artinite\[110\]MgO, [001]artinite\[001\]MgO = 22° and [110]artinite\[110\]MgO = 13°.

REFERENCE

DE WOLFF, P. M. (1952) The crystal structure of artinite, Mg$_2$(OH)$_2$CO$_3$·3H$_2$O. Acta Crystallogr. 5, 286-287.

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SCANDIUM-RICH MINERALS FROM RHYOLITE IN THE THOMAS RANGE, UTAH

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ABSTRACT

Scandium is present in the range 0.1 to 0.7 weight percent Sc$_2$O$_3$ in late-stage minerals, including pseudobrookite, bixbyite, spessartite, hematite and beryl, in the lithophysae of the rhyolite flows of the Thomas Mountains, Utah. The Sc$^{3+}$ ion substitutes for Fe$^{3+}$ and Al in these minerals. Scandium also is enriched in bixbyite from volcanic rocks in Argentina, but is present only in a few ppm in bixbyite from metamorphosed sedimentary manganese deposits.

The literature on the topaz, pseudobrookite, bixbyite, beryl, garnet and other minerals present in the lithophysae of the rhyolite flows of the Thomas Range, Utah, has been summarized by Staatz and Carr (1964). Analyses by neutron activation techniques reveal that some of these minerals contain exceptionally large amounts of scandium, extending to over 0.5 percent Sc$_2$O$_3$ (Table 1).

Sc is a dispersed element usually present in amounts up to a few hundred ppm in solid solution in its various host minerals. Only a very few of the over 1500 analyses of minerals containing Sc as a vicarious constituent, tabulated in large part by Vlasov (1966), Borisenko (1963) and Phan (1963, 1967), report over 0.5 percent Sc$_2$O$_3$. Among them are a beryl with about 1.5 percent Sc$_2$O$_3$ (Oftedal, 1943), chevkinite with 4.14 percent Sc$_2$O$_3$ (Semenov, et al., 1966), and columbite and ilmenorutile with 6.1 and 0.78 percent Sc$_2$O$_3$ respectively (Phan, 1967).

The presence of Sc in substitution for Fe$^{3+}$ and Al in the various host minerals in the Thomas Range rhyolite is well substantiated on crystallochemical grounds. In the case of pseudobrookite, a complete solid solution has been shown by Ito (personal communication) to extend

between Fe$_2$TiO$_5$ and Sc$_2$TiO$_5$ in synthetic material. Bixbyite, α-(Mn, Fe)$_2$O$_3$, is isostructural with Sc$_2$O$_3$. In synthetic material, a considerable mutual solubility has been found between Sc$_2$O$_3$, Mn$_2$O$_3$ and Fe$_2$O$_3$ (Geller, et al., 1961; Komissarova, et al., 1966). The preferences of Sc$^{3+}$, Mn$^{3+}$, and Fe$^{3+}$ for the two nonequivalent cation sites in bixbyite, however, are not known. Sc also is high in the bixbyite from Argentina, which occurs in a silicic volcanic rock, but it is present only in very small amount in bixbyite from the metamorphosed sedimentary manganese ores of South Africa and India.

The substitution of Sc$^{3+}$ for Al appears in the beryl and spessartite, but is virtually nil in the topaz. Sc is a typical trace element in both beryl and garnet. Synthetic scandium analogues of both minerals are known, and establish that the Sc enters the 6-coordinated structural sites normally occupied by Al, Fe$^{3+}$ or other trivalent ions (Froendel, 1968). Nassau and Wood (1968) and Staatz and Carr (1964) report that the Thomas Range beryl contains relatively large amounts of Fe, Mn and certain other trace elements. The garnet usually is called spessartite, but

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**Table 1**

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Locality</th>
<th>Sc$_2$O$_3$ content in weight percent or ppm as noted$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pseudobrookite</td>
<td>Thomas Mtns.$^b$</td>
<td>0.74±0.006 (percent)</td>
</tr>
<tr>
<td>Spessartite</td>
<td>do.</td>
<td>0.55±0.003 do.</td>
</tr>
<tr>
<td>Beryl</td>
<td>do.</td>
<td>0.53±0.003 do.</td>
</tr>
<tr>
<td>Bixbyite</td>
<td>do.</td>
<td>0.38±0.003 do.</td>
</tr>
<tr>
<td>Hematite (specular)</td>
<td>do.</td>
<td>0.16±0.0015 do.</td>
</tr>
<tr>
<td>Topaz</td>
<td>do.</td>
<td>4.5±0.03 ppm</td>
</tr>
<tr>
<td>Rhyolite</td>
<td>do.</td>
<td>4.2±0.03 do.</td>
</tr>
<tr>
<td>Spessartite</td>
<td>Nathrop, Colorado</td>
<td>0.70±0.0045 (percent)</td>
</tr>
<tr>
<td>Bixbyite</td>
<td>Argentina</td>
<td>0.35±0.003 do.</td>
</tr>
<tr>
<td>Bixbyite (sitaparite)</td>
<td>India</td>
<td>1.9±0.17 (ppm)</td>
</tr>
<tr>
<td>Bixbyite (partridgeite)</td>
<td>South Africa</td>
<td>3.4±0.17 do.</td>
</tr>
</tbody>
</table>

$^a$ Plus or minus values represent one standard deviation determined from counting statistics only. The samples were irradiated at a thermal neutron flux of 1.8×10$^{12}$ n/cm$^2$-sec and several weeks were allowed for the decay of shortlived radioisotopes. Samples and standards were counted on a 45 cc Ge(Li) semiconductor detector coupled to a 4096 channel pulse height analyzer. The Sc content was calculated by comparing sample and standard photopeak counting rates from either the 0.89 Mev or 1.12 Mev gamma rays of 84 days Sc$^{46}$. The high Sc content of the pseudobrookite obviated a correction for the Sc$^{46}$ contribution from the fast neutron interaction with the Ti present. The analyses were made by the Activation Analysis Service of Gulf General Atomic, San Diego, California.

$^b$ All analyses were made on crystallized specimens from a single place not precisely located but believed to be on Topaz Mountain.
the data of Staatz and Carr (1964) indicate that it is about midway between spessartite and almandine in composition. The spessartite from Nathrop, Colorado, also occurs in rhyolite lithophysae and has been described by Cross (1886); it is near Sp 67 Al 33.

The gray rhyolite of the Thomas Range contains about 76 percent SiO₂ and 4.22 ppm Sc₂O₃. This Sc content is close to the average of 4.28 ppm reported by Norman and Haskin (1968) for 221 granites containing over 70 percent SiO₂, and to values reported for rhyolites of comparable composition by Frycklund and Fleischer (1963).

In the Thomas Range occurrence, it is evident that some Sc was flushed out during the consolidation of the rhyolite and was concentrated in crystallochemically favorable host minerals during the pneumatolytic stage. This is analogous to the well known concentration of Sc in particular host minerals, among them wolframite, cassiterite, micas, beryl and various yttrium and zirconium minerals, in the hypothermal veins, greisens and pegmatites derived from deeper seated granitic intrusives.

References


