KARENWEBBERITE, $Na(Fe^{2+},Mn^{2+})PO_4$, A NEW PHOSPHATE MINERAL SPECIES FROM THE MALPENSATA PEGMATITE, LECCO PROVINCE, ITALY

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The triphylite group is constituted by several Fe-Mn-bearing phosphates which are widespread in medium to highly evolved LCT granitic pegmatites, ranging from the beryl-columbite-phosphate subtype to the spodumene subtype, according to the classification of Černý and Ercit (2005). This group contains primary and weakly oxidized phosphates, for example: minerals of the triphylite – lithiophilite solid solution series [$Li(Fe^{2+},Mn)PO_4$ – $Li(Mn,Fe^{2+})PO_4$] and natrophilite [$Na(Mn,Fe^{2+})PO_4$], but the oxidation also frequently produces more oxidized phosphates such as ferrisicklerite-sicklerite [$_{1-x}Li_x(Fe^{3+},Mn^{2+})PO_4$ – $_{1-x}Li_x(Mn^{2+},Fe^{3+})PO_4$] or heterosite-purpurite [$(Fe^{3+},Mn^{3+})PO_4$ – $(Mn^{3+},Fe^{3+})PO_4$]. Triphylite hosted by Triassic pegmatites embedded into the crystalline basement of the central Southern Alps had been recently described at Brissago (Switzerland) and Piona (Italy) (Vignola *et al.* 2008a, Vignola *et al.* 2010, Vignola *et al.* 2011a). Here we report the description of a new Na-bearing mineral species belonging to the triphylite group (Table 1), karenwebberite, $Na(Fe^{2+},Mn^{2+})PO_4$ (IMA 2011-015, Vignola *et al.* 2011b; Vignola et al, 2013).

The mineral was found by one of the authors (P.V.) at the Malpensata granitic pegmatite, Colico commune, Lecco province, north Italy. The Malpensata dike, mined for ceramic feldspar and mica during 1943-1946, is located on the east side of the Piona peninsula, 1.2 km north of the Olgiasca village and 200 m south of the Piona Abbey, at an elevation of 110 m above sea level (46°, 07', 20'' N; 9°, 10', 33''E). The Malpensata dyke belongs to the Piona pegmatite swarm which is embedded into the high-grade metapelites (sillimanite-, biotite-bearing mica schists and gneisses) of the Dervio-Olgiasca Zone which constitute the crystalline basement of the Central Southern Alps (Bertotti *et al.* 1999). The dike is constituted by plagioclase ($An_{0.08}$) and quartz, with muscovite, schorl, and almandine-rich garnet as common accessories, and belongs to the beryl-columbite-phosphate sub-type of LCT granitic pegmatites referred to the classification of Černý and Ercit (2005). Karenwebberite rarely occurs in the central portion (the most evolved one) of the blocky plagioclase unit as thin lamellae embedded in graftonite constituting elliptical nodules up to 1 cm diameter. These nodules were found in close association with cassiterite, hafnian zircon, tapiolite-(Fe), oxycalciomicrolite, ferrowyllieite and other evolved phosphates (Vignola *et al.* 2008b, Vignola *et al.* 2010). Karenwebberite, $Na(Fe^{2+},Mn^{2+})PO_4$, belongs to the triphylite group and correspond to the Fe-equivalent of natrophillite or to the Na-equivalent of triphylite. It forms late stage magmatic exsolution lamellae up to 100μm thick, hosted in graftonite and associated with Na-bearing ferrisicklerite and with a heterosite-like phase. Lamellae are pale green, with very pale grayish-green streak. The luster is greasy to vitreous, and lamellae are translucent (pale green) to opaque (dark green). Optically, the mineral is anisotropic, biaxial (+), $\alpha = 1.701(2)$, $\beta = 1.708(2)$, $\gamma = 1.717(2)$ (for $\lambda = 589$ nm), $2V_{meas.} = 87(4)°$, $2V_{calc.} = 41°$, with Z parallel to the *b* axis. Pleochroism is medium with X = dark grey, Y = brown, and Z = yellow. The mineral is brittle with a Mohs hardness of 4.5; in thin section it displays a perfect cleavage along {001} with an irregular fracture. Karenwebberite is non-fluorescent either under short-wave or long-wave ultraviolet light, and its calculated density is 3.65 g/cm^3. The mean chemical composition, determined by the electron-microprobe from 16 point analyses (wt. %), is: P_2O_5 41.12, $Fe_2O_3^*$ 7.00, FeO^* 25.82, MgO 0.23, ZnO 0.11, MnO 9.31, CaO 0.10, Na_2O 14.66, total 98.41 (*: calculated values). The empirical formula, calculated on the basis of 1 P atom per formula unit from, is $(Na_{0.817}Ca_{0.003}\square_{0.180})_{\Sigma 1.000}(Fe^{2+}_{0.622}Mn^{2+}_{0.228}Fe^{3+}_{0.151}Mg_{0.010}Zn_{0.002})_{\Sigma 1.013}PO_4$. Karenwebberite is orthorhombic, space group *Pbnm*, $a = 4.882(1)$Å, $b = 10.387(2)$Å, $c = 6.091(1)$ Å, V = 308.9(1)Å^3, and Z = 4. The mineral, which shows the olivine structure, is characterized by two octahedral sites: M1 which is occupied by Na, and M2 which is occupied by Fe and Mn. The eight strongest lines in the X-ray powder pattern are [*d* in

Å (intensities estimated visually) (*hkl*)]: 5.16 (strong) (020), 4.44 (very strong) (110), 3.93 (very strong) (021), 3.56 (very strong) (120), 3.04 (strong) (002), 2.817 (very strong) (130), 2.559 (very strong) (131), and 1.657 (strong) (061). The mineral has been approved by the Commission on New Minerals and Mineral Names of the International Mineralogical Association under number IMA 2011-015 (Vignola *et al.*, 2011), and is named in honour of Dr. Karen Louise Webber, Assistant Professor Research at the Mineralogy, Petrology and Pegmatology Research Group, Department of Earth and Environmental Sciences, University of New Orleans, Louisiana, U.S.A.

Table 1. Comparison of the physical properties for phosphates of the triphylite group (Vignola et al 2013)

Mineral	Triphylite	Lithiophilite	Natrophilite	Karenwebberite
Ideal formula	$Li(Fe^{2+},Mn)PO_4$	$Li(Mn,Fe^{2+})PO_4$	$Na(Mn,Fe^{2+})PO_4$	$Na(Fe^{2+},Mn)PO_4$
Space group	*Pbnm*	*Pbnm*	*Pbnm*	*Pbnm*
a (Å)	4.6904(6)	4.7383(1)	4.987(2)	4.882(1)
b (Å)	10.2855(9)	10.429(1)	10.523(5)	10.387(2)
c (Å)	5.9871(4)	6.0923(4)	6.312(3)	6.091(1)
Z	4	4	4	4
Strong X-ray	5.175 (34)	5.236 (28)	5.24 (30)	5.16 (25)
lines	4.277 (76)	4.313 (56)	4.50 (60)	4.44 (48)
	-	-	4.05 (60)	-
	3.923 (26)	-	3.90 (30)	3.93 (37)
	-	-	3.66 (50)	3.79 (8)
	3.487 (70)	3.516 (71)	3.61 (10)	3.56 (86)
	3.008 (100)	3.051 (89)	3.15 (50)	3.04 (52)
	-		2.863 (80)	-
	2.781 (34)	-	-	2.817 (57)
	-	-	2.702 (20)	-
	-	-	2.604 (100)	-
	2.525 (81)	2.548 (100)	2.583 (100)	2.559 (100)
	-	2.492 (28)	2.487 (30)	-
Cleavage	{001} perfect, {010} imperfect	{001} perfect, {010} good	{001} good, {010} indistinct, {120} interrupted	{001} perfect
Density	3.54(4)	3.47(3)	3.41; 3.47 (calc.)	3.65 (calc.)
Optical sign	B(+)	B(+)	B(+)	B(+)
2V (°)	0-55	48-70	75(5)	87(4)
α	1.675-1.694	1.663-1.696	1.671(3)	1.701(2)
β	1.684-1.695	1.667-1.700	1.674(3)	1.708(2)
γ	1.685-1.700	1.674-1.702	1.684(3)	1.717(2)
Hardness	4-5	4-5	4.5-5	4.5(5)
Colour	Bluish grey to greenish grey	Yellowish brown, honey-yellow, grey	Deep wine-yellow	Pale green; brownish when oxidized

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