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Primary allanite in vitrophyric rhyolites from the Tweed Shield Volcano, north-eastern New South Wales

ALLANITE is a common accessory mineral in many granitic rocks and especially in pegmatites (Deer *et al.*, 1962) but is quite rare in volcanic rocks. Trace amounts are widely distributed in ash-fall and ash-flow tuffs in the western United States (Izett and Wilcox, 1968) and in rhyodacitic tuffs in northern Queensland (Branch, 1966). However, allanite apparently has not been hitherto described from lava flows. In the southern portion of the Tweed Shield Volcano, north-eastern New South Wales (Wilkinson, 1968; Ewart *et al.*, 1971; Duggan, in preparation) trace amounts of allanite occur in several vitrophyric rhyolites that constitute the chilled lower selvages (up to 10 m thick) to much thicker rhyolite flows (up to 150 m).

TABLE I. *Analyses of rhyolites*

	1	2		1	2
SiO_2	74·52	73·30			
TiO_2	0·20	0·34	C.I.P.W. norms		
Al_2O_3	11·86	12·64			
Fe_2O_3	0·64	0·68	Qz	35·59	34·57
FeO	0·74	0·60	Or	32·98	32·68
MnO	0·02	0·02	Ab	23·35	23·44
MgO	0·05	0·06	An	2·77	3·15
CaO	0·65	0·70	C	0·27	0·95
Na_2O	2·76	2·77	Hy	0·66	0·16
K_2O	5·58	5·53	Mt	0·93	0·99
H_2O^+	2·62	2·69	Il	0·38	0·65
H_2O^-	0·15	0·27	Ap	0·16	0·12
P_2O_5	0·07	0·05	rest	2·77	2·96
Total	99·86	99·65	Total	99·86	99·67

1. Vitrophyric rhyolite (28078), 4·5 km south-west of Nimbin, New South Wales. Nimbin 1:50 000 sheet 9540–IV, grid ref. 182338.
2. Vitrophyric rhyolite (28079), 6·5 km west-south-west of Mullumbimby, New South Wales. Rosebank 1:50 000 sheet 9540–I, grid ref. 423396.

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Most of the rhyolites are porphyritic and contain phenocrysts of quartz, sanidine, minor sodic oligoclase, and sometimes ferrohypersthene, together with accessory amounts of ilmenite, zircon, and, in some specimens, allanite. These are set in a brown or colourless glass, which may contain numerous crystallites. Analyses of two allanite-bearing vitrophyric rhyolites are set down in Table I. They and other mineralogically-similar rhyolites are characterized by relatively high K_2O, extremely low MgO, and low Na/K ratios. The hydrated nature of the residual glass, as indicated by high H_2O+, is thought to be posthumous and not a reflection of high f_{H_2O} in the initial magmas.

Several other features, such as the relative paucity of pyroclastics in the volcanic sequence, the extreme rarity of hydrous phases, the presence of R_2O_3-poor ilmenite as the sole Fe–Ti oxide phase, and the lack of significant oscillatory zoning in plagioclase phenocrysts (cf. Yoder, 1969; Morohashi *et al.*, 1974), collectively indicate that the rhyolite magmas were relatively water-deficient at the time of eruption. A more detailed evaluation of the water contents and eruption temperatures of these magmas will be presented elsewhere (Duggan, in preparation).

The allanite occurs as euhedral grains up to 0·5 mm in diameter, which may be included in sanidine phenocrysts. Optical properties are typical of non-metamict allanites with α *c.* 1·75, light brown, and γ dark brown. Partial microprobe analyses of two allanites gave: SiO_2 29·2 and 29·4 %; TiO_2 2·3, 1·6; Al_2O_3 12·6, 13·5; total iron as FeO 17·7, 17·3; MnO 0·63, 0·48; CaO 10·1, 10·8. Qualitative determination of the principal rare-earth elements indicated the presence of La with Ce and lesser amounts of Sm and Gd; small amounts of other rare earths may also be present. X-ray powder data confirm the identity of the allanite and the analyses indicate close similarity to analysed allanites from pegmatites (Deer *et al.*, 1962, p. 214), although TiO_2 is relatively high. MgO is below the limit of detection of the microprobe ($<$0·1 %).

The occurrence of allanite included in sanidine phenocrysts, and as discrete microphenocrysts in these rhyolites, attest to its undoubted ability to crystallize directly as an early phase from an acid melt (Izett and Wilcox, 1968). Furthermore, the inferred water-deficient nature of the host magmas at the time of crystallization indicates that especially high water-pressures are not critical to its formation. Instead, the appearance of allanite was probably controlled by a relatively high concentration of rare-earth elements in the host magmas, which, on the basis of major and trace-element chemistry may be products of extreme fractionation of a more mafic tholeiitic parent magma.

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