ART. LVIII.—*Eudialyte and Eucolite, from Magnet Cove, Arkansas;* by J. FRANCIS WILLIAMS.

[By permission of the Geological Survey of Arkansas.]

Eudialyte.—As long ago as 1861 Professor C. U. Shepard* discovered small nodules of a brilliant crimson mineral in the feldspar of the elæolite rock of Magnet Cove, Arkansas. He at first supposed this mineral to be corundum, but after testing its hardness (which he found to be less than 6·), and observing that it gelatinized with hydrochloric acid, he decided that it was eudialyte. From that time the occurrence of this mineral in Arkansas has been mentioned in most text-books of mineralogy† on Professor Shepard's authority, but not until very lately has the subject been revived. During the last year William J. Kimzey of Magnet Cove has found a number of good crystals and also a considerable quantity of the nodular material. Hidden and Mackintosh have published a note in this Journal,‡ in which they describe this nodular, rose-red, nearly transparent mineral, and state that it is probably eudialyte, and identical with that discovered by Shepard.

During a recent visit to Magnet Cove, in the interest of the Geological Survey of Arkansas, I was fortunate enough to

* This Journal, II, xxxvii, 405, 1864.

† System of Mineralogy. J. D. Dana. 5th edition, p. 249. Lehrbuch der Mineralogie, G. Tschermak. 2d edition, p. 522. Elemente der Mineralogie, Naumann-Zirkel. 12th edition, p. 745, etc.

‡ Am. Jour. of Sci., III, vol. xxxviii, 494, 1889.

obtain some very good specimens of this rare mineral, several of which were well adapted for crystallographic measurement. Through the kindness of Messrs. W. E. Hidden of New York and C. S. Bement of Philadelphia, I was enabled to measure two other crystals from this locality, which were especially interesting.

The crystals that I have seen from this region range from 3 to 18^{mm} in diameter and are, for the most part, thick tabular parallel to the base. They are transparent to semi-transparent and in color vary from rose-red to deep crimson. Cleavage parallel to the base is indistinct, and the crystals appear to be traversed by irregular cracks in all directions. The cleavage parallel to $\frac{1}{4}R$ and R, as noted in the Greenland eudialyte, has disappeared almost entirely from these crystals. The surface of the crystal is in some cases covered by a yellowish coating of altered material; this, however, does not appear to diminish its brilliancy, but when it occurs on the base increases the luster to mother of pearl.

The crystals may be divided according to their form into two classes: first, those in which the negative rhombohedrons predominate, and second, those in which the positive ones are the larger. In general, the crystals are terminated above and below by hexagonal basal planes, but these occasionally become triangular or disappear entirely. The most satisfactory crystal for the measurement of angles was one of only about 3^{mm} in its greatest diameter and of half that thickness. This crystal belongs to that group in which the negative rhombohedrons predominate, and is shown in fig. 1. The measurements from this, combined with those from several other crystals, are given below, and after each measured angle the extreme variation from the mean is appended.

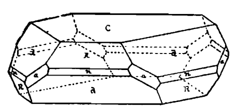

Fig 1

The axial ratio, as calculated from measurements, made on three very good crystals, of the angle between the base and the largest rhombohedron, $-\frac{1}{2}R$, is found to be $a:c = 1:2{\cdot}1174$. As this is deduced from a mean of not less than ten angles, none of which varied more than 25 seconds from the mean angle, 50° 43′ 6″, it is evident that it cannot be far out of the way for the Arkansas variety of eudialyte. Brögger in his splendid work, "Die Mineralien der Syenitpegmatitgänge der Südnorwegischen Augite- und Nephelin-syenite,"* considers the latest measurements of von Kokscharow † the most correct for eudialyte. Von Kokscharow gives $a:c = 1:2{\cdot}1129$, which differs but little from the

* W. C. Brögger, Zeitschrift für Kryst. und Mineral, xvi, p. 498, 1890.
† Von Kokscharow, Verhandl. der kais. russ. min. Gesellschaft zu St. Petersburg, II, xiv, 205, 1879.

ordinarily accepted figures, $a:c = 1:2{\cdot}1117$, while the value for the Arkansas variety is considerably larger.

The following faces have been observed and measured:

$$c = 0R\,(0001),\ a = \infty P2\,(11\bar{2}0),\ R = +R\,(10\bar{1}1),$$
$$d = -\tfrac{1}{2}R\,(01\bar{1}2),\ n = -2R\,(02\bar{2}1).$$

Faces.	Mean angle.	Calculated.	Variation.	Von Koksch. Calculated.
$c:d$, $(0001):(01\bar{1}2)$	50° 43′ 6″	50° 43′ 6″	0′ 24″	50° 38′
$c:R$, $(0001):(10\bar{1}1)$	67 53 48	67 45 24	3 12	67 42
$c:n$, $(0001):(02\bar{2}1)$	78 25	78 26 35	10 30	78 25
$c:a$, $(0001):(11\bar{2}0)$	89 56*	90 0	0 15	90 0
$d:a$, $(10\bar{1}2):(11\bar{2}0)$	47 49 30	47 54 29	4 30	47 58
$d:d$, $(10\bar{1}2):(01\bar{1}2)$	84 21	84 11 2	1 reading	84 4

The variation of these angles and of the axial ratio from those of von Kokscharow would suggest some corresponding variation in the chemical composition, and it is probable that an analysis on which Mr. Hidden is engaged will bring out this difference.

An excellent example of that class of crystals in which the positive rhombohedrons predominate is found in a small specimen—not more than 4^{mm} in its greatest diameter—loaned me by Mr. C. S. Bement. This is shown in fig. 2. In this crystal one face, $+R$ $(10\bar{1}1)$, is so over-developed that all the rest of the faces seem dwarfed by it At the first glance, and in fact until the crystal is carefully measured, this large face would be mistaken for the base, and the fact that opposite to it, the crystal is terminated by a six-sided pyramid would seem to support this view.

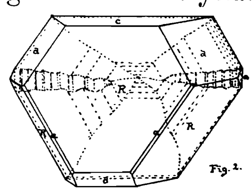

Fig. 2.

The crystal is, in reality, to be placed as shown in the cut, and the faces, which make up the front of the crystal, are designated by the same letters as in the preceding figure. The faces forming the back are for the most part composed of known forms in oscillatory combination. Besides these well known faces a large number of new ones appear, of which, however, only a few are large and sharp enough to be worthy of special mention. The most important of these forms are as follows:

$$-\tfrac{3}{11}R\,(0\ 3.\bar{3}.11),\ \tfrac{1}{4}R\,(10\bar{1}4),\ \tfrac{1}{5}R\,(10\bar{1}5)\text{ and }-\tfrac{4}{5}R5\,(23\bar{6}3).$$

The angles, measured as nearly as possible, were as follows:

Angle.	Measured.	Calculated.
$0R:-\tfrac{3}{11}R$, $(0001):(0\cdot3\cdot\bar{3}\cdot11)$	33° 54′	33° 41′ 52″
$0R:\ \tfrac{1}{4}R$, $(0001):(10\bar{1}4)$	31 54 (±30′)	31 26 12
$0R:\ \tfrac{1}{5}R$, $(0001):(10\bar{1}5)$	25 59 33″	26 3 35

The faces at the back of the crystal lying in the vertical zone and beginning at the top are: $0R$, 0001; $-\tfrac{3}{11}R$, $\bar{3}\cdot0\cdot3\cdot11$;

* Brögger, l. c., measured this angle on Norwegian eucolite as 89° 58′ 30″.

$-\frac{1}{2}R$, $\bar{1}012$ (large); $-\frac{1}{m}R$, $\bar{1}01m$; (point at back) $\frac{1}{n}R$, $\bar{1}01\bar{n}$; $\frac{1}{4}R$, $\bar{1}01\bar{4}$ (large but dull); $\frac{1}{5}R$, $\bar{1}01\bar{5}$ and $0R$, $000\bar{1}$ (bottom).

The right and left inclined zones at the back are made up of the following faces; R, $0\bar{1}11$ and $\bar{1}101$; the prisms $\infty P2$, $\bar{1}\bar{1}20$ and $\bar{2}110$; (point at back) $-\frac{1}{2}R$, $\bar{1}10\bar{2}$ and $0\bar{1}1\bar{2}$. The small zones lying back of a ($\infty P2$, $\bar{1}2\bar{1}0$ and $1\bar{2}10$) are made up of a recurrence of the prisms with the scalenohedrons $-\frac{3}{4}R5$, $\bar{2}36\bar{3}$ and $\bar{6}\bar{3}2\bar{3}$ (determinable only through zone relations.)

In order to make sure that the crystal was properly placed and the faces correctly determined, it was imbedded in a short piece of glass tubing just large enough to hold it, and which was filled with Canada balsam. This was then placed on an object glass and a thin glass cover placed over it.* The outside of the glass tube was covered with black paint, in order to cut off any side reflections, and the preparation was then examined under the polariscope. Owing to the thickness and irregularity of the crystal, the black cross was not very plain, but it was evident on revolving the stage of the polariscope that there was no extinction such as was observed when the crystal was placed in any other position.

The specific gravity is comparatively low and lies between 2·804 and 2·833 at 15° C. These values were obtained from those crystals which were measured, and the lowest was that of the crystal figured in No. 2. The determination was made by means of a cadmium-borotungstate solution, in which the crystals were placed and which was then brought to such a density that the mineral remained suspended, neither rising nor sinking. The specific gravity of the solution was then determined by means of a 12 cc. pycnometer.

Thin sections, cut at right angles to the vertical axis, show in parallel light a pink color, and between crossed nicols remain perfectly dark during a complete revolution of the stage. In convergent polarized light such sections show a wide black cross which sometimes opens a little owing to slight optical anomalies, but no colored rings appear. Both the double refraction and the index of refraction are weak. The index is lower than that of Canada balsam and the surface of the section appears smooth. The character of the double refraction is *positive*. By sinking the polarizer and the converging lens, the irregular cleavage, which lies approximately parallel to $\frac{1}{4}R$ ($10\bar{1}4$), becomes visible.

The mineral is comparatively free from inclusions for a crystal which was formed as late in the period of solidification of the rock as this. Magnetite and ægyrite or acmite are the

* Since making this experiment I have received Professor C. Klein's exhaustive paper on this method of examining crystals without cutting them. Sitzungsber. d. k. Akad., Berlin, xviii, p. 347, 1890.

only inclusions which have been observed. It appears as if sometimes eudialyte and sometimes orthoclase was formed first, for first one and then the other is found in idiomorphic crystals. On the whole the eudialyte appears to be the earlier of the two. Decomposition takes place very rapidly.

Eucolite.—According to Brögger,* all those crystals which have the form of eudialyte, and essentially its chemical composition, but *negative* double refraction in place of *positive*, are to be considered *eucolite*. It appears therefore that the yellowish brown crystals, bearing a great resemblance in form and size to eudialyte, but which are characterized by their *negative* double refraction, are to be classed under this head. The crystals which appear in the Arkansas rock are of a much lighter brown or brownish yellow color than those from Norway. The cleavage parallel to the base (0001) is much more pronounced than in eudialyte, but that in other directions is about equally poor with that already noted.

The following faces have been observed (fig. 3): $c = 0R$ (0001), $R = +R$ $(10\bar{1}1)$, $d = -\frac{1}{2}R$ $(01\bar{1}2)$, $g = \infty P$ $(10\bar{1}0)$, $a = \infty P2$ $(11\bar{2}0)$. Some of the angles between these faces and the base have been measured, but the poor reflections prevent the obtaining of accurate results. The angles recorded are probably not nearer than from 15′ to 30′ to the true angles. Owing to these large limits of error, it is impossible to calculate any axial ratio for this mineral, but the angles as measured do not differ very much from the corresponding angles on eudialyte.

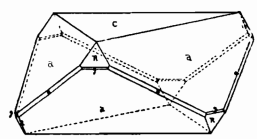

Fig. 3

Angle.	Measured.	Calculated.
$c: d$ $(0001):(01\bar{1}2)$	50° 40′ 30″	50° 43′ 6″
$c: R$ $(0001):(10\bar{1}1)$	67 12	67 45 24
$c: a$ $(0001):(11\bar{2}0)$	89 53	90
$c: g$ $(0001):(10\bar{1}0)$	90 25	90

The specific gravity taken in the same way as that of eudialyte gave 2·6244 to 2·6630 at 15° C. This is extremely low, but even after bringing in a correction for adhering orthoclase (sp. gr. = 2·55–2·62) the figures would not be much higher. Hardness 5 to 5·5.

In thin sections this mineral appears semi-transparent, and is of a white to a very light yellow color. In convergent polarized light, a section perpendicular to the principal axis shows a black cross which when tested with a mica plate establishes the negative character of the double refraction very plainly. The double refraction appears weaker than in eudialyte. Magnetite and ægyrite appear to be the only inclusions. Some

* L. c. page 489.

crystals were found which were made up of both pink and yellowish brown material, and in these cases it was always found that the former was positive and the latter negative.

Wilhelm Ramsay * in his "Geologische Beobachtungen auf den Halbinsel Kola" has observed that, in the eudialyte of the nepheline syenite, which he describes, both positive and negative as well as isotropic zones appear, but that no difference in color nor in the indices of refraction between the various parts was detectable. Ramsay's observations were made by means of a selenite plate on sections, which were slightly inclined to the principal axis, while those on the Arkansas mineral were made by means of a quarter-undulation mica plate on sections parallel to the base.

From the low specific gravity and hardness, as well as the want of complete transparency in the eucolite crystals, it may well be suspected that these crystals are decomposed or weathered eudialyte. To these facts may be added the observations that, in cases where eudialyte has begun to weather, it is found in the form of pink grains surrounded by a soft yellowish brown powder, which resembles very closely the eucolite just described. Moreover it is probable that the yellowish coatings observed on the surface of the eudialyte crystals already described are made up of this same brownish yellow mineral. A determination of the amount of water in a specimen of the eucolite would be of use in deciding the question of its origin.

Both eudialyte and eucolite occur in two places in Magnet Cove; one, one hundred meters northeast of the point where the Hot Springs turnpike crosses Cove Creek, and the other on "the branch" about 150 meters east of where it empties into Cove Creek. Indications of eudialyte have been observed in the elæolite syenite of Saline County, Ark., on the property of Sol. Nethercutt, about seven miles (11 km.) N.E. of Benton. (N.W. of S.E. of Sec. 16, 2S. 14 W.) At this point the mineral was so badly weathered that an exact determination was impossible.

Besides the ægyrite, elæolite and orthoclase of the rock in which the eudialyte occurs, there are found as accessory minerals beautiful little idiomorphic titanites and apatites. As decomposition products there appear ozarkite (thomsonite) and manganopectolite,† which may be due in part at least to the weathering of eudialyte as well as of the other constituents of the rock.

Petrographical Laboratory, Clark University,
Worcester, Mass., June, 1890.

* Wilhelm Ramsay. Fennia, Bulletin de la Société de géographie de Finland, iii, No. 7, pages 42 and 43.

† J. F. Williams. Manganopektolit. Ein Neues Mineral aus Magnet Cove, Ark. Zeitsch. Kryst. Min., xviii, 1890.