XVI.—*On the Chemical Composition of Epidote from Quenast.*

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THIS Epidote is found in the well-known quarries of quartziferous diorite at Quenast.

Without entering into any details regarding its crystalline form, it will suffice to mention that it here occurs in bacillary prisms, often elongated in the direction of the orthoaxis, and almost always macled parallel to the cleavage plane h' ($\infty\bar{P}\infty$). It also occurs frequently in lamellar, fibrous and radiated masses of a pale green color, at times greyish or straw-colored;[1] these groups of crystals, which frequently occupy the geodes of the matrix, are capable of furnishing the mineral in a state of great purity, and well suited for chemical analysis.

By selecting the material for analysis with scrupulous care, we may meet the objection recently raised by M. Laspeyres,[2] that the greater number of analyses of epidote have been made upon impure specimens. We may add that the epidote of Quenast does not exhibit those intimate associations with other minerals which are apt to occur in specimens from many other localities, and that, moreover, any microscopic contaminations can be got rid of without much difficulty. As regards included minerals, particularly quartz, we may say that we have but rarely observed any, when examining sections of the mineral under the microscope. As the crystals from Quenast are pale in color and split readily, along the planes of union, into lamellæ scarcely more than two or three millimetres in thickness, the flakes, which are obtained by roughly crushing them, are transparent; we have been able to determine, by examining these splinters under the microscope, that they contain no included minerals, and are free from those embedded granules of quartz, to the presence of which M. Laspeyres is inclined to attribute the excessive proportions of silica shewn in some analyses.[3] The thin lamellæ were prepared for

(1) Dela Vallée et Renard. Mém. sur les roches pluton. Mém. Cour. de l' Acad. Roy. de Belgique 1876-7, p. 21, et. seq.

(2) Laspeyres. Min. Bemerk. V. Th. Die chemischen Untersuchungen der Epidot Gruppe. Zeitsch. Kryst. u. Min. III, 5 and 6.

(3) Laspeyres. *loc. cit* pp. 533, et. seq.

analysis by removing all external impurity; the splinters were then ground down, until the whole was perfectly homogeneous, and was seen, under the microscope, to be free from all foreign matter.[4]

We have found the specific gravity of this epidote to be 3·4211. The specimen analysed contained silica, alumina, protoxide and peroxide of iron, lime, basic water and traces of manganese and magnesia.

The following are the results of our quantitative determinations:

I.—1·0639 grm. of epidote gave 0·0239 grm. of water, 0·4080 grm. of silica, 0·1240 grm. of peroxide of iron, and 0·2646 grm. of alumina.

II.—1·0758 grm. of epidote gave 0·4104 grm. of silica, 0·2651 grm. of alumina, 0·1262 grm. of peroxide of iron, and 0·2542 grm. of lime.

III.—1·1368 grm. of epidote was treated in a sealed tube with hydrofluoric and sulphuric acids, and used for the determination of the protoxide of iron; it was titrated with a solution of permanganate of potash (1cc. = 0·005846 grm. of Fe O), 1·1cc. being required, corresponding to 0·0064 grm of protoxide of iron.

IV.—1 0061 grm. of epidote gave 0·0229 grm. of water.[5]

	I.	II.	III.	IV.	Mean.
$Si\ O_2$	38·38	38·15	—	—	38·26
$Al_2\ O_3$	24·87	24·64	—	—	24·73
$Fe_2\ O_3$	11·03	11·11	—	—	11·07
Fe O	—	—	0·56	—	0·56
Ca O	—	23·63	—	—	23·63
$H_2\ O$	2·25	—	—	2.27	2·26
Mg O	trace	trace	—	—	trace
Mn O	trace	trace	—	—	trace
					100·51

Before proceeding to establish the formula that may be derived from these analyses, let us examine the generally received theories concerning the composition of epidote; without entering into long discussions, to which the formula of this mineral has given rise, we may content ourselves with stating that, whilst Tschermak[6] and Kenngott[7] have determined it to be $Si_6\ Al_6\ Ca_4\ H_2\ O_{26}$, supporting this result by calculations based on a large number of analyses, Rammelsberg[8] has on the

(4) The experiments upon the solubility of epidote in hydrochloric acid, which we shall detail at the end of this paper, will serve to prove that there was no quartz included in the mineral we analysed.

(5) The water was determined according to the method devised by L. Sipöcz (Sitzungsber. d. K. Ak. Wiss. Wien. II, 1877).

(6) Tschermak. Die Feldspathgruppe. Sitzungsber. d. K. Ak. Wiss. Wien 50·585.

(7) Kenngott. Ueber die Zusammensetzung des Epidots. N. Jahresb. 1871, p. 449.

(8) Rammelsberg. Ueber die Zusammensetzung des Epidots von Sulzbach. Zeitsch. d. Deutsch. Geol. Gesell. 1872, p. 69.

other hand derived for it the formula $Si_9\ Al_8\ Ca_6\ O_{36}$, founded upon his own analysis of epidote from Sulzbach. Fresh Analyses of the Sulzbach mineral, published by Ludwig [9] proved that the results obtained by Rammelsberg are inaccurate, and that his formula should accordingly b, rejected; Ludwig adheres to the formula of Tschermak and Kenngott, demonstrating its agreement with the results of his analyses of the Sulzbach epidote (Si 0·630, Al, Fe, (as peroxide) 0·615, Ca, Fe, (as protoxide) 0·428, H 0·230, O 2·727). Rammelsberg having since then resumed the examination of the Sulzbach epidote [10] and being guided by his study of Manganese-epidote [11] has abandoned his formula and adopted that of Ludwig [12] which, according to the views of Tschermak and Kenngott consists in regarding this species as an isomorphous mixture of alumina-epidote ($Si_6\ Al_6\ Ca_4\ H_2\ O_{26}$) with iron-epidote ($Si\ Fe_6\ Ca_4\ H_2\ O_{26}$). We shall attempt to shew that the results of our analyses agree with these views.

Taking the mean of all the determinations and calculating out each element we obtain:

Silicon	17·85
Aluminium	13·19
Iron (as peroxide)	7·75
Iron (as protoxide)	0·43
Calcium	16·87
Hydrogen	0·25
Oxygen	42·91

or in atomic proportions:

Silicon	0·6375	
Aluminium	0·4813	0.6196
Iron (as peroxide)	0·1383	
Iron (as protoxide)	0·0075	0.4292
Calcium	0·4217	
Hydrogen	0·2500	
Oxygen	2·6818	

which may be rendered by the formula of Kenngott and Tschermak ($Si.(Al,Fe)_6\ Ca_4\ H_2\ O_{26}$).

Rammelsberg [13] does not take into account in his formula the small

(9) Ludwig. Ueber die chemische Formel des Epidots. Ann. d. Chem. u. Pharm. Vol. 165, p. 217.

(10) Rammelsberg. Ueber die Zusammensetzung der Epidot and Zoisit. Zeitsch d. Deutsch. Geol. Gesell. 24, p. 649.

(11) Rammelsberg. Ueber die Zusammensetzung des Manganepidots. Monatsber. d. Berlin. Ak. 487.

(12) Ludwig. *loc. cit.* p. 223.

(13) Rammelsberg *loc. cit.* Zeitsch d. Deutsch. Geol. Gesell. 1873, 24 .p 69.

amount of protoxide of iron which is indicated in the analyses; Ludwig[14] also admits that it may be neglected, or regarded, as has been done by ourselves, as isomorphous with lime.

It now remains for us to state the results of our experiments on the solubility of epidote in hydrochloric acid. Most authors admit with Rammelsberg[15] that both epidote and zoisite are completely soluble in this re-agent, if they are first heated to a sufficiently high temperature, but that they are not attacked by it without previous ignition. Laspeyres[16] has recently investigated this question; he has kept epidote, finely powdered, and not previously ignited, boiling on the sandbath in pure hydrochloric acid for 4 or 5 hours a day during several weeks; at the end of this period the mineral was completely decomposed with the production of gelatinous silica. At the same time he adds that the larger particles are only decomposed with great difficulty and that the action of the acid has to be continued for several weeks.

In order to convince ourselves of the solubility of epidote in hydrochloric acid, we have employed a method more expeditious than the above, and which prevents the accidental introduction of foreign matter into the solution, which may easily occur during the above protracted process. This method consisted in heating 0·7833 grm of finely powdered epidote with about two-thirds of fuming and one-third of common hydrochloric acid in a hard glass tube. The sealed tube was kept in the waterbath for a day and then heated for 7 hours to a temperature of 125° to 130°. This was sufficient to completely decompose the mineral, leaving nothing but a white gelatinous mass suspended in the liquid and exhibiting all the characteristics of silica. This was carefully washed by decantation and boiled in a solution of carbonate of soda during half-an-hour, when it dissolved, a few colorless particles alone remaining in suspension. The latter were collected on a filter and were found to weigh 0·002 grm which weight remained constant on treating the residue with hydrofluoric and sulphuric acids.

We have thus proved that the mineral analysed was free from included quartz, and that the above residue even if it had consisted of foreign matter was so small in amount that its presence could not sensibly affect the results of the analyses.

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(14) Ludwig *loc. cit.* p. 221.

(15) For bibliographical references see Laspeyres' article p. 532.

(16) Laspeyres, *loc. cit.* p. 532.