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AN ASSOCIATION OF NATROLITE AND DATOLITE AT  
POKOLBIN, NEW SOUTH WALES.

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By C. ANDERSON, M.A., B.Sc., Mineralogist.

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In September, 1901, the Trustees of the Australian Museum acquired by exchange with the University of Sydney, through Professor T. W. E. David, Trustee, three specimens of a white, fibrous, radiating mineral, believed to be natrolite. It occurs in veins and cavities in an amygdaloidal hypersthene-andesite (*vide* Prof. David) at Kangaroo Grounds, Millfield, Pokolbin, Co. Northumberland. One specimen, of which an analysis (No. IV.) is given, is undoubtedly typical natrolite, but a preliminary examination showed that the others contain a notable amount of boric acid, and detailed chemical and microscopical investigation left little doubt that we have here an intimate mixture of the two minerals natrolite and datolite. This result is of some interest, as datolite, so far as I am aware, has not hitherto been recorded from the mainland of Australia, though occurring in Tasmania.

*Physical Characters.*—The mixture is white, almost opaque, the fibres radiate from several centres and appear bladed on fracture. It fuses between 2 and 3, with slight intumescence, to a clear glass. Specific gravity determinations gave values varying from 2.27 to 2.54, suggesting a mixture, not a definite mineral. The natrolite does not differ materially in appearance and habit save that it seems less compact. The habit of the two is that which is typical of natrolite, thomsonite and pectolite. The specimens which react for boron look perfectly homogeneous to the eye and, on a superficial examination, might easily be mistaken for a single mineral.

*Microscopic Characters.*—Two sections were prepared, one parallel to the direction of the fibres, the other transverse. The former plainly revealed the presence of two minerals, one of which has a low refractive index and weak birefringence, depolarising in colours of the first order. It is fibrous and striated parallel to its direction of elongation. Extinction is straight and compensation takes place perpendicular to the length of the fibres. The other occupies the interspaces between the fibres of the first, is not striated, has a higher refractive index and stronger birefringence, depolarising in second order colours. The extinction has no constant relation to the borders of the

stripes, shewing that the mineral has no definite orientation. The transverse section is even more conclusive. The field is studded with nearly square cross-sections of a mineral with weak double refraction. It shews well-marked zonal growth, appears rather cloudy, perhaps from inclusions, and extinguishes diagonally. It is biaxial, shewing emergence of a bisectrix, and therefore, the extinction being straight, as already observed in the other section, belongs to the orthorhombic system. The axial plane is parallel to *b*, and the optical sign positive. These are the optical properties of natrolite, and, taking this in conjunction with the occurrence of pure natrolite alongside, we may fairly conclude that one component in the mixture is natrolite. The rest of the section is occupied by an interstitial mineral of rather high double refraction. As to the relations of the two minerals, it is apparent that the one with definite crystal outlines is generally of prior formation to the other, though in some parts of the section portions of the latter are included by the former. This may possibly be explained by solution and intrusion subsequent to the formation of the earlier mineral.

*Chemical Characters.*—The mixture easily decomposes with hydrochloric acid, yielding gelatinous silica. The analytical methods employed call for no particular mention, except as regards the direct determination of boric acid, a somewhat difficult operation, and one involving a considerable expenditure of time. With the exception of the natrolite analysis No. IV, all the determinations were made on the same specimen. Several lumps were broken off, the cleanest selected and broken successively into smaller and smaller pieces, of which the most homogeneous and purest-looking only were taken. The final selection was made under a lens. Two samples A and B were thus procured, and, as might have been expected, were found to differ slightly in composition. In sample A boric acid was estimated directly, in sample B by difference. For the direct estimation 1.3320 grams were taken. The method employed was substantially that of Gooch.<sup>1</sup> A 150 c.c. pipette, suitably bent, was utilised as a retort, and heated up to 160°C in a bath of paraffin melting about 78°C. In a preliminary trial the fine powder was introduced into the retort, and nitric acid and alcohol added, but it was difficult to judge when the mineral was completely decomposed, and also to limit the quantity of acid to a minimum, success in which greatly facilitates the future operations. Subsequently the material was, as recommended by Penfield, fused with sodium carbonate, exhausted with water, carbonate of ammonia added, and the residue and precipitate filtered off and washed. The solution was rendered just acid by

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<sup>1</sup> Gooch—Bull. U.S. Geol. Surv., No. 42, 1888, p. 64.

nitric acid, using methyl orange as indicator. The retort was charged with about 40 c.c. of solution, made up of 20 c.c. of filtrate, 2 c.c. nitric acid and the rest alcohol. The distillate was caught in a flask containing strong ammonia solution,<sup>2</sup> then transferred to a porcelain basin (platinum not being available) and evaporated to dryness over lime. The lime was prepared from pure calcium carbonate, ignited in a platinum crucible until of constant weight, when the bulk of it was transferred to the porcelain basin, the distillate added and evaporated on the water bath, the basin being supported on a porcelain ring inside a somewhat larger basin. By this means the evaporation proceeded with perfect safety, if rather slowly. When dry the contents were removed to the platinum crucible containing the residue of the lime, and heated cautiously at first, and finally ignited over the blast until of constant weight. The residue in the retort was tested unsuccessfully for boron, also the residue from the fusion with sodium carbonate. This proves that all the boric acid was secured in the distillate.

To prevent contamination of silica and the bases by small quantities of boric acid, recourse was had to repeated evaporation with alcohol and a little hydrochloric acid.

For analysis III a quantity of sample B was thrown into methylene iodide diluted with benzene to a specific gravity 2·6, intermediate between the specific gravities of natrolite and datolite. A partial separation took place, and the analysis was made on the lighter portion. A complete separation is unattainable owing to the intimate nature of the mixture.

	A		B		IV	V
	I	II	III	III		
H <sub>2</sub> O @ 100°C—	} 6·87	·26	} 7·56	·34	} 2·95	
H <sub>2</sub> O @ 100°C+		6·89		9·38		
SiO <sub>2</sub> ... ..	43·47	43·44	44·25	46·91	38·72	
Al <sub>2</sub> O <sub>3</sub> ... ..	16·07	18·67	23·47	27·10	—	
CaO ... ..	14·54	13·06	8·42	·63	33·83	
K <sub>2</sub> O ... ..	} 8·96	·39	} 11·57	·14	—	
Na <sub>2</sub> O ... ..		9·23		15·65	—	
B <sub>2</sub> O <sub>3</sub> ... ..	9·93	(8·06)	(4·76)	—	23·66	
	99·84	100·00	100·00	100·15	99·16	

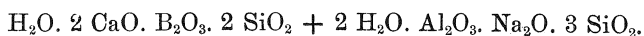
I, II, III. Mixture of natrolite and datolite.

IV. Natrolite.

V. Calculated composition of datolite.

<sup>2</sup> Penfield and Sperry—Am. Journ. Sci., (3), xxxiv., 1887, p. 222.

*Discussion of Analyses.*—Analysis I, in which the boric acid was determined directly, gives us the ratios  $H_2O : SiO_2 : Al_2O_3 : CaO : Na_2O : B_2O_3 = 269 : 507 : 110 : 183 : 101 : 100$ . From this we deduce the empirical formula  $Al_2O_3 \cdot 2 CaO \cdot Na_2O \cdot B_2O_3 \cdot 5 SiO_2 \cdot 3 H_2O$ , which corresponds to



Datolite.

Natrolite.

Therefore we must assume that sample A contains natrolite and datolite in molecular proportions. Analysis II does not yield a simple formula but it is noticeable that lime and boric acid retain the ratio of 2 : 1 and that they vary in the opposite direction to the alumina and soda, which on the other hand retain their ratio of 1 : 1. The same holds with analysis III; therefore it is a fair assumption to conclude that we are dealing with two silicates, one of which contains lime and boric acid, the other alumina and soda. Further relying on the microscopic determination of natrolite in the mixture, and taking analysis IV as representing its composition, we can, by assuming all the alumina and soda in the mixture to belong to natrolite molecules, calculate the composition of the other component. The calculated result is given in analysis V, and is sufficiently near to the published analyses of datolite to warrant the conclusion that datolite does actually exist in the mixture.