Mangani-pargasite, NaCa$_2$(Mg$_4$Mn^{3+})(Si$_6$Al$_2$)O$_{22}$(OH)$_2$, a new mineral species of the amphibole supergroup

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ABSTRACT

Mangani-pargasite, ideally NaCa$_2$(Mg$_4$Mn^{3+})(Si$_6$Al$_2$)O$_{22}$(OH)$_2$, is a new mineral species of the calcium amphibole subgroup of the amphibole supergroup. The type specimen was found on the mine dump of the Långban Fe-Mn-(Ba-As-Pb-Sb) deposit in Värmland, Sweden. Crystal chemical analyses resulted in the empirical chemical formula: ^{A}(Na$_{0.90}$Pb$_{0.07}$K$_{0.03}$)$_{\Sigma1.00}$^{B}(Ca$_{1.93}$Mn$^{2+}_{0.07}$)$_{\Sigma2.00}$^{C}(Mg$_{4.25}$Mn$^{3+}_{0.39}$Al$_{0.26}$Fe$^{3+}_{0.10}$)$_{\Sigma5.00}$^{T}(Si$_{6.35}$Al$_{1.65}$)$_{\Sigma8.00}$O$_{22}$^{W}(OH)$_2$.

In order to complete the description of this newly approved (IMA 2018-151) mineral we report here additional data to those published in papers by Jonsson and Hålenius (2010) and Hålenius and Bosi (2012). Mangani-pargasite is biaxial positive, with α=1.635(5), β=1.645(5), γ=1.660(5) and the measured optic angle 2V is 85(5)°. The dispersion is weak (*r*>*v*), and the optic orientation is: *Y*||*b*; *Z*^*c*=25(3)°. Mangani-pargasite is red to brownish red with weak pleochroism; X=pale reddish brown, Y=pale reddish brown and Z=pale brownish red; X≈Y>Z.

The unit-cell parameters are a=9.9448(5), *b*=18.0171(9), *c*=5.2829(3) Å, β=105.445(3)°, *V*=912.39(9) Å^3, *Z*=2, space group *C*2/*m*. The ten strongest reflections in the X-ray powder diffraction pattern [*d*-values in Å, I, (*h k l*)] are: 8.420, 29, (110); 3.368, 17, (131), 3.279, 49, (240); 3.141, 100, (310); 2.817, 44, (33 0); 2.698, 21, (151); 2.389, 18, (350); 1.904, 29, (510); 1.650, 22, (461) and 1.448, 46, (661).

Keywords: Mangani-pargasite; amphibole; Långban; Sweden.

INTRODUCTION

An unusual brownish purple amphibole enriched in Al, Fe and Mn from the Långban Fe-Mn-(Ba-As-Pb-Sb) deposit in Värmland, Sweden was described by Magnusson (1930) under the name "tibergite". A subsequent study of this amphibole was carried out by Sundius (1946), who concluded that it was a not a valid mineral species but a variety of pargasite. Wet chemical, optical and X-ray powder diffraction data for a Mn-rich pargasite from Långban, which also contained Pb, were published by Gillberg (1959), who suggested that it was probably comparable to "tibergite". Results of crystal structure refinements, chemical analyses and spectroscopic studies on a red coloured Mn-rich pargasite from Långban, Sweden, were presented by Jonsson and Hålenius (2010) and Hålenius and Bosi (2012). Their pargasite sample also contained Pb and is most likely comparable with the amphibole partly characterized by Gillberg (1959).

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After the approval of a new classification and nomenclature scheme for the amphibole supergroup (Hawthorne et al., 2012), which assigns root names to ^{C}(MgAl) compositions and prefixes related to the dominant C cations different fom Mg and Al, it became evident that this Mn-rich paragasite is indeed a new valid mineral species; a fact that was pointed out by Cametti et al. (2018) in their description of the new amphibole vanadio-pargasite. In order to complete the description of the Mn-rich pargasite from Långban we collected additional data on its physical and optical properties and submitted a proposal to the IMA-CNMNC for the new mineral mangani-pargasite, $NaCa_2(Mg_4Mn^{3+})(Si_6Al_2)O_{22}(OH)_2$, in which Mn^{3+} is dominant among the trivalent C cations. This proposal (IMA 2018-151) was approved by the Commission in early 2019 (Miywaki et al., 2019). The holotype specimen of mangani-pargasite is deposited in the mineral collections of the Swedish Museum of Natural History under collection number NRM20100001.

OCCURRENCE, PHYSICAL AND OPTICAL PROPERTIES

The mangani-pargasite type specimen was collected from the mine dump of the Långban Fe-Mn-(Ba-As-Pb-Sb) deposit, in the Filipstad district, Värmland, Bergslagen ore province, Sweden (59.86°N, 14.26°E). The Palaeoproterozoic Långban-type deposits were originally deposited as chemical precipitates from volcanogenic hydrothermal solutions in a shallow submarine environment (Boström et al., 1979).

The host-rock of mangani-paragasite primarily consists of a moderately hausmannite impregnated, silicate-bearing carbonate rock; essentially a low-grade manganese ore. The assemblage is dominated by calcite, hausmannite and manganoan phlogopite. Corroded grains of Mn-bearing forsterite (c. $Fo_{88}Te_{12}$), often with abundant inclusions of braunite, occur dispersed throughout the sample. As-bearing apatite, kentrolite and hedyphane occur as minor components.

The carbonate groundmass, dominated by granoblastic calcite, most likely represents a primary Mn- and Si-bearing carbonate assemblage that was extensively recrystallized during regional metamorphism at c. 1.87-1.80 Ga.

The mostly subhedral mangani-pargasite individuals, sized up to c. 1 mm, poikilitically overgrow abundant euhedral to subhedral hausmannite crystals (Figure 1), demonstrating that the amphibole formed after the Mn-oxide. The amphibole is red to reddish brown in colour and it is transparent with a vitreous luster. It shows a perfect cleavage along {110}. The Mohs' hardness is in analogy with pargasite in the range 5-6. Its density could not be measured due to frequent intergrowths as well as inclusions of small grains of other minerals. The calculated density is 3.127 g·cm^{-3}.

The mineral is biaxial positive. Measured refractive indices using white light are α=1.635(5), β=1.645(5), γ=1.660(5). The measured 2V=85(5)° and the calculated 2V is 79.1°. The dispersion is weak ($r>v$), and the optic orientation is: $Y||b$, $Z^\wedge c$=25(3)°. In thin section the mineral is pale brownish red and it exhibits weak pleochroism; X=pale reddish brown, Y=pale reddish brown and Z=pale brownish red; $X≈Y>Z$. These optical properties are very close to those reported by Gillberg (1959) for a Mn-bearing pargasite from Långban.

OPTICAL ABSORPTION AND INFRARED SPECTROSCOPY

Optical absorption spectra of mangani-pargasite were obtained on polished self-supporting single crystal absorbers with a thickness of 130 μm, as determined by a digital micrometer, at ambient conditions in the spectral range 30000-10000 cm^{-1} (333-1000 nm) using an AVASPEC-ULS2048X16 spectrometer connected via a 400 μm UV fibre cable to a Zeiss Axiotron UV-microscope. A 75W Xenon arc lamp was used as a light source and Zeiss Ultrafluar 10x lenses served as objective and condenser. The spectra were obtained in polarized mode using a UV-quality Glan-Thompson prism with a working range from 40000 to 3704 cm^{-1} (250 to 2700 nm). The wavelength scale of the spectrometer was calibrated with Ho_2O_3-doped and Pr_2O_3/Nd_2O_3-doped reference materials (Hellma glass filters 666F1 and 666F7). Crystals were oriented on the basis of crystal morphology and optical indicators (conoscopic observations of interference figures). In order to avoid micro-fractures and microscopic oxide inclusions, the probed amphibole
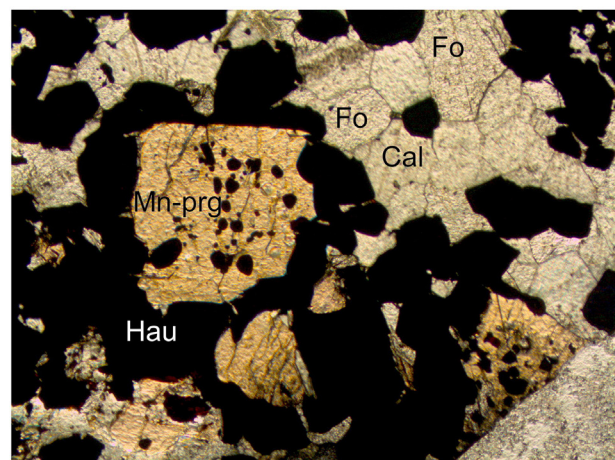

Figure 1. Photomicrograph of a thin section of the holotype specimen showing mangani-pargasite (Mn-prg) with numerous inclusions of hausmannite in a matrix of calcite (Cal), hausmannite (Hau) and forsterite (Fo). Transmitted, plane-polarized light. FOV=2.4 mm.

crystal areas were masked by using circular apertures with diameters in the range 50-80 μm.

The optical absorption spectra of mangani-pargasite (Figure 2) show an intense absorption region between 17000-25000 cm^{-1} and a broad absorption band of moderate intensity at c. 10500 cm^{-1}. Based on the composition of the mineral and the fact that Fe^{3+} and Mn^{2+} can only give rise to weak and narrow absorption bands caused by spin-forbidden electronic d-d transitions, it is evident that the absorption bands recorded in the spectra are due to d-d transitions in Mn^{3+}. Fitting of the recorded spectra show that the absorption feature between 17000-25000 cm^{-1} is caused by three absorption bands at c. 18600, 20500 and 22600 cm^{-1}. The recorded optical absorption spectra are similar to those recorded on manganian riebeckite ("juddite") from India (Ghose et al., 1986). The crystal field splitting parameter, 10Dq, for Mn^{3+} in mangani-pargasite is ~15300 cm^{-1}, which compares well with a value of ~14750 cm^{-1} reported for manganian riebeckite. The molar absorption coefficient, (e), for the strongest Mn^{3+}-band in the spectra of mangani-pargasite is ~40 l·mole^{-1}·cm^{-1}, which is very close to the value of ~35 l·mole^{-1}·cm^{-1} observed for the strongest Mn^{3+}-band in spectra of manganian riebeckite (Ghose et al., 1986).

Polarized FTIR spectra for mangani-pargasite were reported and discussed by Hålenius and Bosi (2012), who observed that spectra in the O-H stretching region are comparable to those reported for synthetic pargasite-dominant amphiboles along the richterite-pargasite join (Della Ventura et al., 1999).

CHEMICAL COMPOSITION

Table 1 summarises the results of electron microprobe analyses from Hålenius and Bosi (2012). It should be noted that direct water analyses were not performed due to frequent occurrence of inclusions of other solid phases (Figure 1). Infrared spectra, however, demonstrated the presence of (OH)-groups (for details, see Hålenius and Bosi, 2012). Fluorine and chlorine were also sought, but could not be detected at levels above their respective detection limits.

X-RAY POWDER AND SINGLE-CRYSTAL DIFFRACTION

Powder X-ray diffraction data were collected on a PANalytical X'Pert3 Powder diffractometer fitted with an X'celerator silicon-strip detector and operated at 40 mA and 45 kV (CuKa-radiation, λ=1.5406 Å). Peak positions were determined with the HighScore Plus 4.6 software and corrected against an external Si standard (NIST SRM640). Indexed d values and relative intensities are given in Table 2. Unit-cell parameters obtained by least-squares refinement (UnitCell by Holland and Redfern, 1997) of the powder diffraction data are as

Table 1. Chemical data (in wt%) for mangani-pargasite from Hålenius and Bosi (2012).

Constituent	Mean	Range	1s
SiO$_2$	44.26	43.71-44.92	0.55
TiO$_2$	0.01	0.00-0.12	0.05
Al$_2$O$_3$	11.21	10.11-11.43	0.12
*Mn$_2$O$_3$	3.56	3.41-3.85	0.16
**Fe$_2$O$_3$	0.89	0.79-0.98	0.07
MgO	19.88	19.51-20.24	0.26
CaO	12.54	12.34-12.70	0.22
PbO	1.73	1.68-1.78	0.05
Na$_2$O	3.33	3.21-3.43	0.08
K$_2$O	0.18	0.15-0.24	0.03
***H$_2$O$_{calc}$	2.09		
Total	99.68		
Cations on the basis of 46 negative charges			
Si	6.350		0.045
Ti	0.001		0.006
Al	1.896		0.020
Mn^{3+}	0.389		0.017
Fe^{3+}	0.096		0.008
Mg	4.252		0.055
Ca	1.928		0.034
Pb	0.067		0.006
Na	0.926		0.022
K	0.033		0.006

*Optical absorption spectra demonstrate presence of Mn^{3+}
** Iron is reported as ferric due to the presence of Mn^{3+} and redox potential arguments.
*** Calculated on the basis of 2 (OH) apfu

follows: a=9.9316(3); b=18.0149(5); c=5.2829(2) Å; $β$=105.428(4)°; V=911.14(4) Å^3 ; $C2/m$; Z=2.

Single-crystal X-ray diffraction measurements were reported by Hålenius and Bosi (2012). The main results can be summarized as follows. Mangani-pargasite is monoclinic, space group $C2/m$, a=9.9448(5), b=18.0171(9), c=5.2829(3) Å, β=105.445(2)°, V=912.39(8) Å^3; Z=2. The crystal structure was refined to R_I=2.64% using 2675 unique reflections collected with MoKa X-ray intensity data.

CRYSTAL CHEMISTRY AND EMPIRICAL FORMULAE OF MANGANI-PARGASITE

In accord with Bosi et al. (2019), two empirical formulae can be proposed for the studied amphibole: the structural formula, defined by the minimum set of

Table 2. Powder X-ray diffraction data (*d* in Å) for mangani-pargasite.

I_{obs}	d_{obs}	d_{cal}	*h*	*k*	*l*	I_{obs}	d_{obs}	d_{cal}	*h*	*k*	*l*
4	8.976	9.007	0	2	0	2	1.888	1.888	4	6	-1
29	**8.420**	**8.454**	**1**	**1**	**0**	2	1.874	1.875	5	3	-1
4	4.765	4.787	2	0	0	3	1.863	1.863	1	9	-1
5	4.498	4.504	0	4	0	9	1.824	1.824	5	3	0
3	4.221	4.227	2	2	0	2	1.802	1.801	0	10	0
17	**3.368**	**3.369**	**1**	**3**	**1**	2	1.699	1.698	0	10	1
49	**3.279**	**3.280**	**2**	**4**	**0**	3	1.687	1.687	2	8	-2
100	**3.141**	**3.142**	**3**	**1**	**0**	3	1.682	1.683	1	3	-3
3	3.029	3.020	2	4	-1	**22**	**1.650**	**1.649**	**4**	**6**	**1**
17	2.932	2.932	2	2	1	11	1.640	1.640	4	8	0
44	**2.817**	**2.818**	**3**	**3**	**0**	9	1.615	1.614	1	11	0
13	2.754	2.755	3	3	-1	16	1.596	1.596	6	0	0
21	**2.698**	**2.698**	**1**	**5**	**1**	4	1.577	1.577	1	5	-3
13	2.586	2.586	0	6	1	8	1.550	1.550	6	0	-2
7	2.545	2.546	2	0	-2	4	1.536	1.536	5	7	0
2	2.416	2.416	2	6	-1	3	1.514	1.514	2	6	-3
18	**2.389**	**2.389**	**3**	**5**	**0**	10	1.503	1.503	5	5	1
17	2.350	2.350	3	5	-1	5	1.467	1.466	6	4	-2
6	2.297	2.297	1	7	-1	3	1.463	1.462	1	5	3
2	2.252	2.252	3	3	1	2	1.457	1.457	3	11	0
17	2.152	2.157	2	6	1	**46**	**1.448**	**1.448**	**6**	**6**	**-1**
8	2.036	2.035	2	0	2	3	1.440	1.440	0	12	1
12	2.015	2.014	3	5	1	2	1.405	1.405	5	9	-1
10	2.003	2.003	3	7	0	3	1.402	1.401	6	2	1
3	1.960	1.959	1	9	0	9	1.364	1.364	7	1	0
29	**1.904**	**1.904**	**5**	**1**	**0**						

Note: the ten strongest reflections are in bold. Only peaks with $I_{rel} \geq 2$ are reported.
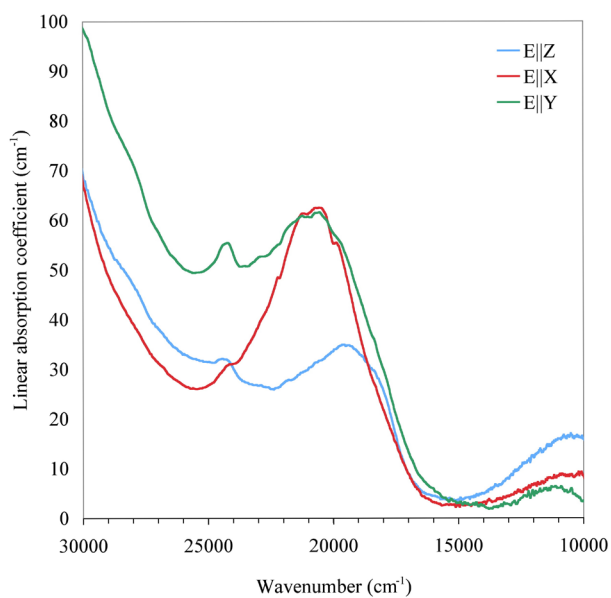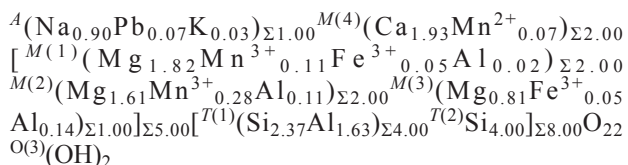

Figure 2. Polarized single crystal optical absorption spectra of mangani-pargasite showing strong absorption bands due to spin-allowed electronic *d-d* transitions in octahedrally coordinated Mn^{3+}.
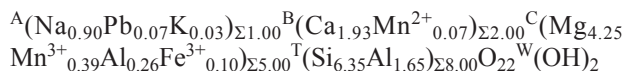
symmetrically distinct sites that constitute amphibole structural arrangement, and the chemical formula, defined by merging the chemical information about the $M(1)$-, $M(2)$- and $M(3)$-sites into the C letter (see below) and used for nomenclature purposes (Hawthorne et al., 2012).

Structural refinement, chemical and spectroscopic analysis of mangani-pargasite resulted in the empirical structural formula:

$$^A(Na_{0.90}Pb_{0.07}K_{0.03})_{\Sigma 1.00}{}^{M(4)}(Ca_{1.93}Mn^{2+}_{0.07})_{\Sigma 2.00}$$
$$[^{M(1)}(Mg_{1.82}Mn^{3+}_{0.11}Fe^{3+}_{0.05}Al_{0.02})_{\Sigma 2.00}$$
$$^{M(2)}(Mg_{1.61}Mn^{3+}_{0.28}Al_{0.11})_{\Sigma 2.00}{}^{M(3)}(Mg_{0.81}Fe^{3+}_{0.05}$$
$$Al_{0.14})_{\Sigma 1.00}]_{\Sigma 5.00}[^{T(1)}(Si_{2.37}Al_{1.63})_{\Sigma 4.00}{}^{T(2)}Si_{4.00}]_{\Sigma 8.00}O_{22}$$
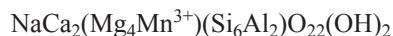$$^{O(3)}(OH)_2$$

A bond-valence analysis for mangani-pargasite is fully consistent with the proposed cation distributions (see Table 6 of Hålenius and Bosi, 2012). In particular, the bond valence sums (BVS) incident at $M(1)$-, $M(2)$- and $M(3)$-sites (2.15, 2.19 and 2.22 valence units, vu, respectively) are significantly larger than 2 vu, indicating the occurrence of trivalent cations at these octahedrally-coordinated sites. BVS at O(3) (1.06 vu) is also consistent with the presence of (OH), whereas the relative low BVS at O(4) (1.88 vu) is a characteristic of amphiboles (Hawthorne, 1983) and relates to local strain in the structure rather than the presence of the other anions at O(4). More details on the site populations can be found in Hålenius and Bosi (2012). Note that in Table 5 of Hålenius and Bosi (2012), 0.04 Mn^{3+} instead of the correct 0.05 Fe^{3+} was erroneously reported at the $M(3)$ site.

On the basis of the general chemical formula of amphibole, $AB_2C_5T_8O_{22}W_2$, and approved nomenclature (Hawthorne et al., 2012), the empirical chemical formula of the studied sample is:

$$^A(Na_{0.90}Pb_{0.07}K_{0.03})_{\Sigma 1.00}{}^B(Ca_{1.93}Mn^{2+}_{0.07})_{\Sigma 2.00}{}^C(Mg_{4.25}$$
$$Mn^{3+}_{0.39}Al_{0.26}Fe^{3+}_{0.10})_{\Sigma 5.00}{}^T(Si_{6.35}Al_{1.65})_{\Sigma 8.00}O_{22}{}^W(OH)_2$$

This leads to the ideal formula:

$$NaCa_2(Mg_4Mn^{3+})(Si_6Al_2)O_{22}(OH)_2$$

RELATION TO OTHER SPECIES

Mangani-pargasite is an analogue of pargasite, in which $^{VI}Al^{3+}$ is substituted by Mn^{3+}. It is also an analogue of vanadio-pargasite (Cametti et al., 2018), in which $^{VI}V^{3+}$ is substituted by Mn^{3+}; and chromio-pargasite (formerly ehimeite) in which $^{VI}Cr^{3+}$ is substituted by Mn^{3+}. Table 3 compares selected properties of these four minerals.

Mangani-pargasite belongs to the amphibole supergroup; (OH-F-Cl) group; Ca subgroup (Hawthorne et al., 2012). It fits the 9.DE.15 subdivision of the Nickel-Strunz classification (Strunz and Nickel, 2001). In the Dana classification (Gaines et al., 1997), mangani-pargasite belongs to type 66.1.3a.12.

REFERENCES

Anthony J.W., Bideaux R.A., Bladh K.W., Nichols M.C., 2001. Handbook of Mineralogy, Mineralogical Society of America, Chantilly, VA 20151-1110, USA. http://www.handbookofmineralogy.org/.

Bosi F., Biagioni C., Oberti R., 2019. On the chemical identification and classification of minerals. Minerals, 9, 591.

Boström K., Rydell H., Joensuu O., 1979. Långban - an exhalative sedimentary deposit? Economic Geology 74, 1002-1011.

Cametti G., Armbruster T., Reznitsky L.Z., Sklyarov E.V., Della Ventura G., 2018. Crystal structure and crystal-chemistry of vanadio-pargasite: a new amphibole from southern Lake Baikal, Siberia, Russia. European Journal of Mineralogy 30, 981-987.

Della Ventura G., Hawthorne F.C., Robert J.-L., Delbove F., Welch M.D., Raudsepp M., 1999. Short-range order of cations in synthetic amphiboles along the richterite-pargasite join. European Journal of Mineralogy 11, 79-94.

Gaines R.V., Skinner H.C., Foord E.E., Mason B., Rosenzweig A., 1997. Dana's New Mineralogy (8th Edition). John Wiley & Sons, New York, N.Y.

Gillberg M., 1959. A lead-bearing variety of pargasite from Långban, Sweden. Arkiv för Mineralogi och Geologi 2, 425-430.

Ghose S., Kersten M., Langer K., Rossi G., Ungaretti L., 1986. Crystal field spectra and Jahn Teller effect of Mn^{3+} in clinopyroxene and clinoamphiboles from India. Physics and Chemistry of Minerals 13, 291-305.

Hålenius U. and Bosi F., 2012. Cation ordering in Pb^{2+}-bearing, Mn^{3+}-rich pargasite from Långban, Sweden. American Mineralogist 97, 1635-1640.

Hawthorne F.C., 1983. Crystal chemistry of the amphiboles. Canadian Mineralogist, 21, 173-480.

Hawthorne F.C., Oberti R., Harlow G.E., Maresch W.V., Martin R.F., Schumacher J.C., Welch M.D., 2012. Nomenclature of the amphibole supergroup. American Mineralogist 97, 2031-2048.

Holland T.J.B. and Redfern S., 1997. UNITCELL: A nonlinear least-squares program for cell-parameter refinement implementing regression and deletion diagnostics. Journal of

Table 3. Selected properties of mangani-pargasite and related mineral species.

Mineral	[1]Pargasite	[2]Chromio-pargasite (originally chimeite; IMA 2011-023)	[3,4]Vanadio-pargasite (IMA 2017-019)	[5,6]Mangani-pargasite (IMA 2018-151)
Formula	NaCa$_2$(Mg$_4$Al)(Al$_2$Si$_6$O$_{22}$)(OH)$_2$	NaCa$_2$(Mg$_4$Cr^{3+})(Al$_2$Si$_6$O$_{22}$)(OH)$_2$	NaCa$_2$(Mg$_4$V^{3+})(Al$_2$Si$_6$O$_{22}$)(OH)$_2$	NaCa$_2$(Mg$_4$Mn^{3+})(Al$_2$Si$_6$O$_{22}$)(OH)$_2$
Crystal system; space group	Monoclinic; C2/m	Monoclinic; C2/m	Monoclinic; C2/m	Monoclinic; C2/m
Unit cell parameters	a = 9.910(1) Å b = 18.022 (1) Å c = 5.312(1) Å $β$ = 105.78 (1) ° V = 905.33 Å^3; Z = 2	a = 9.9176(14) Å b = 18.0009(12) Å c = 5.2850(7) Å $β$ = 105.400(7) ° V = 909.6 Å^3; Z = 2	a = 9.8956(1) Å b = 17.9970(2)Å c = 5.2970(1) Å $β$ = 105.391(1)° V = 909.52 Å^3; Z = 2	a = 9.9448(5) Å b = 18.0171(9) Å c = 5.2829(3) Å $β$ = 105.445(7)° V = 912.39 Å^3; Z = 2
Strongest diffraction lines [d in Å; (I$_{rel}$)]	8.430 (40) 3.269 (35) 3.124 (100) 2.930 (35) 2.805 (25) 2.698 (30) 2.155 (20)	3.370 (58) 2.932 (43) 2.697 (81) 2.585 (50) 2.546 (100) 2.346 (42) 1.514 (55)	8.98 (15) 8.43 (40) 3.27 (30) 3.14 (100) 2.82 (35) 2.70 (18) 2.34 (15) 1.445 (25)	8.42 (29) 3.28 (49) 3.14 (100) 2.82 (44) 2.70 (21) 1.904 (29) 1.650 (22) 1.448 (46)
Density (g·cm^{-3})	3.04 - 3.17 (measured)	3.08 (measured)	3.05 (measured)	3.127 (calculated)
Optical data	Biaxial (+) $α$ = 1.613 - 1.650 $β$ = 1.618 - 1.660 $γ$ = 1.635 - 1.670 $2V_{meas}$ = 70 - 90° $Z^\c \sim 26°$	Biaxial (+) $α$ = 1.644(2) $β$ = 1.647(2) $γ$ = 1.659(2) $2V_{calc}$ = 53°	Biaxial (+) $α$ = 1.643(2) $β$ = 1.650(2) $γ$ = 1.659(2) $2V_{meas}$ = 86(2)° $Z^\c$ = 23 - 25°	Biaxial (+) $α$ = 1.635(5) $β$ = 1.645(5) $γ$ = 1.660(5) $2V_{meas}$ = 85(5)° $Z^\c$ = 25(3)°

References: [1]Anthony et al. (2001); [2]Nishio-Hamane et al. (2012); [3]Reznitsky et al. (2017); [4]Cametti et al. (2018); [5]Hålenius and Bosi (2012); [6]This work

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Applied Crystallography 30, 84-84.

Jonsson E. and Hålenius U., 2010. Mn^{3+}-bearing pargasite from the Långban Fe-Mn oxide mineralisation, Bergslagen, Sweden. GFF, 132, 167-172.

Magnusson N.H., 1930. Långbans malmtrakt. Sveriges Geologiska Undersökning, Ca 23, 1-111. (in Swedish).

Miyawaki R., Hatert F., Pasero M., Mills S., 2019. IMA Commission on New Minerals, Nomenclature and Classification (CNMNC) NEWSLETTER 48: New minerals and nomenclature modifications approved in 2018 and 2019. European Journal of Mineralogy 31, 399-402.

Nishio-Hamane D., Ohnishi M., Minakawa T., Yamaura J., Saito S., Kadota R., 2012. Ehimeite, $NaCa_2Mg_4CrSi_6Al_2O_{22}(OH)_2$: the first Cr-dominant amphibole from the Akaishi Mine, Higashi-Akaishi Mountain, Ehime Prefecture, Japan. Journal of Mineralogical and Petrological Sciences 107, 1-7.

Reznitsky L.Z., Sklyarov E.V., Cametti G., Armbruster T., Suvorova L.F., Ushchapovskaya Z.F., Barash I.G., 2017. Vanadio-pargasite $NaCa_2Mg_4V(Si_6Al_2)O_{22}(OH)_2$ a new mineral of amphibole group. Zapiski Russian Mineralogical Society 146, 62-74.

Strunz H. and Nickel E.H., 2001. Strunz Mineralogical Tables. Chemical-structural mineral classification system. 9th Edition. E. Schweizerbart, Ed., Stuttgart, Germany, 870 pp.

Sundius N., 1946. The classification of the hornblendes and the solid solution relations in the amphibole group. Sveriges Geologiska Undersökning C 480, 1-36.

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