COMPOSITION OF ALLANITE IN THE FOOTWALL OF THE SULLIVAN OREBODY, BRITISH COLUMBIA

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ABSTRACT

Fresh and metamict portions of allanite grains from a vein in footwall rocks of the Sullivan orebody, British Columbia, have been analyzed by means of the electron microprobe. The metamict zones show enrichment in magnesium and thorium as well as water (implied). In the rare-earth-ratio plots of Fleischer (1965), the Sullivan samples resemble granitic and pegmatitic allanite; the authors, however, favor a multiple-stage genesis, which recognizes the potential of contributions of constituents from the original Aldridge Formation, the alteration minerals and the Purcell sills.

Keywords: allanite, Sullivan deposit, British Columbia, origin.

PETROGRAPHY

The allanite occurs in a rock composed predominantly of magnesium-rich tourmaline and quartz, with accessory titanite, pyrrhotite and magnesium-rich chlorite. The grains average 300 μm (long dimension), with a maximum birefringence of approximately 0.02. Metamict areas are not truly isotropic (birefringence 0.002) and occur as patches not necessarily in the core of crystals, and commonly as a rim (Fig. 1). Pleochroism is very faint and largely masked by the strong pleochroic effects of adjacent grains of tourmaline.

ANALYTICAL CONDITIONS

Analytical data were collected using an ARL-EMX electron probe microanalyzer operated at 15 kV. Elemental standards were used for Y, Sm, Th and Gd. A monazite standard, for which Jaffe (1955) reported a chemical composition, was used for Nd, Pr, Ce and La. These elements were checked, where possible, against other rare-earth standards with acceptable results for Nd, Ce and La. Count rates suggest significantly higher Pr in the monazite standard than the chemical analyses indicated; consequently, the Pr content of the Sullivan allanite may be lower than reported. All rare earths were measured using La emission; Pr and Nd were corrected for interfe-
ence by La and Ce $L\beta$ emission, respectively. Matrix corrections were carried out following the method of Bence & Albee (1968), using correction factors of Albee & Ray (1970) and the procedure of Nicholls et al. (1977).

**Composition**

Microprobe data on allanite grains are presented in Table 1. Estimates of water content for the clear areas are included, based on chemical data for allanite reported by Deer et al. (1962). The same value (2.00 wt.%) is tabulated for the metamict samples and should be considered a minimum. In comparison with the clear areas, metamict areas have a lower content of the rare-earth elements but contain significantly more Mg and Th. The analytical total for a metamict area is lower than for a clear area, presumably owing to additional water entering a crystal lattice structurally damaged by bombardment.

**Fig. 1.** Photomicrographs of allanite from the footwall of the Sullivan orebody. Scale bar 100 µm. A. Metamict areas irregularly within and at the edge of prismatic grains (A), associated with quartz (Q) and tourmaline (T). B. Allanite (A) with irregular areas of metamict material (M); some tourmaline and quartz at top and left of photograph.
by alpha particles and nuclei recoil from radioactive elements (Pabst 1952). The structural formula for the average clear material is (Ca,La,Pr,Rb)O, and the average for the metamict material is (Ca,La,Pr)O, representing an enrichment factor of at least five with respect to the clear areas. The relatively high Th content in metamict areas raises a question of cause and effect. The Th may have caused the metamictization, with the patches in part related to original distribution of Th; additional Th may have moved into the damaged lattice along with water and magnesium. It has been demonstrated that not only water but also magnesium may enter the damaged lattice.

In general, the ThO2 content of allanite averages about 1% (Deer et al. 1962); the ThO2 content for the clear areas of the Sullivan allanite is less than 0.06%. In contrast, the average for the metamict areas is 0.32%, representing an enrichment factor of at least five with respect to the clear areas. The relatively high Th content in metamict areas raises a question of cause and effect. The Th may have caused the metamictization, with the patches in part related to original distribution of Th; additional Th may have moved into the damaged lattice along with water and magnesium. It has been demonstrated that Th is concentrated in weathered portions of allanite and that the rare-earth elements are depleted (Deer et al. 1962, p. 216). The trend in element behavior in the samples being described is the same, but water and magnesium. It has been demonstrated that not only water but also magnesium may enter the damaged lattice.

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Hickling et al. (1970) investigated the variation in birefringence (as an indicator of degree of metamictization) as an inverse function of age in allanite.

**TABLE 1. COMPOSITION OF ALLANITE IN THE FOOTBALL AT SULLIVAN**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Grade</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Avg-C</th>
<th>Avg-M</th>
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<tr>
<td>MgO</td>
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<td>2.00</td>
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</table>

**DISCUSSION**

Allanite is a common accessory in granites, granodiorites and granitic pegmatites (Deer et al. 1962). Partial and nearly complete compositions of allanite from plutonic rocks are reported by Adams & Sharp (1972), Hickling et al. (1970), Ghent (1972) and Lee & Bastron (1967). Allanite from a granitic gneiss is described by Cech et al. (1972) and from a dolomitic skarn by Geijer (1927). A more unusual association with stratiform copper mineralization, was described by Demange & Elsass (1973).

The MgO content of allanite is typically 1% or less (Deer et al. 1962). An exception is the magnesian allanite (Geijer 1927) associated with a magnetite deposit in a Mg-Ca-silicate skarn; here, the allanite contains 7.42 and 14.15 wt.% MgO. The increase in Mg in the Sullivan allanite, from 1% MgO in clear areas to 4.6% MgO in metamict areas, suggests that...
Precambrian allanite should be essentially isotropic owing to the long interval of time during which the radiation damage occurs. The high birefringence of the clear areas of the Sullivan allanite suggests that they have been recrystallized, perhaps as late as during the Columbian orogeny.

Fleischer (1965) attempted to classify allanite samples according to the ratios of various rare-earth elements. His data are shown in Figure 2 along with the Sullivan data and the compositions cited previously. The Sullivan allanite and that from the stratiform copper deposit plot close to allanite from granites and pegmatites, although neither occurrence has an obvious spatial or temporal association with igneous rocks of these or any other composition. In view of the variation in the data for plutons shown in Figure 2, it seems unlikely that this approach can be used to directly deduce the environment of formation.

In the case of the Sullivan occurrence, the source of the allanite-forming solutions is speculative. Evidence from Bishop (1976) clearly indicates that allanite is present in the Purcell sills. These rocks alter the tourmalinite and are therefore clearly later than that phase of alteration (Hamilton et al. 1982). The allanite-bearing veins cut the tourmalinite, contain quartz and some redistributed tourmaline, and therefore are perhaps associated with the stage of alteration accompanying the intrusion of the Purcell sills. However, as indicated earlier, the entire area has been affected by the Columbian orogeny, so that the allanite in the Purcell rocks and footwall veins could be associated with this event. The multiple-stage type of sequence documented by Hickling et al. (1970) seems more likely to explain the genesis of the Sullivan allanite than does a single event. Such an origin recognizes that the constituents forming the vein could have been gleaned from one or a combination of: the original Aldridge minerals, the altered Aldridge rocks, or the Purcell sills.

**ACKNOWLEDGMENTS**

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**REFERENCES**


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