research communications

Crystal structure of a silver-, cobalt- and iron-based phosphate with an alluaudite-like structure: $Ag_{1.655}Co_{1.64}Fe_{1.36}(PO_4)_3$

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The new silver-, cobalt- and iron-based phosphate, silver cobalt iron tris(ortho-phosphate), $Ag_{1.655}Co_{1.64}Fe_{1.36}(PO_4)_3$, was synthesized by solid-state reactions. Its structure is isotypic to that of $Na_2Co_2Fe(PO_4)_3$, and belongs to the alluaudite family, with a partial cationic disorder, the Ag^I atoms being located on an inversion centre and twofold rotation axis sites (Wyckoff positions $4a$ and $4e$), with partial occupancies of 0.885 (2) and 0.7688 (19), respectively. One of the two P atoms in the asymmetric unit completely fills one $4e$ site while the Co and Fe atoms fill another $4e$ site, with partial occupancies of 0.86 (5) and 0.14 (5), respectively. The remaining Co^{2+} and Fe^{3+} cations are distributed on a general position, $8f$, in a 0.39 (4):0.61 (4) ratio. All O atoms and the other P atoms are in general positions. The structure is built up from zigzag chains of edge-sharing $[MO_6]$ (M = Fe/Co) octahedra stacked parallel to [101]. These chains are linked together through PO_4 tetrahedra, forming polyhedral sheets perpendicular to [010]. The resulting framework displays two types of channels running along [001], in which the Ag^I atoms (coordination number eight) are located.

1. Chemical context

Compounds belonging to the large alluaudite structural family (Moore, 1971; Moore & Ito, 1979; Hatert *et al.*, 2000, 2004) have been of continuing interest owing to their open-framework architecture, with hexagonal-shaped channels, and their physical properties. This fact is amply justified by their practical applications, for example as corrosion inhibitors, passivators of metal surfaces, and catalysts (Korzenski *et al.*, 1999). In addition, interest in alluaudite phosphates with monovalent cations has continued to grow in the electrochemical field, where they have applications as positive electrodes in lithium and sodium batteries (Trad *et al.*, 2010). Accordingly, our attention is mostly focused on the elaboration and structural characterization of new alluaudite-type phosphates within the $A_2O–MO–P_2O_5$ systems (A = monovalent cation M = divalent cation). For instance, most recently, the hydrothermal investigation of the $Na_2O–MO–P_2O_5$ pseudo-ternary system has allowed the isolation of the sodium- and magnesium-based alluaudite phosphate $NaMg_3(PO_4)(HPO_4)_2$ (Ould Saleck *et al.*, 2015). On the other hand, within the $Na_2O–CoO–Fe_2O_3–P_2O_5$ and $Na_2O–ZnO–Fe_2O_3–P_2O_5$ pseudo-quaternary systems, solid-state synthesis has allowed $Na_2Co_2Fe(PO_4)_3$ (Bouraima *et al.*, 2015) and $Na_{1.67}Zn_{1.67}Fe_{1.33}(PO_4)_3$ (Khmiyas *et al.*, 2015) to be obtained. With the same objective, a new


Ag
FeCo
P
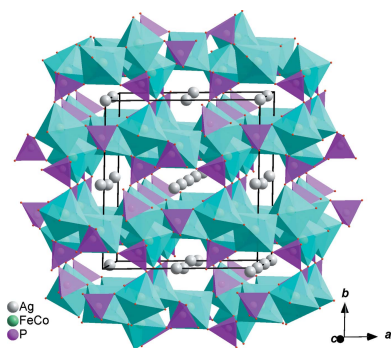
OPEN ACCESS
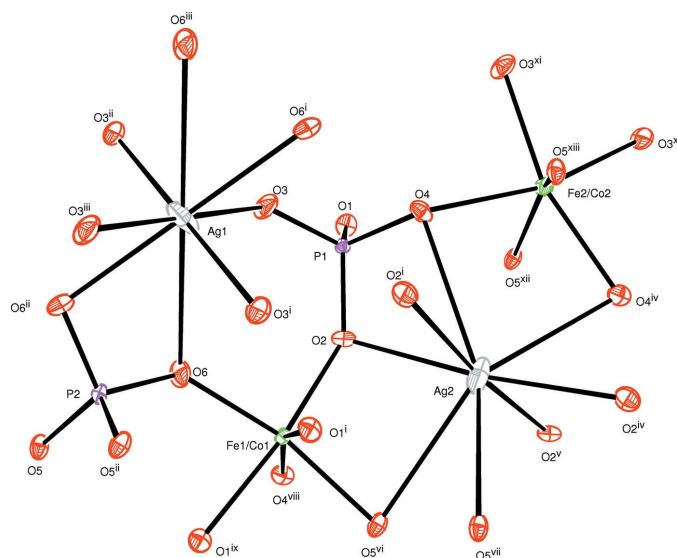
Figure 1
The principal building units in the structure of the title compound. Displacement ellipsoids are drawn at the 50% probability level. [Symmetry codes: (i) x, $-y + 1$, $z + \frac{1}{2}$; (ii) $-x + 1$, y, $-z + \frac{1}{2}$; (iii) $-x + 1$, $-y + 1$, $-z + 1$; (iv) $-x + 2$, y, $-z + \frac{3}{2}$; (v) $-x + 2$, $-y + 1$, $-z + 1$; (vi) $x + \frac{1}{2}$, $-y + \frac{1}{2}$, $z + \frac{1}{2}$; (vii) $-x + \frac{3}{2}$, $-y + \frac{1}{2}$, $-z + 1$; (viii) x, $-y + 1$, $z - \frac{1}{2}$; (ix) $-x + \frac{3}{2}$, $y - \frac{1}{2}$, $-z + \frac{1}{2}$; (x) $x + \frac{1}{2}$, $-y + \frac{3}{2}$, $z + \frac{1}{2}$; (xi) $-x + \frac{3}{2}$, $-y + \frac{3}{2}$, $-z + 1$; (xii) $-x + \frac{3}{2}$, $y + \frac{1}{2}$, $-z + \frac{1}{2}$; (xiii) $x + \frac{1}{2}$, $y + \frac{1}{2}$, $z + 1$.]

silver-, cobalt- and iron-based alluaudite-type phosphate, namely $Ag_{1.655}Co_{1.64}Fe_{1.36}(PO_4)_3$, has been synthesized by means of solid-state reactions and characterized by single crystal X-ray diffraction.

2. Structural commentary

In the new isolated compound, either cobalt or iron atoms are distributed in the two octahedral sites while the phosphorus atoms are tetrahedrally coordinated, as shown in Fig. 1. The structure is built up from two edge-sharing $[(Co1/Fe1)O_6]$ octahedra, leading to the formation of $[(Co1/Fe1)_2O_{10}]$ dimers. Those dimers are connected by a common edge to $[(Fe2/Co2)O_6]$ octahedra, forming an infinite chain (Fig. 2). The junction between these chains is ensured by sharing vertices with the PO_4 tetrahedra so as to form an open layer perpendicular to [010] (Fig. 3). The three-dimensional framework resulting from the stacking of the sheets along the b-axis direction delimits channels parallel to [001] in which the Ag^+ cations are accommodated, as shown in Fig. 4.
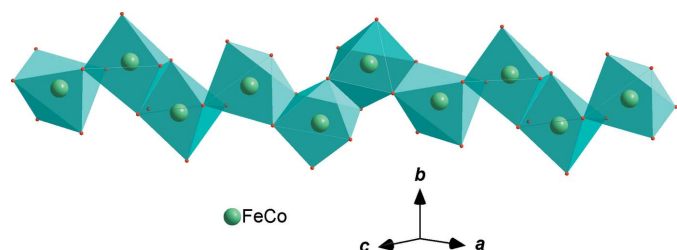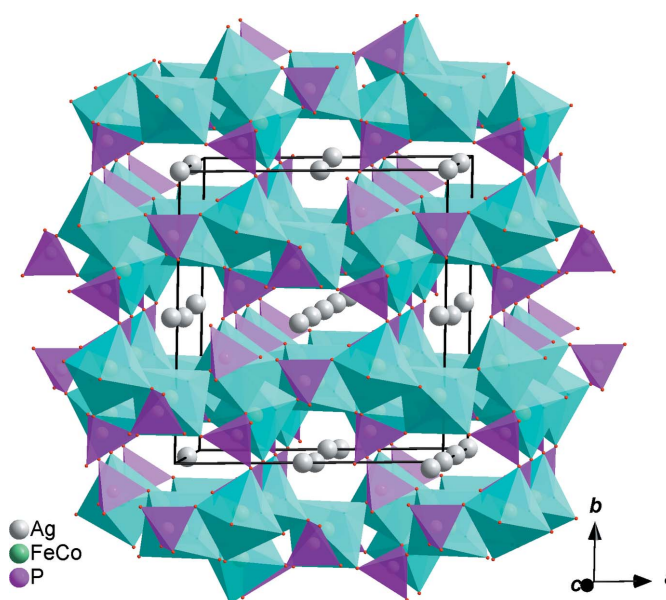

Figure 2
Edge-sharing $[(Fe/Co)O_6]$ octahedra forming a layer parallel to [101].
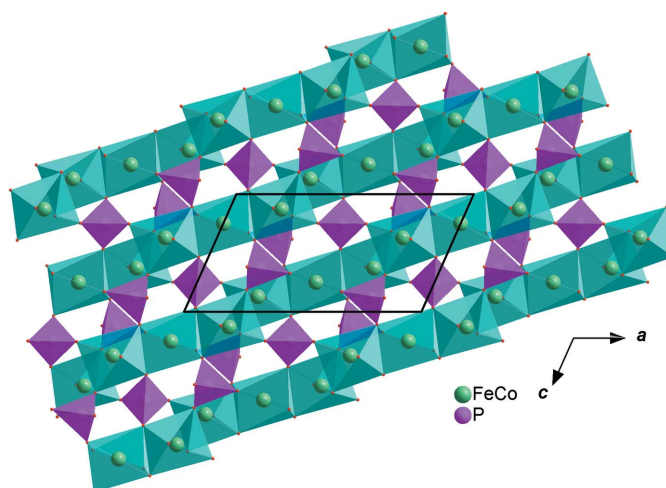
Figure 3
A view along [010], showing a layer resulting from the connection of chains *via* vertices of PO_4 tetrahedra and $[FeO_6]$ octahedra.

3. Comparison with a related structure

It is worth mentioning that the distribution of metallic cations observed in the case of the silver–cobalt–iron-based phosphate is not encountered in the sodium homologue. Hence, in the title silver-based phosphate, the octahedral $M1$ site (Wyckoff position 8f) is occupied to 60% by Fe1 and to 40% by Co1. The octahedrally surrounded $M2$ site (Wyckoff position 4e) is essentially occupied by Fe2 atoms (43%) along with a small amount of Co2 (7%). However, in the $Na_2Co_2Fe(PO_4)_3$ phosphate, the $M1$ and $M2$ sites are entirely occupied by Fe and Co atoms, respectively. For the mixed sites, the occupancy rate was refined without any constraint. The results

Figure 4
Polyhedral representation of $Ag_{1.655}Co_{1.64}Fe_{1.36}(PO_4)_3$, showing channels running along [001].

Table 1
Experimental details.

Crystal data	
Chemical formula	$Ag_{1.655}Co_{1.64}Fe_{1.36}(PO_4)_3$
M_r	2544.10
Crystal system, space group	Monoclinic, $C2/c$
Temperature (K)	296
a, b, c (Å)	11.8680 (3), 12.5514 (3), 6.4386 (2)
β (°)	114.012 (1)
V (Å^3)	876.09 (4)
Z	1
Radiation type	Mo $K\alpha$
μ (mm^{-1})	9.51
Crystal size (mm)	$0.31 \times 0.26 \times 0.22$
Data collection	
Diffractometer	Bruker X8 APEX
Absorption correction	Multi-scan (*SADABS*; Krause *et al.*, 2015)
T_{min}, T_{max}	0.066, 0.124
No. of measured, independent and observed [$I > 2\sigma(I)$] reflections	13097, 2137, 2079
R_{int}	0.030
$(\sin \theta/\lambda)_{max}$ (Å^{-1})	0.833
Refinement	
$R[F^2 > 2\sigma(F^2)]$, $wR(F^2)$, S	0.020, 0.047, 1.19
No. of reflections	2137
No. of parameters	99
$\Delta\rho_{max}$, $\Delta\rho_{min}$ (e Å^{-3})	1.47, −0.92

Computer programs: *APEX2* aand *SAINT* (Bruker, 2009), *SHELXT2014* (Sheldrick, 2015*a*), *SHELXL2014* (Sheldrick, 2015*b*), *ORTEP-3 for Windows* (Farrugia, 2012), *DIAMOND* (Brandenburg, 2006) and *publCIF* (Westrip, 2010).

of the refinements are in good agreement with the electrical neutrality of the compound and calculations of the bond-valence sums of the atoms in the structure (Brown & Altermatt, 1985). Accordingly, in the silver-based phosphate, the cations at the $M1$ site form double octahedra [(Fe1/Co1)$_2$O$_{10}$] alternating with [(Fe2/Co2)O$_6$] octahedra, while in the sodium homologue phosphate, the obtained [Co$_2$O$_{10}$] double octahedra alternate with [FeO$_6$] octahedra (Fig. 4). Moreover, both the Ag1 and Ag2 atoms are located in channels, surrounded by eight oxygen atoms with Ag1—O bond lengths between 2.3320 (13) Å and 2.9176 (13) Å, whereas Ag2—O bond lengths are in the range 2.4733 (13)–2.9035 (12) Å. The structure of the title phosphate is isotypic to that of Na$_2$Co$_2$Fe(PO$_4$)$_3$ (Bouraima *et al.*, 2015) and Na$_{1.67}$Zn$_{1.67}$Fe$_{1.33}$(PO$_4$)$_3$ (Khmiyas *et al.*, 2015).

4. Synthesis and crystallization

The title compound was isolated from solid-state reactions in air by mixing nitrates of silver, cobalt and iron with phosphoric acid. The various precursors are taken in the molar ratio Ag:Co:Fe:P = 2:2:1:3. The mixture was stirred at room temperature overnight. After different heat treatments in a platinum crucible at up to 873 K, the reaction mixture was heated to the melting temperature of 1221 K. The molten product was then cooled to room temperature at a rate of 5 K h^{-1}. Brown homogeneous crystals corresponding to the title compound of a suitable size for X-ray diffraction were obtained.

5. Refinement

Crystal data, data collection and structure refinement details are summarized in Table 1. The maximum and minimum residual electron densities in the final Fourier map are 0.68 and 0.55 Å from Ag1 and Ag2, respectively.

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supporting information

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Computing details

Data collection: *APEX2* (Bruker, 2009); cell refinement: *SAINT* (Bruker, 2009); data reduction: *SAINT* (Bruker, 2009); program(s) used to solve structure: SHELXT2014 (Sheldrick, 2015a); program(s) used to refine structure: *SHELXL2014* (Sheldrick, 2015b); molecular graphics: *ORTEP-3 for Windows* (Farrugia, 2012) and *DIAMOND* (Brandenburg, 2006); software used to prepare material for publication: *publCIF* (Westrip, 2010).

Silver cobalt iron tris(orthophosphate)

Crystal data

$Ag_{1.655}Co_{1.64}Fe_{1.36}(PO_4)_3$	$F(000) = 1194$
$M_r = 2544.10$	$D_x = 4.822$ Mg m^{-3}
Monoclinic, $C2/c$	Mo $K\alpha$ radiation, $\lambda = 0.71073$ Å
$a = 11.8680$ (3) Å	Cell parameters from 2137 reflections
$b = 12.5514$ (3) Å	$\theta = 3.3$–36.3°
$c = 6.4386$ (2) Å	$\mu = 9.51$ mm^{-1}
$\beta = 114.012$ (1)°	$T = 296$ K
$V = 876.09$ (4) Å^3	Block, brown
$Z = 1$	$0.31 \times 0.26 \times 0.22$ mm

Data collection

Bruker X8 APEX diffractometer	13097 measured reflections
Radiation source: fine-focus sealed tube	2137 independent reflections
Graphite monochromator	2079 reflections with $I > 2\sigma(I)$
φ and ω scans	$R_{int} = 0.030$
Absorption correction: multi-scan (SADABS; Krause *et al.*, 2015)	$\theta_{max} = 36.3°$, $\theta_{min} = 3.3°$
	$h = -19 \rightarrow 19$
	$k = -20 \rightarrow 20$
$T_{min} = 0.066$, $T_{max} = 0.124$	$l = -10 \rightarrow 10$

Refinement

Refinement on F^2	$w = 1/[\sigma^2(F_o^2) + (0.0121P)^2 + 3.2851P]$ where $P = (F_o^2 + 2F_c^2)/3$
Least-squares matrix: full	
$R[F^2 > 2\sigma(F^2)] = 0.020$	$(\Delta/\sigma)_{max} = 0.001$
$wR(F^2) = 0.047$	$\Delta\rho_{max} = 1.47$ e Å^{-3}
$S = 1.19$	$\Delta\rho_{min} = -0.92$ e Å^{-3}
2137 reflections	Extinction correction: SHELXL2014 (Sheldrick, 2015b), $Fc^* = kFc[1 + 0.001 xFc^2\lambda^3/\sin(2\theta)]^{-1/4}$
99 parameters	
0 restraints	Extinction coefficient: 0.00102 (10)

Special details

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

Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters (Å²)

	x	*y*	*z*	U_{iso}*/U_{eq}	Occ. (<1)
Ag1	0.5000	0.5000	0.5000	0.01952 (7)	0.885 (2)
Ag2	1.0000	0.48916 (3)	0.7500	0.02408 (10)	0.7688 (19)
Fe1	0.78227 (2)	0.34311 (2)	0.37115 (3)	0.00565 (6)	0.61 (4)
Co1	0.78227 (2)	0.34311 (2)	0.37115 (3)	0.00565 (6)	0.39 (4)
Fe2	1.0000	0.76503 (2)	0.7500	0.00714 (8)	0.14 (5)
Co2	1.0000	0.76503 (2)	0.7500	0.00714 (8)	0.86 (5)
P1	0.76272 (3)	0.61138 (3)	0.37428 (6)	0.00502 (8)	
P2	0.5000	0.28909 (4)	0.2500	0.00535 (10)	
O1	0.77807 (11)	0.67841 (10)	0.18620 (19)	0.00908 (19)	
O2	0.81856 (12)	0.49999 (9)	0.3820 (2)	0.0112 (2)	
O3	0.62598 (11)	0.60711 (11)	0.3280 (2)	0.0135 (2)	
O4	0.83676 (12)	0.66524 (9)	0.60788 (19)	0.00917 (19)	
O5	0.45841 (10)	0.21873 (10)	0.03381 (18)	0.00821 (19)	
O6	0.60284 (12)	0.36401 (10)	0.2530 (2)	0.0122 (2)	

Atomic displacement parameters (Å²)

	U^{11}	U^{22}	U^{33}	U^{12}	U^{13}	U^{23}
Ag1	0.02917 (14)	0.00879 (9)	0.01123 (10)	−0.00389 (7)	−0.00138 (8)	−0.00128 (6)
Ag2	0.01069 (12)	0.02795 (16)	0.02519 (15)	0.000	−0.00133 (10)	0.000
Fe1	0.00485 (9)	0.00657 (9)	0.00575 (9)	0.00037 (6)	0.00240 (6)	0.00058 (6)
Co1	0.00485 (9)	0.00657 (9)	0.00575 (9)	0.00037 (6)	0.00240 (6)	0.00058 (6)
Fe2	0.00620 (12)	0.00833 (13)	0.00796 (13)	0.000	0.00398 (10)	0.000
Co2	0.00620 (12)	0.00833 (13)	0.00796 (13)	0.000	0.00398 (10)	0.000
P1	0.00488 (15)	0.00490 (15)	0.00521 (15)	0.00006 (11)	0.00198 (11)	0.00022 (10)
P2	0.00397 (19)	0.0071 (2)	0.00466 (19)	0.000	0.00138 (16)	0.000
O1	0.0101 (5)	0.0112 (5)	0.0062 (4)	−0.0001 (4)	0.0036 (4)	0.0020 (3)
O2	0.0118 (5)	0.0070 (4)	0.0144 (5)	0.0024 (4)	0.0048 (4)	−0.0013 (4)
O3	0.0067 (4)	0.0125 (5)	0.0221 (6)	0.0007 (4)	0.0066 (4)	0.0031 (4)
O4	0.0127 (5)	0.0083 (4)	0.0062 (4)	−0.0011 (4)	0.0034 (4)	−0.0013 (3)
O5	0.0064 (4)	0.0124 (5)	0.0053 (4)	−0.0011 (4)	0.0018 (3)	−0.0017 (3)
O6	0.0085 (5)	0.0119 (5)	0.0166 (5)	−0.0036 (4)	0.0054 (4)	0.0007 (4)

Geometric parameters (Å, º)

Ag1—O6[i]	2.3320 (13)	Fe1—O4[viii]	2.0481 (12)
Ag1—O6[ii]	2.3320 (13)	Fe1—O1[i]	2.0669 (11)
Ag1—O3[i]	2.4356 (14)	Fe1—O5[vi]	2.0705 (12)
Ag1—O3[ii]	2.4356 (14)	Fe1—O1[ix]	2.1695 (12)

Ag1—O3ⁱⁱⁱ	2.5724 (13)	Fe2—O3ˣ	2.1099 (13)
Ag1—O3	2.5725 (13)	Fe2—O3ˣⁱ	2.1099 (13)
Ag1—O6ⁱⁱⁱ	2.9176 (13)	Fe2—O5ˣⁱⁱ	2.1575 (11)
Ag1—O6	2.9176 (13)	Fe2—O5ˣⁱⁱⁱ	2.1575 (11)
Ag2—O2ⁱᵛ	2.4733 (13)	Fe2—O4ⁱᵛ	2.1717 (12)
Ag2—O2	2.4733 (13)	Fe2—O4	2.1717 (12)
Ag2—O2ⁱ	2.6204 (13)	P1—O3	1.5270 (13)
Ag2—O2ᵛ	2.6204 (13)	P1—O2	1.5393 (12)
Ag2—O4	2.8341 (12)	P1—O1	1.5451 (12)
Ag2—O4ⁱᵛ	2.8341 (12)	P1—O4	1.5543 (12)
Ag2—O5ᵛⁱ	2.9035 (13)	P2—O6ⁱⁱ	1.5346 (13)
Ag2—O5ᵛⁱⁱ	2.9035 (12)	P2—O6	1.5346 (13)
Fe1—O6	1.9656 (13)	P2—O5ⁱⁱ	1.5498 (12)
Fe1—O2	2.0108 (12)	P2—O5	1.5498 (12)
O6ⁱ—Ag1—O6ⁱⁱ	180.00 (4)	O2—Ag2—O1ⁱ	64.62 (4)
O6ⁱ—Ag1—O3ⁱ	80.58 (4)	O2ⁱ—Ag2—O1ⁱ	49.21 (3)
O6ⁱⁱ—Ag1—O3ⁱ	99.42 (4)	O2ᵛ—Ag2—O1ⁱ	136.08 (3)
O6ⁱ—Ag1—O3ⁱⁱ	99.42 (4)	O4—Ag2—O1ⁱ	92.94 (3)
O6ⁱⁱ—Ag1—O3ⁱⁱ	80.58 (4)	O4ⁱᵛ—Ag2—O1ⁱ	162.54 (3)
O3ⁱ—Ag1—O3ⁱⁱ	180.0	O5ᵛⁱ—Ag2—O1ⁱ	52.36 (3)
O6ⁱ—Ag1—O3ⁱⁱⁱ	108.21 (5)	O5ᵛⁱⁱ—Ag2—O1ⁱ	56.78 (3)
O6ⁱⁱ—Ag1—O3ⁱⁱⁱ	71.79 (5)	O2ⁱᵛ—Ag2—O1ᵛ	64.62 (4)
O3ⁱ—Ag1—O3ⁱⁱⁱ	66.27 (5)	O2—Ag2—O1ᵛ	119.96 (4)
O3ⁱⁱ—Ag1—O3ⁱⁱⁱ	113.73 (5)	O2ⁱ—Ag2—O1ᵛ	136.08 (3)
O6ⁱ—Ag1—O3	71.79 (5)	O2ᵛ—Ag2—O1ᵛ	49.21 (3)
O6ⁱⁱ—Ag1—O3	108.21 (5)	O4—Ag2—O1ᵛ	162.54 (3)
O3ⁱ—Ag1—O3	113.73 (5)	O4ⁱᵛ—Ag2—O1ᵛ	92.94 (3)
O3ⁱⁱ—Ag1—O3	66.27 (5)	O5ᵛⁱ—Ag2—O1ᵛ	56.78 (3)
O3ⁱⁱⁱ—Ag1—O3	180.0	O5ᵛⁱⁱ—Ag2—O1ᵛ	52.36 (3)
O6ⁱ—Ag1—O6ⁱⁱⁱ	53.64 (5)	O6—Fe1—O2	93.77 (5)
O6ⁱⁱ—Ag1—O6ⁱⁱⁱ	126.36 (5)	O6—Fe1—O4ᵛⁱⁱⁱ	110.10 (5)
O3ⁱ—Ag1—O6ⁱⁱⁱ	95.49 (4)	O2—Fe1—O4ᵛⁱⁱⁱ	86.76 (5)
O3ⁱⁱ—Ag1—O6ⁱⁱⁱ	84.51 (4)	O6—Fe1—O1ⁱ	86.70 (5)
O3ⁱⁱⁱ—Ag1—O6ⁱⁱⁱ	68.02 (4)	O2—Fe1—O1ⁱ	100.62 (5)
O3—Ag1—O6ⁱⁱⁱ	111.98 (4)	O4ᵛⁱⁱⁱ—Fe1—O1ⁱ	161.33 (5)
O6ⁱ—Ag1—O6	126.36 (5)	O6—Fe1—O5ᵛⁱ	163.25 (5)
O6ⁱⁱ—Ag1—O6	53.64 (5)	O2—Fe1—O5ᵛⁱ	101.04 (5)
O3ⁱ—Ag1—O6	84.51 (4)	O4ᵛⁱⁱⁱ—Fe1—O5ᵛⁱ	78.79 (5)
O3ⁱⁱ—Ag1—O6	95.49 (4)	O1ⁱ—Fe1—O5ᵛⁱ	82.95 (5)
O3ⁱⁱⁱ—Ag1—O6	111.98 (4)	O6—Fe1—O1ⁱˣ	80.26 (5)
O3—Ag1—O6	68.02 (4)	O2—Fe1—O1ⁱˣ	171.95 (5)
O6ⁱⁱⁱ—Ag1—O6	180.0	O4ᵛⁱⁱⁱ—Fe1—O1ⁱˣ	90.22 (4)
O2ⁱᵛ—Ag2—O2	173.70 (6)	O1ⁱ—Fe1—O1ⁱˣ	84.52 (5)
O2ⁱᵛ—Ag2—O2ⁱ	101.33 (4)	O5ᵛⁱ—Fe1—O1ⁱˣ	85.66 (5)
O2—Ag2—O2ⁱ	78.34 (4)	O3ˣ—Fe2—O3ˣⁱ	80.97 (7)
O2ⁱᵛ—Ag2—O2ᵛ	78.34 (4)	O3ˣ—Fe2—O5ˣⁱⁱ	91.27 (5)
O2—Ag2—O2ᵛ	101.33 (4)	O3ˣⁱ—Fe2—O5ˣⁱⁱ	112.81 (5)

O2^i—Ag2—O2^v	174.04 (5)	O3^x—Fe2—O5^{xiii}	112.81 (5)
O2^{iv}—Ag2—O4	118.73 (4)	O3^{xi}—Fe2—O5^{xiii}	91.27 (5)
O2—Ag2—O4	55.50 (4)	O5^{xii}—Fe2—O5^{xiii}	148.74 (7)
O2^i—Ag2—O4	61.33 (4)	O3^x—Fe2—O4^{iv}	85.08 (5)
O2^v—Ag2—O4	113.50 (4)	O3^{xi}—Fe2—O4^{iv}	164.39 (5)
O2^{iv}—Ag2—O4^{iv}	55.50 (4)	O5^{xii}—Fe2—O4^{iv}	74.29 (4)
O2—Ag2—O4^{iv}	118.73 (4)	O5^{xiii}—Fe2—O4^{iv}	87.71 (4)
O2^i—Ag2—O4^{iv}	113.50 (4)	O3^x—Fe2—O4	164.39 (5)
O2^v—Ag2—O4^{iv}	61.33 (4)	O3^{xi}—Fe2—O4	85.08 (5)
O4—Ag2—O4^{iv}	77.51 (5)	O5^{xii}—Fe2—O4	87.71 (4)
O2^{iv}—Ag2—O5^{vi}	114.87 (4)	O5^{xiii}—Fe2—O4	74.29 (4)
O2—Ag2—O5^{vi}	71.23 (4)	O4^{iv}—Fe2—O4	109.56 (7)
O2^i—Ag2—O5^{vi}	101.56 (4)	O3—P1—O2	112.57 (7)
O2^v—Ag2—O5^{vi}	83.86 (4)	O3—P1—O1	108.72 (7)
O4—Ag2—O5^{vi}	125.84 (3)	O2—P1—O1	109.47 (7)
O4^{iv}—Ag2—O5^{vi}	144.70 (3)	O3—P1—O4	109.98 (7)
O2^{iv}—Ag2—O5^{vii}	71.23 (4)	O2—P1—O4	107.31 (7)
O2—Ag2—O5^{vii}	114.87 (4)	O1—P1—O4	108.73 (7)
O2^i—Ag2—O5^{vii}	83.86 (4)	O6^{ii}—P2—O6	104.43 (10)
O2^v—Ag2—O5^{vii}	101.56 (4)	O6^{ii}—P2—O5^{ii}	108.75 (7)
O4—Ag2—O5^{vii}	144.70 (3)	O6—P2—O5^{ii}	112.14 (7)
O4^{iv}—Ag2—O5^{vii}	125.84 (3)	O6^{ii}—P2—O5	112.14 (7)
O5^{vi}—Ag2—O5^{vii}	52.03 (4)	O6—P2—O5	108.75 (7)
O2^{iv}—Ag2—O1^i	119.96 (4)	O5^{ii}—P2—O5	110.52 (9)

Symmetry codes: (i) x, −y+1, z+1/2; (ii) −x+1, y, −z+1/2; (iii) −x+1, −y+1, −z+1; (iv) −x+2, y, −z+3/2; (v) −x+2, −y+1, −z+1; (vi) x+1/2, −y+1/2, z+1/2; (vii) −x+3/2, −y+1/2, −z+1; (viii) x, −y+1, z−1/2; (ix) −x+3/2, y−1/2, −z+1/2; (x) x+1/2, −y+3/2, z+1/2; (xi) −x+3/2, −y+3/2, −z+1; (xii) −x+3/2, y+1/2, −z+1/2; (xiii) x+1/2, y+1/2, z+1.