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Tacharanite from Tasmania, Australia

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THE mineral tacharanite has been recently re-examined by Cliff *et al.* (1975). They worked on material from the original locality, Portree, in Scotland (Sweet, 1961) and from a few new European localities described between 1971 and 1974. None of the post-Sweet authors, however, refer to the second discovery of the mineral from Tasmania where it was identified by this writer in 1961 and recorded in a number of publications (Sutherland, 1965; Sutherland and Corbett, 1967; Sutherland and Hale 1970; Mines Department of Tasmania, 1970; Sutherland, 1973*b*). The first Tasmanian report was communicated to J. M. Sweet, who kindly arranged for the Department of Mineralogy, British Museum, to send the writer a small piece of the Portree material for study. As the Tasmanian find does not seem to be known in the later literature, some more detailed information on its occurrence is presented here for comparison with the European localities.

Occurrence. The tacharanite is found at several localities in the Tertiary basaltic lavas of Tasmania and can be considered a relatively abundant mineral. It mostly occurs in hyaloclastite and hyaloclastite flow-foot breccias formed from flow or eruption of lava into water. These provide permeable and easily altered glassy rocks, forming suitable hosts for extensive deposition of secondary minerals. In the Marrawah–Redpa area and at Brittons Swamp in far NW. Tasmania the breccias formed through eruption into Miocene high seas, but near Gads Hill in the Mersey–Forth valleys, NW. Tasmania, and around Liawenee, Great Lake, Central Tasmania, the breccias represent mid-Tertiary eruptions into freshwater rivers and lakes. The lavas in these sequences are typically near-saturated alkali basalts and olivine tholeiites. There is one tacharanite occurrence (in amygdules) in a sub-aerial flow of olivine nephelinite, 3 km SW. of Scottsdale, NE. Tasmania. The writer is unaware of any tacharanite recorded from mainland Australia, probably because hyaloclastite breccias are much less common there and where they do occur they are usually much younger eruptives that have not been zeolitized.

None of the European tacharanite is found in extensively seamed hyaloclastite breccias, but the writer has recently received an exchange specimen of glassy pillow lava with this secondary mineral from Naoki, Yaizu City, Shizuoka Prefecture, Japan. The material was sent by Dr. Tokiko Tiba, Department of Geology, National Science Museum, Tokyo, with the information that the tacharanite was identified by X-ray diffraction and that this first find from Japan is under study by Dr. A. Kato (Chief Curator of Minerals) and herself.

Properties. Tasmanian tacharanite forms dense white, porcellaneous cryptocrystalline masses, which tend to form spherules and botryoidal crusts where the infilling is incomplete. The surface is commonly altered to a softer chalky residue, which in the Liawenee material gives a positive test for phosphate using ammonium molybdate. This residue has not been positively identified from X-ray powder photographs, but the pattern suggests a mixture that includes calcium carbonate and calcium phosphate.

X-ray powder photographs and diffraction records of the Tasmanian mineral give weak patterns suggestive of poorly crystallized material. There are variations in intensities of lines and in some spacings from different localities; some of the stronger lines of typical tacharanite patterns listed in the literature are not obvious, but the main lines are present.

The Liawenee material gave n 1·5350±0·0015 (sodium light) and the isotropic base contains flecks and patches of birefringent tobermorite. The Redpa material showed slightly lower R.I.s around 1·5255±0·001 and unlike the Liawenee material may contain conspicuous amounts of spherulitic radiating gyrolite. Though there is evidence that the tacharanite has altered into tobermorite, and in some localities to tobermorite and gyrolite, in outcrop exposures, in many instances this is not a rapid breakdown as reported for the Portree material and some specimens remain largely unaltered more than ten years after collection.

A chemical analysis of tacharanite from the Gads Hill locality gave the following composition (analysis by Tasmanian Department of Mines, Chemical Laboratory; J. Furst, analyst; material dried at 110 °C): SiO_2 46·5, Al_2O_3 5·9, Fe_2O_3 0·36, CaO 27·0, MgO 0·76, Na_2O 0·50, K_2O 0·45, H_2O+ 18·6, Total 100·1. H_2O- (110 °C, 5 hr) up to 3·0 %.

The composition approaches those of the Bramburg and Huntly tacharanites more closely than that of the Portree material (Cliff *et al.*, 1975; Table II), but has significantly less CaO and more H_2O than any of the other analyses. This cannot be attributed to any inclusion of tobermorite or gyrolite as both these minerals are less hydrated than, and show similar or greater CaO contents to, the European tacharanites. Similarly, it is unlikely to represent an admixture with more hydrated materials such as gelatinous plombierite or semi-crystalline calcium silicate hydrate (I), since these would raise the CaO content. The poorly crystalline Tasmanian material may include considerable water held by capillary action, which would come off as H_2O- and possibly in part as H_2O+; a little uncombined water is assumed in the idealized tacharanite formula (Cliff *et al.*, 1975). Recalculation of the Tasmanian composition, including allowance for H_2O-, to the water contents shown by the European analyses brings SiO_2 up to around the values of the Bramburg and Huntly analyses, with CaO less deficient but still rather low, and Al_2O_3 slightly high. This may result from impurities such as opal or clays that were not detected in separating the material, or alternatively the poorly crystalline material may represent a Ca-deficient structure distorted by excess Al; such a structure could incorporate variations in molecular water content, which may account for the high H_2O+ and somewhat higher d_{002} spacings of up to 12·87 Å observed in some of the X-ray patterns over the normal 12·7. Differential thermal analyses carried out on Tasmanian material show a broad endothermic peak in the curve, representing loss of water from the structure between 120 and 280 °C.

Associations. The Tasmanian tacharanite is commonly associated with a variety of secondary minerals. While no individual filling contains the complete sequence, the position of tacharanite in the general depositional sequence can be inferred from an over-all study. Detailed examination of the Liawenee material shows that tacharanite follows massive calcite, chabazite, and rare phillipsite and is associated with opal, tobermorite, and nontronite. Apophyllite and calcite are superimposed over the tacharanite group. The Gads Hill sequence is generally similar, but in the Redpa material prevalent Na-rich chabazite and apophyllite overlie the tacharanite crusts and are associated with rarer natrolite and minor thomsonite and analcime. In the sub-aerial Scottsdale flow, the tacharanite is associated with tobermorite and nontronite. Unlike most of the breccia occurrences, it tends to fill separate cavities to those occupied by zeolite assemblages (natrolite, gonnardite, phillipsite, and rare stilbite and apophyllite).

It is clear that most of the Tasmanian tacharanite is associated with typical chabazite-zone minerals (grading in part into the analcime–natrolite zone) found by Walker (1960*a*, 1960*b*, 1971) in basalt piles in the British Isles and Iceland (i.e. chabazite, thomsonite, *levyne*, phillipsite, *gismondite*, *garronite*, calcite, gyrolite, and apophyllite —the italicized species are unrecorded from Tasmanian assemblages). It thus occurs within zeolite sequences typically formed at relatively low temperatures of zeolitization and under basalt overburdens of less than 800 m thickness. Field evidence also suggests that the host basalt piles were originally less than this thickness. At Liawenee the chabazite habits are typical of habits 1–3 from the main part of the chabazite zone, but at Gads Hill and Redpa the chabazite shows the more extreme habits 4–6 indicative of the lower part of the zeolite zone (Walker, 1951); thus the tacharanite occurs through the full range of the chabazite habits.

Genesis. The Tasmanian association, within the chabazite zone, differs markedly from that of the Mull and Morven basalt piles; there tacharanite and tobermorite are only associated with the mesolite and laumontite zones at original depths exceeding 1500 m and are related to relatively higher temperatures of zeolitization (Walker, 1971). Similarly, at Portree the tacharanite occurs with mesolite (Sweet, 1961) and at Bramburg it is part of a suite of calcium hydrated silicates formed from hydrothermal alteration at temperatures between 160 and 250 °C (Koritnig, 1972).

To explain the anomalous Tasmanian associations in terms of the European associations, a period of elevated temperature is required interspersing lower-temperature zeolite deposition. Detailed field mapping at Liawenee shows that the tacharanite-bearing zeolitized breccias are overlain by a succession of subaerial flows dated between 22·9 and 23·6 Myr (Sutherland and Hale, 1970; Sutherland *et al.*, 1973). This sequence is overlapped on its east side by a younger succession of closely similar, but unzeolitized, breccias dated around 21·8 to 22·3 Myr and erupted from a fissure lying 0·5 to 5 km from the zeolitized breccias. The following history of volcanism and secondary mineral deposition could be proposed for the basalt successions: Eruption of older basalt breccias and capping flows (140+ m thick); post-eruptive deposition of calcite and chabazite (+phillipsite); eruption of younger basalt breccias and isolated flow caps (> 80 m thick); elevation of local temperatures along the erupting fissure and deposition of the tacharanite group in the adjacent older breccias; and finally post-eruptive deposition of calcite and apophyllite in the older breccias, with no deposition in the younger breccias due to insufficient thickness to allow initiation of zeolitization.

Similar explanations could apply to other Tasmanian tacharanite assemblages, as at least two periods of volcanism can be demonstrated on stratigraphical grounds in the Marrawah–Redpa area (Sutherland, 1973*a*) and the Mersey–Forth successions contain basal tacharanite-bearing breccias as well as zeolitized breccias that lack tacharanite and overlie interbasaltic sediments. Only one eruption is represented at Brittons Swamp where tacharanite forms the main cement of the breccia, but this is probably a vent rock and may have been subjected to higher post-eruptive heat flow than would normally be expected in thin-flow successions. At Scottsdale, the amygdaloidal tacharanite is found within a single flow, and there is little field evidence of any significant cover of former flows; however, this olivine nephelinite is intersected by later coarser nephelinite phases and may lie in the proximity of a vent (Tasmanian Department of Mines, 1965, p. 50), so that late-stage heating may have effected the deposition of the secondary minerals.

There is thus circumstantial evidence that Tasmanian tacharanite is found in eruptives that have been subjected to late-stage hydrothermal reactions or later post-eruptive heating. In the occurrences with pre-tacharanite lower-temperature chabazite-zone minerals, the later elevation in temperatures must have remained below 240 to 255 °C, above which the chabazite would break down (Coombs *et al.*, 1959).

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