ART. XVI.—*On the Chondrodite from the Tilly-Foster Iron Mine, Brewster, New York*; by EDWARD S. DANA. With plates v, vi and vii.*

THE method of occurrence of the Chondrodite at the Tilly-Foster iron mine, near Brewster, Dutchess Co., New York, has been fully described by Professor Dana in a memoir on the Serpentine and other pseudomorphs of the region.† It may be of interest, however, to review the subject again in this place.

The chondrodite forms the gangue of the magnetite, being everywhere disseminated through it in varying proportions. In the parts of the mine where the ore is purest and perfectly firm and solid, —the so-called “blue ore”—the associated chondrodite is sparsely sprinkled through it in small yellow grains, showing no trace of crystalline form.

In the larger portion of the mine as now opened, however, the soft “yellow ore” predominates: the chondrodite is present in it in much larger quantities, and, like the other associated minerals, it has almost universally suffered extensive alteration. A large number of these products of alteration have been described by Prof. Dana in the memoir alluded to. The chondrodite in this “yellow ore” is generally massive; but occasionally fragments of large coarse crystals have been found, some of which measured five or six inches in length. These are always more or less altered; moreover the material of which they are formed is far from homogeneous, masses of magnetite, and also chlorite, being often enclosed. Dolomite is the most constantly associated mineral and occurs in rhombohedrons of considerable size: these, as well as the crystals of chondrodite, are often coated with magnetite.

Better crystals of chondrodite than those just mentioned are sometimes found in what were once cavities in this massive material. Unfortunately these have all suffered from the general alteration and now have little or no luster, and often are not even smooth. These crystals vary in size, being sometimes an inch or two in length. A crystallographic examination of them is seldom possible, but a few of the crystals found allow of it, and the results are described beyond. The form is usually very simple, and the color varies from a deep red to a light yellow.

Material much better adapted for crystallographic study also occurs, though this is rarely true. Narrow veins are sometimes met with, two or three inches across, which were origin-

* Abstract of a memoir, published in full in the Transactions of the Connecticut Academy of Sciences, vol. iii, pp. 67 to 96, prepared for this place by the author.

† This Journal, III, viii, 371, 447, 1874.

ally lined with more or less perfectly crystallized chondrodite, and also with dodecahedrons of magnetite, crystals of ripidolite, and rarely apatite; and then subsequently filled in with dolomite. Where this has been the case and the dolomite has remained intact the chondrodite has been protected and the crystals have retained perfectly their brilliant luster and garnet-red color.

The species chondrodite is of especial interest because of its relation to the Vesuvian humite. As shown by Scacchi, and confirmed by vom Rath, the humite crystals are of *three types*, alike in the ratio of their vertical axes but differing in the length of the vertical axes. Chondrodite is identical with humite in chemical composition, and, as shown by the investigation of the Brewster mineral, alike in crystalline form. Until now the correspondence of the two minerals had been proved only for the *second type*. But the Tilly-Foster mine has afforded crystals of each of the three types, and I am therefore enabled to announce a close relation between the two for all the types.

1. *Description of Crystals belonging to Type II.*

Some difficulty was found in obtaining the value of the fundamental angles from the fact that many crystals, though faultless in luster, yet gave uncertain measurements. This was due to the fractured condition of many of the planes, which, though often not very apparent even under a magnifier, yet gave rise to a variety of reflected images in the goniometer, no one of which could be accepted as trustworthy. The presence of these cracks gave the crystals the appearance of having suffered sudden contraction, by which the planes had been irregularly drawn inward, forming re-entrant angles; in fact, in this respect, as in general appearance, this chondrodite might be aptly compared to a resin.

The smallest crystals proved to be free from this cause of irregularity, and one of them, on which the faces were exceptionally brilliant, was chosen for careful measurement. It may be added that all the measurements were made with an Oertling goniometer, provided with two telescopes; but using in the second telescope, in place of the ordinary spider lines, a cross cut in tin-foil illuminated brilliantly by a gas burner—a device for which I am indebted to Prof. Schrauf of Vienna.

The mean of 30 measurements of A ($O=001$) on r^1 gave: $135^{\circ} 18' 50''$. The maximum variation from the mean given was $\pm 45''$. The mean of 30 measurements of A on e^a gave: $149^{\circ} 55' 48''$. Maximum variations $\pm 45''$. These were accepted as

the fundamental angles. Calculated from these angles the parameters are:

$$a \text{ (vert.)} = 1.57236; b = 1; c = 1.08630;$$

and the angle for the fundamental prism is

$$I \wedge I(110 \wedge \bar{1}\bar{1}0) = 58^\circ 15' 46'' \text{ or } 94^\circ 44' 14''.$$

TABLE I.

			<i>Chondrodite.</i>		<i>Humite.</i>	
			<i>C</i> = <i>i</i> $\bar{1}$ (010) Calculated.	<i>A</i> = <i>O</i> (001) Measured.	Calculated.	<i>A</i> (v. Rath) Calculated.
<i>i</i>	1 $\bar{1}$	011	147° 32' 39"	122° 44' (ap.)	122° 27' 21"	122° 27' 49"
<i>e</i> ^a	$\frac{2}{5} \bar{1}$	205	90	*149 55 48	149 58 48	
<i>e</i> ¹	$\frac{2}{3} \bar{1}$	203	90	135 59	136 1 17	135 52 15
<i>e</i> ²	2 $\bar{1}$	201	90	109 4	109 3 24	108 57 50
<i>r</i> ¹	$\frac{4}{7} \bar{2}$	$\bar{2}$ 47	129 42 9	*135 18 50	135 18 50	135 17 40
<i>r</i> ²	$\frac{4}{5} \bar{2}$	245	137 25 45	125 52	125 50 6	125 49 0
<i>r</i> ³	$\frac{4}{3} \bar{2}$	$\bar{2}$ 43	146 27 42	113 25½	113 25 36	113 24 45
<i>r</i> ⁴	4 $\bar{2}$	241	154 2 9	98 14	98 13 6	98 12 47
<i>m</i> ²	$6 \frac{3}{2} \bar{3}$	$\bar{6}$ 41	125 43 56	95 22	95 19 40	95 17 59
<i>n</i> ¹	$\frac{2}{3}$	$\bar{2}$ 23	127 1 31		125 3 49	125 2 47
<i>n</i> ²	2	221	135 45 24	103 11	103 10 4	103 9 35

The preceding table* (I) includes the principal angles measured on the same crystal, and also those calculated from the above parameters: in addition, the corresponding angles for humite, type II, are also given, as calculated by vom Rath. The angles of the macrodomes agree very closely, it will be observed, in chondrodite and humite; in the brachydomes, on the other hand, there is a divergence of 6 or 7 minutes.

* Both the symbols of Naumann (in the form used in Dana's "Mineralogy") and also of Miller are given; the signs belonging to each plane are omitted here, as the relations of the planes are shown with sufficient clearness on the spherical projection, Plate VII.

The fundamental form employed is the same as that adopted in Dana's Mineralogy; for the reasons for retaining it, as also its relation to those of other authors, reference must be made to the complete memoir. The letters used are those of Scacchi, with this change, that for the planes of the *third* type the corresponding Greek letters, and for the *first* type the corresponding capital letters, are employed.

TABLE II.

 $A = O(001).$

TABLE III.

 $C = i\bar{i}(010).$

			Calculated.	II.	III.	IV.	Calculated.	II.	III.	IV.
i^1	$1-\bar{i}$	011	$57^\circ 33'$	$57^\circ 28'$			$32^\circ 27'$	$\begin{cases} 32^\circ 28' \\ 32^\circ 32' \end{cases}$		
ea	$\frac{2}{5}\bar{i}$	205	30 4				90			
e^1	$\frac{2}{3}\bar{i}$	203	43 $58\frac{1}{2}$				90			
e^2	$2-\bar{i}$	201	70 57				90			
r^1	$\frac{4}{7}\bar{2}$	$\bar{2}47$	44 41	$\begin{cases} 44^\circ 40\frac{1}{2}' \\ 44^\circ 40' \end{cases}$	$44^\circ 37'$	$44^\circ 41'$	50 18	$\begin{cases} 50^\circ 7' \\ 50^\circ 30' \end{cases}$	$\begin{cases} 50^\circ 13' \\ 50^\circ 30' \end{cases}$	$50^\circ 12'$
r^2	$\frac{4}{5}\bar{2}$	$\bar{2}45$	$54 10$		$54 12$		42 34	42 39	42 32	42 35
r^3	$\frac{4}{3}\bar{2}$	$\bar{2}43$	66 34	$\begin{cases} 66^\circ 39' \\ 66^\circ 32' \end{cases}$	66 25	66 35	33 32	$\begin{cases} 33^\circ 31' \\ 33^\circ 32' \end{cases}$	33 30	33 27
r^4	$4-\bar{2}$	241	81 47	81 52			25 58		$\begin{cases} 26^\circ 0' \\ 25^\circ 57\frac{1}{2}' \end{cases}$	
m^1	$\frac{2}{3}$	$\bar{2}23$	54 56				44 $14\frac{1}{2}$		44 11	
m^2	2	221	76 50				52 58			
m^2	$\frac{3}{2}$	$\bar{6}41$	84 40				54 16		54 18	

In tables II and III are given the angles on A and C as measured in a series of crystals here numbered II, III, IV. (The measured angles of other crystals are given in the memoir.) They are important as showing how far the angles are constant. Some considerable variations from calculated angles in a few instances are to be explained by the cause already mentioned—the occurrence of irregular fractures across the planes.

Of the planes which occur, according to Scacchi and vom Rath, on type II of humite, I have identified all but m of Scacchi ($\frac{6}{5}-\bar{2}$) and $\frac{2}{3}-e$ of vom Rath ($\frac{6}{5}-\bar{i}$). Of new planes I have found

the following which fall in the old vertical or horizontal zones, and many others to be described later; $o(i\bar{2}=210)$, $i^2(2\bar{1}=021)$, $i^a(\frac{1}{2}\bar{1}=047)$, $i^b(\frac{2}{3}\bar{1}=025)$, $e^a(\frac{2}{3}\bar{1}=205)$, $r^a(\frac{3}{8}\bar{2}=\bar{4}89)$. Of these the most interesting is the prism $i\bar{2}$, as hitherto no vertical prism has been found on either the 2d or 3d types.

Hemihedrism.—The crystals of chondrodite should show an entire correspondence to humite in hemihedral characters. Taking the same position for the crystals as vom Rath, r^2 and r^4 appear uniformly in the positive (or upper) quadrants, r^1 and r^3 always in the negative (or lower) and n^2 is both + and −, but where occurring alone is generally negative; n^1 is generally, and m^2 is always, negative. Of the brachydomes it may be said that they are often holohedral, but this is not always the case. The various figures on the two plates will show the true relation better than words. It is to be said, however, that when the brachydomes are $\pm$ they are still distinguished from each other physically. Thus the + series may be largely developed and rough, destitute of any semblance to polish, when the negative series is as lustrous as the pyramidal planes.

Habit.—With regard to the general habit of the crystals, it is interesting to note the wide variation which is shown. Figures 1, 2, 6, 9, 10 are intended to give some idea of the crystals, as drawn symmetrically, and figures 7, 10, 14, 15, 16, 17, 18, 19, of their actual appearance. As will be seen, the figures are drawn with C in front: this was necessary in order to give a true idea of their real appearance. Since the prism $i\bar{2}$ is so acute ($49\frac{1}{2}^\circ$) toward the eye the projection gives it but little width. It is hence clear that while fig. 3 is an almost exact reproduction of an actual crystal, fig. 5, by the other method of projection, gives a wrong idea of its appearance.

The crystals from which the partial figures, 7, 10, 16, 17, were drawn, along with others quite as diverse, were all in one single group only half an inch in length. The crystals drawn in figures 16 and 19 also occurred closely conjoined in the same group; and other examples of like diversity in associated crystals might be mentioned. One crystal of a very prismatic appearance (when placed in an inverted position) is shown in figure 19.

Presence of minute planes.—The most remarkable feature of the mineral from this locality is the multitude of minute planes which modify many of the solid angles. One single case will be discussed in detail, as the planes admitted of more than usually exact determination; it serves well to illustrate the subject. A horizontal projection of a portion of the crystal is shown in fig. 14. The crystal itself was small, and unfortunately so imbedded in dolomite that it was for the most part rough

and beyond even approximate measurements. The part available showed C faultless, also r^3 good; and less satisfactory r^1 , r^2 and r^4 . On the solid angle between C , r^3 , and r^2 , a large number of minute planes were observed; they were so extremely small (all covering a surface not .03 of an inch in breadth) that any exact measurements seemed at first hopeless. They were sharply defined, however, and brilliant, and when the attempt was made it was found that they gave perfectly distinct though faint reflections.

TABLE IV.*

			$C = \bar{c}\bar{c}(010).$		$r^3 = \bar{2}43.$		$\bar{r}^2 = 201.$	
			Meas.	Calc.	Meas.	Calc.	Meas.	Calc.
$\bar{z}^2$	$2\bar{z}$	021	17° 37'	17° 38½'	23° 58'	23° 49'		
$+x^1$	$\frac{12}{7}\bar{6}$	2·12·7	22 9	21 53	31 4	31 12	8° 21'	8° 37'
$+x^2$	$\frac{26}{9}\bar{13}$	2·26·9	12 55	12 58	29 32	29 27	6 36	6 35
$+x^3$	$\frac{26}{7}\bar{13}$	2·26·7	10 34	10 30	30 37	30 42	8 50	8 54
$+x^4$	$\frac{34}{7}\bar{17}$	4·34·7	9 42	9 39	33 41	33 41	12 0	11 53
$-x^5$	$\frac{12}{7}\bar{24}$	1·24·14	20 21	20 28	21 11	21 6	3 25	3 24
$-x^5$	$\frac{13}{12}\bar{13}$	5·13·12	34 32	34 27	7 32	7 15	21 15	21 8
$-x^7$	$\frac{13}{7}\bar{13}$	1·13·7	18 50	19 17	19 40	19 47	4 5	4 3
$-x^8$	$\frac{24}{13}\bar{4}$	6·24·13	22 24	22 31	12 15	11 59	12 22	12 22
$-x^9$	$\frac{5}{2}\bar{15}$	2·15·6	16 5	15 47	18 51	19 7	7 39	7 34
$-x^{10}$	$\frac{13}{7}\bar{13}$	4·13·7	24 22	23 59	9 26	9 47	15 25	15 3
$-y^2$	$\frac{25}{9}\bar{25}$	7·25·9	18 54	19 2	14 45	14 38	14 40	14 52
$-y^1$	$3\bar{8}$	9·24·8	21 55	22 4	13 18	13 14	19 32	19 29
$-y^4$	$9\bar{9}$	291	11 43	12 13	23 31	23 14		
$-y^3$	$24\bar{24}$	9·24·1	18 45	19 5	25 34	25 27		

The measurements were all taken with the greatest care; and after the calculations had been made, they were repeated; and

*Table VI in the Memoir.

rarely was a variation found greater than two minutes. The preceding table contains the supplement angles for each of these minute planes as measured on U and r^3 , and also on i^2 .

The calculated symbols are also given, with the angles which belong to them. It will be noticed that i^2 is itself one of the minute planes, of the same character as those surrounding it; and its presence gives a reality to them which they would not otherwise have, and shows what degree of reliance is to be placed on the angles.

The symbols* calculated for this series of planes are certainly not simple; and yet a moment's consideration will show that this was exactly what was to be expected. Crowded together so closely, they would be abnormal if occurring on crystals of any species, while this becomes still more true for a mineral like chondrodite. The constantly recurring common planes have ratios which in any other species would be considered next to impossible: thus, in type II, $1:\frac{1}{8}:\frac{1}{8}:\frac{1}{7}$; and in type III, $1,\frac{1}{8},\frac{1}{8},\frac{1}{7},\frac{1}{6},\frac{1}{7}$. It is not surprising, then, that these minute planes should themselves have symbols totally at variance with the accepted law of simplicity of the indices.

It will be noticed, however, that, lawless as they appear at first, there is an attempt at system in the symbols given. Thus, in the ratio of the brachydiagonal to the vertical axis, we have:

x^1 12: 7	y^2 24: 13	x^7 12: 7	x^3 26: 7
x^6 12: 7	y^1 24: 8	x^{10} 13: 7	x^2 26: 9
	y^3 24: 1	x^5 13: 12	

and so on.

Almost all of the twenty and more smaller crystals examined showed some of these secondary planes. I have measured, in fact, upward of one hundred of them. Examples of a number of them are shown in the figures on the plates and their angles are given in several tables in the original memoir. The description of the one case above given is sufficient for this place.

Twins.—The humite crystals of Vesuvius, as well as the Swedish chondrodite, has been shown by vom Rath to possess so great a tendency to twinning that it is a little remarkable that the contrary should be true of the mineral from Brewster. Figs. 20, 21, show the only method of twinning which has been found. The axis of revolution here is the vertical axis of the crystal, and the composition-face the basal plane A . Unfortunately the crystal in question was quite imperfect, and all that was available is shown in the figure. A revolution of the

* In the symbols given in the tables (i. e., those according to Naumann) the mark over the second figure, or fraction, has been omitted (in order to simplify the work of the printer). This has also been done in all the following tables, being made possible by the fact that all these planes, with one or two exceptions, belong to the *macrodiagonal* series.

kind mentioned (in a perfectly symmetrical crystal) would, so far as this half of the crystal goes, have the effect only of making it holohedral, giving no re-entrant angles; but, in case of any irregularity, it might give, as here, a re-entrant angle in the planes which are hemihedral in their occurrence.

The measurement of the supplement re-entrant angles here observed gave for $m^2 \wedge \bar{m}^2$, $10^\circ 38'$ and $10^\circ 40'$; required $10^\circ 39'$.

A noteworthy fact in the crystal is the occurrence of the prism o ($i:2=210$), the first time that any of the vertical prisms has been observed in the 2d type of either humite or chondrodite. It lies in both the zones $e^2(201)$, $n^2(2\bar{2}1)$, and $e^2(22\bar{1})$, $n^2(2\bar{2}1)$ which answers sufficiently to determine what it is; and the result thus obtained is fully sustained by good measurements. This plane is distinctly present on one side only of B ; on the other side its presence is barely indicated. Its place here is taken by a well polished and conspicuous plane ϕ , which is another striking instance of the peculiar nature of this species. The index was calculated for each pair of measurements $38^\circ 14'$, $39^\circ 24'$ on $e^2(201$ and $20\bar{1})$ and $4^\circ 31'$, $6^\circ 31'$ on $m^2(641$ and $64\bar{1})$, and the results obtained were identical. From the first pair of measured angles $\phi \wedge B$ was found to be $34^\circ 30\frac{1}{2}'$, and from the second $\phi \wedge B=34^\circ 31'$ (required $34^\circ 32' 38''$). The index obtained was $60\cdot\frac{2}{15}$ or $60\cdot38\cdot1$, and, abnormal as it certainly is, it expresses the exact position of the plane.

An interesting crystal is shown in fig. 4. It is conspicuously hemimorphic, as far as the form goes. It is large, and admits only of approximate measurements; but there is no doubt that the planes as given have been determined correctly. It is altogether probable that a revolution parallel to the basal plane would form an ample explanation of what is observed.

Chemical composition.—I am glad to be able to add here the results of a chemical examination of the chondrodite of the 2d type from this locality, by Mr. G. W. Hawes of the Sheffield Scientific School.

The material analyzed by Mr. Hawes consisted of fragments of crystals of the 2d type, selected with great care to avoid the presence of any altered material. It had a deep garnet-red color and a brilliant vitreous luster. Its specific gravity, as determined by Mr. Hawes, was 3.22. Two analyses gave:

	Analysis I.	Analysis II.
Silica	34.10	34.05
Magnesia	53.17	53.72
Ferrous oxide	7.17	7.28
Alumina	.48	.41
Fluorine	4.14	3.88
	<hr/> 99.06	<hr/> 99.34

Following the view of Rammelsberg (that, in consequence of the unavoidable loss in the course of the analysis, the higher value of each constituent comes nearest to the truth,) Mr. Hawes's analysis becomes as follows. For comparison the results obtained by vom Rath for 2d type crystals from Vesuvius and from Sweden are added.

	CHONDRODITE.		HUMITE.
	Brewster, N. Y., <i>Hawes.</i>	Sweden, <i>v. Rath.</i>	Vesuvius, <i>v. Rath.</i>
Silica	34.10	33.96	34.02
Magnesia	53.72	53.51	59.23
Ferrous oxide	7.28	6.83	1.78
Alumina	0.48	0.72	0.99
Fluorine	4.14	4.24	2.74
	<hr/> 99.72	<hr/> 99.26	<hr/> 98.76
Silicon	15.91	15.85	15.88
Magnesium	32.23	32.11	35.54
Iron	5.66	5.31	1.38
Aluminum	0.26	0.38	0.53
Fluorine	4.14	4.24	2.74
Oxygen	39.78	39.58	41.54
	<hr/> 97.98	<hr/> 97.47	<hr/> 97.61

Transforming the iron into an equivalent of magnesium, as also the alumina ($2Al=3Mg$), Mr. Hawes obtains further:

Silicon 15.91, Magnesium 35.00, Fluorine 4.14, Oxygen 39.78.

From these values a formula is deduced, which is essentially that of the Swedish mineral according to *v. Rath*,

It would have been extremely interesting to have added analyses also of crystals of the 1st and 3d types; but, as will be apparent from what follows, the material was not to be obtained.

In completing the description of this variety of the mineral, it may be repeated that it occurs usually in narrow veins, and when free from alteration has uniformly a deep *garnet-red* color. A *cleavage* such as exists in humite (parallel to the basal plane), and has been observed by Kokscharow on chondrodite from Pargas, could in no case be discovered. The fracture is always conchoidal.

2. Description of Crystals of Type III.

The crystals of the 3d type are exceedingly rare, three or four specimens being all that have thus far been found, and from these only two individual crystals could be obtained which

allowed of measurement. Fortunately these two crystals are very satisfactory, being small and brilliant, and establish the fact as well as hundreds could do. Figures 11 and 12 show one of the crystals, and figure 13 the other. The appearance of the first crystal is best shown in the second of these figures. As will be seen, the planes are the same as in humite, and they are for the most part hemihedral and situated in the same way. No brachydomes are visible, the edge being rounded and rough.

TABLE V.*

			Chondrodite.			Humite.		
			A = O (001).			v. Rath.		
			Calc.	Meas.(XX).	Meas.(XXI)	Calculated.		
ϵ^4	$4-\bar{1}$	041	100°	1'	7"			
ϵ^3	$2-\bar{1}$	021	109	27	35		109°	27' 54"
ϵ^2	$1-\bar{1}$	011	125	14	49		125	15 18
ϵ^1	$\frac{2}{3}-\bar{1}$	023	136	40	4		136	40 34
ρ^3	$\frac{8}{11}-\bar{2}$	$\bar{2}811$	131	25	57	131° 46'	131° 24'	131 24 49
ρ^4	$\frac{8}{9}-\bar{2}$	289	125	50	6	{ 125 37 125 47	125 48	125 49 0
ρ^5	$\frac{8}{7}-\bar{2}$	$\bar{2}87$	119	19	18	{ 119 35 119 15	118 36	119 18 19
ρ^6	$\frac{8}{5}-\bar{2}$	285	111	51	38	{ 111 44 111 49	112 0	111 50 50
ρ^7	$\frac{8}{3}-\bar{2}$	$\bar{2}83$	103	32	4	103 41	103 38	103 31 33
ρ^8	$8-\bar{2}$	281	94	35	15	{ 94 31 94 13	94 48	94 35 4
ν^1	$\frac{4}{7}$	447	132	17	48		132 16	132 16 43
ν^2	$\frac{4}{5}$	445	123	1	8		122 32	123 0 8
ν^3	$\frac{4}{3}$	443	111	18	7		111 5	111 17 23
ν^4	4	441	97	24	20		97 29	97 24 3

The second crystal is of very different form, and was imbedded in brucite, and entirely free in it. It was perfectly formed on all sides, being almost as perfect as the drawing, with the exception, however, of the acute (brachydiagonal) edge, which was mostly broken. When only the upper part of the crystal is

* Table XII of the memoir. Other angles of these crystals are given in Table XIII.

considered, it will be seen that the hemihedrism is like that in the other case, except that ρ^8 is holohedral. For macrodomes there are $i^1(\frac{2}{3}\bar{i}=023)$, $i^2(1\bar{i}=011)$, $i^3(2\bar{i}=021)$, $i^4(4\bar{i}=041)$; the last has not been observed on humite. On measuring the planes below, it was found that they were not distributed as was expected in accordance with the monoclinic character of the crystal: instead, either extremity of the brachydiagonal axis was differently developed. There are present also at one extremity $\pm e'(\frac{4}{7}\bar{i}=407)$, though the plane could be only approximately measured. This is probably also to be explained as having resulted from a revolution parallel to the basal plane. The crystal was very small and not at all adapted to experiments having in view the discovery of any proper hemimorphic development. Some of the angles measured on both these crystals are contained in the preceding table.

Unfortunately the inclination to C on no one of the pyramidal planes could be measured with perfect accuracy; the measurements are good, yet not entirely trustworthy. These planes, though brilliant, are uniformly fractured in the manner already explained, and this made all the angles a little uncertain. The calculated angles as given have as their basis the prismatic angle $I \wedge I = 94^\circ 44' 14''$, and the macrodome angle $C \wedge i^2 = 144^\circ 45' 11''$, following the analogy of humite in which the vertical axes of types II and III have the ratio 10 to 9.

The corresponding parameters are:

$$a(\text{vert.}) = 1.41512; b = 1; c = 1.08630.$$

Very little further can be said in regard to the crystals of the 3d type. Those observed had a somewhat different color from those of type II; that is, the color was more yellowish, less of a pure garnet-red—though this may be accidental. No analysis was possible of course. The method of occurrence was much like that of the brilliant crystals of the second type; and the associated minerals were the same, with, probably as a later formation, brucite.

3. Description of Crystals of Type I.

The occurrence of large coarse crystals of quite impure chondrodite, imbedded in the massive material, has already been described. These belong, at least in part, to the *first* of Scacchi's types. As has been remarked, the crystals of this character do not often admit of exact determination, but in two cases they were so good as to allow of their crystallographic relations being accurately made out. The accompanying wood-cuts, figures 22 and 23, give faithful representations of their appearance and size. It will be seen that they are both quite imperfect, and

it was on this account that no attempt was made to make a symmetrical drawing of either of them.

Fig. 22.

Fig. 23.

R^3 on R^2 (behind) gave measurements varying, in a series of trials, from 78° to 79° : required $79^\circ 4'$.

R^3 on R^3 (behind) gave $62\frac{1}{2}^\circ$, required $63^\circ 1'$.

R^3 on R^3 (behind) gave 72, required $71^\circ 17\frac{1}{2}'$.

R^3 on R^2 (behind) gave 72, required $71^\circ 17\frac{1}{2}'$.

These angles on both crystals were identical within the allowed error of observation (say $30'$). The above are the best angles afforded by any of the planes.

These angles can be referred only to the 1st type of humite. Decisive proof that this is right is found in the fact that both crystals are *holohedral*, the planes on both sides being identical, with the exception of R^1 .

The measured angles of C on R^5 , right and left, were identical, though not obtainable with exactness; the measurements gave $152\frac{1}{2}^\circ$ – 154° : this is also true for C on R^3 , right and left, $=140\frac{1}{2}^\circ$ – $142\frac{1}{2}^\circ$.

The following table includes the most important angles for the occurring planes, calculated from the fundamental form of the second type on the assumption that the lateral axes are equal and the vertical axes have the ratio of 14:15. The measured angles are also added, though only approximate; in the form given they were obtained immediately from the measurements over the top of the crystals (see above).

The two crystals described are the only ones which could be positively identified. It is very probable, however, that of those found others also belong here, as they have much the same appearance and habit. These crystals are all considera-

bly altered, being generally soft enough to be cut with a knife, and for this reason a chemical analysis would be of little value.

TABLE VII.*

			Chondrodite.			Humite.		
			$C = i\bar{1} (010)$ Calculated.	$A = O (001)$ Meas. Calc.		v. Rath. Calculated.		
J^2	$1\bar{1}$	011	145° 43' 44"		124° 16' 16"	124° 16' 45"		
J^1	$\frac{3}{5}\bar{1}$	035				138 38 38		
R^1	$\frac{3}{5}\bar{2}$	3·6·10	129 12 57	135°	135 53 35	135 52 23		
R^2	$\frac{3}{4}\bar{2}$	368	134 28 38	129½	129 32 3	129 30 52		
R^3	$1\bar{2}$	122	140 30 10	121½	121 45 28	121 44 23		
R^4	$\frac{3}{2}\bar{2}$	364	147 6 34		112 25 28	112 24 37		
R^5	$3\bar{2}$	362	152 49 49	101	101 39 30	101 39 2		

The color of the crystals is gray to grayish-yellow, and the material of which they are composed is never pure, and often quite heterogeneous.

4. *On the Optical Properties of Chondrodite.*

In the preceding pages the question of the orthorhombic or clinorhombic crystallization of the chondrodite has not been discussed. In fact, nothing was detected by the measurements sustaining any other conclusion than that of Scacchi and vom Rath, that the crystals were fundamentally orthometric. Still the hemihedral character of the second and third types seem to point to a clinometric form, and this is apparently supported by the optical characters obtained. The material available for optical investigations was very scanty, and, with the exception of one crystal, poorly adapted for the purpose.

The crystal referred to was, properly, but the fragment of what was originally a specimen of considerable size and beauty; when unbroken it must have been nearly an inch in length. In the condition in which it was found it showed only the brachydomes e^1 and e^2 , with the pyramids n^1 , n^2 , and m^2 ; it had the deep garnet-red color of crystals of the second type, and with the exception of the universally present fractures was perfectly clear and transparent.

* Table XIV of the Memoir.

Guided by the observations on the optical properties of humite made by Descloiseaux and given in his *Mineralogy* (p. 14), a section was cut from the crystal described parallel to C , i. e., perpendicular to the brachydomes present. The examination of this section showed: 1st, that the acute bisectrix is normal to C ($i\text{-}\bar{i}$, 010); 2d, that this bisectrix is positive; 3d, that the optic-axial angle is large, the axes being seen only when oil is used; but 4th, that *the axes do not lie in the basal plane*, but in a plane making an angle of about $15\frac{1}{2}^\circ$ with it. This last point was so unexpected and anomalous that every effort was made to explain the measurements in some other way, but with no success. By means of a stauroscope, made by Fuess in Berlin after the excellent pattern of Groth, the position of the two axes of polarization, as referred to e^1 , and also to e^2 in plane C , were carefully determined. The measurements were repeated twenty times, the error arising from an imperfect adjustment of the Nicols being eliminated in the usual manner. The result was as follows:

Supplement angle made by the plane of the axes—

with e^1 ($\frac{2}{3}i=203$), $18^\circ 9'$; hence with the basal plane, C , $25^\circ 50'$.
 with e^2 ($2\text{-}\bar{i}=201$), $45^\circ 9'$; “ “ “ “ C , $25^\circ 46'$.

In order to confirm these results, other crystals were sought, which would admit of like determinations. None could be found which would serve for measuring the axial angle; but two small ones, on which the plane C was naturally developed, proved to be clear enough to allow of measurements with the stauroscope. The first alone gave accurate results; on it the angle of the same plane with e^a ($\frac{2}{3}i=205$) was determined with equal care. The results were:

$4^\circ 55'$ for the angle with e^a ; and hence $25^\circ 59'$ with C .

The agreement with the angles given above is as close as could be desired. In the other case, the rather rare plane B ($i\text{-}\bar{i}=100$) was present; the crystal was minute, however, and the determination only approximate. It was found that the normal to the axial plane made with B an angle of 65° – 70° , and hence with the normal to the basal plane 20° – 25° .

With so ample confirmation the point made cannot be even questioned, and it remains to reconcile it with the crystallographic properties of the species. It will be seen at once that the position of the optic axes is totally at variance with the accepted orthorhombic character of the crystals; but it conforms to the rule of monoclinic crystals, as one axis of polarization is normal to the plane of symmetry C , and the others lie in it, or in other words, the optic-axes lie in a plane perpendicular to the axis of symmetry. The angles measured and calculated,

given in the various tables, show that the variation from the rectangular type, if it really exist, must be very slight, as the agreement between the angles measured and those calculated on the assumed prismatic basis is very close—it being remarked that some considerable variation in the angles given in the tables are simply explained by the imperfection of the crystals. Note the angles measured for $m^2 \wedge \bar{m}^2$ on the twin crystals described on page 96. It was not to be expected that the variation in the optical character of the crystals would be so decided in view of the slight divergence which is possible in the crystalline form. I reserve for the future the careful revision of the angles of this species, when I shall hope to be able to command a more abundant supply of satisfactory material. It may be added that the hemihedral character of the second and third types of humite long ago suggested the idea that they were oblique in form; but all the crystallographic investigations thus far have seemed to deny this. In the Mineralogy of Brook and Miller, the form is made oblique, but this seems to be due to a misunderstanding of the planes occurring on the crystals.

The axes, as already mentioned, do not appear distinctly except in oil; in the first mentioned section they admitted of good measurements. The mean of thirty determinations of the angle for red rays gave—

2 $H\alpha = 88^\circ 48'$: the extremes being $88^\circ 36'$ and $89^\circ 0'$.

With a yellow light (sodium) the angle was essentially the same, but the mean was $10'$ or $15'$ smaller, which would indicate that the dispersion is $\rho > v$, but the matter cannot be considered to be beyond doubt.

The index of refraction of the oil employed, as determined by Professor Wright and myself, was 1.466.

In conclusion, I have to express my very great obligations to Prof. Allen for his kindness in giving me free use of all the specimens in his valuable cabinet. Both of the crystals of the third type, as well as several others mentioned, came from his collection; in fact it was Prof. Allen who first made known the special interest connected with the locality. To Mr. Cosgriff, the superintendent of the Tilly-Foster Iron Mine, I am also much indebted for his uniform kindness and courtesy to me at the several occasions when I have visited the mine, and also for the gift of several fine specimens.

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CHONDRODITE, BREWSTER, N. Y.

Fig. 11.

Fig. 12.

Fig. 13.

Fig. 14.

Fig. 15.

Fig. 16.

Fig. 18.

Fig. 17.

Fig. 20.

Fig. 19.

Fig. 21.

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