STEACYTE, A NEW NAME, AND A RE-EVALUATION OF THE NOMENCLATURE OF “EKANITE”-GROUP MINERALS

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ABSTRACT

Ekanite from the type locality (Sri Lanka), ThCa$$_{1-x}$$Si$_3$O$_{26}$, is metamict and gives only a very poor Debye-Scherrer diagram; heated Sri Lanka ekanite is body-centred tetragonal, with $a$ 7.46, $c$ 14.96 Å. Natural ekanite from the Tombstone Mountains, Yukon Territory (Szymanski et al. 1982) has the same chemical composition and gives a powder pattern that matches that of heated ekanite from Sri Lanka. The crystal structure of ekanite is characterized by Si$_3$O$_6$ sheets, space group I422, $a$ 7.483(3), $c$ 14.893(6) Å. Steacyite corresponds to Th(Na,Ca)$_2$(K$_{1-x}$,$\square$)$_x$Si$_8$O$_{20}$, $z$ = 0.39, described by Perrault & Richard (1973) under the name “ekanite”. The crystal structure of steacyite is characterized by discrete pseudocubic arrangements of Si$_8$O$_{20}$, space group P4/mcc, $a$ 7.58(1), $c$ 14.77(2) Å, $Z$=2. Powder diagrams of ekanite and steacyite show significant differences. A Th–Ca–K silicate from central Asia was described by Ginzburg et al. (1965) under the name “ekanite”; it corresponds to Th(Ca,Na)$_2$(K$_{1-x}$,$\square$)$_x$Si$_8$O$_{20}$, with $z$ between 0.23 and 0.40. Space group, cell dimensions and powder pattern are essentially identical to those of steacyite; this mineral should receive a name other than ekanite. These two minerals may define a continuous series. The name honors H.R. Steacy of the Geological Survey of Canada. Iraqite (Livingstone et al. 1976) gives a powder pattern identical to that of steacyite and is presumed isostructural. It corresponds to (RE, Th)Ca$_2$(K$_{1-x}$,$\square$)$_x$Si$_8$O$_{20}$, with $z$ = 0.47.

Keywords: new mineral name, steacyite, Ca-Na “ekanite”, Saint-Hilaire, “kanaekanite”, iraqite, mineral series steacyite – Na,Ca “ekanite”.

INTRODUCTION

The name ekanite was originally given by Anderson et al. (1961) to a metamict mineral corresponding to ThCa$_2$Si$_8$O$_{20}$. In recent mineralogical literature (Ginzburg et al. 1965, Mokeyeva & Golovastikov 1966, Perrault & Richard 1973, Richard & Perrault 1972), the name has been applied to Th(Ca,Na)$_2$(K$_{1-x}$,$\square$)$_x$Si$_8$O$_{20}$ and to Th(Na,Ca)$_2$(K$_{1-x}$,$\square$)$_x$Si$_8$O$_{20}$. Furthermore, the new name kanaekanite has been used by Povarennykh (1966) and Povarennykh et al. 1982) a la même composition chimique et donne un diagramme de poudre identique à celui de l’ékanite chauffée du Sri Lanka. La structure cristalline de l’ékanite est caractérisée par des feuillets Si$_3$O$_6$; groupe d’espace I422, $a$ 7.483(3), $c$ 14.893(6) Å. La steacyite correspond à Th(Na, Ca)$_2$(K$_{1-x}$,$\square$)$_x$Si$_8$O$_{20}$, $z$ = 0.39; le minéral avait d’abord été décrit par Perrault & Richard (1973) sous le nom d’ékanite. La steacyite est caractérisée par des groupes distincts Si$_8$O$_{20}$, groupe d’espace P4/mcc, $a$ 7.58(1), $c$ 14.77(2) Å, et $Z$=2. Les diagrammes Debye-Scherrer de l’ékanite et de la steacyite montrent des différences. Un silicate de Th–Ca–K a été décrit par Ginzburg et al. (1965) sous le nom d’ékanite. On le trouve en Asie centrale. Ce silicate correspond à un Th(Ca,Na)$_2$(K$_{1-x}$,$\square$)$_x$Si$_8$O$_{20}$, avec $z$ entre 0.23 et 0.40. Le groupe d’espace, les dimensions de la maille cristalline et le diagramme de poudre sont identiques à ceux de la steacyite. Ce minéral devrait être désigné sous un autre nom que celui d’ékanite. Ces deux minéraux définiraient une série continue. Le nom honore H.R. Steacy de la Commission géologique du Canada. L’iraqite (Livingstone et al. 1976) donne un diagramme de poudre identique à celui de la steacyite; on les présume isostructuraux. L’iraqite correspond à (TR, Th)Ca$_2$(K$_{1-x}$,$\square$)$_x$Si$_8$O$_{20}$ avec $z$ = 0.47.


SOMMAIRE

L’ékanite du lieu d’origine (Sri Lanka), ThCa$_2$Si$_8$O$_{20}$, est métamict et donne un diagramme Debye-Scherrer de mauvaise qualité; l’ékanite chauffée du Sri Lanka est quadratique à maille centrée. $a$ 7.46, $c$ 14.96 Å. L’ékanite naturelle du mont Tombstone (territoire du Yukon) (Szymanski et al. 1982) a la même composition chimique et
& Dusmatov (1970) to designate Th(Na,Ca)$_2$(K$_{1-z}$)$_2$Si$_8$O$_{20}$. The structure of nonmetamict ekanite of composition ThCa$_2$Si$_8$O$_{20}$ has recently been solved by Szymański (1981). It is now quite clear, particularly in the light of the crystal-structure work (Szymański 1981, Szymański et al. 1982, Mokeyeva & Golovastikov 1966, Richard & Perrault 1972) that the above constitute one distinct mineral species (ekanite), and one distinct mineral series between stea-cyte, Th(Na,Ca)$_2$(K$_{1-z}$)$_2$Si$_8$O$_{20}$ and another species (as yet unnamed), Th(Ca,Na)$_2$(K$'$,K$''$)$_2$Si$_8$O$_{20}$.

**ORIGINAL EKANITE AND TOMBSTONE MOUNTAINS EKANITE**

Ekanite is the name proposed by Anderson et al. (1961) to designate the green, transparent to translucent mineral from Sri Lanka; chemical composition of this material is given in Table 1, column 2, and the chemical formula is given in Table 2, column 2. Essentially, this material is ThCa$_2$Si$_8$O$_{20}$.

Anderson et al. (1961) recognized that their natural ekanite was completely metamict and did not give an X-ray-diffraction pattern. However, Dr. R.J. Davis (unpubl. data) obtained a powder pattern on heating the ekanite above 650°C; it is reproduced in Table 3, column 2 (E.J. Fejer, pers. comm., 1980). Anderson et al. (1961) concluded that heated ekanite had a body-centred tetragonal cell with $a=7.46$, $c=14.96$ Å.

Szymański et al. (1982) reported on a mineral from the Tombstone Mountains, Yukon Territory, that corresponds to ThCa$_2$Si$_8$O$_{20}$. Their microprobe analysis failed to reveal the presence of any K or Na. Difficulties in analyzing this material with the electron microprobe led them to prefer the theoretical composition ThCa$_2$Si$_8$O$_{20}$ to the measurements obtained with the microprobe; the microprobe measurements gave a structural formula close to the theoretical composition. This mineral is crystalline, non-metamict ekanite. Ekanite from the Tombstone Mountains has space group $I4_2$ with $a=7.46$, $c=14.96$ Å.

Table 1. Chemical Composition of Ekanite, An Unnamed Th-Ca-K Silicate, Steacyite and Iraquite.

<table>
<thead>
<tr>
<th>Ekanite</th>
<th>Unnamed</th>
<th>Steacyite</th>
<th>Iraquite</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) (2)</td>
<td>(3) (4)</td>
<td>(5) (6)</td>
<td>(7)</td>
</tr>
<tr>
<td>SiO$_2$</td>
<td>56.10%</td>
<td>55.65%</td>
<td>54.80%</td>
</tr>
<tr>
<td>Al$_2$O$_3$</td>
<td>7.01%</td>
<td>6.79%</td>
<td>6.29%</td>
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<tr>
<td>ThO$_2$</td>
<td>30.81%</td>
<td>27.6%</td>
<td>23.74%</td>
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<tr>
<td>UO$_2$</td>
<td>2.1%</td>
<td>1.46%</td>
<td>1.46%</td>
</tr>
<tr>
<td>Fe$_2$O$_3$</td>
<td>0.5%</td>
<td>0.57%</td>
<td>0.10%</td>
</tr>
<tr>
<td>MgO</td>
<td>0.8%</td>
<td>0.36%</td>
<td>0.07%</td>
</tr>
<tr>
<td>RE$_2$O$_3$</td>
<td>1.59%</td>
<td>0.17%</td>
<td>0.35%</td>
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<tr>
<td>ZrO$_2$</td>
<td>0.14%</td>
<td>0.17%</td>
<td>0.35%</td>
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<td>CaO</td>
<td>13.29%</td>
<td>13.7%</td>
<td>10.44%</td>
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<td>0.22%</td>
<td>0.02%</td>
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<td>SrO</td>
<td>0.03%</td>
<td>0.02%</td>
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<td>MgO</td>
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<td>FeO</td>
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<td>K$_2$O</td>
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<tr>
<td>F</td>
<td>0.26%</td>
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</table>

(1) Theoretical ThCa$_2$Si$_8$O$_{20}$, Tombstone Mountains material is very close to this. Szymański et al. (1982).
(2) SiO$_2$.
(3) Central Asia: specimen 65185 of Ginzburg et al. (1965).
(4) Central Asia: specimen 65630 of Ginzburg et al. (1965).
(5) Central Asia: specimen 65186 of Ginzburg et al. (1965).
(6) St-Iliaite, Quebec, Canada: Perruchot & Richard (1973).
(7) J. T. Jagodny.

†There is a minor typographical error in this abstract: six lines from the bottom, SiO$_{20}$ should read SiO$_{20}$.

**Th-Ca-K Silicate and Th-Na-K Silicate**

A Th-Ca-K silicate (Ginzburg et al. 1965)
TABLE 3. DEBYE-SCHERRER PATTERNS FOR EKANITE, AN UNNAMED Th-Ca-K SILICATE, STEACYITE AND IRAQITE

<table>
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<th>Th-Ca-K silicate</th>
<th>STEACYITE</th>
<th>Th-Na-K silicate</th>
<th>IRAQITE</th>
<th>RE-Ca-K silicate</th>
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</table>

| a       | 7.483 (3)      | 7.46             | 7.58      | 7.58             | 7.61    | 7.61            |
| c       | 14.893 (6)     | 14.96            | 14.82     | 14.77            | 14.72   |                 |

(1) + (7): see Table 1. Powder patterns of (3), (4) and (5) are reportedly identical.
and Th–Na–K silicate (Perrault & Richard 1973) were originally described as ekanite. X-ray-diffraction and chemical data on these minerals are quite complete. The Th–Ca–K silicate corresponds to Th(Ca,Na)\(_2\)(K\(_{1-x}\)Na\(_x\))Si\(_2\)O\(_8\) (Table 1, columns 3 and 4; Table 2, columns 3 and 4). It is characterized by preponderance of Ca\(^{2+}\) in the B sites of the structure; in addition, K\(^+\) is prevalent in the C position although there are important vacancies (\(z\) in the range 0.23 to 0.40).

The Th–Na–K silicate corresponds to Th(Na, Ca)\(_2\)(K\(_{1-x}\)Na\(_x\))Si\(_2\)O\(_8\) (Table 1, columns 5 and 6; Table 2, columns 5 and 6). It is characterized by preponderance of Na\(^+\) in the B sites; in addition, K\(^+\) is prevalent in the C position although there are important vacancies (\(z\) in the range 0.20 to 0.30). This mineral has now been renamed steacyite. The space group for both minerals is identical, as are Debye-Scherrer diagrams; cell-size variations are within the estimated standard deviation. These data are \(P4/mnc\), \(a\) 7.58(1), \(c\) 14.77(2) Å, \(Z=2\).

**Crystal Structures**

The crystal structures of ekanite from the Tombstone Mountains and that of steacyite are illustrated in the following paper (Figs. 2 and 4, Szymański et al. 1982). The two structures differ in two important features: 1) the manner of arrangement of SiO\(_4\) tetrahedra: the ekanite from the Tombstone Mountains shows a puckered sheet arrangement of SiO\(_4\) tetrahedra of composition Si\(_2\)O\(_8\) (Fig. 2 in Szymański et al. 1982), whereas steacyite from Saint-Hilaire shows independent discrete SiO\(_2\) units (pseudocubic arrangement of tetrahedra: Fig. 2 in Richard & Perrault 1972, Fig. 4 in Szymański et al. 1982). 2) the potassium site; the potential potassium site in the ekanite from the Tombstone Mountains is completely vacant, whereas in the Saint-Hilaire steacyite, it is more than 50\% occupied.

These two differences are obviously linked: the presence of K\(^+\) at (0,0,\(\frac{1}{2}\)) in steacyite annuls any possibility of bridging bonds between adjacent SiO\(_2\) groups and favors the closure of Si–O bonds into a cubic arrangement of tetrahedra. The complete absence of K\(^+\) favors a sheet-like organization of SiO\(_2\) in ekanite. We consider that these major structural differences are justification for different mineral names.

**Iraqite**

The mineral *iraqite* (Livingstone et al. 1976), discovered in granites from northern Iraq, has a Debye-Scherrer pattern identical with those of Th–Ca–K silicate and steacyite. It has a space group \(P4/mcc\), \(a\) 7.61(1), \(c\) 14.77(2) Å, \(Z=2\). Rare-earth elements are preponderant in the A sites. Chemical composition and powder pattern are given in Tables 1, 2 and 3, column 7. Ca\(^{2+}\) is preponderant in the B sites and K\(^+\) is prevalent in the C position, although there are important vacancies (\(z=0.47\)).

**Total Valence Charges**

Ekanite presents balanced valence charges when perfectly stoichiometric with 40 positive charges and 40 negative charges. Both Sri Lanka ekanite and Tombstone Mountains ekanite very nearly approach perfect stoichiometry (Table 2, col. 1 and 2).

There is no chemical formula with balanced valence charges and full occupancy of each atomic position by one single element for steacyite; ThNa\(_2\)KSi\(_2\)O\(_8\) yields 39\% and 40\%. Partial occupancy of the C sites and substitution of Na\(^+\) by Ca\(^{2+}\) in the B sites are necessary for valence charge-balance. In the Saint-Hilaire steacyite, occupancies are 0.92 for A, 1.85 for B and 0.61 for C (Table 2, col. 6); Na\(^+\) is prevalent in the B sites (0.90) but Ca\(^{2+}\) is important (0.73). In the central Asia steacyite, occupancies are 1.04 for A, 2.03 for B and 0.80 for C; Na\(^+\) just slightly exceeds Ca\(^{2+}\) (1.05 versus 0.98; Table 2, col. 5).

Similarly, there is no chemical formula with balanced valence charges and full occupancy of each atomic position by one single element for the Th–Ca–K silicate from central Asia; ThCa\(_2\)KSi\(_2\)O\(_8\) yields 41\% and 40\%. Partial occupancy of the C sites and substitution of Ca\(^{2+}\) by Na\(^+\) in the B sites are necessary for valence charge-balance. Principal compensation for the more calcic members would seem to come predominantly through partial occupancy of C (0.60 in the central Asia material, Table 2, col. 3).

Charge balance is attained in ThCaNaKSi\(_2\)O\(_8\). This formula requires strict equality between Ca\(^{2+}\) and Na\(^+\) and full occupancy of all sites. Crystal-structure analysis does not support this formula; Ca\(^{3+}\) and Na\(^+\) occupy the same sites, and partial occupancies, especially in the K position, are more general than exceptional.

**Name**

The name *steacyite* honors Mr. Harold R. Steacy, curator of the National Mineral Col-
lection housed at the Geological Survey of Canada, in recognition of his life-long studies of Canadian radioactive minerals and their occurrences. Type material has been deposited with the Collection principale de l'École polytechnique de Montréal (E.P. 12480) and co-type material, with the National Mineral Collection at the Geological Survey of Canada (61529).

NOMENCLATURE

The name *steacyite* as defined in this text has been approved by the IMA Commission on New Minerals and Mineral Names. Usage of the name *kanaekanite* should be discouraged; it implicitly relates *steacyite* and the other Th–Ca–K silicate, as yet unnamed, to ekanite. Structural analysis shows this to be incorrect. A new name should be proposed for the Th–Ca–K silicate from central Asia: we would certainly favor the usage of the name *steacyite* with a suitable chemical prefix.

REFERENCES


Szymański, I.T. (1981): The crystal structure of ekanite, ThCa₆Si₈O₂₅. *Acta Cryst.* A37, C-189 (abstr.).


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