

## TRIDYMITE AND CHRISTENSENITE

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In 1944 Barth and Kvalheim described a mineral from a lava from Deception Island as a solid solution of about 5%  $\text{NaAlSiO}_4$  in  $\text{SiO}_2$ , with the tridymite structure, and gave it the name christensenite, to distinguish it from "pure" tridymite, which they presumably consider as 100%  $\text{SiO}_2$ . The purpose of this note is to point out that the original tridymite from Cerro San Cristobal, Pachuca, Mexico, also contains Al, Na, and other elements in solid solution, and that this is probably the case with all natural tridymites. Under these circumstances the name christensenite seems superfluous.

The two analyses of the original tridymite from Pachuca published by vom Rath (1868) show 96.1% and 95.5%  $\text{SiO}_2$ , the remainder being reported as ferric oxide, alumina, magnesia, and loss on ignition; the presence of sodium and potassium was also established. Vom Rath evidently considered tridymite to be pure  $\text{SiO}_2$ , and believed that most of the ferric oxide was derived from the steel mortar in which the material was crushed, and that the remainder, together with the magnesium, alumina, and alkalies, represented admixed rock material, although he stated that several days were spent in selecting pure material for analysis. During a visit to Mexico in 1950 I took the opportunity of collecting some specimens of the tridymite-bearing andesite from the type locality at Pachuca. Pure tridymite was separated from this material by density and magnetic separation, and was analyzed spectrographically by Mr. R. K. Leininger, of the Indiana Geological Survey, to whom I would express my grateful thanks. This analysis gave the following percentages:  $\text{Al}_2\text{O}_3$  2.4,  $\text{Fe}_2\text{O}_3$  0.36,  $\text{MgO}$  0.3,  $\text{CaO}$  0.4,  $\text{TiO}_2$  0.26,  $\text{Na}_2\text{O}$  0.80,  $\text{K}_2\text{O}$  0.37,  $\text{MnO}$  0.003,  $\text{SiO}_2$  by difference 95.1. When this analysis is recalculated into atomic percentages it is found that  $2\text{Ca} + \text{Na} + \text{K}$  equals Al within the probable error of the analysis; i.e., if  $\text{Al}^{3+}$  replaces  $\text{Si}^{4+}$  in the tridymite lattice, electrical neutrality is preserved by the introduction of an equivalent amount of calcium, sodium, and potassium cations in vacant positions in the tridymite lattice.

A similar result was obtained with tridymite from a trachyte dike near Lyttleton, New Zealand. Tridymite separated from this rock and purified by density and magnetic separations gave the following analysis:  $\text{Al}_2\text{O}_3$  2.7,  $\text{Fe}_2\text{O}_3$  0.25,  $\text{MgO}$  0.4,  $\text{CaO}$  0.2,  $\text{TiO}_2$  0.28,  $\text{Na}_2\text{O}$  0.67,  $\text{K}_2\text{O}$  0.75,  $\text{MnO}$  0.0005,  $\text{SiO}_2$  by difference 95.1. This analysis shows a close similarity to that of the tridymite from Pachuca. Again there is a balance be-

tween the amount of aluminum and that of the alkali and alkaline earth elements, which corroborates the hypothesis that the aluminum is replacing silicon and the alkali and alkaline earth cations make up the resulting charge deficiency by entering vacant lattice positions. The few published analysis of tridymite from other localities also indicate that natural tridymite is never pure  $\text{SiO}_2$ , in contrast to quartz.

Barth and Kvalheim remark that the optical properties of the Deception Island mineral support the view that it is a solid solution of  $\text{NaAlSiO}_4$  in  $\text{SiO}_2$ ; its refractive indices are considerably higher than those of synthetic tridymite made from pure  $\text{SiO}_2$ ,  $\beta$  for the Deception Island material being 1.480, in contrast to  $\beta=1.470$  for the synthetic material. The Pachuca and Lyttleton tridymites show the same phenomenon,  $\beta$  being 1.478 in each of these. Barth and Kvalheim pointed out that tridymite from Japanese lavas also has higher refractive indices than those of synthetic tridymite, and Durrell (1940) recorded the following indices for tridymite from andesite near Portola, Plumas County, California:  $\alpha=1.478$ ,  $\beta=1.479$ ,  $\gamma=1.481$ .

Thus all the evidence indicates that the original tridymite, and all natural tridymites, are not pure  $\text{SiO}_2$ , but contain aluminum and alkali and alkaline earth elements in solid solution. In view of the ability of the tridymite lattice to accommodate foreign ions, it is quite unlikely that pure  $\text{SiO}_2$  will crystallize in the tridymite lattice in any natural environment, where foreign ions are universally present. Buerger (1935) has pointed out that tridymites in lavas have probably been deposited outside the stability field of pure  $\text{SiO}_2$  tridymite, the stabilizing factor being the presence of large cations buttressing the open tridymite lattice. There is no essential difference between the original tridymite from Pachuca and that from Deception Island and hence no occasion for the introduction of a new mineral name on this account. The name christensenite is therefore superfluous.

## REFERENCES

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