

Redetermination of tricalcium trilanthanum pentakis(orthoborate) from single-crystal data

Tianyong Zhou and Ning Ye*

Fujian Institute of Research on the Structure of Matter, Chinese Academy of Sciences, Fuzhou, Fujian 350002, People's Republic of China

Correspondence e-mail: nye@fjirsm.ac.cn

Received 30 April 2008; accepted 15 May 2008

 Key indicators: single-crystal X-ray study; $T = 293$ K; mean $\sigma(\text{La}-\text{B}) = 0.004$ Å; R factor = 0.012; wR factor = 0.031; data-to-parameter ratio = 10.1.

Single crystals of the title compound, $\text{Ca}_3\text{La}_3(\text{BO}_3)_5$, were obtained by spontaneous nucleation from a high-temperature melt. The crystal structure of $\text{Ca}_3\text{La}_3(\text{BO}_3)_5$ has been determined previously from X-ray powder data [Zhang, Liang, Chen, He & Xu (2001). *J. Alloys Compd.*, **327**, 96–99]. The present refinement shows a significant improvement in terms of the precision of the geometric parameters and the correct determination of the absolute configuration in space group $P6_3mc$ with all atoms refined with anisotropic displacement parameters. The structure consists of isolated BO_3 triangles and distorted $[\text{CaO}_8]$ and $[\text{LaO}_{10}]$ polyhedra. Except for one O atom, all other atoms are situated on special positions: La, all O and one B atom on mirror planes, and two B atoms with site symmetry $3m$.

Related literature

For phase equilibria in the system $\text{La}_2\text{O}_3-\text{CaO}-\text{B}_2\text{O}_3$, see: Zhang *et al.* (2001a). For a previous structure analysis of $\text{Ca}_3\text{La}_3(\text{BO}_3)_5$ based on X-ray powder diffraction data, see: Zhang *et al.* (2001b). For non-linear optical (NLO) applications of borate crystals containing triangular BO_3 anions, see: Chen *et al.* (1999). For a review of the geometry of the BO_3 group, see: Zobetz (1982). For the potential applications of $\text{Ca}_3\text{La}_3(\text{BO}_3)_5$ for photoluminescence, see: Zhang *et al.* (2005); Han *et al.* (2007).

Experimental

Crystal data

$\text{Ca}_3\text{La}_3(\text{BO}_3)_5$	$Z = 2$
$M_r = 831.02$	Mo $K\alpha$ radiation
Hexagonal, $P6_3mc$	$\mu = 11.59$ mm ⁻¹
$a = 10.530$ (3) Å	$T = 293$ (2) K
$c = 6.398$ (2) Å	$0.22 \times 0.12 \times 0.10$ mm
$V = 614.4$ (3) Å ³	

Data collection

Rigaku Mercury CCD diffractometer	4065 measured reflections
Absorption correction: multi-scan (<i>CrystalClear</i> ; Rigaku, 2000)	534 independent reflections
$T_{\min} = 0.206$, $T_{\max} = 0.304$	534 reflections with $I > 2\sigma(I)$
	$R_{\text{int}} = 0.035$

Refinement

$R[F^2 > 2\sigma(F^2)] = 0.012$	$\Delta\rho_{\text{max}} = 0.41$ e Å ⁻³
$wR(F^2) = 0.030$	$\Delta\rho_{\text{min}} = -0.59$ e Å ⁻³
$S = 0.89$	Absolute structure: Flack (1983), 236 Friedel pairs
534 reflections	Flack parameter: -0.03 (3)
53 parameters	
1 restraint	

Table 1

Selected geometric parameters (Å, °).

Ca1—O4 ⁱ	2.3139 (13)	La1—O3 ^{viii}	2.8112 (8)
Ca1—O1 ⁱⁱ	2.376 (3)	B1—O4	1.358 (6)
Ca1—O3	2.382 (4)	B1—O1 ⁱ	1.384 (3)
Ca1—O1 ⁱⁱⁱ	2.662 (3)	B2—O2 ^{viii}	1.374 (3)
La1—O1 ^{iv}	2.501 (2)	B3—O3	1.389 (3)
La1—O4 ^v	2.516 (4)		
La1—O2 ^{vi}	2.6639 (15)		
O4—B1—O1 ⁱ	119.7 (2)	O2 ^{viii} —B2—O2 ^{xi}	120
O1 ⁱ —B1—O1 ^x	120.6 (4)	O3 ^x —B3—O3	120

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

Data collection: *CrystalClear* (Rigaku, 2000); 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: *enCIFer* (Allen *et al.*, 2004).

This project was supported by the National Science Foundation of China (grant No. 60608018).

Supplementary data and figures for this paper are available from the IUCr electronic archives (Reference: WM2179).

References

- Allen, F. H., Johnson, O., Shields, G. P., Smith, B. R. & Towler, M. (2004). *J. Appl. Cryst.* **37**, 335–338.
- Brandenburg, K. (2004). *DIAMOND*. Crystal Impact GbR, Bonn, Germany.
- Chen, C. T., Ye, N., Lin, J., Jiang, J., Zeng, W. R. & Wu, B. C. (1999). *Adv. Mater.* **11**, 1071–1078.
- Flack, H. D. (1983). *Acta Cryst.* **A39**, 876–881.
- Han, B., Liang, H. B. & Lin, H. H. (2007). *Appl. Phys. A Matter. Sci. Process.* **88**, 705–709.
- Rigaku (2000). *CrystalClear*. Rigaku Corporation, Tokyo, Japan.
- Sheldrick, G. M. (2008). *Acta Cryst.* **A64**, 112–122.
- Zhang, Y., Chen, X. L., Liang, J. K., Gao, Y. G. & Xu, T. (2001a). *J. Alloys Compd.* **315**, 198–202.
- Zhang, Y., Li, Y. D. & Yin, Y. S. (2005). *J. Alloys Compd.* **400**, 222–226.
- Zhang, Y., Liang, J. K., Chen, X. L., He, M. & Xu, T. (2001b). *J. Alloys Compd.* **327**, 96–99.
- Zobetz, E. (1982). *Z. Kristallogr.* **160**, 81–92.

supplementary materials

Acta Cryst. (2008). E64, i37 [doi:10.1107/S1600536808014785]

Redetermination of tricalcium trilanthanum pentakis(orthoborate) from single-crystal data

T. Zhou and N. Ye

Comment

Borate crystals containing parallel aligned BO_3 anions are predicted to have large nonlinear optical (NLO) coefficients, moderate birefringence and wide transparency in the UV-region. Therefore they are considered to be good candidates for NLO applications (Chen, 1999). The title compound $\text{Ca}_3\text{La}_3(\text{BO}_3)_5$, (I), has been investigated previously by Zhang *et al.* (2001a) during analysis of phase equilibria in the system $\text{La}_2\text{O}_3\text{—CaO—B}_2\text{O}_3$, and NLO and luminescent properties of this material have also been reported (Zhang, 2005; Han, 2007). The crystal structure of $\text{Ca}_3\text{La}_3(\text{BO}_3)_5$ was originally determined from X-ray powder diffraction data in conjunction with IR spectroscopy (Zhang *et al.*, 2001b).

The structure of compound (I) can be described in terms of BO_3 triangles and complex irregular $[\text{CaO}_8]$ and $[\text{LaO}_{10}]$ polyhedra. Each of the three crystallographically different B atoms is coordinated to three O atoms to form planar BO_3 triangles. The B—O bond lengths range from 1.384 (3) to 1.389 (3) Å, which is in good agreement with the results of geometric studies of the BO_3 unit (Zobetz, 1982). Two of the three BO_3 groups exhibit $3m$ symmetry, and the third BO_3 group has m symmetry with O—B—O angles very close to 120° . The La^{3+} cations are 10-fold coordinated by oxygen atoms with La—O bond lengths ranging from 2.501 (2) to 2.812 (2) Å. The $[\text{LaO}_{10}]$ polyhedra are connected to each other and to the borate groups by sharing corners and edges forming a three-dimensional network with channels running parallel to $[001]$. In these channels the Ca^{2+} cations are situated and are surrounded by eight oxygen atoms with Ca—O bond lengths ranging from 2.3139 (13) to 2.662 (3) Å (Table 1).

Experimental

Single crystals of compound (I) were grown using a LiBO_2 -containing flux. The composition of the mixture for crystal growth was 1:1:4:3 of CaCO_3 (Sinopharm Reagent, AR), La_2O_3 (Materials, 99.8%), H_3BO_3 (Sinopharm Reagent, 99.99%), and Li_2CO_3 (Sinopharm Reagent, AR). The mixture was heated in a platinum crucible to 1373 K, held at this temperature for several hours, and then cooled at a rate of 10 K/h from 1373 to 873 K. The remaining solidified flux attached to the crystals was readily dissolved in water. Crystals with an average size of 0.5 mm and mostly rod shaped habit were obtained.

Refinement

The present study confirms the basic structural features determined from the previous investigation by Zhang *et al.* (2001b) with a much higher precision and with all displacement parameters refined anisotropically.

Figures

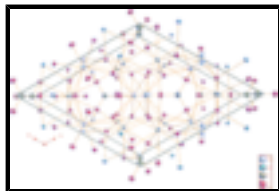


Fig. 1. The structure of (I) in a projection approximately along the [001] direction with displacement ellipsoids drawn at the 85% probability level.

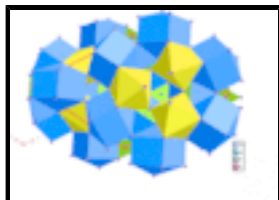


Fig. 2. Packing diagram of the structure of (I). [CaO₈] polyhedra are yellow, [LaO₁₀] polyhedra are blue and [BO₃] units are green.

tricalcium trilanthanum pentakis(orthoborate)

Crystal data

Ca₃La₃(BO₃)₅

$M_r = 831.02$

Hexagonal, *P6₃mc*

Hall symbol: P 6c -2c

$a = 10.530 (3) \text{ \AA}$

$b = 10.530 (3) \text{ \AA}$

$c = 6.398 (2) \text{ \AA}$

$\alpha = 90^\circ$

$\beta = 90^\circ$

$\gamma = 120^\circ$

$V = 614.4 (3) \text{ \AA}^3$

$Z = 2$

$F_{000} = 752$

$D_x = 4.492 \text{ Mg m}^{-3}$

Mo $K\alpha$ radiation

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

Cell parameters from 1909 reflections

$\theta = 2.2\text{--}27.5^\circ$

$\mu = 11.59 \text{ mm}^{-1}$

$T = 293 (2) \text{ K}$

Rod, colourless

$0.22 \times 0.12 \times 0.10 \text{ mm}$

Data collection

Rigaku Mercury CCD
diffractometer

Radiation source: Sealed Tube

Monochromator: Graphite Monochromator

Detector resolution: $14.6306 \text{ pixels mm}^{-1}$

$T = 293(1) \text{ K}$

CCD_Profile_fitting scans

Absorption correction: multi-scan
(CrystalClear; Rigaku, 2000)

$T_{\min} = 0.206$, $T_{\max} = 0.304$

4065 measured reflections

534 independent reflections

534 reflections with $I > 2\sigma(I)$

$R_{\text{int}} = 0.035$

$\theta_{\text{max}} = 27.5^\circ$

$\theta_{\text{min}} = 2.2^\circ$

$h = -13 \rightarrow 13$

$k = -13 \rightarrow 13$

$l = -8 \rightarrow 7$

Refinement

Refinement on F^2	Secondary atom site location: difference Fourier map
Least-squares matrix: full	$w = 1/[\sigma^2(F_o^2) + (0.02P)^2 + 1.5843P]$
$R[F^2 > 2\sigma(F^2)] = 0.012$	where $P = (F_o^2 + 2F_c^2)/3$
$wR(F^2) = 0.030$	$(\Delta/\sigma)_{\max} < 0.001$
$S = 0.89$	$\Delta\rho_{\max} = 0.41 \text{ e } \text{\AA}^{-3}$
534 reflections	$\Delta\rho_{\min} = -0.59 \text{ e } \text{\AA}^{-3}$
53 parameters	Extinction correction: SHELXL97 (Sheldrick, 2008), $F_c^* = kFc[1+0.001xFc^2\lambda^3/\sin(2\theta)]^{-1/4}$
1 restraint	Extinction coefficient: 0.0632 (12)
Primary atom site location: structure-invariant direct methods	Absolute structure: Flack (1983), 236 Friedel pairs Flack parameter: -0.03 (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	$U_{\text{iso}}^*/U_{\text{eq}}$
Ca1	0.47334 (5)	0.52666 (5)	0.76261 (15)	0.00673 (19)
La1	0.156065 (12)	0.843935 (12)	0.08229 (8)	0.00493 (11)
B1	0.1989 (3)	0.8011 (3)	0.5473 (8)	0.0049 (10)
B2	0	0	0.2435 (15)	0.0086 (17)
B3	0.6667	0.3333	0.598 (3)	0.0092 (19)
O1	0.6272 (3)	0.9278 (2)	0.4462 (4)	0.0067 (5)
O2	0.07534 (16)	0.92466 (16)	0.7399 (6)	0.0097 (7)
O3	0.59052 (16)	0.40948 (16)	0.5984 (8)	0.0083 (6)
O4	0.22657 (17)	0.77343 (17)	0.7443 (5)	0.0066 (6)

Atomic displacement parameters (\AA^2)

	U^{11}	U^{22}	U^{33}	U^{12}	U^{13}	U^{23}
Ca1	0.0060 (3)	0.0060 (3)	0.0073 (4)	0.0023 (3)	-0.0001 (2)	0.0001 (2)
La1	0.00442 (12)	0.00442 (12)	0.00474 (14)	0.00129 (9)	0.00003 (8)	-0.00003 (8)
B1	0.0052 (15)	0.0052 (15)	0.007 (3)	0.0044 (18)	-0.0006 (10)	0.0006 (10)

supplementary materials

B2	0.011 (3)	0.011 (3)	0.003 (4)	0.0057 (13)	0	0
B3	0.009 (2)	0.009 (2)	0.009 (6)	0.0046 (11)	0	0
O1	0.0069 (10)	0.0056 (10)	0.0073 (11)	0.0029 (9)	-0.0014 (10)	0.0016 (9)
O2	0.0090 (12)	0.0090 (12)	0.0124 (16)	0.0055 (14)	-0.0005 (7)	0.0005 (7)
O3	0.0101 (10)	0.0101 (10)	0.0067 (17)	0.0065 (11)	0.0005 (9)	-0.0005 (9)
O4	0.0067 (11)	0.0067 (11)	0.0055 (16)	0.0026 (13)	-0.0014 (7)	0.0014 (7)

Geometric parameters (\AA , $^\circ$)

Ca1—O4 ⁱ	2.3139 (13)	La1—O1 ⁱ	2.678 (3)
Ca1—O4 ⁱⁱ	2.3139 (13)	La1—O3 ^{xiv}	2.8112 (8)
Ca1—O1 ⁱⁱⁱ	2.376 (3)	La1—O3 ^{xv}	2.8112 (8)
Ca1—O1 ^{iv}	2.376 (3)	La1—B2 ^{xvi}	3.028 (3)
Ca1—O3	2.382 (4)	La1—B1	3.076 (5)
Ca1—O3 ^v	2.444 (5)	B1—O4	1.358 (6)
Ca1—O1 ⁱⁱ	2.662 (3)	B1—O1 ⁱ	1.384 (3)
Ca1—O1 ^{vi}	2.662 (3)	B1—O1 ^{xiii}	1.384 (3)
Ca1—B1 ⁱ	2.858 (4)	B1—Ca1 ⁱ	2.858 (4)
Ca1—B1 ⁱⁱ	2.858 (4)	B1—Ca1 ⁱⁱ	2.858 (4)
Ca1—Ca1 ^v	3.3435 (11)	B2—O2 ^{xvii}	1.374 (3)
Ca1—Ca1 ^{vii}	3.3435 (11)	B2—O2 ^{xviii}	1.374 (3)
La1—O1 ^{viii}	2.501 (2)	B2—O2 ^{xix}	1.374 (3)
La1—O1 ^{ix}	2.501 (2)	B2—La1 ^{xx}	3.028 (3)
La1—O4 ^x	2.516 (4)	B2—La1 ⁱ	3.028 (3)
La1—O2 ^x	2.639 (3)	B2—La1 ^{xxi}	3.028 (3)
La1—O2 ^{xi}	2.6639 (15)	B3—O3 ^{xxii}	1.389 (3)
La1—O2 ^{xii}	2.6639 (15)	B3—O3 ^{xxiii}	1.389 (3)
La1—O1 ^{xiii}	2.678 (3)	B3—O3	1.389 (3)
O4 ⁱ —Ca1—O4 ⁱⁱ	93.58 (15)	O1 ^{ix} —La1—O3 ^{xiv}	116.83 (10)
O4 ⁱ —Ca1—O1 ⁱⁱⁱ	151.80 (11)	O4 ^x —La1—O3 ^{xiv}	64.52 (12)
O4 ⁱⁱ —Ca1—O1 ⁱⁱⁱ	80.01 (9)	O2 ^x —La1—O3 ^{xiv}	122.29 (12)
O4 ⁱ —Ca1—O1 ^{iv}	80.01 (9)	O2 ^{xi} —La1—O3 ^{xiv}	155.42 (13)
O4 ⁱⁱ —Ca1—O1 ^{iv}	151.80 (11)	O2 ^{xii} —La1—O3 ^{xiv}	121.81 (10)
O1 ⁱⁱⁱ —Ca1—O1 ^{iv}	92.72 (12)	O1 ^{xiii} —La1—O3 ^{xiv}	88.50 (10)
O4 ⁱ —Ca1—O3	126.18 (10)	O1 ⁱ —La1—O3 ^{xiv}	65.77 (12)
O4 ⁱⁱ —Ca1—O3	126.18 (10)	O1 ^{viii} —La1—O3 ^{xv}	116.83 (9)
O1 ⁱⁱⁱ —Ca1—O3	77.64 (10)	O1 ^{ix} —La1—O3 ^{xv}	69.51 (8)
O1 ^{iv} —Ca1—O3	77.64 (10)	O4 ^x —La1—O3 ^{xv}	64.52 (12)
O4 ⁱ —Ca1—O3 ^v	73.69 (10)	O2 ^x —La1—O3 ^{xv}	122.29 (12)
O4 ⁱⁱ —Ca1—O3 ^v	73.69 (10)	O2 ^{xi} —La1—O3 ^{xv}	121.81 (10)
O1 ⁱⁱⁱ —Ca1—O3 ^v	78.17 (9)	O2 ^{xii} —La1—O3 ^{xv}	155.42 (13)
O1 ^{iv} —Ca1—O3 ^v	78.17 (9)	O1 ^{xiii} —La1—O3 ^{xv}	65.77 (12)

O3—Ca1—O3 ^v	144.65 (19)	O1 ⁱ —La1—O3 ^{xv}	88.50 (10)
O4 ⁱ —Ca1—O1 ⁱⁱ	56.39 (9)	O3 ^{xiv} —La1—O3 ^{xv}	50.66 (12)
O4 ⁱⁱ —Ca1—O1 ⁱⁱ	112.85 (10)	O4—B1—O1 ⁱ	119.7 (2)
O1 ⁱⁱⁱ —Ca1—O1 ⁱⁱ	151.00 (8)	O4—B1—O1 ^{xiii}	119.7 (2)
O1 ^{iv} —Ca1—O1 ⁱⁱ	86.53 (8)	O1 ⁱ —B1—O1 ^{xiii}	120.6 (4)
O3—Ca1—O1 ⁱⁱ	73.88 (10)	O2 ^{xvii} —B2—O2 ^{xviii}	120.00 (0)
O3 ^v —Ca1—O1 ⁱⁱ	129.62 (7)	O2 ^{xvii} —B2—O2 ^{xix}	120.00 (0)
O4 ⁱ —Ca1—O1 ^{vi}	112.85 (10)	O2 ^{xviii} —B2—O2 ^{xix}	120.00 (0)
O4 ⁱⁱ —Ca1—O1 ^{vi}	56.39 (9)	O3 ^{xxii} —B3—O3 ^{xxiii}	120.00 (0)
O1 ⁱⁱⁱ —Ca1—O1 ^{vi}	86.53 (8)	O3 ^{xxii} —B3—O3	120.00 (0)
O1 ^{iv} —Ca1—O1 ^{vi}	151.00 (8)	O3 ^{xxiii} —B3—O3	120.00 (0)
O3—Ca1—O1 ^{vi}	73.88 (10)	B1 ⁱⁱ —O1—Ca1 ^{xv}	147.6 (3)
O3 ^v —Ca1—O1 ^{vi}	129.62 (7)	B1 ⁱⁱ —O1—La1 ^{xxiv}	114.0 (3)
O1 ⁱⁱ —Ca1—O1 ^{vi}	80.50 (11)	Ca1 ^{xv} —O1—La1 ^{xxiv}	94.81 (8)
O1 ^{viii} —La1—O1 ^{ix}	138.96 (12)	B1 ⁱⁱ —O1—Ca1 ⁱ	83.5 (2)
O1 ^{viii} —La1—O4 ^x	73.88 (6)	Ca1 ^{xv} —O1—Ca1 ⁱ	82.95 (8)
O1 ^{ix} —La1—O4 ^x	73.88 (6)	La1 ^{xxiv} —O1—Ca1 ⁱ	87.75 (8)
O1 ^{viii} —La1—O2 ^x	71.80 (6)	B1 ⁱⁱ —O1—La1 ⁱⁱ	92.9 (2)
O1 ^{ix} —La1—O2 ^x	71.80 (6)	Ca1 ^{xv} —O1—La1 ⁱⁱ	89.98 (9)
O4 ^x —La1—O2 ^x	64.64 (11)	La1 ^{xxiv} —O1—La1 ⁱⁱ	111.47 (9)
O1 ^{viii} —La1—O2 ^{xi}	121.07 (8)	Ca1 ⁱ —O1—La1 ⁱⁱ	160.08 (10)
O1 ^{ix} —La1—O2 ^{xi}	71.30 (9)	B2 ^{xxv} —O2—La1 ^{xxvi}	123.0 (5)
O4 ^x —La1—O2 ^{xi}	137.71 (9)	B2 ^{xxv} —O2—La1 ^{xxvii}	91.42 (19)
O2 ^x —La1—O2 ^{xi}	82.07 (7)	La1 ^{xxvi} —O2—La1 ^{xxvii}	107.69 (7)
O1 ^{viii} —La1—O2 ^{xi}	71.30 (9)	B2 ^{xxv} —O2—La1 ^{xxviii}	91.42 (19)
O1 ^{ix} —La1—O2 ^{xi}	121.07 (8)	La1 ^{xxvi} —O2—La1 ^{xxviii}	107.69 (7)
O4 ^x —La1—O2 ^{xi}	137.71 (9)	La1 ^{xxvii} —O2—La1 ^{xxviii}	135.45 (14)
O2 ^x —La1—O2 ^{xi}	82.07 (7)	B3—O3—Ca1	154.0 (8)
O2 ^{xi} —La1—O2 ^{xi}	53.07 (13)	B3—O3—Ca1 ^{vii}	118.3 (8)
O1 ^{viii} —La1—O1 ^{xiii}	137.03 (9)	Ca1—O3—Ca1 ^{vii}	87.71 (10)
O1 ^{ix} —La1—O1 ^{xiii}	83.72 (6)	B3—O3—La1 ^{xxix}	94.64 (7)
O4 ^x —La1—O1 ^{xiii}	129.92 (8)	Ca1—O3—La1 ^{xxix}	86.76 (7)
O2 ^x —La1—O1 ^{xiii}	146.79 (6)	Ca1 ^{vii} —O3—La1 ^{xxix}	85.94 (9)
O2 ^{xi} —La1—O1 ^{xiii}	68.76 (8)	B3—O3—La1 ⁱⁱⁱ	94.64 (7)
O2 ^{xii} —La1—O1 ^{xiii}	92.23 (9)	Ca1—O3—La1 ⁱⁱⁱ	86.76 (7)
O1 ^{viii} —La1—O1 ⁱ	83.72 (6)	Ca1 ^{vii} —O3—La1 ⁱⁱⁱ	85.94 (9)
O1 ^{ix} —La1—O1 ⁱ	137.03 (9)	La1 ^{xxix} —O3—La1 ⁱⁱⁱ	169.80 (13)
O4 ^x —La1—O1 ⁱ	129.92 (8)	B1—O4—Ca1 ⁱⁱ	98.91 (12)
O2 ^x —La1—O1 ⁱ	146.79 (6)	B1—O4—Ca1 ⁱ	98.91 (12)
O2 ^{xi} —La1—O1 ⁱ	92.23 (9)	Ca1 ⁱⁱ —O4—Ca1 ⁱ	145.78 (15)
O2 ^{xii} —La1—O1 ⁱ	68.76 (8)	B1—O4—La1 ^{xxvi}	127.4 (3)

supplementary materials

O1^{xiii}—La1—O1ⁱ 53.37 (10) Ca1ⁱⁱ—O4—La1^{xxvi} 96.00 (9)

O1^{viii}—La1—O3^{xiv} 69.51 (8) Ca1ⁱ—O4—La1^{xxvi} 96.00 (9)

Symmetry codes: (i) $-y+1, x-y+1, z$; (ii) $-x+y, -x+1, z$; (iii) $x-y+1, x, z+1/2$; (iv) $-x+1, -x+y, z+1/2$; (v) $-x+1, -y+1, z+1/2$; (vi) $x, x-y+1, z$; (vii) $-x+1, -y+1, z-1/2$; (viii) $y-1, x, z-1/2$; (ix) $-x+1, -y+2, z-1/2$; (x) $x, y, z-1$; (xi) $x-y+1, x+1, z-1/2$; (xii) $y-1, -x+y, z-1/2$; (xiii) $-x+y, y, z$; (xiv) $x-y, x, z-1/2$; (xv) $y, -x+y+1, z-1/2$; (xvi) $x, y+1, z$; (xvii) $y-1, -x+y-1, z-1/2$; (xviii) $x-y+1, x, z-1/2$; (xix) $-x, -y+1, z-1/2$; (xx) $-x+y-1, -x, z$; (xxi) $x, y-1, z$; (xxii) $-x+y+1, -x+1, z$; (xxiii) $-y+1, x-y, z$; (xxiv) $-x+1, -y+2, z+1/2$; (xxv) $-x, -y+1, z+1/2$; (xxvi) $x, y, z+1$; (xxvii) $y-1, -x+y, z+1/2$; (xxviii) $x-y+1, x+1, z+1/2$; (xxix) $y, -x+y, z+1/2$.

Fig. 1

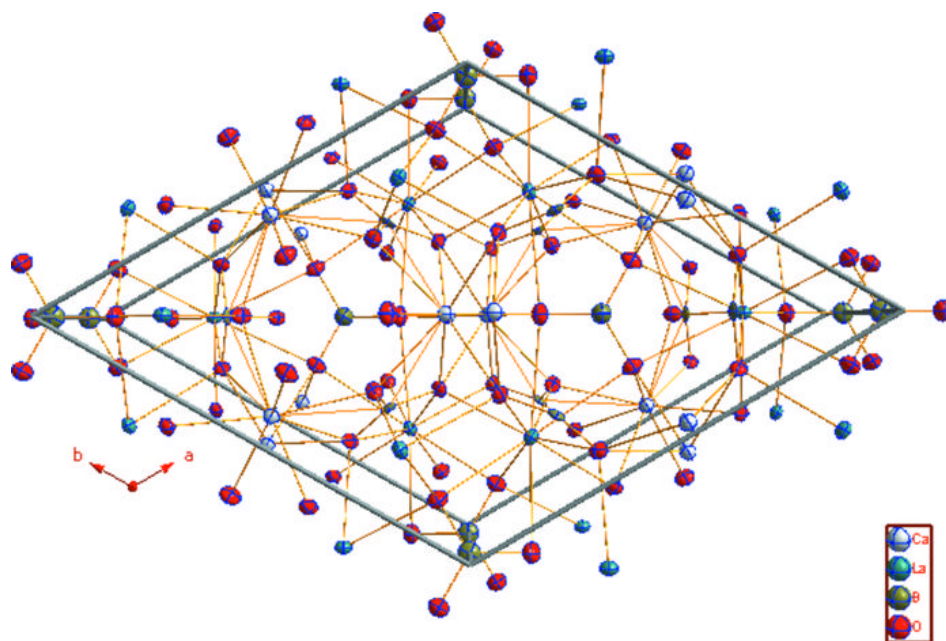


Fig. 2

