

Na₅(NH₄)Mn₃[B₉P₆O₃₃(OH)₃]·1.5H₂O

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Key indicators: single-crystal X-ray study; *T* = 295 K; mean $\sigma(\text{O}-\text{B}) = 0.006 \text{ \AA}$; H-atom completeness 31%; disorder in solvent or counterion; *R* factor = 0.040; *wR* factor = 0.099; data-to-parameter ratio = 15.1.

The overall hexagonal framework of the title compound, pentasodium ammonium trimanganese(II) borophosphate sesquihydrate, consists of tube-like borophosphate anions, $\infty^1\{[\text{B}_3\text{P}_2\text{O}_{11}(\text{OH})]^{4-}\}$, made up of corner-sharing PO₄ and BO₄ tetrahedra and BO₂(OH) triangles, forming ten-membered ring windows. The tubes are interconnected *via* distorted MnO₆ octahedra, establishing a three-dimensional open-framework structure with two different types of ring-channels (12- and six-membered) that run along [001]. The 12-membered ring channels are occupied by NH₄⁺ ions and water molecules. The ten-membered ring windows in the walls of the tubes are occupied by Na⁺ ions. The remaining Na⁺ ions and the water molecules, one of which is half-occupied, reside within the six-membered ring channels. The structural setup is consolidated by an O—H...O hydrogen bond between the OH group and an opposite O atom of the framework. Donor–acceptor distances ranging from 2.80 to 3.35 Å between the ammonium N atom, water O atoms and framework O atoms indicate further hydrogen-bonding interactions.

Related literature

Reviews on the preparation, crystal chemistry and applications of borophosphates are given in Kniep *et al.* (1998) and Ewald *et al.* (2007). For isostructural compounds, see Yang, Li *et al.* (2006) for Na₂Mn[B₃P₂O₁₁(OH)]·0.67H₂O; Yang, Yu *et al.* (2006) for Na₅(H₃O)Mn₃[B₉P₆O₃₃(OH)₃]·2H₂O; Liu *et al.* (2006) for Na₆Cu₃[B₉P₆O₃₃(OH)₃]·2H₂O.

Experimental

Crystal data

Na₅(NH₄)Mn₃[B₉P₆O₃₃(OH)₃]·1.5(H₂O)
M_r = 2373.94
 Hexagonal, *P*6₃
a = 11.9331 (2) Å
c = 12.1290 (4) Å
V = 1495.76 (6) Å³
Z = 1
 Mo *K*α radiation
 $\mu = 1.79 \text{ mm}^{-1}$
T = 295 K
 0.08 × 0.04 × 0.04 mm

Data collection

Rigaku Mercury AFC7 CCD diffractometer
 Absorption correction: multi-scan (Blessing, 1995)
T_{min} = 0.779, *T_{max}* = 0.931
 12243 measured reflections
 2891 independent reflections
 2784 reflections with *I* > 2σ(*I*)
R_{int} = 0.030

Refinement

$R[F^2 > 2\sigma(F^2)] = 0.040$
 $wR(F^2) = 0.099$
S = 1.12
 2891 reflections
 191 parameters
 1 restraint
 H atoms treated by a mixture of independent and constrained refinement
 $\Delta\rho_{\text{max}} = 0.66 \text{ e \AA}^{-3}$
 $\Delta\rho_{\text{min}} = -0.81 \text{ e \AA}^{-3}$
 Absolute structure: Flack (1983), 1374 Friedel pairs
 Flack parameter: 0.43 (3)

Table 1

Hydrogen-bond geometry (Å, °).

<i>D</i> —H... <i>A</i>	<i>D</i> —H	H... <i>A</i>	<i>D</i> ... <i>A</i>	<i>D</i> —H... <i>A</i>
O12—H1...O4 ⁱ	0.86 (7)	2.11 (7)	2.959 (3)	167 (3)
O13...O10 ⁱⁱ	—	—	2.8035 (11)	—
O13...N ⁱⁱⁱ	—	—	3.077 (16)	—
O14...O8 ^{iv}	—	—	3.284 (5)	—
O14...O6 ^{iv}	—	—	3.333 (3)	—
N...O13 ^v	—	—	2.988 (16)	—
N...O3 ^{vi}	—	—	2.991 (3)	—
N...O7 ^v	—	—	3.047 (3)	—

Symmetry codes: (i) $x - y + 1, x, z + \frac{1}{2}$; (ii) $-x + y, -x, z$; (iii) $-x, -y, z + \frac{1}{2}$; (iv) $x - y, x, z + \frac{1}{2}$; (v) $x, y, z - 1$; (vi) $x - 1, y - 1, z$.

Data collection: *CrystalClear* (Rigaku/MS, 2005); cell refinement: *CrystalClear*; data reduction: *CrystalClear*; program(s) used to solve structure: *SHELXS97* (Sheldrick, 2008); program(s) used to refine structure: *SHELXL97* (Sheldrick, 2008); molecular graphics: *DIAMOND* (Brandenburg, 2004); software used to prepare material for publication: *SHELXL97*.

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Supplementary data and figures for this paper are available from the IUCr electronic archives (Reference: WM2204).

References

- Blessing, R. H. (1995). *Acta Cryst.* **A51**, 33–38.
 Brandenburg, K. (2004). *DIAMOND*. Crystal Impact GbR, Bonn, Germany.
 Ewald, B., Huang, Y.-X. & Kniep, R. (2007). *Z. Anorg. Allg. Chem.* **633**, 1517–1540.
 Flack, H. D. (1983). *Acta Cryst.* **A39**, 876–881.
 Kniep, R., Engelhardt, H. & Hauf, C. (1998). *Chem. Mater.* **10**, 2930–2934.

Liu, W., Huang, Y.-X., Cardoso, R., Schnelle, W. & Kniep, R. (2006). *Z. Anorg. Allg. Chem.* **632**, 2413.
Rigaku/MS (2005). *CrystalClear*. Rigaku/MS, The Woodlands, Texas, USA.
Sheldrick, G. M. (2008). *Acta Cryst.* **A64**, 112–122.

Yang, T., Li, G., Ju, J., Liao, F., Xiong, M. & Lin, J. (2006). *J. Solid State Chem.* **179**, 2534–2540.
Yang, M., Yu, J., Di, J., Li, J., Chen, P., Fang, Q., Chen, Y. & Xu, R. (2006). *Inorg. Chem.* **45**, 3588–3593.

supplementary materials

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Na₅(NH₄)Mn₃[B₉P₆O₃₃(OH)₃]·1.5H₂O

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Comment

In the past several years, borophosphates have attracted extensive attention due to their rich structural chemistry and potential applications as catalysts (Kniep *et al.*, 1998; Ewald *et al.*, 2007). Although a large variety of borophosphate anions has been reported, tube-like borophosphate anions are particularly rare (Liu *et al.*, 2006; Yang *et al.*, 2006a; Yang *et al.*, 2006b). Up to now, only two manganese compounds containing borophosphate tubes, *viz.* Na₂Mn[B₃P₂O₁₁(OH)]·0.67H₂O (Yang *et al.*, 2006a) and Na₅(H₃O)Mn₃[B₉P₆O₃₃(OH)₃]·2H₂O (Yang *et al.*, 2006b) are listed in the literature. Here, we report on an ammonium substituted sodium manganese borophosphate, Na₅(NH₄)Mn₃[B₉P₆O₃₃(OH)₃]·1.5H₂O.

The crystal structure of the title compound comprises tube-like borophosphate anions, $\infty^1\{[B_3P_2O_{11}(OH)]^{4-}\}$, which are built from 12-membered rings of alternating BO₄ and PO₄ tetrahedra, further interlinked by sharing common O-corners of neighbouring rings, and loop-branched by BO₂(OH) triangles resulting in 10-membered ring windows on the walls of the tubes (Fig. 1). The manganese atoms are in a distorted octahedral coordination, surrounded by four oxygen atoms from phosphate tetrahedra (O1, O2, O5, O6) and two oxygen atoms from borate tetrahedra (O10, O11). The Mn-coordination octahedra interconnect the neighboring borophosphate tubes to form a three-dimensional framework with two different types of channels (Fig. 2), namely 6- and 12-membered ring channels. The 12-membered ring channels are occupied by NH₄⁺ ions and water molecules; the 10-membered ring windows in the walls of the tubes are occupied by Na⁺ ions. The remaining Na⁺ ions and water molecules reside in the 6-membered ring channels. The structural setup is consolidated by an O—H···O hydrogen bond between the OH group and an opposite O atom of the framework. Donor-acceptor distances ranging from 2.8 to 3.35 Å between the ammonium N atom, water O atoms and framework O atoms indicate further hydrogen bonding interactions, but the corresponding H atoms were not located.

Experimental

Transparent, colourless single crystals of the title compound were synthesized hydrothermally from a mixture of H₃BO₃ (32.2 mmol), Mn(CH₃COO)₂·4H₂O (3 mmol), (NH₄)₂HPO₄ (6.4 mmol), NaF (5 mmol), and water (133.4 mmol). The educt mixture was transferred into a Teflon-lined stainless steel autoclave (internal volume 25 ml) and kept at 513 K for five days. The autoclave was cooled down to ambient temperature by removing out of the oven. The reaction products were washed with hot distilled water (333 K) until the boric acid was completely removed. Finally, the solids were dried in air at 333 K. Hexagonal prismatic crystals were selected for single-crystal diffraction. The NH₄⁺ content was determined by elemental analysis and confirmed by IR spectroscopy.

Refinement

The measured crystal was racemically twinned with an approximate twin fraction of 2:3. The hydrogen position bonded to O12 was found in a difference Fourier map and was refined freely. The hydrogen positions of the ammonium N atom and of the uncoordinated water atoms at O13 and O14 were not localized. The occupancy of O13 was refined to 0.50 (2). In the last refinement cycle this value was fixed to 0.50.

Figures

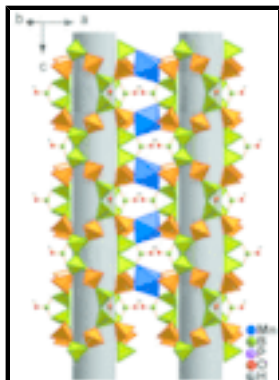


Fig. 1. Borophosphate tubes in the crystal structure of $\text{Na}_5(\text{NH}_4)\text{Mn}_3[\text{B}_9\text{P}_6\text{O}_{33}(\text{OH})_3]\cdot 1.5\text{H}_2\text{O}$ interconnected by MnO_6 coordination octahedra.

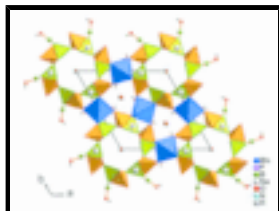


Fig. 2. The overall framework of $\text{Na}_5(\text{NH}_4)\text{Mn}_3[\text{B}_9\text{P}_6\text{O}_{33}(\text{OH})_3]\cdot 1.5\text{H}_2\text{O}$ viewed along [001], showing the resulting channel-system.

Pentasodium ammonium trimanganese(II) borophosphate sesquihydrate

Crystal data

$\text{Na}_5(\text{NH}_4)\text{Mn}_3[\text{B}_9\text{P}_6\text{O}_{33}(\text{OH})_3]\cdot 1.5(\text{H}_2\text{O})$

$M_r = 2373.94$

Hexagonal, $P6_3$

Hall symbol: P 6c

$a = 11.9331(2) \text{ \AA}$

$b = 11.9331(2) \text{ \AA}$

$c = 12.1290(4) \text{ \AA}$

$\alpha = 90^\circ$

$\beta = 90^\circ$

$\gamma = 120^\circ$

$V = 1495.76(6) \text{ \AA}^3$

$Z = 1$

$F_{000} = 1164$

$D_x = 2.635 \text{ Mg m}^{-3}$

Mo $K\alpha$ radiation

$\lambda = 0.71073 \text{ \AA}$

Cell parameters from 7346 reflections

$\theta = 2.0\text{--}33.6^\circ$

$\mu = 1.79 \text{ mm}^{-1}$

$T = 295 \text{ K}$

Prism, colourless

$0.08 \times 0.04 \times 0.04 \text{ mm}$

Data collection

Rigaku Mercury AFC7 CCD diffractometer	2891 independent reflections
Radiation source: fine-focus sealed tube	2784 reflections with $I > 2\sigma(I)$
Monochromator: graphite	$R_{\text{int}} = 0.030$
$T = 295$ K	$\theta_{\text{max}} = 30.0^\circ$
ω -scans	$\theta_{\text{min}} = 2.0^\circ$
Absorption correction: multi-scan (Blessing, 1995)	$h = -16 \rightarrow 12$
$T_{\text{min}} = 0.779$, $T_{\text{max}} = 0.931$	$k = -16 \rightarrow 16$
12243 measured reflections	$l = -16 \rightarrow 16$

Refinement

Refinement on F^2	Hydrogen site location: difference Fourier map
Least-squares matrix: full	H atoms treated by a mixture of independent and constrained refinement
$R[F^2 > 2\sigma(F^2)] = 0.040$	$w = 1/[\sigma^2(F_o^2) + (0.0419P)^2 + 2.5644P]$
$wR(F^2) = 0.099$	where $P = (F_o^2 + 2F_c^2)/3$
$S = 1.12$	$(\Delta/\sigma)_{\text{max}} < 0.001$
2891 reflections	$\Delta\rho_{\text{max}} = 0.66 \text{ e } \text{\AA}^{-3}$
191 parameters	$\Delta\rho_{\text{min}} = -0.81 \text{ e } \text{\AA}^{-3}$
1 restraint	Extinction correction: none
Primary atom site location: structure-invariant direct methods	Absolute structure: Flack (1983), 1374 Friedel pairs
Secondary atom site location: difference Fourier map	Flack parameter: 0.43 (3)

Special details

Geometry. All e.s.d.'s (except the e.s.d. in the dihedral angle between two l.s. planes) are estimated using the full covariance matrix. The cell e.s.d.'s are taken into account individually in the estimation of e.s.d.'s in distances, angles and torsion angles; correlations between e.s.d.'s in cell parameters are only used when they are defined by crystal symmetry. An approximate (isotropic) treatment of cell e.s.d.'s is used for estimating e.s.d.'s involving l.s. planes.

Refinement. Refinement of F^2 against ALL reflections. The weighted R -factor wR and goodness of fit S are based on F^2 , conventional R -factors R are based on F , with F set to zero for negative F^2 . The threshold expression of $F^2 > \sigma(F^2)$ is used only for calculating R -factors(gt) *etc.* and is not relevant to the choice of reflections for refinement. R -factors based on F^2 are statistically about twice as large as those based on F , and R -factors based on ALL data will be even larger.

Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters (\AA^2)

	x	y	z	$U_{\text{iso}}^*/U_{\text{eq}}$	Occ. (<1)
Mn2	0.50444 (6)	0.50073 (7)	0.04544 (11)	0.01330 (12)	
P1	0.62139 (9)	0.81051 (9)	0.00965 (7)	0.0111 (2)	
P2	0.37924 (9)	0.19394 (10)	0.08857 (7)	0.0120 (2)	
B1	0.2928 (4)	0.2502 (4)	0.6961 (4)	0.0118 (7)	

supplementary materials

B2	0.2992 (4)	0.2504 (5)	0.8974 (4)	0.0151 (8)	
B3	0.4938 (3)	0.4004 (3)	0.7921 (5)	0.0159 (6)	
O1	0.5750 (3)	0.6785 (3)	0.9591 (3)	0.0169 (6)	
O2	0.7011 (3)	0.9084 (3)	0.9177 (2)	0.0162 (6)	
O3	0.7199 (3)	0.8385 (3)	0.1043 (2)	0.0150 (6)	
O4	0.5126 (3)	0.8296 (3)	0.0515 (3)	0.0177 (5)	
O5	0.2925 (3)	0.0953 (3)	0.1789 (2)	0.0152 (5)	
O6	0.4181 (3)	0.3245 (3)	0.1360 (3)	0.0179 (6)	
O7	0.2859 (3)	0.1639 (3)	0.9886 (3)	0.0182 (6)	
O8	0.6857 (3)	0.5090 (3)	0.0545 (3)	0.0175 (6)	
O9	0.5731 (3)	0.6364 (3)	0.1961 (3)	0.0147 (5)	
O10	0.26579 (18)	0.17981 (18)	0.7974 (3)	0.0132 (3)	
O11	0.4355 (3)	0.3637 (3)	0.8933 (3)	0.0157 (6)	
O12	0.6273 (2)	0.4785 (2)	0.7907 (3)	0.0235 (5)	
H1	0.648 (7)	0.498 (7)	0.723 (6)	0.07 (2)*	
Na1	0.71486 (14)	0.73129 (14)	0.8014 (2)	0.0273 (3)	
Na2	0.3333	0.6667	0.9533 (3)	0.0251 (6)	
N	0.0000	0.0000	0.0452 (12)	0.0243 (10)	
Na3	0.6667	0.3333	0.9477 (3)	0.0248 (6)	
O13	0.0000	0.0000	0.8007 (19)	0.041 (2)*	0.50
O14	0.3333	0.6667	0.7692 (9)	0.090 (3)*	

Atomic displacement parameters (\AA^2)

	U^{11}	U^{22}	U^{33}	U^{12}	U^{13}	U^{23}
Mn2	0.0140 (2)	0.01171 (19)	0.0136 (2)	0.00596 (15)	-0.00045 (17)	0.00050 (14)
P1	0.0127 (4)	0.0114 (4)	0.0093 (4)	0.0061 (3)	0.0005 (3)	0.0014 (3)
P2	0.0128 (4)	0.0126 (4)	0.0103 (4)	0.0061 (4)	-0.0003 (4)	0.0009 (3)
B1	0.0110 (17)	0.0120 (17)	0.0113 (18)	0.0050 (14)	0.0000 (15)	0.0011 (15)
B2	0.018 (2)	0.0153 (18)	0.014 (2)	0.0096 (16)	0.0016 (16)	0.0004 (16)
B3	0.0135 (13)	0.0121 (12)	0.0206 (17)	0.0054 (10)	0.0010 (19)	0.0038 (19)
O1	0.0212 (13)	0.0161 (12)	0.0113 (14)	0.0079 (11)	0.0016 (11)	0.0013 (10)
O2	0.0210 (14)	0.0136 (12)	0.0125 (12)	0.0076 (11)	0.0022 (11)	0.0018 (10)
O3	0.0168 (13)	0.0148 (12)	0.0128 (14)	0.0075 (10)	-0.0020 (11)	0.0041 (10)
O4	0.0158 (12)	0.0161 (12)	0.0214 (14)	0.0081 (11)	0.0002 (11)	-0.0001 (11)
O5	0.0188 (13)	0.0134 (12)	0.0129 (12)	0.0078 (10)	0.0019 (11)	0.0022 (10)
O6	0.0211 (13)	0.0129 (12)	0.0184 (15)	0.0074 (11)	0.0021 (12)	0.0014 (11)
O7	0.0179 (14)	0.0180 (13)	0.0150 (15)	0.0061 (11)	-0.0019 (12)	0.0034 (11)
O8	0.0124 (11)	0.0162 (12)	0.0229 (14)	0.0064 (10)	0.0007 (11)	-0.0036 (11)
O9	0.0159 (12)	0.0160 (12)	0.0086 (12)	0.0053 (10)	0.0001 (11)	-0.0001 (11)
O10	0.0151 (8)	0.0132 (8)	0.0117 (8)	0.0074 (7)	-0.0023 (13)	-0.0018 (13)
O11	0.0146 (12)	0.0156 (12)	0.0142 (14)	0.0055 (10)	-0.0013 (11)	-0.0007 (11)
O12	0.0143 (10)	0.0297 (12)	0.0193 (13)	0.0055 (9)	-0.0020 (14)	0.0008 (15)
Na1	0.0289 (7)	0.0381 (7)	0.0212 (7)	0.0215 (6)	-0.0001 (10)	-0.0012 (11)
Na2	0.0238 (8)	0.0238 (8)	0.0278 (15)	0.0119 (4)	0.000	0.000
N	0.0161 (12)	0.0161 (12)	0.041 (3)	0.0081 (6)	0.000	0.000
Na3	0.0241 (8)	0.0241 (8)	0.0261 (14)	0.0121 (4)	0.000	0.000

Geometric parameters (Å, °)

Mn2—O8	2.118 (3)	O5—B1 ^{ix}	1.475 (5)
Mn2—O1 ⁱ	2.126 (3)	O5—Na1 ^{iv}	2.584 (3)
Mn2—O6	2.127 (3)	O6—Na1 ^{iv}	2.434 (4)
Mn2—O4 ⁱⁱ	2.162 (3)	O7—P2 ^{vii}	1.562 (3)
Mn2—O9	2.303 (3)	O8—P2 ^x	1.505 (3)
Mn2—O11 ⁱ	2.326 (4)	O8—Na3 ⁱ	2.376 (3)
Mn2—Na3 ⁱ	3.6069 (13)	O9—B3 ^{iv}	1.354 (6)
Mn2—Na2 ⁱ	3.6582 (12)	O9—B1 ^{iv}	1.493 (5)
P1—O1 ⁱ	1.513 (3)	O10—Na1 ⁱⁱⁱ	2.360 (2)
P1—O4	1.514 (3)	O11—Mn2 ^{vii}	2.326 (4)
P1—O2 ⁱ	1.550 (3)	O12—Na1	2.656 (3)
P1—O3	1.555 (3)	O12—Na3	2.768 (4)
P1—Na2 ⁱ	3.0544 (12)	O12—H1	0.86 (8)
P1—Na1 ⁱ	3.094 (3)	Na1—O10 ^x	2.360 (2)
P2—O6	1.500 (3)	Na1—O6 ^{vi}	2.434 (4)
P2—O8 ⁱⁱⁱ	1.505 (3)	Na1—O5 ^{vi}	2.584 (3)
P2—O5	1.562 (3)	Na1—P1 ^{vii}	3.094 (3)
P2—O7 ⁱ	1.562 (3)	Na1—P2 ^{vi}	3.118 (3)
P2—Na1 ^{iv}	3.118 (3)	Na1—H1	2.66 (8)
P2—Na3 ⁱ	3.4270 (19)	Na2—O14	2.232 (11)
B1—O10	1.430 (5)	Na2—O4 ^{xi}	2.370 (3)
B1—O5 ^v	1.475 (5)	Na2—O4 ^{vii}	2.370 (3)
B1—O3 ^{vi}	1.491 (5)	Na2—O4 ^{xii}	2.370 (3)
B1—O9 ^{vi}	1.493 (5)	Na2—O1 ^{viii}	2.817 (3)
B2—O10	1.416 (6)	Na2—O1 ⁱⁱ	2.817 (3)
B2—O7	1.466 (6)	Na2—P1 ^{xi}	3.0544 (12)
B2—O2 ⁱⁱ	1.494 (5)	Na2—P1 ^{vii}	3.0544 (12)
B2—O11	1.509 (5)	Na2—P1 ^{xii}	3.0544 (12)
B3—O9 ^{vi}	1.354 (6)	Na2—Mn2 ^{xi}	3.6582 (12)
B3—O11	1.371 (6)	Na2—Mn2 ^{xii}	3.6582 (12)
B3—O12	1.386 (4)	Na3—O8 ^{xiii}	2.376 (3)
O1—P1 ^{vii}	1.513 (3)	Na3—O8 ^{xiv}	2.376 (3)
O1—Mn2 ^{vii}	2.126 (3)	Na3—O8 ^{vii}	2.376 (3)
O1—Na1	2.407 (4)	Na3—O12 ⁱⁱⁱ	2.768 (4)
O1—Na2	2.817 (3)	Na3—O12 ^x	2.768 (4)
O2—B2 ^{viii}	1.494 (5)	Na3—P2 ^{xiv}	3.4270 (19)
O2—P1 ^{vii}	1.550 (3)	Na3—P2 ^{xiii}	3.4270 (19)
O2—Na1	2.614 (4)	Na3—P2 ^{vii}	3.4270 (19)

supplementary materials

O3—B1 ^{iv}	1.491 (5)	Na3—Mn2 ^{xiii}	3.6069 (13)
O4—Mn2 ^{viii}	2.162 (3)	Na3—Mn2 ^{xiv}	3.6069 (13)
O4—Na2 ⁱ	2.370 (3)	Na3—Mn2 ^{vii}	3.6069 (13)
O8—Mn2—O1 ⁱ	95.34 (12)	B3 ^{iv} —O9—Mn2	120.6 (2)
O8—Mn2—O6	89.88 (12)	B1 ^{iv} —O9—Mn2	118.7 (2)
O1 ⁱ —Mn2—O6	174.49 (15)	B2—O10—B1	118.2 (2)
O8—Mn2—O4 ⁱⁱ	174.93 (18)	B2—O10—Na1 ⁱⁱⁱ	115.7 (3)
O1 ⁱ —Mn2—O4 ⁱⁱ	88.22 (11)	B1—O10—Na1 ⁱⁱⁱ	119.3 (3)
O6—Mn2—O4 ⁱⁱ	86.46 (12)	B3—O11—B2	117.6 (3)
O8—Mn2—O9	86.00 (12)	B3—O11—Mn2 ^{vii}	122.7 (2)
O1 ⁱ —Mn2—O9	82.24 (11)	B2—O11—Mn2 ^{vii}	116.6 (3)
O6—Mn2—O9	96.39 (14)	B3—O12—Na1	115.5 (2)
O4 ⁱⁱ —Mn2—O9	90.91 (12)	B3—O12—Na3	94.0 (3)
O8—Mn2—O11 ⁱ	93.89 (12)	Na1—O12—Na3	125.72 (15)
O1 ⁱ —Mn2—O11 ⁱ	97.79 (14)	B3—O12—H1	106 (5)
O6—Mn2—O11 ⁱ	83.59 (12)	Na1—O12—H1	81 (5)
O4 ⁱⁱ —Mn2—O11 ⁱ	89.20 (12)	Na3—O12—H1	135 (5)
O9—Mn2—O11 ⁱ	179.89 (14)	O10 ^x —Na1—O1	125.56 (16)
O1 ⁱ —P1—O4	113.43 (17)	O10 ^x —Na1—O6 ^{vi}	120.09 (16)
O1 ⁱ —P1—O2 ⁱ	105.09 (17)	O1—Na1—O6 ^{vi}	108.15 (9)
O4—P1—O2 ⁱ	112.12 (18)	O10 ^x —Na1—O5 ^{vi}	114.43 (12)
O1 ⁱ —P1—O3	111.51 (18)	O1—Na1—O5 ^{vi}	111.70 (11)
O4—P1—O3	109.4 (2)	O6 ^{vi} —Na1—O5 ^{vi}	57.80 (11)
O2 ⁱ —P1—O3	104.87 (18)	O10 ^x —Na1—O2	117.98 (12)
O6—P2—O8 ⁱⁱⁱ	114.34 (17)	O1—Na1—O2	57.76 (11)
O6—P2—O5	104.92 (18)	O6 ^{vi} —Na1—O2	111.69 (11)
O8 ⁱⁱⁱ —P2—O5	112.87 (17)	O5 ^{vi} —Na1—O2	67.76 (7)
O6—P2—O7 ⁱ	110.57 (19)	O10 ^x —Na1—O12	80.64 (8)
O8 ⁱⁱⁱ —P2—O7 ⁱ	109.5 (2)	O1—Na1—O12	85.06 (12)
O5—P2—O7 ⁱ	104.11 (17)	O6 ^{vi} —Na1—O12	79.46 (12)
O10—B1—O5 ^v	109.7 (3)	O5 ^{vi} —Na1—O12	136.89 (14)
O10—B1—O3 ^{vi}	108.1 (3)	O2—Na1—O12	142.78 (14)
O5 ^v —B1—O3 ^{vi}	108.4 (3)	O14—Na2—O4 ^{xi}	120.17 (10)
O10—B1—O9 ^{vi}	110.9 (3)	O14—Na2—O4 ^{vii}	120.17 (10)
O5 ^v —B1—O9 ^{vi}	110.6 (3)	O4 ^{xi} —Na2—O4 ^{vii}	96.95 (13)
O3 ^{vi} —B1—O9 ^{vi}	109.0 (3)	O14—Na2—O4 ^{xii}	120.17 (10)
O10—B2—O7	109.1 (4)	O4 ^{xi} —Na2—O4 ^{xii}	96.95 (13)
O10—B2—O2 ⁱⁱ	109.2 (3)	O4 ^{vii} —Na2—O4 ^{xii}	96.95 (13)
O7—B2—O2 ⁱⁱ	107.9 (3)	O14—Na2—O1 ^{viii}	91.45 (9)
O10—B2—O11	111.2 (3)	O4 ^{xi} —Na2—O1 ^{viii}	57.64 (10)
O7—B2—O11	110.1 (4)	O4 ^{vii} —Na2—O1 ^{viii}	69.66 (9)

O2 ⁱⁱ —B2—O11	109.2 (4)	O4 ^{xii} —Na2—O1 ^{viii}	147.64 (16)
O9 ^{vi} —B3—O11	123.0 (3)	O14—Na2—O1 ⁱⁱ	91.45 (9)
O9 ^{vi} —B3—O12	120.0 (5)	O4 ^{xi} —Na2—O1 ⁱⁱ	69.66 (10)
O11—B3—O12	117.0 (5)	O4 ^{vii} —Na2—O1 ⁱⁱ	147.64 (16)
P1 ^{vii} —O1—Mn2 ^{vii}	126.55 (19)	O4 ^{xii} —Na2—O1 ⁱⁱ	57.64 (10)
P1 ^{vii} —O1—Na1	101.82 (16)	O1 ^{viii} —Na2—O1 ⁱⁱ	119.937 (9)
Mn2 ^{vii} —O1—Na1	121.96 (15)	O14—Na2—O1	91.45 (9)
P1 ^{vii} —O1—Na2	83.98 (13)	O4 ^{xi} —Na2—O1	147.64 (16)
Mn2 ^{vii} —O1—Na2	94.45 (11)	O4 ^{vii} —Na2—O1	57.64 (10)
Na1—O1—Na2	123.48 (15)	O4 ^{xii} —Na2—O1	69.66 (9)
B2 ^{viii} —O2—P1 ^{vii}	135.3 (3)	O1 ^{viii} —Na2—O1	119.937 (9)
B2 ^{viii} —O2—Na1	132.2 (3)	O1 ⁱⁱ —Na2—O1	119.937 (8)
P1 ^{vii} —O2—Na1	92.40 (14)	O8 ^{xiii} —Na3—O8 ^{xiv}	93.15 (13)
B1 ^{iv} —O3—P1	127.0 (3)	O8 ^{xiii} —Na3—O8 ^{vii}	93.15 (13)
P1—O4—Mn2 ^{viii}	127.87 (17)	O8 ^{xiv} —Na3—O8 ^{vii}	93.15 (13)
P1—O4—Na2 ⁱ	101.43 (16)	O8 ^{xiii} —Na3—O12 ⁱⁱⁱ	120.52 (9)
Mn2 ^{viii} —O4—Na2 ⁱ	107.56 (13)	O8 ^{xiv} —Na3—O12 ⁱⁱⁱ	78.10 (11)
B1 ^{ix} —O5—P2	131.9 (3)	O8 ^{vii} —Na3—O12 ⁱⁱⁱ	145.34 (9)
B1 ^{ix} —O5—Na1 ^{iv}	133.0 (2)	O8 ^{xiii} —Na3—O12 ^x	78.10 (10)
P2—O5—Na1 ^{iv}	94.29 (14)	O8 ^{xiv} —Na3—O12 ^x	145.34 (9)
P2—O6—Mn2	125.0 (2)	O8 ^{vii} —Na3—O12 ^x	120.52 (9)
P2—O6—Na1 ^{iv}	102.20 (17)	O12 ⁱⁱⁱ —Na3—O12 ^x	77.89 (13)
Mn2—O6—Na1 ^{iv}	128.53 (15)	O8 ^{xiii} —Na3—O12	145.34 (9)
B2—O7—P2 ^{vii}	127.6 (3)	O8 ^{xiv} —Na3—O12	120.52 (9)
P2 ^x —O8—Mn2	128.59 (17)	O8 ^{vii} —Na3—O12	78.10 (10)
P2 ^x —O8—Na3 ⁱ	122.40 (16)	O12 ⁱⁱⁱ —Na3—O12	77.89 (13)
Mn2—O8—Na3 ⁱ	106.59 (13)	O12 ^x —Na3—O12	77.89 (13)
B3 ^{iv} —O9—B1 ^{iv}	119.0 (3)		

Symmetry codes: (i) $x, y, z-1$; (ii) $-x+y, -x+1, z$; (iii) $-y+1, x-y, z$; (iv) $-x+1, -y+1, z-1/2$; (v) $x-y, x, z+1/2$; (vi) $-x+1, -y+1, z+1/2$; (vii) $x, y, z+1$; (viii) $-y+1, x-y+1, z$; (ix) $y, -x+y, z-1/2$; (x) $-x+y+1, -x+1, z$; (xi) $-y+1, x-y+1, z+1$; (xii) $-x+y, -x+1, z+1$; (xiii) $-x+y+1, -x+1, z+1$; (xiv) $-y+1, x-y, z+1$.

Hydrogen-bond geometry ($\text{\AA}, ^\circ$)

$D-H\cdots A$	$D-H$	$H\cdots A$	$D\cdots A$	$D-H\cdots A$
O12—H1 ^{iv} —O4 ^{xv}	0.86 (7)	2.11 (7)	2.959 (3)	167 (3)
O13— \cdots O10 ^{xvi}	.	.	2.8035 (11)	.
O13— \cdots N ^{xvii}	.	.	3.077 (16)	.
O14— \cdots O8 ^v	.	.	3.284 (5)	.
O14— \cdots O6 ^v	.	.	3.333 (3)	.
N— \cdots O13 ⁱ	.	.	2.988 (16)	.
N— \cdots O3 ^{xviii}	.	.	2.991 (3)	.

$N\cdots O7^i$

3.047 (3)

Symmetry codes: (xv) $x-y+1, x, z+1/2$; (xvi) $-x+y, -x, z$; (xvii) $-x, -y, z+1/2$; (v) $x-y, x, z+1/2$; (i) $x, y, z-1$; (xviii) $x-1, y-1, z$.

Fig. 1

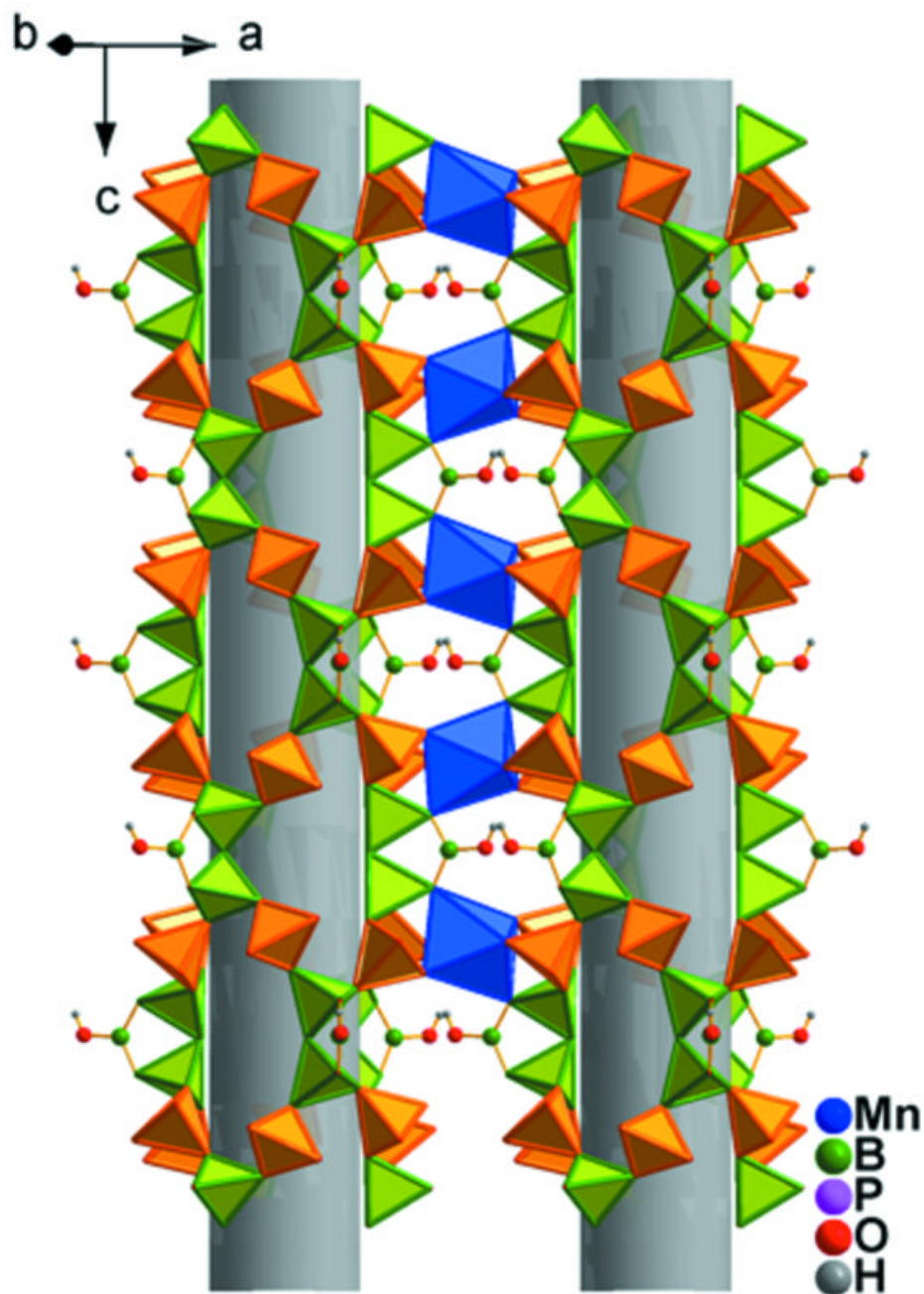


Fig. 2

