

REDEFINITION OF ZIRCOPHYLLITE, IDEALLY $K_2NaMn_7Zr_2(Si_4O_{12})_2O_2(OH)_4F$, A KUPLETSKITE-GROUP MINERAL OF THE ASTROPHYLLITE SUPERGROUP (IN ACCORD WITH IMA 15-B) AS AN ASTROPHYLLITE-GROUP MINERAL, IDEALLY $K_2NaFe^{2+}_7Zr_2(Si_4O_{12})_2O_2(OH)_4F$ (IMA 17-D)

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ABSTRACT

Zircophyllite is redefined as an astrophyllite-group mineral, ideally $K_2NaFe^{2+}_7Zr_2(Si_4O_{12})_2O_2(OH)_4F$ (Fe^{2+} -dominant at C_7) (IMA 17-D). Zircophyllite was previously considered to be a kupletskite-group mineral of the astrophyllite supergroup (Mn^{2+} -dominant at C_7), with ideal formula $K_2NaMn_7Zr_2(Si_4O_{12})_2O_2(OH)_4F$ (IMA 15-B). The latter formula is not in agreement with that reported in the original description of zircophyllite.

LETTER

Kapustin (1972, 1973) described zircophyllite from the Korgeredabin massif, Tuva, Russia. He called zircophyllite a “zirconium analogue of astrophyllite” and wrote its empirical formula as follows: $(K_{1.70}Na_{0.71}Ca_{0.24}Mn_{0.35})_{\Sigma 3}(Fe^{2+}_{3.57}Mn_{3.43})_{\Sigma 7}(Zr_{1.58}Nb_{0.25}Ti_{0.17})_{\Sigma 2}(Si_{7.76}Ti_{0.24})_{\Sigma 8}[O_{26.84}(OH)_{3.26}F_{0.90}]_{\Sigma 31}(H_2O)_{0.9}$, where the composition of the O sheet is $C_7 = (Fe^{2+}_{3.57}Mn_{3.43})_{\Sigma 7}$, *i.e.*, $Fe^{2+} > Mn$ and Fe^{2+} is the dominant cation in the O sheet (Table 1). However, inspection of the empirical formula of Kapustin (1972, 1973) shows that total Mn is dominant over Fe^{2+} : $Mn = 3.43$ (C-group) + 0.35 (B site) = 3.78 *apfu* > 3.57 Fe^{2+} *apfu* (atoms per formula unit). Because in the empirical formula of Kapustin (1972, 1973) $Mn > Fe^{2+}$, Sokolova (2012) and then Sokolova, Cámara, Hawthorne, and Ciriotti, authors

of the proposal [IMA 15-B] (30.06.2015), placed zircophyllite in the kupletskite group.

Further chemical and structure work on zircophyllite (Sokolova & Hawthorne 2016) made us rethink the position of zircophyllite in the kupletskite group. First, based on the empirical formula of Kapustin (1972, 1973), 3.78 Mn + 3.57 Fe^{2+} = 7.35 *apfu*, whereas the cations of the C-group must sum to ≤ 7 *apfu*. This tells us that the analysis in question was probably done on zoned crystals. Second, Kapustin (1972, 1973) defined zircophyllite as a “zirconium analogue of astrophyllite” and wrote the composition of the O sheet as $(Fe^{2+}_{3.57}Mn_{3.43})_{\Sigma 7}$, where $Fe^{2+} > Mn$ and Fe^{2+} is the dominant cation in the O sheet and of the C-group. We think that Kapustin (1972, 1973) described zircophyllite based on highly zoned and heavily twinned crystals that were probably a mixture of several phases. In Table 1 we present a chemical analysis of zircophyllite from

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TABLE 1. CHEMICAL COMPOSITION AND UNIT FORMULA FOR ZIRCOPHYLLITE (AFTER SOKOLOVA & HAWTHORNE 2016)

| Constituent | wt.% | | apfu | | |
|--------------------------------|------------------------|------------------------------|------------------------|------------------------------|-------------|
| | This work ¹ | Kapustin (1972) ² | This work ¹ | Kapustin (1972) ² | |
| Nb ₂ O ₅ | 2.07 | 2.30 | Si | 7.54 | 7.76 |
| ZrO ₂ | 8.65 | 13.61 | Al | 0.43 | 0 |
| TiO ₂ | 4.48 | 2.30 | Ti | <u>0</u> | <u>0.24</u> |
| SiO ₂ | 31.89 | 32.64 | ΣT | 7.97 | 8.00 |
| Al ₂ O ₃ | 1.54 | n.d. | | | |
| SrO | 0.10 | n.d. | Fe ²⁺ | 3.48 | 3.57 |
| ZnO | 0.48 | 0.23 | Mn | 3.44 | 3.43 |
| FeO | 17.60 | 18.06 | Zn | 0.08 | 0 |
| MnO | 17.19 | 18.83 | Mg | <u>0.08</u> | <u>0</u> |
| CaO | 0.62 | 0.94 | ΣM | 7.09 | 7.00 |
| MgO | 0.22 | n.d. | | | |
| Rb ₂ O | 0.19 | n.d. | Zr | 1.00 | 1.58 |
| Cs ₂ O | 0.10 | 0.93 | Ti | 0.80 | 0.17 |
| K ₂ O | 6.13 | 5.61 | Nb | <u>0.22</u> | <u>0.25</u> |
| Na ₂ O | 1.91 | 1.55 | ΣD | 2.02 | 2.00 |
| H ₂ O | 2.53* | 3.20 | | | |
| F | 1.36 | 1.20 | Na | 0.83 | 0.71 |
| F=O | <u>-0.57</u> | <u>-0.49</u> | Ca | 0.16 | 0.24 |
| Total | 96.48 | 99.75 | Sr | 0.01 | 0 |
| | | | Mn | <u>0</u> | 0.35 |
| | | | ΣB | 1.00 | 1.30 |
| | | | K | 1.85 | 1.70 |
| | | | Rb | 0.03 | 0 |
| | | | Cs | 0.01 | 0 |
| | | | Na | <u>0.05</u> | <u>0</u> |
| | | | ΣA | 1.94 | 1.70 |
| | | | ΣA+B | 2.94 | 3.00 |
| | | | | | |
| | | | F | 1.02 | 0.90 |
| | | | OH | 3.98 | 3.26 |
| | | | H ₂ O | 0 | 0.90 |

¹Locality: Mont Saint-Hilaire, Québec, Canada; formula unit calculated on 31 (O + F) *pfu*.

²Locality: Korgeredabin massif, Tuva, Russia; formula unit taken from Kapustin (1972).

n.d. = not detected;

*Calculated from crystal-structure analysis.

Mont Saint-Hilaire, Canada (Sokolova & Hawthorne 2016), and compare it with that of Kapustin (1972, 1973). Based on this comparison we decided that the description of zircophyllite by Kapustin (1972, 1973) as an astrophyllite group mineral was accurate, despite the empirical formula presented in that work, and we therefore placed zircophyllite in the astrophyllite group (Sokolova *et al.* 2017). We submitted the proposal 17-D “Redefinition of zircophyllite, ideally $K_2NaMn_7Zr_2(Si_4O_{12})_2O_2(OH)_4F$, a kupletskite-group mineral of the astrophyllite supergroup (in accord with IMA 15-B) as an astrophyllite-group mineral, ideally $K_2NaFe^{2+}_7Zr_2(Si_4O_{12})_2O_2(OH)_4F$ ” to the CNMNC-IMA. This proposal was accepted,

and zircophyllite has been redefined as an astrophyllite-group mineral, ideally $K_2NaFe^{2+}_7Zr_2(Si_4O_{12})_2O_2(OH)_4F$ (Fe²⁺-dominant at C₇).

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