, to that containing 95 per cent of antimony; but only two crystalline forms were observed, that of Sb Zn^2 and that of Sb Zn^3 . The crystals of the

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two compounds both belong to the trimetric system; but they differ from each other, not only in their crystallographic elements, but also in their whole "habitus." Stibiotrizincyle crystallizes in long acicular prisms, which group themselves together into larger prismatic aggregates; while stibiobizincyle crystallizes in broad plates, which twin together on an octahedral face, and form a very characteristic cellular structure. This very striking difference in the character of the crystals proved to be an important circumstance in the investigation, as it enabled me to distinguish with certainty between the two compounds, even when the faces of the crystals were so imperfect that a measurement of angles was impossible.

The most remarkable result of the investigation, and the one to which I wish to direct especial attention, is the fact that each of the two crystalline forms was found to be constant under very wide variations in the per-centage composition of the crystals. As this is a point of great importance, it will be necessary to enter more into detail, considering in the first place the crystals of Sb Zn^3 . The crystals of this compound are obtained in the greatest perfection from an alloy containing the two metals in just the proportions represented by the formula, namely, 42·8 parts of zinc, and 57·2 parts of antimony. They are then comparatively large, generally aggregated, and, as the three analyses cited in the accompanying Table indicate, they have the same composition as the alloy.

Composition of the alloy by synthesis.		Composition of the crystals by analysis.		
Per cent of Zn.	Per cent of Sb.	Per cent of Zn.	Per cent of Sb.	Sum.
42·80	58·20	43·15	56·93	100·08
"	"	43·06	56·50	99·56
"	"	42·83	57·24	100·07

On increasing gradually the amount of zinc in the alloy up to 48·7, the crystals continued to have the composition of the alloy; and the only difference which could be observed in their character was that they were smaller, and more frequently isolated. Between these limits the whole mass of the alloy exhibited a strong tendency to crystallization; and by pouring it, as it cooled, from one vessel to another, it could be crystallized to the last drop. On increasing the amount of zinc in the alloy to 50·7 per cent, the amount of zinc found in the crystals was uniformly less than it was in the alloy; but no closer relation between the two could be detected, owing, undoubtedly, to the unavoidable irregularity in the crystallization of the alloys which contained more than 50 per cent of zinc. This arose from a peculiar pasty condition which the liquid mass assumed at the point of crystallization. Definite crystals, however, were obtained from an alloy of 60 per cent zinc containing 55 per cent; above this the crys-

tals became less and less abundant, and gradually faded out, although the alloy of 86 per cent of zinc exhibited a radiated crystalline texture; and a trace of this structure could still be discovered even in the alloy containing only 4 per cent of antimony. It was very interesting to trace the gradual fading out of the crystalline structure, as the character of the phenomenon was entirely analogous to that which may be noticed in many crystalline rocks.

Finding that the crystalline form of Sb Zn^3 was constant under so great an increase of the proportion of zinc in the crystals, it might be supposed that, on returning to the alloy of 42.8 per cent of zinc and increasing the amount of antimony, we should obtain crystals containing an excess of antimony; but so far is this from being true, that the slightest excess of antimony entirely changes the character of the crystallization. On crystallizing an alloy containing 41.8 per cent of zinc, not a trace of any prismatic crystals could be seen; but in their place there was found a confused mass of thin metallic scales, which, as will soon be shown, are imperfect crystals of Sb Zn^2 . Thus it appears that, although perfectly formed crystals of Sb Zn^3 can be obtained containing 55 per cent of zinc (that is, 12 per cent above the typical proportions), they cannot be made to take up the slightest excess of antimony.

Let us pass now to the crystals of Sb Zn^2 . In order to obtain crystals having the exact typical constitution, it was found necessary to crystallize an alloy at least as low as 31.5 per cent of zinc. At this point large compound crystals are obtained corresponding to the large crystals of Sb Zn^3 ; and the same was true of alloys down to 27 per cent of zinc. Between these two limits (namely, alloys of 31.5 and 27 per cent of zinc) the crystals formed were found to have the theoretical composition of Sb Zn^2 , indicating of course a tendency towards this point; but on increasing or diminishing the amount of zinc in the alloy beyond these limits, the composition of the crystals immediately began to vary in the same direction as that of the alloy. The crystals of Sb Zn^2 containing an excess of zinc are smaller and more frequently isolated than those having the exact theoretical composition. A similar fact, it will be remembered, is true of the crystals of Sb Zn^3 .

At the alloy of 33 per cent of zinc, the definite crystals of Sb Zn^2 begin to disappear, and are succeeded by thin metallic scales, which are obviously imperfect crystals of the same form. This was established, not only by the obvious law of continuity noticed in the different specimens (the perfect crystals gradually passing into the scales), but also by the peculiar mode of twinning, which was the same with the scales as with the large crystals, forming the peculiar cellular structure already referred to. Moreover, the angle between two scales thus united was found

to be equal to the basal angle of the perfect crystals, at least as nearly as could be measured. These scales continue up to the alloy of 41·8 per cent of zinc, becoming, however, less abundant and less distinct. Several specimens of them were analyzed; but no regularity could be detected in their composition, except that they all contained a much larger amount of zinc than the alloys in which they were formed.

Crystals of Sb Zn^2 containing an excess of antimony were readily obtained from alloys containing less than 27 per cent of zinc. They became more and more imperfect as the excess of antimony increased, and finally faded out altogether in the alloys below 20 per cent of zinc. It is evident, therefore, that definite and perfect crystals of Sb Zn^2 can be obtained with a large excess either of zinc or antimony above the theoretical composition. It is also evident that, of the two compounds, Sb Zn^2 is the most stable,—first, because it is formed to the exclusion of Sb Zn^3 in all alloys containing less zinc than the amount corresponding to the typical composition of the last compound; and secondly, because the crystals retain the typical composition under quite a wide variation (viz. between 31·5 and 27 per cent) in the composition of the alloy.

The facts above stated are fully illustrated by the following Table, which gives the results of a large number of analyses of crystals of both compounds formed in alloys containing different proportions of the two metals:—

Analyses of the Crystals formed in the Alloys of Zinc and Antimony.

Stibiotrizincyle.					Stibiobizincyle.				
Composition of the alloys by synthesis.		Composition of the crystals by analysis.			Composition of the alloys by synthesis.		Composition of the crystals by analysis.		
Per cent of Zn.	Per cent of Sb.	Per cent of Zn.	Per cent of Sb.	Sum.	Per cent of Zn.	Per cent of Sb.	Per cent of Zn.	Per cent of Sb.	Sum.
70·40	29·60	64·15	35·77	99·92	33·00	67·00	35·37	64·57	99·94
66·50	33·50	61·00	39·00	*100·00	33·00	67·00	35·40	64·60	†100·00
64·50	35·50	53·50	41·44	99·94	32·50	67·50	34·62	64·92	99·94
....	....	55·49	44·42	99·91	32·50	67·50	34·61	65·39	†100·00
60·60	39·40	55·00	45·09	100·09	31·50	68·50	33·95	66·09	100·04
58·60	41·40	50·39	49·29	99·68	29·50	70·50	33·62	66·38	†100·00
56·60	43·40	49·92	50·05	99·97	29·50	70·50	33·62	66·38	†100·00
54·70	45·30	48·26	51·42	99·68	27·50	72·50	33·85	65·81	99·66
52·70	47·30	47·47	52·53	†100·00	26·50	73·50	32·08	67·60	99·68
....	....	....	....	....	26·00	74·00	30·74	69·06	99·80
50·70	49·30	46·89	53·11	†100·00	25·50	74·50	30·43	69·51	99·94
50·70	49·30	46·45	53·55	†100·00	25·00	75·00	29·88	70·20	100·08
48·70	51·30	48·66	51·34	†100·00	24·50	75·50	28·76	71·24	100·00
46·70	53·30	46·77	53·23	†100·00	23·50	76·50	27·93	71·85	99·78
44·80	55·20	44·26	55·73	†100·00	22·50	77·50	26·62	73·27	99·89
43·80	56·20	44·04	55·96	†100·00	21·50	78·50	24·83	74·74	99·87
42·80	58·20	43·15	56·93	100·08	20·12	79·88	20·58	79·42	100·00
42·80	58·20	43·06	56·50	99·56					
42·80	58·20	42·83	57·24	100·07					

* In this analysis the antimony only was determined.

† In this analysis the zinc only was determined.

The relation between the composition of the crystals Sb Zn^3 and that of the alloy in which they are formed, is discussed at length in the memoir already referred to. It is there shown to be a very simple function of the mass of metal which is in excess in the alloy, and of the force which determines the union of the elements in definite proportions. The whole order of these phenomena seem to the Author to point to the existence of a power in the mass of metal which is in excess in the alloy, to disturb the action of the force, whatever it may be, which tends to unite the elements in definite proportions. There is, in the first place, a strong tendency in the elements to unite and form crystals having the exact typical composition; and secondly, this tendency is only overcome by a certain excess of either metal in the alloy. Then, again, the crystals of one compound obviously interfere with those of the other. This certainly has the appearance of one force interfering with the action of another,—the force of mass (if I may so call it) perturbing the action of the chemical force. But it is not my object at present to enter into a discussion on the cause of this variation. Moreover, since such a discussion must be based on purely hypothetical grounds, we could not expect to arrive at any definite conclusion. The facts will be viewed differently according to the theory which may be adopted in regard to that long-controverted subject, the essential constitution of matter. Leaving, however, all theoretical considerations aside, there are certain practical bearings of the *observed facts* on the science of mineralogy which are of immediate application.

Here are two beautifully crystallized products, as well crystallized as any that occur in nature, and yet the different specimens of the crystals differ from each other so widely in composition that any single analysis might lead to an entirely erroneous conclusion in regard to the general formula of the substance. Were a chemist to analyse accidentally solely the crystals obtained from an alloy containing 58·6 per cent of zinc, he would at once determine that the formula of the compound was Sb Zn^4 ; and by a like accident he might be led to any other formula between this and Sb Zn^3 : in fact, by an analysis of a number of specimens of needle-shaped crystals obtained from alloys of copper and tin, Rieffel was led to several just such improbable formulæ; and in my own investigations it was not until I had analysed a whole series of crystals, that the real nature of the phenomena became apparent, and the true constitution of the compounds determined. If, then, such great variations in composition are compatible with a definite crystalline form in these furnace products, may not similar variations occur in the crystalline minerals formed in nature?

It is not necessary to make an extended investigation in order

to answer this question; for the materials at our hands are sufficient to give us a satisfactory reply.

There is a compound of antimony and silver called discrasite, which occurs in many localities crystallized in trimetric prisms homœomorphous with Sb Zn^3 . The formula of the mineral is therefore probably Sb Ag^3 , which would require 71·5 per cent. of silver; but the per cent as given by analysis varies between 75·25 and 78 per cent, and one analysis gives the per cent as high as 85. Further analyses of this mineral are required in order to determine its constitution, but there can be no doubt that it varies in composition like Sb Zn^3 .

Silver-glance is another highly crystalline mineral. Theoretically it should contain 87·1 per cent of silver and 12·9 per cent of sulphur; but in a specimen analysed by Klaproth, the proportions were 85 and 15.

Again, the analyses of pyrrhotine (magnetic pyrites) give results varying between 38·78 per cent sulphur, 60·52 per cent iron (variety from Bodenmais), and 43·63 sulphur, 56·37 iron (variety from Barèges). The constitution of the mineral is still uncertain; but its true formula is probably FeS , which would require 36·4 per cent sulphur and 63·6 per cent iron. Lastly, the analyses of antimony-glance give results varying between

Antimony 74·06,		Antimony 73·5,
Sulphur 25·94,	and	Sulphur 26·5.

The true formula of this mineral is undoubtedly Sb S^3 , which would require only 72·88 per cent of antimony.

Similar examples may be greatly multiplied. Those just cited were selected at random from the first few pages of Dana's 'System of Mineralogy.' They are all examples of binary compounds which occur almost chemically pure in nature; so that the phenomena in question are not complicated by those of isomorphism.

When we pass to minerals of more complex constitution, the same phenomena can be made evident, although not quite so easily, on account of the introduction of the phenomena of substitution by isomorphous elements. It will not, however, be necessary for me to cite examples; for it is a fact perfectly well known to all mineralogists, that, after making allowances for the substitution of isomorphous elements, the various analyses of such minerals as mica, hornblende, garnet, and tourmaline differ very greatly from each other,—a difference, moreover, which no mere error of analysis will explain, and which must therefore be referred to an actual variation in composition. In the silicates this variation in composition is made evident by the variation of what is termed the "oxygen ratios;" and it is well known to mineralogists that in many species this variation is very large.

For example, in mica the following ratios between the oxygen in the base and acid have been observed in merely the Muscovite variety:—13:16, $13\frac{1}{2}$:16, and $14\frac{2}{3}$:16; and similarly wide variations might be pointed out in other well known species. It is in consequence of such variations as these that the general chemical formulæ of some of the best known mineral species, such as mica and tourmaline, are still uncertain; and in other cases, where the true formulæ is probably known, the constitution of the mineral has been determined quite as much from other considerations as from the chemical analyses.

Sufficient has been said, I think, to show that variations in composition similar to those which I have observed in zinc and antimony occur in many minerals; and I trust that the results of my investigation will serve to throw light on this whole class of phenomena, which have so greatly perplexed mineralogists, and rendered all strictly chemical classifications of mineral species so unsatisfactory. This investigation has shown that a definite crystalline form is compatible with quite a wide variation of composition, and has in this way pointed out an explanation of the variation observed in the mineral kingdom. But more than this, the investigation has also indicated a method by which, amidst all this variation, the true constitution of the mineral can be determined.

In the compounds of zinc and antimony, although the definite crystalline form was compatible with a wide variation in the proportions of the constituent elements, yet the point corresponding to the typical composition was marked by several unmistakable properties, which clearly enough indicated the true formulæ of the compounds. These properties are discussed at length in my original memoir, and need therefore only to be alluded to in this connection.

It has already been stated that the crystals, both of Sb Zn^3 and Sb Zn^2 , having the theoretical composition are, as a rule, larger and more generally aggregated than those containing an excess of either metal. Moreover, in Sb Zn^2 the general character of the crystals appears to be modified by the change of composition, although the crystallographic elements remain the same. Thus in the crystals having the theoretical composition, the octahedral planes are greatly developed, giving to the crystals the general appearance of a truncated octahedron.* But as the crystals take up an excess either of antimony or zinc, the basal planes become more and more dominant, and the crystals are at last reduced to thin plates. In fact, so marked are these changes, that, after a little experience, a person could tell the approximate composition of the crystals from their general appear-

* See figure accompanying my original memoir.

ance. Similar changes in the appearance of many minerals are familiar to the mineralogist. They are seen in calcite, heavy spar, Anglesite, and others, and may serve as guides in tracing variations of composition.

Again, the specific gravity of the crystals, both of Sb Zn^2 and Sb Zn^3 , was taken with great care through the whole series, and the results are tabulated below. The union of the two elements is attended with an increase of volume, and this increase is at a maximum at the points corresponding to the theoretical composition. These points would therefore be marked in a set of crystals by being points of minimum specific gravity; and they could be determined with great accuracy by means of this property, even in a series of alloys of the two metals which had not been crystallized. This fact is illustrated by the following Table, reprinted from the original memoir.

Specific Gravities of Crystals formed in the Alloys of Zinc and Antimony.

Composition of the alloys.		Composition of the crystals.		Spec. grav. of crystals by experiment.	Mean spec. grav. of zinc and antimony.	Expansion in crystallizing.
Per cent of Zn.	Per cent of Sb.	Per cent of Zn.	Per cent of Sb.			
100 00	.....	....	....	7.153	7.153	0.000
*96.00	4.00	....	....	7.069	7.133	0.064
*86.20	13.80	....	....	6.898	7.082	0.184
*76.30	23.70	....	....	6.769	7.032	0.263
70.40	29.60	64.20	35.80	6.699	6.975	0.276
66.50	33.50	61.00	39.00	6.628	6.959	0.331
64.50	35.50	58.56	41.44	6.596	6.948	0.352
62.50	37.50	55.53	44.47	6.506	6.933	0.427
60.60	39.40	55.00	45.00	6.440	6.931	0.491
58.60	41.40	50.39	49.61	6.396	6.909	0.513
56.60	43.40	49.95	50.05	6.388	6.906	0.518
48.70	51.30	48.66	51.34	6.404	6.900	0.496
46.70	53.30	46.77	53.23	6.376	6.891	0.515
44.80	55.20	44.26	55.74	6.341	6.879	0.538
†42.80	57.20	43.09	56.91	6.327	6.874	0.547
*40.00	60.00	....	....	6.386	6.860	0.474
*35.00	65.00	....	....	6.404	6.837	0.433
33.00	67.00	35.37	64.63	6.401	6.838	0.437
†29.50	70.50	33.62	66.38	6.384	6.830	0.446
†27.50	72.50	33.85	66.15	6.383	6.831	0.448
26.50	73.50	32.08	67.92	6.400	6.822	0.422
26.00	74.00	31.07	68.93	6.418	6.818	0.400
25.50	74.50	30.43	69.57	6.428	6.816	0.388
24.50	75.50	28.76	71.24	6.449	6.807	0.358
22.50	77.50	26.62	73.38	6.453	6.798	0.345
21.50	78.50	24.83	75.17	6.467	6.790	0.323
*15.00	85.00	....	....	5.564	6.744	0.180
*10.00	90.00	....	....	6.603	6.721	0.118
*5.00	95.00	....	....	6.655	6.698	0.043
....	100.00	....	....	6.677	6.677	0.000

* Alloys not crystallized. † Point of typical composition of Sb Zn^2 .

‡ Point of typical composition of Sb Zn^3 .

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The point of typical composition in the case of the crystals of Sb Zn^3 was still further marked in a most decided manner by a very remarkable property. It has already been stated that this compound has the power of decomposing water with rapidity at 100°C. ; but this is true only of those crystals which have approximately the theoretical composition. During the course of my investigation I determined the quantity of hydrogen evolved by alloys of different composition during a given time, taking care, of course, that the circumstances should be the same in all cases; and I found that with the alloy containing 43 per cent of zinc, there is an immense maximum, confined at most between 2 per cent on either side, the alloy of 43 per cent yielding over nine times as much gas as an alloy of 50 per cent, although the crystals of the last were fully as definite as those of the first.*

It is evident from the above facts, that the points corresponding to the theoretical composition of the two compounds of zinc and antimony, are also *points of maxima and minima* of various properties. Now I have no doubt that the same truth will be found to hold in the mineral kingdom. In a mineral like tourmaline or mica, for example, the specimen having the exact theoretical composition may probably be discovered by examining a large number of specimens, and discussing their various physical properties. All the physical properties may be of value in this connection, such as lustre, hardness, specific gravity, specific heat, &c.; and no mechanical rules can be laid down. Much must depend on the discretion of the observer; and in any cases such properties will be selected as are best adapted to the circumstances of the case. In comparing different crystals of the same mineral, it is obviously important to select such as have been formed in a different matrix; for it is only with such that we should be led to expect great variations of composition. It is also evident that the phenomena would be complicated when there has been a substitution of isomorphous elements; and until the effect of such substitution on the physical properties can be traced, it will be necessary to select specimens of as uniform a constitution as possible.

With one other consideration I will close this paper. The principle which has been here discussed must modify materially our notion of a mineral species. The idea of a mineral species has hitherto involved chiefly two distinct characters:—first, a definite crystalline form; second, a constant general formula; and any important variation in either of these characters has been regarded as equivalent to a change of species. Rutile and anatase are regarded as different species, because their crystalline forms are slightly different, although both minerals have identically the same constitution; and again, magnetite and Franklin-

* See Table in the memoir before cited.

ite, which have the same form, are regarded as different species, because they have a slightly different composition. It is true that the actual composition of a mineral may vary very greatly by the substitution of isomorphous elements, and yet, if the general formula remains constant, the species may not be changed. But the extent to which such substitution can be carried without changing the species is not so well settled among mineralogists as could be desired, and the same rule is not applied to all species. The difference between the *varieties* of garnet, for example, is as great as that between the *species* magnetite and Franklinite. Leaving, however, this point undetermined, all mineralogists have agreed that any *essential change* in the *general formula* was inconsistent with the idea of the *same species*. The result, however, of my investigation is to show that the general formula of a mineral species may vary also, or, as I should rather say, the *general formula* is not necessarily the actual formula of each given specimen, but only the *typical formula* of the species towards which the mineral tends, and which it would unquestionably reach if it could be several times recrystallized.

According to this view, the general formula represents not the *actual constitution* of the mineral, but only a certain *typical composition*, which perhaps is never realized with any actual specimen. The fact that the composition of a mineral species may be modified by the substitution of isomorphous elements, was first established by Mitscherlich, and has long been an admitted principle in mineralogy. We must now, as I think, still further expand our idea of a mineral species, and admit that its composition may be modified by an actual variation in the proportions of its constituents. Thus it is that in mineralogy, as in other sciences, we are led to admit the truth of that maxim which every advance in true knowledge seems to verify, "*Natura non facit saltus.*"

While the results of my investigations thus serve to render the idea of a mineral species less definite than before, I cannot but hope that they will tend ultimately to simplify the whole subject of mineralogy; for not only may we expect to reduce the number of mineral species, but also, by simplifying the general formulæ of those which remain, to classify the whole with a greater precision than is now possible. To do this, however, implies a careful revision of the whole subject-matter of mineralogy on the principles above given,—a labor of which few can appreciate the extent, except those who are familiar with the methods of physical research. The work cannot be done by any one person; and it is the chief object of the present paper to call the attention of mineralogists to the importance of the subject.

I have not thought it necessary to dwell in this paper on the obvious distinction between the phenomena here in considera-

tion, and those of isomorphism. It was shown in my previous memoir, that the variation in the composition of the crystals of Sb Zn^3 and Sb Zn^2 could not be explained by this principle; and the distinction between the two classes of phenomena has been still further illustrated by a recent investigation on the crystals formed in alloys of copper and zinc, made in my laboratory by Mr. F. H. Storer. These crystals, which are undoubtedly mixtures of isomorphous elements, give no indications whatever of points of typical composition,—thus illustrating not only the characters of an isomorphous mixture, but also the distinction between such a mixture and a true chemical compound. Admitting, then, the possibility of a variation of composition in a mineral species, independent of the phenomena of isomorphism, it becomes of importance to distinguish this new class of phenomena by a separate term; and I would propose for this purpose the word *Allomerism*. By this word I would designate a *variation in the proportions of the constituents of a crystallized compound without any essential change in the crystalline form*. If, then, we also use the word *typical* to indicate the condition of *definite composition*, we may speak of those specimens of a mineral species which contain an excess of one or the other constituent, as *allomeric variations from the typical composition*. The degree of allomerism would then be measured by the excess of the *allomeric constituent* above the typical composition. Thus the crystals of Sb Zn^3 containing 42·3 per cent of zinc would be said to have the typical composition; while those containing 55 per cent of zinc would be distinguished as an allomeric variety, the degree of allomerism in this instance amounting to 12 per cent, and zinc being the allomeric constituent. In the case of the mineral Discrasite, it is probable that no specimen having the typical composition has yet been analyzed. Those specimens whose analyses are given in Dana's 'System of Mineralogy,' are all probably *allomeric varieties* of the mineral, silver being the allomeric constituent, and the degree of allomerism varying from 4 to 7 per cent. It is unnecessary, however, to multiply examples, as the above are sufficient to illustrate the use of the term.