Zirconolite CaZrTi\textsubscript{2}O\textsubscript{7}

Crystal Data: Monoclinic; hexagonal; orthorhombic; commonly metamict.  
Point Group:  
2/m; 2\text{\textprime}m; 2/m 2\text{\textprime}m 2/m.  
Crystals, typically prismatic, elongated along [001], to 5 cm; polytypes are commonly intergrown.  
Twinning: Polysynthetic.

Physical Properties: Cleavage: \{100\}, \{010\} in traces.  
Fracture: Irregular to conchoidal.  
Tenacity: Brittle.  
Hardness = 6.5  
D(meas.) = 4.017–4.237; 4.77–4.85  
D(calc.) = [4.38]  
Radioactive.

Optical Properties:  
Opaque, transparent in thin fragments.  
Color: Brown to black; yellowish or brownish in thin section.  
Streak: Brownish yellow to dark brown.  
Luster: Submetallic; adamantine to greasy.  
Optical Class: Isotropic.  
n = 2.06–2.17; 2.215 (“polymignyte”).

Cell Data:  
Space Group: C\textsubscript{2}/c or Cc (2M), with  
a = 12.431(1)  
b = 7.224(1)  
c = 11.483(3)  
\(\beta = 100.33(1)^\circ\)  
Z = 8, or  
Space Group: P3\textsubscript{1}21 (3T), with  
a = 7.287(2)  
c = 16.886(9)  
Z = 3, or  
Space Group: Acam (3O), with  
a = 10.148(4)  
b = 14.147(5)  
c = 7.278(3)  
Z = 8.

X-ray Powder Pattern: Afrikanda massif, Russia; after heating at 1000 °C for two hours; polytypes cannot be distinguished by powder X-ray methods.  
2.914 (10), 1.980 (9), 1.792 (9), 2.506 (4), 3.176 (3), 1.517 (1), 1.156 (1)

Chemistry:  

<table>
<thead>
<tr>
<th>Element</th>
<th>(1)</th>
<th>(2)</th>
<th>(1)</th>
<th>(2)</th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U\textsubscript{3}O\textsubscript{8}</td>
<td>1.53</td>
<td></td>
<td>UO\textsubscript{2}</td>
<td>1.4</td>
<td>MgO</td>
<td>0.45</td>
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<tr>
<td>Nb\textsubscript{2}O\textsubscript{5}</td>
<td>3.26</td>
<td>15.7</td>
<td>Al\textsubscript{2}O\textsubscript{3}</td>
<td>1.03</td>
<td>CaO</td>
<td>11.05</td>
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<tr>
<td>SiO\textsubscript{2}</td>
<td>2.05</td>
<td></td>
<td>RE\textsubscript{2}O\textsubscript{3}</td>
<td>6.22</td>
<td>Na\textsubscript{2}O</td>
<td>0.37</td>
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<td>TiO\textsubscript{2}</td>
<td>31.69</td>
<td>22.7</td>
<td>Fe\textsubscript{2}O\textsubscript{3}</td>
<td>5.49</td>
<td>Na\textsubscript{2}O</td>
<td>0.37</td>
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<tr>
<td>ZrO\textsubscript{2}</td>
<td>32.84</td>
<td>34.8</td>
<td>FeO</td>
<td>2.28</td>
<td>H\textsubscript{2}O</td>
<td>3.35</td>
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<tr>
<td>ThO\textsubscript{2}</td>
<td>0.58</td>
<td>4.1</td>
<td>MnO</td>
<td>0.06</td>
<td>Total</td>
<td>99.97</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>99.9</td>
</tr>
</tbody>
</table>

(1) Afrikanda massif, Russia; LOI taken as H\textsubscript{2}O, corresponds to \((\text{Ca}_{0.76}\text{Ce}_{0.15}\text{Na}_{0.04}\text{U}_{0.02}\text{Th}_{0.01})_{\Sigma=0.89}\text{Zr}_{1.03}\text{(Ti\textsubscript{1.53}Fe\textsubscript{0.27}Nb\textsubscript{0.09}Al\textsubscript{0.08}Mg\textsubscript{0.04})}_{\Sigma=2.01}O\textsubscript{7}\).  
(2) Kaiserstuhl, Germany; by electron microprobe, corresponding to \((\text{Ca}_{0.85}\text{Th}_{0.06}\text{U}_{0.02}\text{RE}_{0.02})_{\Sigma=0.95}\text{Zr}_{1.08}\text{(Ti\textsubscript{1.08}Nb}_{0.45}F\textsubscript{3+}Fe\textsubscript{2+}_{0.25}Fe\textsubscript{2+}_{0.12}Mn_{0.01})_{\Sigma=1.91}O\textsubscript{7}\).

Polymorphism & Series: Polytypoids 2M, 3T, 3O are known.

Occurrence: In alkaline rocks, as carbonatites, kimberlites, syenites, sanidinites; more rarely in ultramafic rocks; in felsic pegmatite in gabbro; a detrital mineral.

Association: Apatite, clinohumite, phlogopite, richterite, pyrochlore, baddeleyite, perovskite, titanite, pyrrhotite, calcite.

Distribution: In the Afrikanda pyroxenite massif, Kola Peninsula, Russia. At Fredriksvärn, and Agnes Sandefjord, Vestfold, Norway. In the Kaiserstuhl carbonatite, Baden-Württemberg, Germany. From Monte di Procida, Campi Flegrei, Campania, Italy. In the Laouni intrusive, 250 km south of Tamanrasset, Algeria. In Sri Lanka, from Walaweduwa; in the Alupola stream, Bambabarabotuwa district; and elsewhere in Sabaragamuwa Province. In some basalt samples from the Moon.

Name: As a ZIRCONium-bearing mineral.

Type Material: A.E. Fersman Mineralogical Museum, Academy of Sciences, Moscow, Russia, 59249–59251, vis6008, vis6012, vis6018.

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