ART. VI.—*On Solid Solution in Minerals. III. The Constant Composition of Albite*; by H. W. FOOTE and W. M. BRADLEY.

IN recent years, the fact is becoming more and more recognized that certain minerals are capable of taking up or dissolving, in solid solution, foreign components which from their nature can hardly be considered as isomorphous mixtures in the ordinary sense. Thus, the mineral pyrrhotite has recently been shown* to be a solid solution of sulphur in ferrous sulphide; nephelite always contains an excess of silica,† and analcite, of a hydrated silica.‡ It is impossible in most cases, with our present knowledge, to state with certainty the form in which the admixture occurs. The dissolved sulphur of pyrrhotite, for instance, may be as pyrite, the excess silica of nephelite may be as albite and the excess of hydrated silica in analcite as some other silicate, but in whatever form the admixture occurs, the solid solution is quite different in character from ordinary isomorphous replacement, such as is found in the feldspars where potash replaces soda.

Whether this capacity to form solid solutions with compounds of different type is fairly common among silicates or is limited to a few minerals can hardly be stated with certainty at present. This is chiefly due to the fact that most minerals have been chosen for analysis on account of their purity and freedom from mechanical admixture with other substances. If, however, a compound can dissolve another, it is evident that it will have taken up the maximum amount when it is found mixed mechanically with an excess of the substance dissolved. Thus, nephelite occurs with varying amounts of excess silica in solid solution, but it contains the maximum amount when it crystallizes with albite, which contains more silica than nephelite but the same proportions of soda and alumina. In order, then, to determine whether a mineral can form a solid solution with another, and to what extent this is possible, the composition of the mineral when associated with the other must be determined. If the composition remains fixed, independent of association, no solid solution takes place. If it changes with its association, then the maximum amount of solid solution can be determined.§

Albite sometimes occurs, associated with an excess of its

* Allen, Crenshaw and Johnston, this Journal, xxxiii, 169, 1912.

† Ibid., xxxi, 25, 1911.

‡ Ibid., xxxiii, 433, 1912.

§ This leaves out of account the possible effect of temperature on the maximum amount dissolved, but this is probably small under actual conditions of crystallization.

components, the latter either in the free condition, as corundum or silica, or in combination, as nephelite. These associations make it possible, as shown above, to determine with some definiteness whether solid solution occurs between albite and any of its components, and if so, to what extent. The mineral is such an important component of many rocks that it has seemed well worth while to investigate this problem.

Fortunately, excellent analyses of albite associated with quartz have already been made. These minerals occur together, beautifully crystallized, in a large pegmatite vein at Amelia Court House, Va., and an analysis of the albite was made by Musgrave under the direction of Prof. J. W. Mallett.* Another specimen from the same locality was analyzed by Robertson.† Specimens of albite from this locality in the Brush collection show quartz intimately associated with it, but in neither article was there any statement of the association. Professor Mallett, shortly before his death, however, wrote us as follows regarding the occurrence: "The albite you refer to occurs as a constituent of an extremely coarse-grained granite with abundance of quartz. The feldspar crystals are sometimes more than two feet long and there are sheets of mica twenty inches across." The analyses of this albite will be given below.

The occurrence of albite with corundum is much more uncommon. An analysis of this type of albite was published many years ago by Silliman.‡ The ratio between alkalis, alumina and silica was 1:1.16:6.04, which indicates a considerable excess of alumina above the theoretical ratio, but the analysis was made before heavy solutions were in use and the material was presumably not as pure as it is possible to obtain at present. On the other hand, Moroscewicz§ has shown that artificial fused mixtures of albite and anorthite, with excess of alumina, separate the latter as corundum on cooling, but his results hardly prove that some alumina in excess may not be retained in solid solution.

We have been able to obtain but one specimen of a rock containing both albite and corundum. This was a corundum-syenite from Brudenell, Renfrew Co., Canada, furnished us by Prof. L. V. Pirsson. It also contained nephelite. Preliminary tests showed that the albite contained calcium, indicating the presence of some anorthite in solid solution.

In preparing the sample for analysis, the rock was crushed and albite separated by hand as carefully as possible. It was then sifted to a uniform grain and put through a heavy solution. On account of their higher specific gravity, there was no difficulty whatever in separating the mica and corundum.

* Chem. News, xlii, 204, 1882.

† Chem. News, 1, 208, 1884.

‡ This Journal, viii, 390, 1849.

§ Min. petr. Mitt., xviii, 1, 1898.

Nephelite, however, has nearly the same specific gravity as albite and could not be entirely separated from the latter by this means. The material obtained floated in heavy solution of sp. gr. 2.645 and sank at 2.626. To free the material completely from a very small amount of nephelite, it was boiled three times with dilute hydrochloric acid. The solution from the first treatment gelatinized when evaporated, showing the presence of nephelite, but nothing further was extracted. Under the microscope, no impurities could be detected in the purified material.

The usual precautions were observed in the analysis. Silica, after being weighed, was tested for alumina by evaporating with sulphuric and hydrofluoric acids, and alumina, after weighing, was dissolved in a bisulphate fusion to test for silica. Evaporations were made in platinum. Alkalies were determined by a Smith fusion. The analyses by Robertson, Musgrave, and our own are given in Table I.

TABLE I.
Analyses of Albite.

	1 Albite associated with quartz (Robertson)	2 Albite associated with quartz (Musgrave)	3 Albite associated with corundum and nephelite (Bradley)		
			A	B	Average
SiO ₂	67.06	68.44	63.82	63.90	63.86
Al ₂ O ₃	21.72	19.35	23.40	23.24	23.32
CaO	1.59	----	3.77	3.75	3.76
MgO	.03	----	----	----	----
Na ₂ O	10.01	11.67	9.15	9.24	9.20
K ₂ O	.39	.43	.15	.17	.16
H ₂ O	----	----	.25	.24	.24
	100.80	99.89	100.54	100.54	100.54

In calculating the ratios from these analyses, it is necessary to make allowance for anorthite in the two specimens containing lime. The ratios, with corrections, are given in Table II.

TABLE II.
Ratios calculated from the Analyses of Table I.

	1 Ratios for anorthite		2 Ratios for albite	3 Ratios for anorthite		Ratios for albite
SiO ₂	1.110	.056	1.054	1.057	.134	.923
Al ₂ O ₃	.212	.028	.184	.228	.067	.161
CaO	.028	.028		.067	.067	
Na ₂ O } ..	.165		.165	.149		.149
K ₂ O }						

The albite ratios of Table II are recalculated on the basis $\text{SiO}_2 = 6.00$ in Table III.

TABLE III.

	1	2	3
	Albite associated with quartz	Albite associated with quartz	Albite associated with corundum and nephelite
SiO_2 -----	6.00	6.00	6.00
Al_2O_3 -----	1.04	1.00	1.04
$\text{Na}_2\text{O} + \text{K}_2\text{O}$	.93	1.02	.94

The ratios in Nos. 1 and 3 are practically identical, though the associations are at opposite extremes. They differ considerably less than Nos. 1 and 2, where the association in both cases was with quartz. In no case is the variation greater than is common in minerals, due to errors of analysis or slight impurities in the minerals themselves. It seems fair to conclude, therefore, that no solid solution of quartz, corundum or nephelite in albite occurs which is greater than the apparent variation in composition, due to the ordinary errors of analysis.

Chemical and Mineralogical Laboratories of the
Sheffield Scientific School of Yale University,
New Haven, Conn., April, 1913.