



Received 10 December 2015

Accepted 30 December 2015

Edited by M. Weil, Vienna University of
Technology, Austria**Keywords:** crystal structure; intermetallic
compound; linear platinum chains**CCDC reference:** 1444811**Supporting information:** this article has
supporting information at journals.iucr.org/e

Crystal structure of Sr_2CdPt_2 containing linear platinum chains

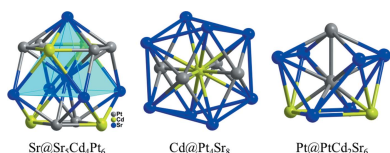
Effendi Nawawi,^a Fakhili Gulo^{a*} and Jürgen Köhler^b^aDepartment of Chemical Education, Sriwijaya University, Inderalaya, Ogan Ilir 30662, South Sumatra, Indonesia, and^bMax Planck Institut für Festkörperforschung, Heisenbergstr. 1, 70698 Stuttgart, Germany. *Correspondence e-mail: fgulo@unsri.ac.id

The ternary intermetallic title phase, distrontium cadmium diplatinum, was prepared from stoichiometric amounts of the elements at 1123 K for one day. The crystal structure adopts the orthorhombic Ca_2GaCu_2 structure type in space group *Immm*. Its main features are characterized by linear $(\text{Pt}-\text{Pt}\cdots\text{Pt}-\text{Pt})_n$ chains that are aligned along [010] and condensed through cadmium atoms forming Cd-centred $\text{Pt}_2\text{Cd}_{2/2}$ rectangles to build up sheets parallel to (001). These sheets are connected to each other *via* alternating (001) sheets of strontium atoms along [001]. The strontium sheets consists of corrugated Sr_4 units that are condensed to each other through edge-sharing parallel to [100].

1. Chemical context

A large number of transition metal-based ternary intermetallic phases have been studied in terms of metal–metal interactions and structure–property relationships (Corbett, 2010). Exploratory synthetic approaches in systems $A/\text{Cd}/\text{Pt}$ (A = alkaline earth metal) have revealed a great compositional and structural diversity. The calcium phase $\text{Ca}_6\text{Cd}_{16}\text{Pt}_8$ contains a three-dimensional array of isolated Cd_8 tetrahedral stars (TS) and a face-centred cube of $\text{Pt}@Ca_6$ octahedra (Samal *et al.*, 2013) whilst the structure of $\text{Ca}_6\text{Cd}_{11}\text{Pt}$ crystallizes in its own structure type consisting of apically interbonded Cd_7 pentagonal bipyramids and five-membered rings of Ca atoms (Gulo *et al.*, 2013). The strontium phase SrCd_4Pt_2 is made up of chains of edge-sharing Cd_4 tetrahedra bridged by four-bonded Sr atoms (Samal *et al.*, 2013) and SrCdPt presents six-membered rings of Sr atoms in a chair conformation (Gulo & Köhler, 2014). The barium phase BaCd_2Pt exhibits zigzag chains of Ba atoms and Pt-centred boat and anti-boat conformations formed by six-membered rings of Cd atoms (Gulo & Köhler, 2015). The Pt-based ternary intermetallic compounds with general formula $A_2X\text{Pt}_2$ (A = alkaline-earth or rare-earth metal; X = diel, triel, or tetrel element) adopt five different structure types. Sr_2InPt_2 (Muts *et al.*, 2007) crystallizes in the monoclinic $\text{Ca}_2\text{Ir}_2\text{S}$ type (Schoolaert & Jung, 2002), Pu_2SnPt_2 (Pereira *et al.*, 1997) in the tetragonal Mo_2FeB_2 type (Gladyshevskii *et al.*, 1996) while U_2CdPt_2 has its own structure type (Gravereau *et al.*, 1994). Ce_2CdPt_2 (Pöttgen *et al.*, 2000) adopts the tetragonal U_3Si_2 type (Zachariasen, 1948), and Ca_2CdPt_2 (Samal & Corbett, 2012) the orthorhombic Ca_2GaCu_2 type (Fornasini & Merlo, 1988).

In this article we present the crystal structure of the novel intermetallic phase Sr_2CdPt_2 containing linear $(\text{Pt}-\text{Pt}\cdots\text{Pt}-\text{Pt})_n$ chains as a principal structural motif.



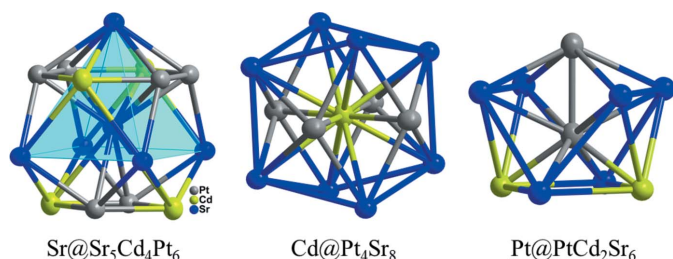


Figure 1
Coordination of strontium, cadmium, and platinum atoms in Sr_2CdPt_2 . Displacement ellipsoids are displayed at the 90% probability level.

2. Structural commentary

The ternary intermetallic title phase adopts the orthorhombic Ca_2GaCu_2 structure type (Fornasini & Merlo, 1988) with the Ca, Ga, and Cu sites replaced by Sr, Cd, and Pt sites, respectively. The three atoms occupy three independent sites in the unit cell. The Sr atom resides on a special position with site symmetry $mm2$ (Wyckoff site 4 j), the Cd atom occupies a special positions with site symmetry mmm (2 a) and the Pt atom is on a special positions with site symmetry $m2m$ (4 h). In the two structures, the transition metals (platinum and copper, respectively) occupy the same positions. In contrast, in the structure of SrCd_4Pt_2 (Samal *et al.*, 2013) which is isotypic with ZrFe_4Si_2 (Yarmolyuk *et al.*, 1975), the transition metals (platinum and iron, respectively) occupy different positions and the Pt atoms reside on the respective Si sites because silicon and platinum atoms are the most electronegative atoms in the two systems. The new phase Sr_2CdPt_2 contains 26 valence electrons and, as already mentioned, is isotypic with

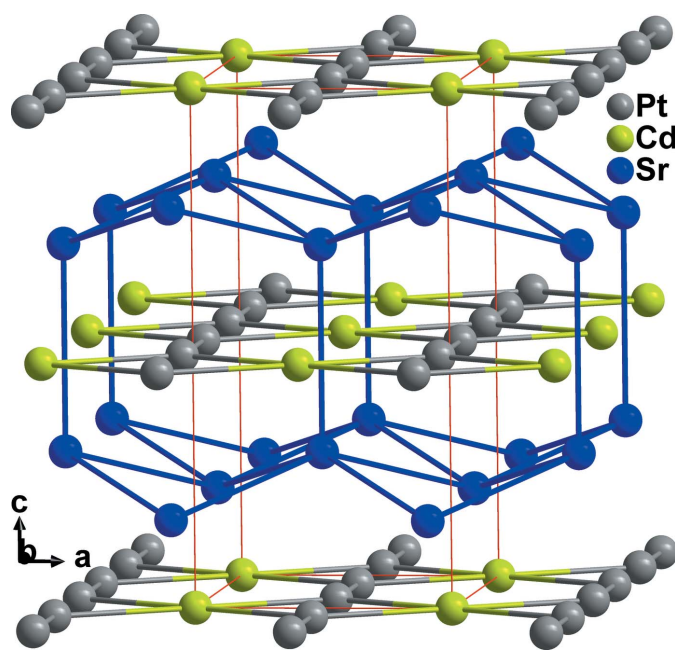


Figure 2
Projection of the crystal structure of Sr_2CdPt_2 approximately along the b axis.

Ca_2GaCu_2 . However, in comparison the structure of Sr_2CdPt_2 is appreciably distorted along the platinum chains, presumably because Ca_2GaCu_2 contains much smaller Cu atoms and a larger valence electron count of 29. Coordination spheres of each atomic site in the title structure are illustrated in Fig. 1. The Sr atom is coordinated by five other Sr, four Cd, and four Pt atoms. The Sr–Sr bond lengths vary from 3.674 (3) to 3.854 (1) Å, the Sr–Cd distances range from 3.490 (1) to 3.577 (1) Å, whereas the Sr–Pt values vary only slightly, from 3.188 (1) to 3.231 (1) Å. Six Sr atoms construct a square-planar pyramid, $\text{Sr}@\text{Sr}_5$. The existence of Sr–Sr strong bonds is observable in SrCdPt (Gulo & Köhler, 2014) but not in SrCd_4Pt_2 (Samal *et al.*, 2013). The Cd atom exhibits a coordination number of twelve and has eight Sr and four Pt atoms in its environment with Cd–Pt distances of 2.785 (1) Å. The Pt atom is surrounded by six Sr, two Cd and one Pt atoms with a Pt–Pt distance of 2.734 (1) Å. This distance is slightly longer than those found in Ca_2CdPt_2 (2.659 Å; Samal & Corbett, 2012) or Sr_2InPt_2 (2.707 Å; Muts *et al.*, 2007) but shorter than those in Pu_2SnPt_2 (Pereira *et al.*, 1997), U_2CdPt_2 (Gravereau *et al.*, 1994) or Ce_2CdPt_2 (Pöttgen *et al.*, 2000). All other interatomic distances (Sr–Cd, Sr–Pt, and Cd–Pt) are in agreement with those found in some ternary compounds in $A/\text{Cd}/\text{Pt}$ systems (A = alkaline earth metal).

3. Packing features

Sr atoms are bound together into corrugated sheets consisting of edge-sharing Sr_4 -units. These sheets spread parallel to (001) and are linked by another Sr–Sr bond of 3.674 (3) Å along [001]. (Fig. 2). The crystal structure is also characterized by the existence of linear $(\text{Pt}–\text{Pt} \cdots \text{Pt}–\text{Pt})_n$ chains along [010] with longer distances of 3.2010 (14) Å between pairs of tightly

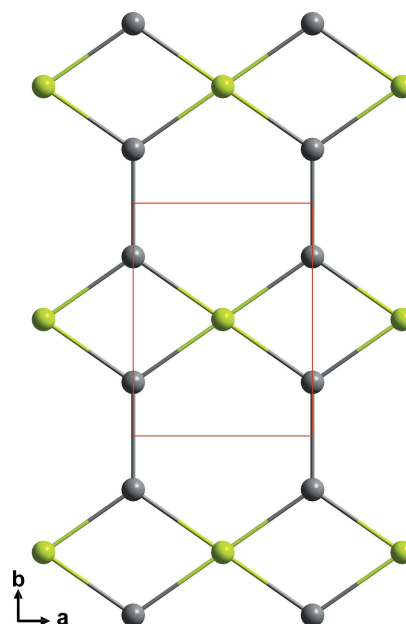


Figure 3
Projection of linear platinum chains that are aligned along the b axis and condensed *via* cadmium atoms forming $\text{Pt}_2\text{Cd}_{22}$ -rectangles in the ab -plane

Table 1
Experimental details.

| | |
|--|--|
| Crystal data | |
| Chemical formula | CdPt ₂ Sr ₂ |
| <i>M_r</i> | 677.82 |
| Crystal system, space group | Orthorhombic, <i>Immm</i> |
| Temperature (K) | 293 |
| <i>a</i> , <i>b</i> , <i>c</i> (Å) | 4.5596 (9), 5.9351 (12), 9.1874 (18) |
| <i>V</i> (Å ³) | 248.63 (9) |
| <i>Z</i> | 2 |
| Radiation type | Mo <i>K</i> α |
| <i>μ</i> (mm ⁻¹) | 81.39 |
| Crystal size (mm) | 0.08 × 0.06 × 0.05 |
| Data collection | |
| Diffractometer | Bruker P4 |
| Absorption correction | Multi-scan (<i>SADABS</i> ; Bruker, 2001) |
| <i>T_{min}</i> , <i>T_{max}</i> | 0.004, 0.017 |
| No. of measured, independent and observed [<i>I</i> > 2σ(<i>I</i>)] reflections | 1069, 190, 172 |
| <i>R_{int}</i> | 0.025 |
| (sin θ/λ) _{max} (Å ⁻¹) | 0.666 |
| Refinement | |
| <i>R</i> [<i>F</i> ² > 2σ(<i>F</i> ²)], <i>wR</i> (<i>F</i> ²), <i>S</i> | 0.022, 0.058, 1.16 |
| No. of reflections | 190 |
| No. of parameters | 13 |
| Δρ _{max} , Δρ _{min} (e Å ⁻³) | 1.84, -2.51 |

Computer programs: *XSCANS* (Bruker, 2001), *SHELXS97* and *SHELXL97* (Sheldrick, 2008) and *DIAMOND* (Brandenburg, 2010).

bound Pt–Pt dumbbells, a significant distortion in the direction of dimerization. The platinum chains are condensed into (001) sheets through Cd atoms, forming Cd-centred rectangles with composition Pt₂Cd_{2/2} (Fig. 3). The Pt₂Cd_{2/2} layers are stacked along [001] and are linked through the corrugated sheets of Sr atoms.

4. Database survey

A search of the Pearson's Crystal Data – Crystal Structure Database for Inorganic Compounds (Villars & Cenzual, 2015) for the Sr/Cd/Pt family of compounds returned two compounds only: SrCd₄Pt₂ (Samal *et al.*, 2013) and SrCdPt (Gulo & Köhler, 2014).

5. Synthesis and crystallization

The title compound was synthesized from starting materials of Sr granules (99.9+%, Alfa Aesar), Cd powder (99.9+%, Alfa Aesar) and Pt powder (99.95%, Chempur). A stoichiometric mixture of these elements was loaded into a Nb ampoule in an Ar-filled dry box. The Nb ampoule was then weld-sealed

under an Ar atmosphere and subsequently enclosed in an evacuated silica jacket. The sample was then heated to 1123 K for 15 h, equilibrated at 923 K for 4 days, and followed by slow cooling to room temperature.

6. Refinement

Crystal data, data collection and structure refinement details are summarized in Table 1. The maximum and minimum remaining electron densities are located 1.66 and 0.81 Å⁻³, respectively, from the Pt site.

Acknowledgements

Financial support for EN and FG from PNBPN Unsri is gratefully acknowledged.

References

- Brandenburg, K. (2010). *DIAMOND*. Crystal Impact GbR, Bonn, Germany.
- Bruker (2001). *XSCANS* and *SADABS*. Bruker AXS Inc., Madison, Wisconsin, USA.
- Corbett, J. D. (2010). *Inorg. Chem.* **49**, 13–28.
- Fornasini, M. L. & Merlo, F. (1988). *J. Less-Common Met.* **142**, 289–294.
- Gladyshevskii, E. I., Fedorov, T. F., Kuz'ma, Y. B. & Skolozdra, R. V. (1996). *Sov. Powder Metall. Met. Ceram.* **5**, 305–309.
- Gravereau, P., Mirambet, F., Chevalier, B., Weill, F., Fournès, L., Laffargue, D., Bourée, F. & Etourneau, J. R. (1994). *J. Mater. Chem.* **4**, 1893–1895.
- Gulo, F. & Köhler, J. (2014). *Acta Cryst.* **E70**, 590–592.
- Gulo, F. & Köhler, J. (2015). *Z. Anorg. Allg. Chem.* **641**, 557–560.
- Gulo, F., Samal, S. L. & Corbett, J. D. (2013). *Inorg. Chem.* **52**, 10112–10118.
- Muts, I. R., Nilges, T., Rodewald, U. C., Zaremba, V. I. & Pöttgen, R. (2007). *Z. Naturforsch. B*, **62**, 1563–1566.
- Pereira, L. C. J., Wastin, F., Winand, J. M., Kanellakopoulos, B., Rebizant, J., Spirlet, J. C. & Almeida, M. (1997). *J. Solid State Chem.* **134**, 138–147.
- Pöttgen, R., Fugmann, A., Hoffmann, R. D., Rodewald, U. C. & Niepmann, D. (2000). *Z. Naturforsch. B*, **55**, 155–161.
- Samal, S. L. & Corbett, J. D. (2012). *Z. Anorg. Allg. Chem.* **638**, 1963–1969.
- Samal, S. L., Gulo, F. & Corbett, J. D. (2013). *Inorg. Chem.* **52**, 2697–2704.
- Schoolaert, S. & Jung, W. (2002). *Z. Anorg. Allg. Chem.* **628**, 1806–1810.
- Sheldrick, G. M. (2008). *Acta Cryst.* **A64**, 112–122.
- Villars, P. & Cenzual, K. (2015). *Pearson's Crystal Data – Crystal Structure Database for Inorganic Compounds*. Release 2015/16. ASM International, Materials Park, Ohio, USA.
- Yarmolyuk, Y. P., Lysenko, L. A. & Gladyshevskii, E. I. (1975). *Uopov. Akad. Nauk Ukr. RSR, Ser. A*. 279.
- Zachariasen, W. H. (1948). *Acta Cryst.* **1**, 265–268.

supporting information

Acta Cryst. (2016). E72, 144-146 [doi:10.1107/S2056989015024937]

Crystal structure of Sr₂CdPt₂ containing linear platinum chains

Effendi Nawawi, Fakhili Gulo and Jürgen Köhler

Computing details

Data collection: *XSCANS* (Bruker, 2001); cell refinement: *XSCANS* (Bruker, 2001); data reduction: *XSCANS* (Bruker, 2001); program(s) used to solve structure: *SHELXS97* (Sheldrick, 2008); program(s) used to refine structure: *SHELXL97* (Sheldrick, 2008); molecular graphics: *DIAMOND* (Brandenburg, 2010); software used to prepare material for publication: *SHELXL97* (Sheldrick, 2008).

Distrontium cadmium diplatinum

Crystal data

CdPt₂Sr₂

$M_r = 677.82$

Orthorhombic, *Immm*

Hall symbol: -I 2 2

$a = 4.5596$ (9) Å

$b = 5.9351$ (12) Å

$c = 9.1874$ (18) Å

$V = 248.63$ (9) Å³

$Z = 2$

$F(000) = 560$

$D_x = 9.054$ Mg m⁻³

Mo $K\alpha$ radiation, $\lambda = 0.71073$ Å

Cell parameters from 25 reflections

$\theta = 12\text{--}18^\circ$

$\mu = 81.39$ mm⁻¹

$T = 293$ K

Block, brown

0.08 × 0.06 × 0.05 mm

Data collection

Bruker P4 4-circle
diffractometer

Radiation source: fine-focus sealed tube

Graphite monochromator

Detector resolution: 0 pixels mm⁻¹

ω -scans

Absorption correction: multi-scan

(*SADABS*; Bruker, 2001)

$T_{\min} = 0.004$, $T_{\max} = 0.017$

1069 measured reflections

190 independent reflections

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

$R_{\text{int}} = 0.025$

$\theta_{\max} = 28.3^\circ$, $\theta_{\min} = 4.1^\circ$

$h = -5 \rightarrow 6$

$k = -7 \rightarrow 7$

$l = -11 \rightarrow 11$

Refinement

Refinement on F^2

Least-squares matrix: full

$R[F^2 > 2\sigma(F^2)] = 0.022$

$wR(F^2) = 0.058$

$S = 1.16$

190 reflections

13 parameters

0 restraints

Primary atom site location: structure-invariant
direct methods

Secondary atom site location: difference Fourier
map

$w = 1/[\sigma^2(F_o^2) + (0.0337P)^2 + 3.9776P]$

where $P = (F_o^2 + 2F_c^2)/3$

$(\Delta/\sigma)_{\max} < 0.001$

$\Delta\rho_{\max} = 1.84$ e Å⁻³

$\Delta\rho_{\min} = -2.51$ e Å⁻³

Extinction correction: *SHELXL*,

$F_c^* = kFc[1 + 0.001xFc^2\lambda^3/\sin(2\theta)]^{-1/4}$

Extinction coefficient: 0.0024 (4)

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)

| | <i>x</i> | <i>y</i> | <i>z</i> | $U_{\text{iso}}^*/U_{\text{eq}}$ |
|----|----------|--------------|--------------|----------------------------------|
| Pt | 0.0000 | 0.23034 (10) | 0.5000 | 0.0172 (3) |
| Cd | -0.5000 | 0.5000 | 0.5000 | 0.0172 (4) |
| Sr | 0.0000 | 0.5000 | 0.19995 (16) | 0.0162 (4) |

Atomic displacement parameters (\AA^2)

| | U^{11} | U^{22} | U^{33} | U^{12} | U^{13} | U^{23} |
|----|------------|------------|------------|----------|----------|----------|
| Pt | 0.0156 (4) | 0.0205 (4) | 0.0155 (4) | 0.000 | 0.000 | 0.000 |
| Cd | 0.0157 (8) | 0.0152 (8) | 0.0207 (9) | 0.000 | 0.000 | 0.000 |
| Sr | 0.0171 (8) | 0.0169 (8) | 0.0146 (8) | 0.000 | 0.000 | 0.000 |

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

| | | | |
|--|--------------|--|--------------|
| Pt—Pt ⁱ | 2.7341 (13) | Cd—Sr ^{vii} | 3.4901 (10) |
| Pt—Cd ⁱⁱ | 2.7855 (5) | Cd—Sr ^{viii} | 3.5773 (12) |
| Pt—Cd | 2.7855 (5) | Cd—Sr ⁱⁱⁱ | 3.5773 (13) |
| Pt—Sr ⁱⁱⁱ | 3.1876 (14) | Cd—Sr | 3.5773 (12) |
| Pt—Sr | 3.1876 (14) | Cd—Sr ^{ix} | 3.5773 (13) |
| Pt—Pt ⁱⁱⁱ | 3.2010 (14) | Sr—Pt ⁱⁱⁱ | 3.1876 (14) |
| Pt—Sr ^{iv} | 3.2312 (10) | Sr—Pt ^{iv} | 3.2312 (10) |
| Pt—Sr ^v | 3.2312 (10) | Sr—Pt ^{xii} | 3.2312 (10) |
| Pt—Sr ^{vi} | 3.2312 (10) | Sr—Pt ^{xiii} | 3.2312 (10) |
| Pt—Sr ^{vii} | 3.2312 (10) | Sr—Pt ^v | 3.2312 (10) |
| Cd—Pt ⁱⁱⁱ | 2.7855 (5) | Sr—Cd ^{xiv} | 3.4901 (10) |
| Cd—Pt ^{viii} | 2.7855 (5) | Sr—Cd ^{xiii} | 3.4901 (10) |
| Cd—Pt ^{ix} | 2.7855 (5) | Sr—Cd ⁱⁱ | 3.5773 (12) |
| Cd—Sr ^{iv} | 3.4901 (10) | Sr—Sr ^{xv} | 3.674 (3) |
| Cd—Sr ^x | 3.4901 (10) | Sr—Sr ^{xvi} | 3.8535 (9) |
| Cd—Sr ^{xi} | 3.4901 (10) | | |
| Pt ⁱ —Pt—Cd ⁱⁱ | 125.070 (13) | Sr ^{viii} —Cd—Sr ⁱⁱⁱ | 180.0 |
| Pt ⁱ —Pt—Cd | 125.070 (13) | Pt ⁱⁱⁱ —Cd—Sr | 58.560 (14) |
| Cd ⁱⁱ —Pt—Cd | 109.86 (3) | Pt ^{viii} —Cd—Sr | 121.440 (14) |
| Pt ⁱ —Pt—Sr ⁱⁱⁱ | 120.139 (18) | Pt ^{ix} —Cd—Sr | 121.440 (14) |
| Cd ⁱⁱ —Pt—Sr ⁱⁱⁱ | 73.232 (13) | Pt—Cd—Sr | 58.560 (14) |
| Cd—Pt—Sr ⁱⁱⁱ | 73.232 (13) | Sr ^{iv} —Cd—Sr | 66.071 (12) |

| | | | |
|--|--------------|---|--------------|
| Pt ⁱ —Pt—Sr | 120.139 (18) | Sr ^x —Cd—Sr | 113.929 (12) |
| Cd ⁱⁱ —Pt—Sr | 73.232 (13) | Sr ^{xi} —Cd—Sr | 66.071 (12) |
| Cd—Pt—Sr | 73.232 (13) | Sr ^{vii} —Cd—Sr | 113.929 (12) |
| Sr ⁱⁱⁱ —Pt—Sr | 119.72 (4) | Sr ^{viii} —Cd—Sr | 79.18 (3) |
| Pt ⁱ —Pt—Pt ⁱⁱⁱ | 180.0 | Sr ⁱⁱⁱ —Cd—Sr | 100.82 (3) |
| Cd ⁱⁱ —Pt—Pt ⁱⁱⁱ | 54.930 (13) | Pt ⁱⁱⁱ —Cd—Sr ^{ix} | 121.440 (14) |
| Cd—Pt—Pt ⁱⁱⁱ | 54.930 (13) | Pt ^{viii} —Cd—Sr ^{ix} | 58.560 (14) |
| Sr ⁱⁱⁱ —Pt—Pt ⁱⁱⁱ | 59.861 (18) | Pt ^{ix} —Cd—Sr ^{ix} | 58.560 (14) |
| Sr—Pt—Pt ⁱⁱⁱ | 59.861 (18) | Pt—Cd—Sr ^{ix} | 121.440 (14) |
| Pt ⁱ —Pt—Sr ^{iv} | 64.971 (13) | Sr ^{iv} —Cd—Sr ^{ix} | 113.929 (12) |
| Cd ⁱⁱ —Pt—Sr ^{iv} | 145.14 (2) | Sr ^x —Cd—Sr ^{ix} | 66.071 (12) |
| Cd—Pt—Sr ^{iv} | 70.466 (13) | Sr ^{xi} —Cd—Sr ^{ix} | 113.929 (12) |
| Sr ⁱⁱⁱ —Pt—Sr ^{iv} | 134.76 (2) | Sr ^{vii} —Cd—Sr ^{ix} | 66.071 (12) |
| Sr—Pt—Sr ^{iv} | 73.786 (15) | Sr ^{viii} —Cd—Sr ^{ix} | 100.82 (3) |
| Pt ⁱⁱⁱ —Pt—Sr ^{iv} | 115.029 (13) | Sr ⁱⁱⁱ —Cd—Sr ^{ix} | 79.18 (3) |
| Pt ⁱ —Pt—Sr ^v | 64.971 (13) | Sr—Cd—Sr ^{ix} | 180.0 |
| Cd ⁱⁱ —Pt—Sr ^v | 70.466 (13) | Pt ⁱⁱⁱ —Sr—Pt | 60.28 (4) |
| Cd—Pt—Sr ^v | 145.14 (2) | Pt ⁱⁱⁱ —Sr—Pt ^{iv} | 134.76 (2) |
| Sr ⁱⁱⁱ —Pt—Sr ^v | 134.76 (2) | Pt—Sr—Pt ^{iv} | 106.214 (15) |
| Sr—Pt—Sr ^v | 73.786 (15) | Pt ⁱⁱⁱ —Sr—Pt ^{xii} | 106.214 (15) |
| Pt ⁱⁱⁱ —Pt—Sr ^v | 115.029 (13) | Pt—Sr—Pt ^{xii} | 134.76 (2) |
| Sr ^{iv} —Pt—Sr ^v | 89.75 (3) | Pt ^{iv} —Sr—Pt ^{xii} | 50.06 (3) |
| Pt ⁱ —Pt—Sr ^{vi} | 64.971 (13) | Pt ⁱⁱⁱ —Sr—Pt ^{xiii} | 106.214 (15) |
| Cd ⁱⁱ —Pt—Sr ^{vi} | 70.466 (13) | Pt—Sr—Pt ^{xiii} | 134.76 (2) |
| Cd—Pt—Sr ^{vi} | 145.14 (2) | Pt ^{iv} —Sr—Pt ^{xiii} | 110.71 (5) |
| Sr ⁱⁱⁱ —Pt—Sr ^{vi} | 73.786 (15) | Pt ^{xii} —Sr—Pt ^{xiii} | 89.75 (3) |
| Sr—Pt—Sr ^{vi} | 134.76 (2) | Pt ⁱⁱⁱ —Sr—Pt ^v | 134.76 (2) |
| Pt ⁱⁱⁱ —Pt—Sr ^{vi} | 115.029 (13) | Pt—Sr—Pt ^v | 106.214 (15) |
| Sr ^{iv} —Pt—Sr ^{vi} | 129.94 (3) | Pt ^{iv} —Sr—Pt ^v | 89.75 (3) |
| Sr ^v —Pt—Sr ^{vi} | 69.29 (5) | Pt ^{xii} —Sr—Pt ^v | 110.71 (5) |
| Pt ⁱ —Pt—Sr ^{vii} | 64.971 (13) | Pt ^{xiii} —Sr—Pt ^v | 50.06 (3) |
| Cd ⁱⁱ —Pt—Sr ^{vii} | 145.14 (2) | Pt ⁱⁱⁱ —Sr—Cd ^{xiv} | 151.90 (4) |
| Cd—Pt—Sr ^{vii} | 70.466 (13) | Pt—Sr—Cd ^{xiv} | 91.620 (18) |
| Sr ⁱⁱⁱ —Pt—Sr ^{vii} | 73.786 (15) | Pt ^{iv} —Sr—Cd ^{xiv} | 48.779 (16) |
| Sr—Pt—Sr ^{vii} | 134.76 (2) | Pt ^{xii} —Sr—Cd ^{xiv} | 93.47 (3) |
| Pt ⁱⁱⁱ —Pt—Sr ^{vii} | 115.029 (13) | Pt ^{xiii} —Sr—Cd ^{xiv} | 93.47 (3) |
| Sr ^{iv} —Pt—Sr ^{vii} | 69.29 (5) | Pt ^v —Sr—Cd ^{xiv} | 48.779 (16) |
| Sr ^v —Pt—Sr ^{vii} | 129.94 (3) | Pt ⁱⁱⁱ —Sr—Cd ^{xiii} | 91.620 (19) |
| Sr ^{vi} —Pt—Sr ^{vii} | 89.75 (3) | Pt—Sr—Cd ^{xiii} | 151.90 (4) |
| Pt ⁱⁱⁱ —Cd—Pt ^{viii} | 180.0 | Pt ^{iv} —Sr—Cd ^{xiii} | 93.47 (3) |
| Pt ⁱⁱⁱ —Cd—Pt ^{ix} | 109.86 (3) | Pt ^{xii} —Sr—Cd ^{xiii} | 48.779 (16) |
| Pt ^{viii} —Cd—Pt ^{ix} | 70.14 (3) | Pt ^{xiii} —Sr—Cd ^{xiii} | 48.779 (16) |
| Pt ⁱⁱⁱ —Cd—Pt | 70.14 (3) | Pt ^v —Sr—Cd ^{xiii} | 93.47 (3) |
| Pt ^{viii} —Cd—Pt | 109.86 (3) | Cd ^{xiv} —Sr—Cd ^{xiii} | 116.48 (4) |
| Pt ^{ix} —Cd—Pt | 180.0 | Pt ⁱⁱⁱ —Sr—Cd ⁱⁱ | 48.21 (2) |
| Pt ⁱⁱⁱ —Cd—Sr ^{iv} | 119.245 (13) | Pt—Sr—Cd ⁱⁱ | 48.21 (2) |
| Pt ^{viii} —Cd—Sr ^{iv} | 60.755 (13) | Pt ^{iv} —Sr—Cd ⁱⁱ | 152.59 (2) |
| Pt ^{ix} —Cd—Sr ^{iv} | 119.245 (13) | Pt ^{xii} —Sr—Cd ⁱⁱ | 152.59 (2) |

| | | | |
|---|--------------|--|--------------|
| Pt—Cd—Sr ^{iv} | 60.755 (13) | Pt ^{xiii} —Sr—Cd ⁱⁱ | 89.339 (16) |
| Pt ⁱⁱⁱ —Cd—Sr ^x | 60.755 (13) | Pt ^v —Sr—Cd ⁱⁱ | 89.339 (16) |
| Pt ^{viii} —Cd—Sr ^x | 119.245 (13) | Cd ^{xiv} —Sr—Cd ⁱⁱ | 113.929 (12) |
| Pt ^{ix} —Cd—Sr ^x | 60.755 (13) | Cd ^{xiii} —Sr—Cd ⁱⁱ | 113.929 (12) |
| Pt—Cd—Sr ^x | 119.245 (13) | Pt ⁱⁱⁱ —Sr—Cd | 48.21 (2) |
| Sr ^{iv} —Cd—Sr ^x | 180.00 (4) | Pt—Sr—Cd | 48.21 (2) |
| Pt ⁱⁱⁱ —Cd—Sr ^{xi} | 60.755 (13) | Pt ^{iv} —Sr—Cd | 89.339 (16) |
| Pt ^{viii} —Cd—Sr ^{xi} | 119.245 (13) | Pt ^{xii} —Sr—Cd | 89.339 (16) |
| Pt ^{ix} —Cd—Sr ^{xi} | 60.755 (13) | Pt ^{xiii} —Sr—Cd | 152.59 (2) |
| Pt—Cd—Sr ^{xi} | 119.245 (13) | Pt ^v —Sr—Cd | 152.59 (2) |
| Sr ^{iv} —Cd—Sr ^{xi} | 116.48 (4) | Cd ^{xiv} —Sr—Cd | 113.929 (12) |
| Sr ^x —Cd—Sr ^{xi} | 63.52 (4) | Cd ^{xiii} —Sr—Cd | 113.929 (12) |
| Pt ⁱⁱⁱ —Cd—Sr ^{vii} | 119.245 (13) | Cd ⁱⁱ —Sr—Cd | 79.18 (3) |
| Pt ^{viii} —Cd—Sr ^{vii} | 60.755 (13) | Pt ⁱⁱⁱ —Sr—Sr ^{xv} | 149.861 (18) |
| Pt ^{ix} —Cd—Sr ^{vii} | 119.245 (13) | Pt—Sr—Sr ^{xv} | 149.861 (18) |
| Pt—Cd—Sr ^{vii} | 60.755 (13) | Pt ^{iv} —Sr—Sr ^{xv} | 55.35 (2) |
| Sr ^{iv} —Cd—Sr ^{vii} | 63.52 (4) | Pt ^{xii} —Sr—Sr ^{xv} | 55.35 (2) |
| Sr ^x —Cd—Sr ^{vii} | 116.48 (4) | Pt ^{xiii} —Sr—Sr ^{xv} | 55.35 (2) |
| Sr ^{xi} —Cd—Sr ^{vii} | 180.0 | Pt ^v —Sr—Sr ^{xv} | 55.35 (2) |
| Pt ⁱⁱⁱ —Cd—Sr ^{viii} | 121.440 (14) | Cd ^{xiv} —Sr—Sr ^{xv} | 58.24 (2) |
| Pt ^{viii} —Cd—Sr ^{viii} | 58.560 (14) | Cd ^{xiii} —Sr—Sr ^{xv} | 58.24 (2) |
| Pt ^{ix} —Cd—Sr ^{viii} | 58.560 (14) | Cd ⁱⁱ —Sr—Sr ^{xv} | 140.409 (17) |
| Pt—Cd—Sr ^{viii} | 121.440 (14) | Cd—Sr—Sr ^{xv} | 140.409 (17) |
| Sr ^{iv} —Cd—Sr ^{viii} | 66.071 (12) | Pt ⁱⁱⁱ —Sr—Sr ^{xvi} | 53.63 (3) |
| Sr ^x —Cd—Sr ^{viii} | 113.929 (12) | Pt—Sr—Sr ^{xvi} | 100.38 (5) |
| Sr ^{xi} —Cd—Sr ^{viii} | 66.071 (12) | Pt ^{iv} —Sr—Sr ^{xvi} | 151.51 (5) |
| Sr ^{vii} —Cd—Sr ^{viii} | 113.929 (12) | Pt ^{xii} —Sr—Sr ^{xvi} | 103.14 (3) |
| Pt ⁱⁱⁱ —Cd—Sr ⁱⁱⁱ | 58.560 (14) | Pt ^{xiii} —Sr—Sr ^{xvi} | 52.59 (2) |
| Pt ^{viii} —Cd—Sr ⁱⁱⁱ | 121.440 (14) | Pt ^v —Sr—Sr ^{xvi} | 92.53 (2) |
| Pt ^{ix} —Cd—Sr ⁱⁱⁱ | 121.440 (14) | Cd ^{xiv} —Sr—Sr ^{xvi} | 141.30 (3) |
| Pt—Cd—Sr ⁱⁱⁱ | 58.560 (14) | Cd ^{xiii} —Sr—Sr ^{xvi} | 58.05 (2) |
| Sr ^{iv} —Cd—Sr ⁱⁱⁱ | 113.929 (12) | Cd ⁱⁱ —Sr—Sr ^{xvi} | 55.88 (3) |
| Sr ^x —Cd—Sr ⁱⁱⁱ | 66.071 (12) | Cd—Sr—Sr ^{xvi} | 101.13 (5) |
| Sr ^{xi} —Cd—Sr ⁱⁱⁱ | 113.929 (12) | Sr ^{xv} —Sr—Sr ^{xvi} | 103.81 (4) |
| Sr ^{vii} —Cd—Sr ⁱⁱⁱ | 66.071 (12) | | |

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